PROSIDING

PERSIDANGAN KEBANGSAAN TEKNOLOGI KEJURUTERAAN 2015

National Conference On Engineering Technology (NCET) 2015

'Bridging Technology Into The Future'

Volume 3, 2015

Jabatan Tenaga Manusia
Kementerian Sumber Manusia

PROSIDING

PERSIDANGAN KEBANGSAAN TEKNOLOGI KEJURUTERAAN 2015

NATIONAL CONFERENCE ON ENGINEERING TECHNOLOGY (NCET) 2015

Cetakan Pertama 2015

Harga: RM 90.00

ISBN: 978-967-99984-5-0

Diterbitkan Oleh:

Jabatan Tenaga Manusia
Kementerian Sumber Manusia

Aras 6 Blok D4 Kompleks D
Pusat Pentadbiran Kerajaan Persekutuan
62530 W.P. Putrajaya
Tel: 03-8886 5555
Faks: 03-88892417
Laman web: www.jtm.gov.my

Diurus Cetak Oleh:

Institut Latihan Perindustrian (ILP) AP Nibong Tebal

PROSIDING

PERSIDANGAN KEBANGSAAN TEKNOLOGI KEJURUTERAAN 2015

National Conference on Engineering Technology (NCET) 2015
'Bridging Technology Into The Future'

14 - 15 September 2015
ADTEC, Taiping, Perak

URUSETIA PENERBITAN
Bahagian Perancangan dan Penyelidikan
Jabatan Tenaga Manusia (JTM)

PENGANJUR
Jabatan Tenaga Manusia (JTM), Kementerian Sumber Manusia (KSM)

KANDUNGAN

PRAKATA iii

KATA ALUAN
YBhg. Dato' Chin Phaik Yoong, Ketua Pengarah JTM iv

JAWATANKUASA PERLAKSANAAN PERSIDANGAN v

UCAPTAMA vi
Ucaptama 1 :
Tajuk : Perkembangan Masa Hadapan Kerjaya Teknologi Kejuruteraan
Oleh : YBhg. Professor Dr. Abd. Rashid Abd. Aziz
Timbalan Naib Canselor (Penyelidikan & Inovasi), Universiti Teknologi Petronas (UTP) viii
Ucaptama 2 :
Tajuk: Sistem Perlindungan Harta Intelek di Malaysia
Oleh : Hj Norman bin Kusin
Pengarah (Pembangunan Kemahiran), Jabatan Tenaga Manusia xii

KATEGORI TEKNOLOGI KEJURUTERAAN ELEKTRIKAL / ELEKTRONIK / TELEKOMUNIKASI 1
E01: Rekabentuk Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) dengan Rangkaian Suapbalik Ragam Sepunya (CMFB) 3
E02: Electrical Bleeding System 20
E04: Carbon Dioxide Testing and Monitoring Via SMS 26
E05: Pembinaan Sistem Penerima Radio Melalui Serakan Meteor 34
E06: Development of Cost Effective PLC Training Kit by Using Arduino Platform (PLCduino) 44
E07: Performance Analysis of Gas Discharge Tube (GDT) at Telecommunication Drop Wire Termination System 53
E08: Smart Vehicle Child Safety System 58
E10: Development on DC Grass Cutter 65
E11: Development on 3S Generator 70
E12: The Effect of Electromagnetic Force (EMF) Radiation at Mobile Phone Base Station 73
E13: Sparring Kickboxing Machine 79
E14: Kesan Penggunaan Kit Pengujian Contactor dan Auxillary Contact terhadap Minat Pelajar sebagai Alat dan Bahan Bantuan Mengajar 86
E15: Home Integrated System for Surveillances and Automation using NFC Technology 92
E16: Keys Protection System 102
E17: Smart Genetic Algorithm Controller 110
E18: E-Basic Electricity For Beginner 116
E19: Solar Powered Lawn Mower 118
E20: Prototaip Sistem Amaran Kepala Air 120
E22: Application of Microwave Bandpass Filter as a Sensor 126
E26: Friendly Digital Incubator 132
E27: Switch Smart Phone 136
E29: Analyzing The Major Influential Factors That Affect The Deterioration of AGV Battery Performance 139
E30: Sistem Pemantauan Banjir 149
E31: Mesin Pengitar Semula Layan Diri 156
E32: Analysis on Handover Parameters in Femtocell LTE Based Network 162
E33: Performance Study of Wireless Body Area Network (WBAN) in Medical Environment 172
E35: Fabrication and Characterization of Metal Thin Film Produced By PVD Process 177

KATEGORI TEKNOLOGI KEJURUTERAAN MEKANIKAL 189
M1: Effect of Welding Heat Input on The Microstructure and Mechanical Properties at Coarse Grain Heat Affected Zone (CGHAZ) of ABS Grade A Steel 191
M2: Modelling of Pad Support For Foot Osteoarthritis 201
M3: Reverse Engineering of Micro Light Aircraft Systems and Design 216
M4: Stress Intensity Factors of Edge Cracks in Dissimilar Joint Plates 222
M5: Merekabentuk dan Membangunkan Sebuah Mesin Tuangan Empar Mudah Alih 229
M6: Pemecah Kulit Telur Rebus 235
M7: Oil Filter Scrapper 239
M9: Performance Evaluation of R290 Propane Refrigerant at Existing R22 Air Conditioning System: Drop in Case Study 242
M10: The Effect of Storage on Some Fresh-Cut Fruits in Controlled Cooling Temperature and Ice Cubes 246
M11: Application of Solar Photovoltaic (PV) to Drive The Air Conditioning System at Residential House: A Preliminary Case Study 251
M12: Minimization of Spent Acid Waste from Galvanizing Plant in Malaysia 255
M13: Rekabentuk dan Fabrikasi Sateportwo 266
M14: Technology Management of Galvanised Iron in Active Fire Protection Components and System 274
M17: Study And Analyze The Optimum Parameters Of Wirecut-EDM (Sodick VZ 500l) For SKD11 Tool Steel Machining 284
M19: Effect of Wire-EDM Parameters on Machining Characteristics of Titanium Alloy (Ti6Al4V) Using Taguchi Method 294
M20: Mesin Bebola Daging Menggunakan Sistem Empat Penggelek 306
M21: Mould Insert Surface Roughness Optimization by Orthogonal Array Methodology in Electrical Discharge Machining 311

KATEGORI TEKNOLOGI KEJURUTERAAN PERCETAKAN / BUKAN LOGAM / HAL EHWAL LATIHAN KEMAHIRAN 319
O1: Pelaksanaan *Welding Qualification Test (WQT)* di Institusi Latihan Jabatan Tenaga Manusia(ILJTM) 321
O6: e-JUST (e-JTM Unified Sources Transaction): Manifestasi Terhadap Pusat Sumber dan Multimedia ILJTM 331
O10: Assessing Acceptance Sampling Application in Manufacturing Electrical and Electronics Products 336
O12: Kenaf-Epoxy Composites: Effects of Fiber Content and Kenaf Treatment on Mechanical Properties 348
O13: Flame Retardant Composite Product Via Pultrusion Process 358
O14: Kemahiran *Employability* Pelajar Diploma Teknologi Komputer Rangkaian di ILJTM 361
O15: Synthesis and Characterization of Porous MAS with Different Pore Content of PU Sponge For Catalyst Support Application 370

KATEGORI TEKNOLOGI KEJURUTERAAN SIVIL 377
C03: Penggunaan *Glow Powder* Sebagai Bahan Tambah Pada Campuran Garisan Jalan Bagi Mengurangkan Penggunaan *Glass Beads* Dan *Cat Eyes* 379

KATEGORI TEKNOLOGI KEJURUTERAAN KOMPUTER / TEKNOLOGI MAKLUMAT 385
I4: Rural Wireless Communication & Network Using TV White Space Technology 387
I5: Internet Based Remote Fluid Ph Monitoring Using Iot Node 392
I6: Quadrant Directional Switching Equalization of Separated Plateau Limit Sub-Histograms for Local Content 400
I11: Remote AC Power Control Using Android 413

PRAKATA

NATIONAL CONFERENCE ON ENGINEERING AND TECHNOLOGY (NCET)

National Conference on Engineering Technology (NCET) adalah aktiviti perkongsian ilmiah melalui pembentangan kajian penyelesaian masalah dalam bidang kejuruteraan dan teknologi. Antara objektif utama penganjuran persidangan ini adalah untuk menggalakkan aktiviti penyelidikan, pembangunan dan inovasi di kalangan para pensyarah kemahiran khususnya pensyarah ILJTM. Berikut adalah objektif persidangan iaitu:

i) Menggalakkan penyelidikan, pembangunan dan inovasi di kalangan pensyarah dan pengajar melalui pembentangan kajian penyelesaian masalah dalam bidang kejuruteraan dan teknologi.
ii) Menyokong, menggalak dan menambah penerbitan teknikal oleh mana-mana institusi pengajian tinggi dan institusi latihan yang berteraskan teknologi dan kemahiran.
iii) Perkongsian pengetahuan, kemahiran dan kepakaran melalui pembentangan kertas kerja persidangan.

Selaras dengan dasar kerajaan terhadap Pendidikan Teknikal & Latihan Vokasional (TVET), dengan bertemakan "*Bridging Technology into The Future*", NCET 2015 turut mendapat penyertaan daripada tenaga pengajar atau pensyarah dalam bidang Teknik dan Vokasional daripada Politeknik, Kolej komuniti, IPTA serta ILKA selain daripada pengajar dan pensyarah Institusi Latihan Jabatan Tenaga Manusia (ILJTM). NCET berjaya dilaksanakan buat pertama kalinya pada tahun 2011 dimana pembentangan kertas persidangan adalah sebanyak 61 kertas persidangan manakala pada tahun 2013 sebanyak 68 kertas persidangan telah dibentangkan. NCET 2015 yang telah diadakan di Pusat Latihan Teknologi Tinggi (ADTEC) Taiping pada 14-15 September 2015 telah menerima sebanyak 87 kertas persidangan dari warga ILK dan TVET dan 63 kertas persidangan terpilih untuk pembentangan yang dikategorikan kepada lima (5) bidang iaitu:

1. Mechanical Engineering Technology;
2. Electrical, Electronic & Telecommunication Engineering Technology;
3. Computer & Information Technology;
4. Civil Engineering Technology; dan
5. Non-metal Engineering, Printing & Training Institutes Issues.

KATA ALUAN

YBhg. Dato' Chin Phaik Yoong
Ketua Pengarah JTM

Prosiding
National Conference On Engineering Technology (NCET) 2015

Salam sejahtera dan Salam 1 Malaysia

JTM telah berjaya mengadakan Persidangan Kebangsaan Teknologi Kejuruteraan (National Conference on Engineering Technology - NCET) 2015 untuk kali ke-3 pada 14 dan 15 September 2015, bertempat di Pusat Latihan Teknologi Tinggi (ADTEC) Taiping, Perak Darul Ridzuan. Saya ingin merakamkan ribuan penghargaan dan ucapan terima kasih kepada semua pihak yang terlibat dalam menjayakan persidangan tersebut yang telah diadakan khas bersempena dengan Karnival Teknologi JTM Peringkat Kebangsaan.

Persidangan seumpama ini telah menampakkan bakat pensyarah ILK dan TVET dalam penyelidikan, pembangunan dan inovasi daripada pelbagai bidang dimana telah dipamerkan dalam persidangan NCET 2015 ini dengan pembentangan sebanyak 63 kertas persidangan. Semoga ia terus kekal dan terus menunjukkan peningkatan yang memberangsangkan di masa akan datang.

NCET 2015 telahpun berjalan dengan jayanya dengan kerjasama pelbagai pihak. Adalah diharapkan agar persidangan seterusnya akan mendapat penyertaan daripada lebih banyak institusi pengajian tinggi dan institusi latihan kemahiran (awam dan swasta) dan juga sektor lain yang berkaitan demi untuk memartabatkan pendidikan dan latihan dalam bidang teknologi dan kemahiran vokasional di Malaysia ini.

Akhir kalam, saya ingin mengambil peluang ini untuk merakamkan setinggi-tinggi penghargaan kepada semua yang terlibat dalam menjayakan Persidangan Kebangsaan Teknologi Kejuruteraan (NCET) yang ke-3 tahun 2015 dan seterusnya membolehkan prosiding ini diterbitkan.

Sekian, terima kasih.

(DATO' CHIN PHAIK YOONG)

KETUA PENGARAH
JABATAN TENAGA MANUSIA
KEMENTERIAN SUMBER MANUSIA

JAWATANKUASA PERLAKSANAAN PERSIDANGAN

PENAUNG : YBhg. Dato' Chin Phaik Yoong
Ketua Pengarah JTM

PENGERUSI : Tn. Hj. Syed Mohamad Noor bin Syed Mat Ali
Timbalan Ketua Pengarah JTM

JAWATANKUASA TEKNIKAL

PENGERUSI : En. Zaihan bin Shukri
NAIB PENGERUSI : En. Mohd Manoj bin Jumidali
AHLI :

1. Ir. Halim Azhar bin Hj Mohd Yatim
2. En. Ahmad Hanapi bin Yusof
3. Tn. Hj. Sabri bin Zainuddin
4. Tn. Hj. Azman Bin Hj. Ibrahim
5. En. Zamzuri bin Hassan
6. Pn. Junnaina bt Husin Chua
7. En. Muzafar Shah bin Mohd Shah
8. En. Mohd Yusri bin Mohd Rahim
9. En. Munirshah bin Sumiri
10. Tn. Hj. Mohd Zaibidi bin Nordin
11. Hjh. Syamsiah bt Salleh
12. En. Azizi bin Bahari
13. En. Mohamad Safri bin Mohd Dali
14. Pn. Norhayati bt Ishak
15. Cik Nurul Hanida bt Abd. Wahab
16. Pn. Mariam bt Mohamed
17. En. Sakundan A/L Subramaniam
18. Tn. Hj. Mohd Faizal Bin Tokeran
19. Pn. Nor Azlina bt Ismail
20. Cik Hjh Marina bt Sukor
21. Pn. Siti Aidah bt Wardi

URUSETIA PERSIDANGAN

1. Pn. Faizah bt Harun
2. Pn. Rd Khairina bt Khirotdin
3. Pn. Intan Sharfinas bt Mohd Nasir
4. Pn. Norhidayati bt Nordin
5. Tn. Sheikh Ezamuddin bin Sheikh Mohd Mutaffa

UCAPTAMA

UCAPTAMA

Ucaptama 1 :

Tajuk : Perkembangan Masa Hadapan Kerjaya Teknologi Kejuruteraan

Oleh : YBhg. Professor Dr. Abd. Rashid Abd. Aziz
Timbalan Naib Canselor (Penyelidikan & Inovasi)
Universiti Teknologi Petronas (UTP)

Yang berusaha Tuan Pengerusi Majlis, yang dihormati Pengarah ADTEC, Encik Ir Halim Azhar, dif-dif jemputan, wakil-wakil jabatan kerajaan, universiti dan pusat latihan, para pensyarah dan pelajar-pelajar, serta tuan-tuan dan puan-puan hadirin sekalian, assalamualaikum warahmatullahi wabarakatuh, salam sejahtera dan salam satu Malaysia.

Saya berasa amat berbesar hati dan berterima kasih di atas jemputan pihak penganjur untuk memberikan ucaptama pada persidangan pagi ini, iaitu Persidangan Kebangsaan Teknologi Kejuruteraan Kali Ke-3 ataupun *"The 3rd National Conference on Engineering Technology"* yang diadakan atas tujuan untuk memupuk sifat-sifat cemerlang dan berinovasi di kalangan pensyarah-pensyarah, para teknologis, juruteknik dan pelajar-pelajar.

Tajuk syarahan saya pada pagi ini ialah "Perkembangan Masa Hadapan Kerjaya Teknologi Kejuruteraan". Saya rasa tajuk ini sesuai dengan tema persidangan kita pada hari ini, iaitu *"Bridging Technology into The Future"*.

Sebelum saya pergi dengan lebih lanjut kepada topik syarahan ini, ingin saya menarik perhatian tuan-tuan dan puan-puan kepada rancangan-rancangan pembangunan pendidikan yang telah dirombak oleh kerajaan dan Kementerian Pendidikan untuk menambah-baikkan sistem pendidikan di negara kita ini.

Sebagaimana yang tuan-tuan dan puan-puan sedia maklum, pihak Kementerian Pengajian Tinggi baru-baru ini telah pun memperkenalkan Pelan Pembangunan Pendidikan Malaysia 2015-2025 (Pengajian Tinggi). Terkandung di dalam pelan ini ialah sepuluh lonjakan, di mana salah satu daripada sepuluh lonjakan ini ialah meningkatkan kualiti pendidikan TVET iaitu Pendidikan dan Latihan Teknikal dan Vokasional, sesuai dengan hasrat kerajaan dan kementerian untuk melahirkan insan seimbang dari segi akhlak dan ilmu yang bukan sahaja boleh mencari pekerjaan, malah boleh mencipta pekerjaan baru atau mencipta perusahaan baru melalui ciri-ciri pemikiran keusahawanan dan kepakaran yang diperolehi semasa dalam pengajian di universiti dan pusat-pusat latihan serantau.

Lonjakan ini adalah perlu untuk menampung keperluan pekerja-pekarja mahir di dalam jurusan teknikal dan vokasional yang dijangkakan akan meningkat kepada 1.3 juta pekerja menjelang tahun 2020 di dalam 12 sektor Bidang Ekonomi Utama Negara atau lebih dikenali dengan panggilan NKEA (iaitu *National Key Economic Area*). Untuk memenuhi keperluan tenaga kerja ini, enrolmen dalam TVET perlu dipertingkatkan kepada dua setengah kali ganda iaitu sebanyak 650,000 pelajar menjelang 2025. Di masa hadapan, kita akan dapati bahawa pekerjaan dalam TVET adalah sama penting dalam fungsi untuk menaiktarafkan negara kita kepada negara membangun sepenuhnya menjelang 2020.

Ingin saya menarik perhatian tuan-tuan dan puan-puan kepada satu tarikh sepuluh tahun yang lepas, di mana Kementerian Pengajian Tinggi telah memperkenalkan Pelan Strategik Pengajian Tinggi Negara Melangkau Tahun 2020 di mana salah satu daripada tujuh teras dalam pembangunan pendidikan tinggi negara adalah untuk membudayakan pembelajaran sepanjang hayat atau "*life-long learning*".

Cabaran ini banyak digalas oleh IPT, politeknik dan kolej komuniti untuk menyediakan ruang dan peluang terutamanya untuk pelajar-pelajar lepasan SPM untuk meningkatkan tahap pembelajaran dan kepakaran ke peringkat yang lebih tinggi, iaitu dari pengajian di peringkat sijil dan diploma, kepada pengajian di peringkat ijazah sarjana muda dan sarjana, dan seterusnya ke peringkat doktor falsafah.

Saya berpendapat bahawa strategi ini adalah amat tepat dan berkesan kepada halatuju TVET kerana ia memberi peluang kepada graduan TVET untuk meningkatkan kepakaran di dalam bidang masing-masing di samping terus bekerja. Graduan TVET saya lihat adalah lebih kepada "*hands-on*" dan praktikal dan dengan itu dapat memilih bidang pengajian yang lebih menjurus kepada kepakaran yang dikehendaki oleh majikan. Ini akan dapat menaikkan daya saing graduan TVET dan meningkatkan mutu produk yang dimajukan oleh usahawan-usahawan kerana mereka telah mempunyai kepakaran yang tinggi dan tidak perlu lagi dilatih.

Saya yakin bahawa graduan TVET akan dapat memenuhi hasrat Wawasan 2020 untuk menjadikan Malaysia sebuah negara membangun yang mempunyai masyarakat yang saintifik dan progresif, innovatif dan memandang ke hadapan, serta bukan sahaja pengguna teknologi, tetapi sebagai penyumbang kepada sains dan teknologi untuk masyarakat masa hadapan.

Jadi, apakah ciri-ciri yang dapat memupuk perkembangan masa hadapan kerjaya teknologi kejuruteraan? Saya akan mengolah ciri-ciri ini dari 4 haluan :

Haluan Pertama - Sifat (atau *Attributes*) kerjaya Teknologi Kejuruteraan di masa hadapan

Haluan Kedua - Tahap pendidikan (atau *Qualifications*) kerjaya Teknologi Kejuruteraan di masa hadapan

Haluan Ketiga - Laluan Kerjaya (atau *Career Path*) Teknologi Kejuruteraan di masa hadapan

dan Haluan Keempat - Watak (atau *Character*) kerjaya Teknologi Kejuruteraan di masa hadapan

Pertama, dari segi sifat atau "*attributes*", ingin saya mengambil sedikit pendekatan yang telah dilakukan di UTP dalam visi kami untuk melahirkan graduan serba boleh atau lebih dikenali dengan "*well-rounded graduates*". Graduan serba boleh UTP mempunyai beberapa sifat tertentu yang dibentuk semasa pelajar-pelajar ini berada di kampus UTP. Antara sifat-sifat tersebut yang saya kira relevan juga untuk kerjaya teknologi kejuruteraan ialah :

1. Kebolehan Belajar Sepanjang Hayat
2. Berfikiran Kritis
3. Celik Perniagaan (*Business Acumen*)
4. Kebolehan Menyelesai Masalah

Jika sekarang kita menjangkakan bahawa di dalam kerjaya teknologi kejuruteraan, graduan TVET mempunyai sifat-sifat seperti :

1. Boleh mengendalikan peralatan dengan cekap
2. Boleh mengawal selia peralatan
3. dan boleh membaik pulih peralatan dengan cekap

maka di masa akan datang, menjangkau 2020 hingga 2030, graduan TVET dijangkakan :

1. Bukan sahaja boleh mengendalikan peralatan, tetapi dapat menyarankan atau mengesyorkan penambahbaikan kepada pengendalian peralatan dengan inovasi pada proes-proses atau pada pengurangan penggunaan bahan dan tenaga.
2. Graduan TVET bukan sahaja boleh mengawal selia peralatan, tetapi dapat mengubah suai dan menambah baik peralatan untuk meningkatkan prestasi peralatan tesebut dari segi kebolehan dan keberkesanan.
3. Graduan TVET juga bukan sahaja boleh membaik pulih peralatan, tetapi dapat membuat jangkaan tentang keboleh-peranan peralatan dan mengenal pasti kebolehpercayaan (*reliability*) dan risiko peralatan.

Graduan TVET saya jangkakan akan mengendalikan peralatan yang lebih kompleks dan canggih di masa hadapan. Sekiranya sekarang graduan TVET dapat mengendalikan peralatan seperti *3-axis CNC lathe & turning machine*, maka di masa hadapan, mereka perlu bekebolehan mengendalikan peralatan *5-axis CNC machine* dan juga peralatan canggih seperti *Rapid Prototyping Machine*, *Laser Sintering Machine* dan sebagainya . Ini adalah kerana di negara-negara yang sudah membangun di mana mereka mencipta dan mereka bentuk teknologi-teknologi baru, peralatan canggih ini dikendalikan oleh graduan TVET yang berkemahiran tinggi.

Untuk mencapai ke arah ini, graduan TVET perlu mempertingkatkan kelayakan mereka lebih dari memegang sijil kebolehan dan diploma. Ini adalah ciri kedua kerjaya teknologi kejuruteraan di masa akan datang di mana saya menjangkakan graduan TVET perlu untuk mempunyai kelayakan di peringkat sarjana muda, sarjana sehinggalah ke peringkat ijazah kedoktoran.

Ini bukanlah sesuatu yang mustahil, kerana saya mendapati hasil dari lawatan ke makmal-makmal dan pusat-pusat kecemerlangan baik di universiti-universiti terkemuka luar negara dan industri-industri yang tersohor, kebanyakan pekerja-pekerja yang berkait dengan peralatan canggih ini mempunyai ijazah kedua atau ketiga. Mereka menyumbang di dalam kerja-kerja pembangunan teknologi bukan setakat sebagai pengendali peralatan tersebut, tetapi dikira sebagai salah seorang ahli di dalam kumpulan pembangunan teknologi kerana kepakaran tinggi yang dimiliki oleh mereka. Kebanyakan mereka ini dilahirkan dari sistem yang mirip seperti TVET.

Contohnya sistem pembelajaran KOSEN di Jepun telah dapat melahirkan ramai teknologis mahir. Sebahagiannya dapat menyambung pengajian mereka di peringkat Sarjana dan Doktor Falsafah. Buktinya, pemegang kursi professor Teknologi Hijau di UTP sendiri adalah seorang Professor berkelayakan PhD yang dihasilkan dari sistem KOSEN. Walaupun ini adalah satu contoh terpencil, ia tetap menunjukkan bahawa mereka yang melalui sistem ini mempunyai peluang yang sama dalam meningkatkan tahap pengajian masing-masing dan boleh menyumbang kepada pembangunan negara. Malah saya sendiri mendapati Professor dari Jepun ini adalah seorang yang sangat mahir dari segi "*hands-on*" kerana beliau boeh membina sendiri peralatan penyelidikannya.

Satu lagi sistem yang mirip kepada TVET ialah sistem *Fachhochschulen* di Germany. Sistem ini yang mementingkan aspek praktikal di dalam pembelajaran menghendaki pelajar-pelajarnya meluangkan masa beberapa semester dalam latihan industri, di samping sistem pembelajaran yang lebih mementingkan aspek praktikal dan penyelesaian kepada masalah daripada aspek teori dan analisis. Sistem ini juga memerlukan tenaga pengajarnya mempunyai pengalaman industri yang luas. Malah pensyarah mereka adalah diwajibkan untuk berkhidmat di industri selama sekurang-kurangnya 6 bulan setiap 4 tahun untuk memastikan pengalaman industri mereka adalah relevan dan terkini. Di Germany, graduan *Fachhochschulen* membentuk lebih dari 20% dari jumlah graduan IPT.

Saya mencadangkan graduan TVET yang mempunyai sijil dan diploma untuk mengambil ijazah B. Tech atau B. Sc. iaitu ijazah sarjana muda teknologi kejuruteraan atau ijazah sarjana muda sains dan ini boleh dilakukan melalui pengajian separuh masa, pengajian jarak jauh atau pun pengajian secara atas talian sekiranya ianya tidak dapat dijalankan dengan sepenuh masa. UTP sendiri telah mula mengorak langkah dengan menggalakkan juruteknik-juruteknik kami yang berkebolehan dan berbakat untuk meneruskan pengajian secara separuh masa di dalam jurusan Sarjana Muda Sains bidang Fizik dan Kimia Gunaan atau *Applied Physics* dan *Applied Chemistry*. Mereka ini dijangka akan ditempatkan di pusat-pusat kecemerlangan UTP dan meneruskan kerjaya mereka sebagai teknologis berkepakaran tinggi. Mereka ini akan dibimbing untuk meneruskan pengajian sehingga ke peringkat Doktor Falsafah dan akan sama-sama menyumbang untuk menjadikan UTP sebuah universiti terkemuka satu hari nanti.

Inilah, pada pandangan saya, ciri ketiga yang perlu ada pada kerjaya teknologi kejuruteraan, iaitu laluan kerjaya atau "*career path*" berteraskan teknikal. Majikan perlu bersedia untuk mengambil kira perkembangan kelayakan dan kebolehan graduan TVET yang telah dapat meningkatkan kepakaran mereka dengan menyediakan laluan kerjaya yang menjurus kepada kerjaya teknikal. Di negara-negara membangun, graduan TVET yang berkemahiran tinggi ini dapat menikmati tangga kelayakan jawatan dan tanggagaji yang setara dengan graduan kejuruteraan. Di peringkat awal, graduan TVET boleh menjawat jawatan Teknologis.

Di peringkat pertengahan graduan TVET boleh dinaikkan pangkat ke jawatan Pegawai Teknologi Kanan dan di peringkat tertinggi, mereka boleh menjawat jawatan Pakar atau "*Specialist*". Di peringkat Pakar, graduan TVET dijangkakan mempunyai kelayakan peringkat ijazah kedoktoran (PhD) dan bekebolehan untuk mengubahsuai peralatan untuk memenuhi tujuan-tujuan tertentu dalam pembangunan teknologi.

Ciri keempat kerjaya teknologi kejuruteraan masa hadapan berpaksikan kepada keseimbangan akhlak dan ilmu. Ini merupakan salah satu dari aspirasi Pelan Pembangunan Pendidikan Malaysia (Pendidikan Tinggi) yang menghendaki graduan yang berkemahiran tinggi tetapi juga beretika dan bermoral.

Ciri keempat iaitu watak atau "*character*" yang diperlukan dalam kerjaya teknologi kejuruteraan masa hadapan ialah :

1. Peka kepada kesejahteraan masyarakat atau pun "*society well being*"
2. Peka kepada kelestarian alam sekitar atau pun "*sustainability*"
3. Beretika dan berintergriti tinggi serta professional
4. Bersatu dan sehaluan dalam kerja atau pun "*united in purpose*"
5. Semangat setiakawan dan bekerja secara berkumpulan atau pun "*teamwork and teamplayer*"

Watak atau "*character*" ini penting kerana kerjaya teknologi kejuruteraan di masa hadapan akan berhadapan dengan cabaran-cabaran yang hebat yang memerlukan watak yang seimbang. Graduan teknologi kejuruteraan adalah salah seorang dari ahli penting yang menyumbang kepada penghasilan produk-produk yang akan memberi impak yang tinggi kepada masyarakat. Sifat beretika dan professional dan peka kepada kebajikan masyarakat dan alam sekitar akan mendorong kepada kesejahteraan negara di samping dapat membangunkan negara sesuai dengan matlamat Wawasan 2020. Sebaliknya, jika para teknologis tidak mempunyai sifat-sifat atau watak yang disebut tadi maka satu tragedi besar boleh berlaku, baik dari segi keselamatan produk atau keselamatan persekitaran.

Sebagai penutup kepada syarahan saya pada pagi ini, saya ingin menarik kembali perhatian tuan-tuan dan puan-puan hadirin sekalian kepada empat ciri-ciri yang dapat memupuk ke arah perkembangan kerjaya teknologi kejuruteraan masa hadapan iaitu :

Pertama - Sifat (*Attributes*) kerjaya Teknologi Kejuruteraan di masa hadapan

Kedua - Tahap pendidikan (*Qualifications*) kerjaya Teknologi Kejuruteraan di masa hadapan

Ketiga - Laluan Kerjaya (*Career Path*) Teknologi Kejuruteraan di masa hadapan

dan Keempat - Watak (*Character*) kerjaya Teknologi Kejuruteraan di masa hadapan

Saya berpendapat bahawa keempat-empat ciri ini perlu berlaku secara serentak sekiranya kita inginkan graduan TVET menjadi cemerlang dan menyumbang kepada pembangunan negara secara progresif dan dinamik. Kerjaya teknologi kejuruteraan perlu dilihat sebagai sumber penting sebagai katalis di dalam pembangunan teknologi di masa hadapan, sejajar dengan matlamat negara untuk menjadi negara membangun menjelang 2020.

Akhir sekali, saya mendoakan agar persidangan kita pada hari ini akan membuahkan hasil yang dapat mengembangkan dan menjurus kepada ciri-ciri kerjaya teknologi kejuruteraan masa hadapan.

Wabillahittaufik wal hidayah, Wassalaamualaikum warahmatullahi wabarakaatuh.

Sekian, terima kasih.

Ucaptama 2 :

Tajuk: Sistem Perlindungan Harta Intelek di Malaysia

Oleh : Hj Norman bin Kusin
Pengarah (Pembangunan Kemahiran)
Jabatan Tenaga Manusia

Tajuk "Sistem Perlindungan Harta Intelek di Malaysia" merupakan satu topik yang berkesinambungan dan seiring dengan tema persidangan, iaitu "Bridging Technology into the Future". Peranan *Inovation Department*, selaku pencetus idea *Think Out of Box* berperanan besar dalam membangun Harta Intelek bagi sesuatu organisasi.

Harta Intelek (Intelectual Property) - "Adalah *hasil ciptaan minda*; rekacipta, karya sastera dan seni; dan simbol, nama dan imej yang digunakan dalam perdagangan."

Rekacipta merujuk kepada Kreativiti & Inovasi iaitu "Kreativiti adalah mencari penyelesaian kepada masalah tertentu"

Contoh:

" Thomas Edison Tested Over 3000 Filaments Before He Came Up With His Version of a Practical Light Bulb. As Shocking As It May Seem, This Was Not His Greatest Invention", in 1879, after spending $40,000, and performing 1,200 experiments with 5,000 researchers, .''

SIAPA BERTANGGUNGJAWAB DALAM PENGUATKUASAAN HARTA INTELEK?

- Specialized Agency of the United Nations
- Based in Geneva, Switzerland
- 184 Member States
- Dedicated to developing a balanced and accessible international IP system by:
  - Administration of 24 international treaties
  - Service delivery: PCT, Madrid Treaty, The Hague Treaty, etc.

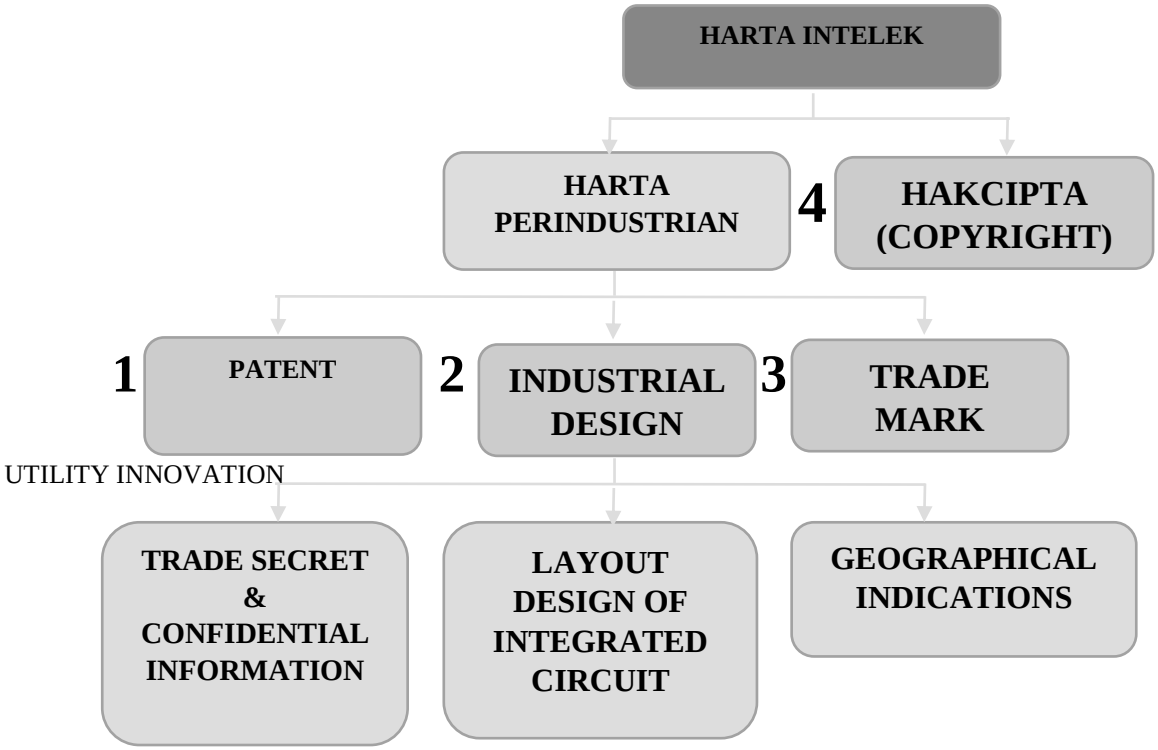
WIPO Administered Treaties In The Field Of Patents

Remarks	Member States
Paris Convention for the Protection of Industrial Property (1883)	172
Patent Cooperation Treaty (1970)	138
Strasbourg Agreement Concerning the International Patent Classification (IPC) (1971)	58
Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure (1977)	68
Patent Law Treaty (2000)	17

Perbadanan Harta Intelek Malaysia (Intellectual Property Corporation Of Malaysia) atau nama ringkasannya MyIPO

- Badan berkanun di bawah Kementerian Perdagangan Dalam Negeri, Koperasi & Kepenggunaan mulai 03 Mac 2003
- Sempena Hari Harta Intelek Kebangsaan pada 3 Mac 2005, dikenali sebagai MyIPO (Intellectual Property Corporation of Malaysia)
- Bertanggungjawab untuk mewujudkan sistem pentadbiran harta intelek yang kukuh dan cekap di Malaysia.
- Website : www.myipo.gov.my

Komponen Harta Intelek (IP)



Laws Governing Intellectual Property In Malaysia

- Patents Act 1983
- Trade marks act 1976
- Copyright Act 1987
- Geographical Indications Act 2000
- Layout Designs of Integrated Circuits Act 2000
- Akta Perbadanan Harta Intelek 2002

1. Paten

"Hal ekslusif yang diberikan kepada perekacipta terhadap sesuatu rekacipta untuk membuat, mengguna atau menjual rekaciptanya, bagi produk ataupun proses penghasilan cara baru untuk membuat sesuatu ataupun penyelesaian teknikal terhadap sesuatu masalah."

Pembaharuan Utiliti

"Perakuan perbaharuan utilti diberi ke atas rekacipta yang minor, yang tidak menepati ujian langkah merekacipta seperti paten, tetapi ia adalah baru.

2. Industrial Design

Reka bentuk perindustrian ialah rupa bentuk luaran secara keseluruhan yang memberi suatu penampilan yang unik pada suatu barang atau produk yang dihasilkan secara perindustrian.

2.1 Reka bentuk Perindustrian dan Paten

Konsep Asas Perlindungan Harta Intelek

i. Paten – rekabentuk seperti enjin dan brek
ii. Industrial Design – bentuk, paten, warna atau gabungan seperti chasis kereta
iii. Trademark - logo, jenama produk dan perkhidmatan seperti BMW & Benz

2.2 Permohonan Perlindungan Rekabentuk Perindustrian

i. Di bawah Akta Rekabentuk perindustrian 1999
ii. Pemfailan permohonan dibuat sebelum barang dipasarkan
iii. Perlindungan 5 tahun – boleh dilanjutkan sehingga dua tempoh, jumlah 15 tahun
iv. Bayaran Permohonan pendaftaran RM400
(Lampiran 5 -Borang RP1)

3. Cap Dagangan (Trademark)

i. Akta Cap Dagangan 1976
ii. Perlindungan kepada perkataan, nama, simbol, bunyi atau warna yang diguna untuk membezakan produk dan perkhidmatan.
iii. Cap Dagangan boleh diperbaharui selama-lamanya selagi ia diguna dalam perniagaan
iv. Pemohon dinasihatkan membuat carian terlebih dahulu sebelum mengemukakan permohonan. Bayaran RM20 sejam jika membuat carian awam di MyIPO

4. Hakcipta (Copyright)

Perlindungan hasil kerja penerbitan seperti penulisan, muzik, permainan video dan hasil seni

4.1 Permohonan Perlindungan Hakcipta

i. Akta Hakcipta 1987
ii. Pemfailan permohonan dibuat sebelum barang dipasarkan
iii. Perlindungan 5 tahun – boleh dilanjutkan sehingga dua tempoh, jumlah 15 tahun
iv. Bayaran Permohonan pendaftaran RM400

5. Lain-Lain IP

i. Akta Rekabentuk Susun Atur Litar bersepadu 2000 adalah susunan tiga dimensi unsur-unsur sesuatu litar bersepadu dan sebahagian atau semua saling hubungan litar bersepadu itu atau susunan tiga dimensi sedemikian yang disediakan bagi sesuatu litar bersepadu yang dimaksudkan untuk dikilang.

ii. Akta Petunjuk Geografi 2000, suatu petunjuk yang mengenal pasti apa-apa barang sebagai berasal dari sesuatu negara atau wilayah, atau sesuatu kawasan atau tempat dalam negara atau wilayah itu, jika suatu kualiti, reputasi atau ciri lain tertentu barang itu adalah berpunca dari tempat asal geografinya. *Trade secret & confidential information*

Bengkel Berfikir Di Luar Kotak:
Aplikasi Maklumat Paten Dalam Kreativiti Dan Inovasi (7 – 9 Dis 2015) Rainbow Paradise Beach Resort, Pulau Pinang membincang jenis dan definasi paten :-

Jenis Paten

- **Paten biasa**:
  merangkumi produk, proses, kaedah/penggunaan

- **Pembaharuan Utiliti (Utility Innovation):**
  Hanya melibatkan produk yang mempunyai kegunaan praktis sahaja

Apa itu Paten?

- Paten adalah satu hak eksklusif yang diberikan terhadap suatu rekacipta, sama ada satu produk ataupun proses untuk menghasilkan cara baru bagi membuat sesuatu, ataupun untuk penyelesaian teknikal bagi sesuatu masalah.
- Dilindungi di bawah Akta Paten 1983 dan
- perlindungan paten adalah selama 20 tahun dari tarikh pemfailan**.**

What is a UTILITY INNOVATION?

- Satu hak eksklusif yang diberikan terhadap suatu rekacipta kecil yang tidak memerlukan ujian langkah merekacipta sebagaimana yang diperlukan untuk mendapat paten.
- Pembaharuan utiliti dilindungi selama 10 tahun dari tarikh pemfailan.
- Boleh dilanjutkan ke 5+5 tahun bergantung kepada penggunaan.
- Jumlah Perlindungan : 20 tahun

DIFFERENCES BETWEEN PATENT AND UTILITY INNOVATION

Patent	Utility Innovation
Criteria for patentability: New Involves Inventive Step Industrially applicable **Duration for protection** 20 years from the filing date **Request fees** Form 1: RM290	**Criteria for patentability:** New Industrially applicable **Duration for protection** 10+5+5 years from the filing date **Request fees** Form 14: RM140

DEFINISI

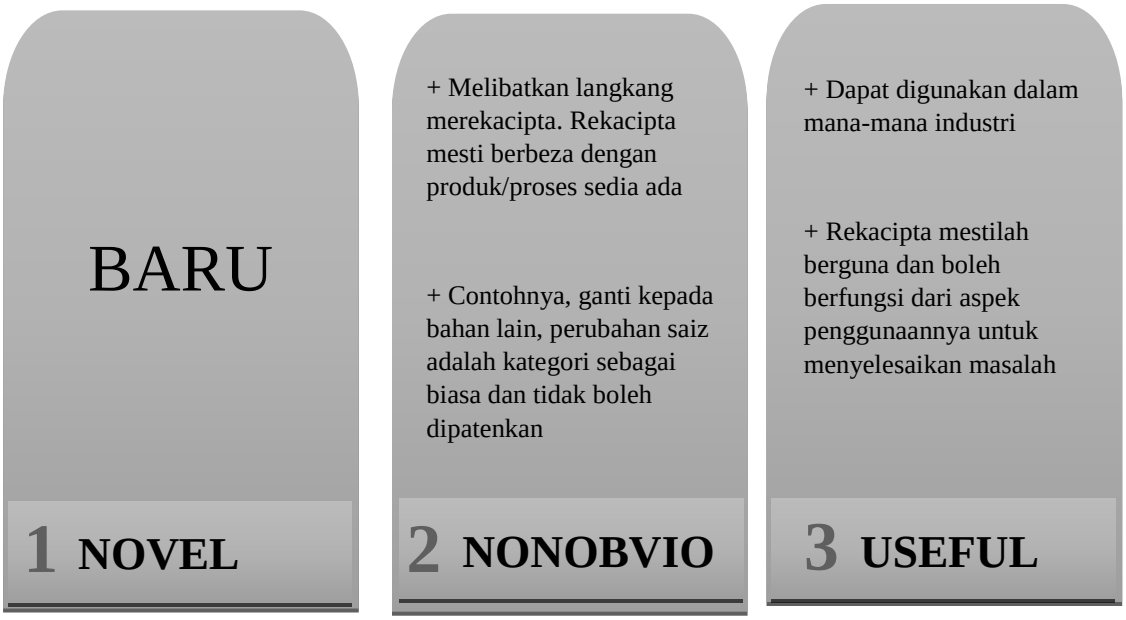
- **Invensi** adalah idea inventor yang dihasilkan untuk kegiatan penyelesaian masalah yang spesifik di bidang teknologi
- **Inventor** adalah seorang yang secara perseorangan atau berkumpulan, bersama-sama melaksanakan idea tersebut
- **Pemegang paten** adalah inventor sebagai pemilik paten atau pihak yang menerima hak tersebut atau pihak lain yang menerima lebih lanjut hak tersebut
- Rekacipta yang memberi penyelesaian teknikal terhadap sesuatu masalah (Bukan semua penyelesaian boleh mendapat hak paten)
- Hak eksklusif yang diberikan terhadap suatu rekacipta, samada produk atau proses untuk menghasilkan cara baru bagi membuat sesuatu.
- Paten diluluskan ikut 'territorial' (mengikut negara seperti Malaysia, Korea dsb). Perlindungan dibawah Akta Paten 1983
- Tempoh perlindungan : 20 tahun
  (bergantung kepada bayaran yuran tahunan selenggaraan)

Kelebihan Daftar Paten

- Pendaftaran Paten di Perbadanan Harta Intelek Malaysia (MyIPO)
- Hak eksklusif yang diberikan terhadap suatu rekacipta untuk menghalang orang lain dari membuat, mengguna, mengimport, menjual rekacipta selama 20 tahun tanpa kebenaran perekacipta.
- Memberi peluang kepada perekacipta untuk membuat dan memasarkan idea atau melesenkan kepada pihak lain dan memperoleh keuntungan.

Syarat Utama Pemberian Paten

Rekacipta mestilah ;



Syarat Perlindungan Paten

- **Baru**

  Invensi dianggap baru jika pada tarikh permohonan, invensi tersebut tidak sama dengan teknologi yang diungkapkan sebelumnya. Pengungkapan samada berbentuk huraian lisan, pameran atau cara lain yang memungkinkan seseorang yang ahli/pakar mampu untuk melaksanakan invensi tersebut.

- **Langkah Inventif**

  Invensi yang dihasilkan itu berkaitan perkara yang tidak dapat diduga sebelumnya (non-obvious) oleh mereka yang ahli dalam bidang tersebut semasa permohonan dipohon**.**

- **Dapat Diterapkan Dalam Industri**

  Invensi dapat diterapkan dalam industri sesuai dengan huraian dalam permohonan. Jika invensi tersebut berbentuk produk, produk tersebut mampu dibuat secara berulang dengan kualiti yang sekata. Jika invensi berbentuk proses, proses tersebut harus mampu dijalankan atau digunakan di industri.

Technical Disclosure

- Patents must disclose an invention in a manner sufficiently clear and complete so that the invention can be carried out by a person having ordinary skill in the art.
- Patent information is disclosed globally through publication on the internet, etc
  i.e. anyone, anywhere in the world can learn from this information & use it

PENDAFTARAN PATEN

- Memfailkan Patent Form No.1. Beserta spesifikasi Paten dan fi RM290.
- Tempoh dua tahun, fail Patent Form No. 2, untuk pemeriksaan substantif, fi RM1100
- Patent Form no. 18: Pendaftaran agen paten ,Kos sedia dokumen paten
  ≈ RM 8,000- RM 25,000
  Kos daftar & pemeriksaan paten (MyIPO) – RM 1,470
- Pengumuman selepas 18 bulan. Permohonan dilulus/ditolak. Kos yuran selenggara paten (20 thn) – RM 21,520

Kajian Kes

Kes pelanggaran hak paten oleh Samsung terhadap produk Apple (iPhone dan iPad). Mahkamah USA mengarahkan Samsung Electronics membayar lebih dari US$ 1 billion kepada Apple

- **Apple files first.**

  Apple Inc. sued Samsung Electronics Co. in April 2011, saying the Korean electronics maker “made a deliberate decision to copy Apple’s iPhone and iPad. The intellectual property that Apple has asserted against Samsung goes to the heart of the extraordinary success of the iPhone and the iPad.

- **Apple’s design, utility patents.**

  Apple is claiming that Samsung infringed four industrial design patents, covering the look and feel of the devices, and three utility patents, which cover how the gadgets work. It’s got a list of more than 20 Samsung devices that it says infringe on Apple’s patents, including the popular Samsung’s Galaxy S phones and Galaxy Tab tablets.

REKACIPTA YANG TIDAK BOLEH DIPATENKAN

i. Kepelbagaian binatang
ii. Skim Perniagaan Pak Man Telo
iii. Kaedah Permainan
iv. Kaedah Rawatan

REKACIPTA YANG TIDAK BOLEH DIPATENKAN (Seksyen 13)

- Penemuan, teori saintifik dan kaedah matematik.
- Kepelbagaian jenis tumbuhan atau binatang atau proses biologi yang perlu bagi pengeluaran tumbuhan atau binatang, selain dari mikro-organisma hidup buatan manusia, proses mikro-biologi dan keluaran proses mikro-organisma itu.
- Skim, kaedah atau cara untuk menjalankan perniagaan, perbuatan-perbuatan mental semata-mata atau bermain apa-apa permainan.
- Cara untuk merawat tubuh manusia atau binatang melalui pembedahan atau terapi, dan cara diagnosis yang dilakukan ke atas tubuh manusia atau binatang.
- Walau bagaimanapun, ini tidak termasuk ke atas keluaran-keluaran yang digunakan mengikut apa-apa cara seperti itu.

PATENT COOPERATION TREATY (PCT)

- PCT - suatu sistem pendaftaran paten di peringkat antarabangsa, yang diajukan hanya pada satu pejabat paten yang bertindak sebagai 'Receiving Office'
- Bukan merupakan sistem pemberian hak paten antarabangsa

MANAFAAT INFORMASI DARI PENERBITAN DOKUMEN PATEN

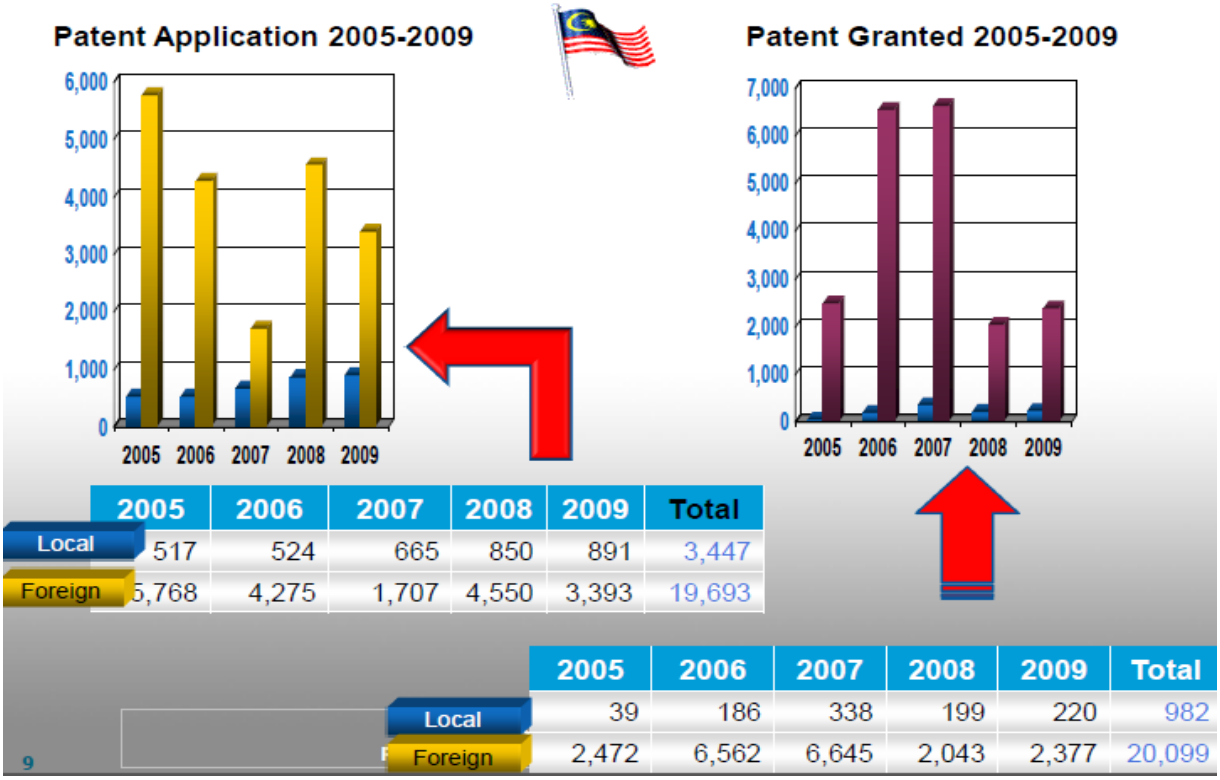
- Mengetahui hak harta intelek sesuatu produk di sesebuah negara
  (hak perlindungan, pemilikan)
- mencegah pelanggaran paten
- Mendapat pengetahuan terdahulu (prior art) dalam teknologi spesifik
- mengetahui perkembangan teknologi terkini
- Menilai kebolehpatenan (patentability) produk yang sedang diusahakan, jika ingin dipohon pendaftaran paten
- Memperbaiki produk atau proses sedia ada
- Mengembangkaan produk atau proses baru
- Membuat penilaian teknologi spesifik dan mengenalpasti memegang lesen teknologi tersebut
- Mengenalpasti teknologi alternatif dan sumbernya
- Menilai pendekatan teknik yang spesifik: mencegah berlakunya pengulangan (duplication) dalam R & D.
- Menilai aktiviti pesaing di dalam atau di luar negeri
- Menilai 'trend' teknologi baru pada tahap awal.

KEBAIKAN DOKUMEN PATEN SEBAGAI SUMBER RUJUKAN

- Asas pengembangan teknologi baru.
- Mengandungi maklumat terkini.
- Sumber informasi: Pengetahuan baru (invensi) dan maklumat yang sudah ada sebelumnya (latar belakang invensi).
- Struktur yang seragam.
- Mengandungi informasi yang tiada dalam bahan teknikal (literature) lain.
- Abstrak dapat diguna untuk memperoleh ide secara umum.
- Simbol klasifikasi.

TOP TEN COUNTRIES FOR PATENT AND UTILITY INNOVATION APPLICATIONS, 2013

COUNTRY	2013
USA	1,592
Japan	1,414
Malaysia	1,269
Germany	485
Switzerland	445
France	237
South Korea	216
United Kingdom	212
China	166
Taiwan	158



CARIAN PATEN

Bagaimana nak pastikan idea rekacipta belum dipaten? Layari dan search dalam:-

Google patents beta

MyIPO
Perbadanan Harta Intelek Malaysia
Intellectual Property Corporation of Malaysia
www.myipo.gov.my

Europäisches Patentamt
European Patent Office
Office européen des brevets

WIPO
WORLD INTELLECTUAL PROPERTY ORGANIZATION

UNITED STATES PATENT AND TRADEMARK OFFICE
DEPARTMENT OF COMMERCE

Akhir sekali, saya mendoakan agar persidangan kita pada hari ini akan membuahkan hasil yang dapat mengembang dan memberi manfaat kepada kerjaya juru teknologi di negara kita pada masa hadapan.

Wabillahi taufik wal hidayah, Wassalaamu alaikum warahmatullahi wabarakaatuh.
Sekian, terima kasih.

KATEGORI TEKNOLOGI KEJURUTERAAN ELEKTRIKAL / ELEKTRONIK / TELEKOMUNIKASI

E01: Rekabentuk Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) dengan Rangkaian Suapbalik Ragam Sepunya (CMFB)

Anis Binti Abdul Kahar1, Nurul Hana Binti Mahdir2
Politeknik Mukah, Sarawak

[1]*anis@pmu.edu.my*

Abstrak

Teknologi pembuatan litar bersepadu (IC) kini semakin berkembang seiring dengan perubahan teknologi masakini. Dalam hal ini, satu penyelidikan telah dibuat bagi menghasilkan Litar Pembezaan Penuh Penguat Kendalian (OTA) dengan Rangkaian Suapbalik Ragam Sepunya (CMFB) dengan menggunakan model teknologi transistor 0.18µm. Litar penyelidikan ini akan memenuhi spesifikasi gandaan kebezaan frekuensi rendah ≥ 80dB, gandaan kebezaan lebarjalur produk > 1MHz dan mempunyai jidar fasa > 60^0. Penyelidikan ini dijalankan dengan merekabentuk litar penyelidikan dengan menggunakan perisian Spice Simulator dan disimulasikan bagi mendapatkan spesifikasi yang dikehendaki. Saiz Transistor (Width/Length) yang digunakan di dalam penyelidikan ini ditentukan dengan menggunakan kaedah persamaan matematik dan kaedah cuba jaya. Daripada analisis-analisis yang dijalankan didapati hasil penyelidikan bagi gandaan kebezaan frekuensi rendah bersamaan -81.44dB, manakala analisis gandaan kebezaan lebarjalur produk bersamaan 10MHz dan akhir sekalai analisis bagi mendapatkan jidar fasa bersamaan dengan 181.2^0. Bagi merekabentuk litar ini pada masa akan datang, litar penyelidikan ini haruslah dilihat dari aspek pincangan yang berlaku di dalam litar dan prestasi saiz transistor yang ditetapkan. Implikasi yang dapat dilihat dari penyelidikan ini, saiz transistor (Width/Length) yang ditentukan akan memberi impaks yang besar kepada keluaran prestasi yang dikehendaki.

***Kata Kunci**: LitarPembezaan Penuh Penguat Kendalian (OTA), Rangkaian Suapbalik Ragam Sepunya (CMFB), Saiz Transistor (Width/Length), Lebarjalur Produk.*

1.0 PENGENALAN

Penguat pembezaan (*differential-amplifier*) atau pasangan pembezaan (*differential-pair*) telah digunakan secara meluas dalam merekabentuk litar bersepadu analog.

Justeru itu, terdapat dua sebab mengapa penguat pembezaan ini sangat sesuai digunapakai dalam fabrikasi litar bersepadu. Antaranya adalah, pertama: sebagaimana yang kita ketahui, setiap prestasi (*performance*) penguat pembezaan akan bergantung secara kritikal kepada kesepadanan (*matching*) antara dua belah litar. Fabrikasi litar bersepadu secara sistematik seperti teknik '*common centroid*' berupaya memberi kesepadanan (*matching*) yang diperlukan untuk menjamin operasi optimum litar tersebut. Sebab yang keduanya, penguat pembezaan menggunakan banyak komponen (menghampiri dua kali ganda banyaknya) berbanding dengan litar peringkat pertama (*single-ended circuit*). Oleh yang demikian, teknologi litar bersepadu telah memberi kesan terhadap keupayaan menggabungkan sejumlah transistor dalam satu cip yang bersaiz kecil.

Secara asasnya, terdapat dua sebab mengapa penguat pembezaan dipilih berbanding dengan penguat peringkat pertama. Pertama, litar penguat pembezaan kurang sensitif kepada hingar dan gangguan (*interference*) berbanding dengan penguat peringkat pertama. Keduanya, dengan menggunakan penguat pembezaan, konfigurasi membolehkan berlaku pincangan pada penguat dan membuatkan gabungan tahap masukan tanpa perlu kapasitor pintasan (*bypass*) dan gandingan (*coupling*) sebagai contoh dalam merekabentuk discrete-circuit amplifier.

Oleh yang demikian, dalam penyelidikan ini, litar pembezaan penuh penguat kendalian transkonduktan (OTA) akan dibangunkan dan digabungkan bersama Rangkaian Suapbalik Ragam Sepunya (CMFB). Di dalam topologi penguat pembezaan, berlaku ketidaksepadanan (*mismatches*). Ketidaksepadanan adalah keadaan yang berlaku di punca arus (*current source*) jenis-N dan jenis-P yang akan menolak keluaran OTA keduanya ke bekalan voltan dan merujuk kepada keadaan persekitaran pembezaan di dalam sistem, yang mepengaruhi pengesanan tahap seterusnya atau pembetulan dalam sistem. Oleh sebab itulah, bagi menangani masalah ini, CMFB diperlukan bagi mengawal masukan operasi yang digunakan.

Dalam merekabentuk CMFB, isyarat utama adalah dalam bentuk pembezaan dan isyarat ragam sepunya (common-*mode*) mestilah dikesan dan ditindas dengan litar yang laju dan ringkas. Ia juga mempunyai sedikit nilai galangan bagi isyarat ragam sepunya tetapi mempunyai nilai galangan yang tinggi bagi isyarat pembezaan. Justeru itu, dengan adanya litar CMFB ini dapat memantapkan litar dan memberikan prestasi mengikut spesifikasi yang dinyatakan. Bagi merekabentuk dan membuat simulasi litar penyelidikan ini, satu perisian telah digunapakai bagi tujuan tersebut. Perisian yang digunakan adalah LT SPICE SIMULATOR, dimana perisian ini dapat membuat simulasi terhadap litar analog dan memudahkan bagi mendapatkan prestasi yang dikehendaki.

2.0 PERNYATAAN MASALAH

Dalam kajian penyelidikan ini, litar yang akan terhasil adalah merangkumi litar pembezaan penuh OTA dengan CMFB. Tetapi ia perlulah menepati spesifikasi yang dikehendaki iaitu

- Gandaan kebezaan frekuensi rendah $\geq$ 80dB
- Gandaan kebezaan lebarjalur produk > 1MHz
- Jidar Fasa > 60^0

3.0 OBJEKTIF KAJIAN

Di dalam menjalankan penyelidikan ini, terdapat dua fasa utama yang perlu diselesaikan iaitu merekebentuk litar penyelidikan dan membuat simulasi ke atasnya. Hasil yang bakal diperolehi akan menentukan tahap ketepatan objektif penyelidikan ini. Objektif utama kajian penyelidikan ini adalah:

i. Untuk memahami konsep OTA dan CMFB
ii. Untuk menerokai penggunaan Perisian SPICE bagi merekabentuk litar analog
iii. Untuk menghasilkan rekabentuk litar skematik Gabungan OTA dengan CMFB
iv. Untuk menambahbaik rekabentuk litar bagi mendapatkan spesifikasi yang dikehendaki
v. Untuk membuat verifikasi akhir litar supaya spesifikasi yang diberikan dipenuhi

4.0 SKOP KAJIAN

Penyelidikan ini hanya berdasarkan simulasi dan tidak akan menghasilkan sebarang prototaip. Justeru itu, penyelidikan ini terbahagi kepada tiga fasa bagi memastikan objektif penyelidikan tercapai. Antaranya ialah

i. Merekabentuk Litar Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) dengan Rangkaian Suapbalik Ragam Sepunya (CMFB) dengan menggunakan model matematik.
ii. Membuat simulasi terhadap litar yang telah direkabentuk.
iii. Menambahbaik prestasi litar dengan menukar saiz transistor supaya spesifikasi yang diberikan dipenuhi.

5.0 METODOLOGI KAJIAN

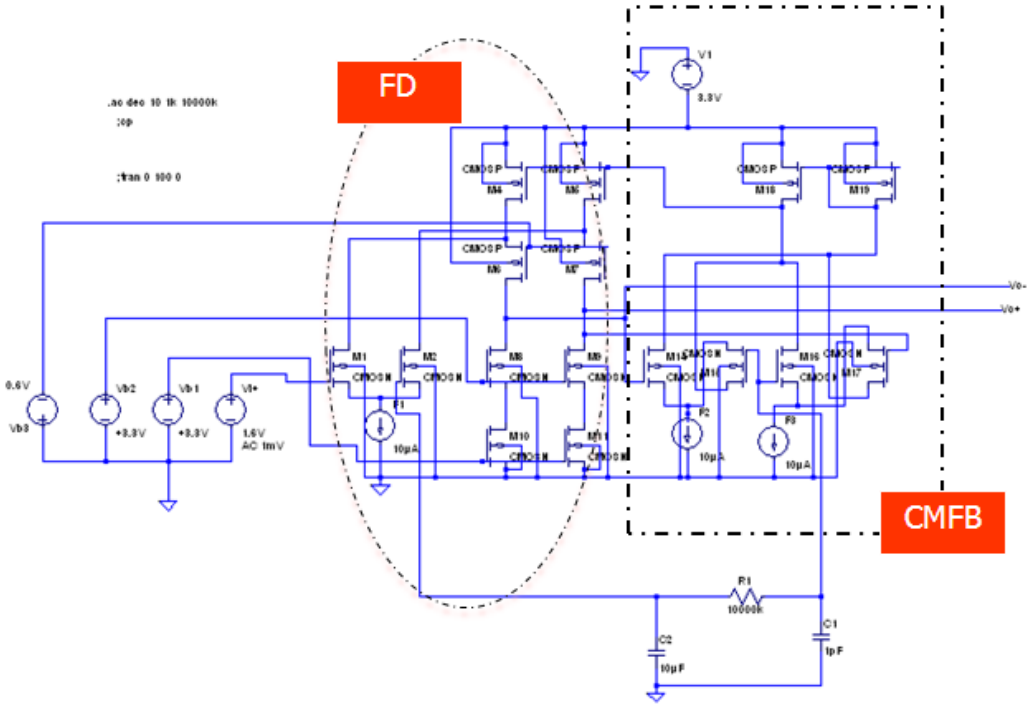
Bab ini, menerangkan tentang kaedah dan prosedur kajian yang dijalankan. Aspek penting yang dibincangkan dalam bab ini ialah rekabentuk dan kaedah yang dilakukan dalam kajian penyelidikan ini.

5.1 PENGENALAN

Metodologi kajian adalah pelan dan strategi untuk mendapatkan jawapan bagi persoalan kajian. Menurut Kumar (1999), metodologi kajian adalah pelan prosedur yang akan diadaptasi oleh pengkaji untuk menjawab soalan secara sahih, berobjektif, tepat dan ekonomi. Manakala menurut Azniza (2004), metodologi kajian merujuk kepada cara yang paling berkesan bagi mendapatkan maklumat yang berguna untuk mencapai sesuatu matlamat penyelidikan. Seterusnya menurut Wiersma (2000), metodologi kajian ialah pendekatan yang dipilih untuk menjalankan kajian di mana ia dapat menerangkan bagaimana sesuatu kajian dijalankan dan penerangannya perlu dibuat secara terperinci supaya pengkaji dapat merangka perjalanan kajian.

5.2 REKABENTUK LITAR PEMBEZAAN PENUH PENGUAT KENDALIAN TRANSKONDUKTAN (OTA) DENGAN RANGKAIAN SUAPBALIK RAGAM SEPUNYA (CMFB)

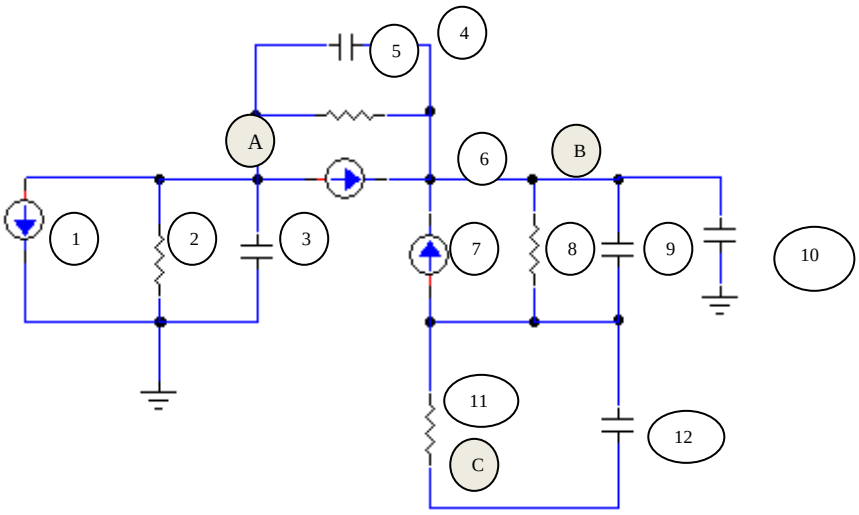
Topologi bagi litar OTA dengan CMFB yang akan dibangunkan adalah seperti dalam Rajah 1. Bagi peringkat awal, model matematik bagi litar ini akan dipastikan sebelum perisian SPICE digunakan untuk menyelesaikan persamaan matematik tersebut.



Rajah 1: **Gambarajah Litar Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) Dengan Rangkaian Suapbalik Ragam Sepunya (CMFB)**

5.3 MENENTUKAN PERSAMAAN MATEMATIK BAGI LITAR OTA DENGAN CMFB

Bagi mendapatkan persamaan matematik litar penyelidikan haruslah diringkaskan seperti Rajah 2 di bawah.



Rajah 2: **Gambarajah Model Litar persamaan separuh pembezaan frekuensi tinggi yang diringkaskan**

1	g_{m1}
2	V_{in}
3	g_{din}
4	C_{db6}
5	g_{d6}
6	g_{m6}
7	g_{m8}
8	r_{d8}
9	C_{db8}
10	C_{LB}
11	g_{d10}
12	C_{LC}

Titik nodan : A,B dan C
Jumlah kapasitor : C_{LA}, $C_{LB,}$ dan C_{LC}
C_L = Kapasitor beban luar pada terminal keluaran

Berdasarkan gambarajah litar diatas, jumlah kapasitor bagi setiap titik nodan adalah seperti persamaan berikut:

$C_{LA} = C_{gd4} + C_{db4} + C_{db1} + C_{gs6} + C_{gb6} + C_{gd1}$
$C_{LB} = C_{gd8} + C_{gd6} + C_{gb14} + C_{gs14} + C_{gd14} + C_L$
$C_{LC} = C_{db10} + C_{gd10} + C_{gs8} + C_{gb8}$

i. Persamaan Gandaan Kebezaan, A_d

$$A_d = - \frac{g_{m1}\, g_{m6}\, g_{m8} \left[1 + \frac{sC_{db6}}{g_{m6}} \right] \left[1 + \frac{s(C_{LC}+C_{db8})}{g_{m8}} \right]}{P_1(s) + P_2(s)} \longrightarrow (1)$$

Di mana

$$P_1(s) = g_{d8}\, g_{d10}\, g_{m6} \left[1 + \frac{sC_{db8}}{g_{d8}} \right] \left[1 + \frac{sC_{LC}}{g_{d10}} \right] \left[1 + \frac{s(C_{LA}+C_{db6})}{g_{m6}} \right]$$

$$P_2(s) = g_{in}\, g_{d6}\, g_{m8} \left[1 + \frac{sC_{LA}}{g_{in}} \right] \left[1 + \frac{sC_{LC}}{g_{m8}} \right] \left[1 + \frac{s(C_{LB}+C_{db6})}{g_{d6}} \right]$$

ii. Penentuan Frekuensi Kutub (*Pole Frequency*)

Bagi menentukan kutub bagi fungsi pindah, persamaan umum adalah seperti di bawah

$$A_d(s) = \frac{A_0 \left[1 - \frac{s}{z_1} \right] \left[1 - \frac{s}{z_2} \right]}{\left[1 - \frac{s}{p_1} \right] \left[1 - \frac{s}{p_2} \right] \left[1 - \frac{s}{p_3} \right]}$$

Di mana A_0 adalah gandaan isyarat kecil arus terus bagi penguat diberi seperti

$$A_0 = - \frac{g_{m8}}{\frac{g_{ds}\, g_{d10}}{g_{m8}} + \frac{(g_{d1}+g_{d4})}{g_{m6}}\, g_{d6}}$$

Penyebut boleh ditulis sebagai persamaan kubik:

$$1 - s\left(\frac{1}{p_1} + \frac{1}{p_2} + \frac{1}{p_3}\right) + s^2\left(\frac{1}{p_1 p_2} + \frac{1}{p_2 p_3} + \frac{1}{p_1 p_3}\right) - s^3\left(\frac{1}{p_1 p_2 p_3}\right)$$

Sekiranya litar direkabentuk untuk menghasilkan kutub dominan $P_1 \ll P_2, P_3$, persamaan di atas boleh ditulis sebagai

$$1 - \frac{s}{P_1} + s^2\left[\frac{1}{P_1}\left(\frac{1}{P_2}+\frac{1}{P_3}\right)\right] - \left(\frac{s^3}{P_1P_2P_3}\right) = 0 \longrightarrow (2)$$

Setelah memanipulasikan penyebut dari persamaan (1) dan menyamakan sebutan dalam persamaan (1) dan (2), perkaitan berikut dapat diperolehi: kutub dominan diberi sebagai

$$P_1 = -\frac{1}{R_0 C_{L2}}$$

dan kutub bukan dominan diberi sebagai

$$P_2 = -\frac{g_{m6}}{C_{L1}},\ P_3 = -\frac{g_{m8}}{C_{L3}}$$

Oleh yang demikian, 'zero' adalah menghampiri pada $-\frac{g_{m8}}{C_{L3}}$, justeru itu, kesan pada P_3 telah dipotong. C_{L1} boleh diwakilkan sebagai C_{gs6}, kapasitan pada 'gate-source' di transistor kaskod, bergantung kepada pertindihan dan kapasitan parasitik di nodan kaskod.

Oleh kerana kutub yang kedua telah direkabentuk menjadi P_2, jidar fasa bagi penguat ini menjadi fungsi utama kepada kapasitan parasitik pada nodan kaskod. Antara persamaan-persamaan lain yang terbentuk adalah:

i. Persamaan Gandaan Frekuensi, g_{m1}
$g_{m1} = \omega_0 C_L$

ii. Persamaan Jidar Fasa, g_{m6}
$g_{m6} = \omega_0 C_L \tan(PM)$

iii. Persamaan Kadar Slew, SR
$I_{SS} = 2 \times SR \times C_L$

iv. Persamaan Ayunan Keluaran, $\Delta V_0^{\pm}$
$\Delta V_0^- = (Vdd - V_{0max}) /2$
$\Delta V_0^+ = (Vdd - V_{0min}) /2$

v. Persamaan Arus pincangan pada kaskod, I_{kaskod}
$I_{kaskod} = \omega_0 C_L \tan(PM)\, \Delta V_0^+$

vi. Persamaan Gandaan Jalur Pertengahan (mid-band), A_0
$$A_0 = \frac{2g_{m1}}{\lambda^2 I_{kaskod}\left[\Delta V_0^+ + \Delta V_0^- + \frac{I_{ss}}{g_{m6}}\right]}$$

vii. Persamaan Kuasa (power consumption), P
$P = (2 I_{case} + I_{ss})(Vdd + V_{ss})$

Kesemua persamaan matematik diatas, digunakan ke atas litar penyelidikan bagi mendapatkan prestasi mengikut spesifikasi yang dikehendaki.

5.4 PENGUJIAN SAIZ TRANSISTOR (W/L) DENGAN MENGGUNAKAN PERSAMAAN MATEMATIK

Oleh yang demikian, berdasarkan perhubungan teori yang telah dijelaskan diatas, persamaan-persamaan matematik tersebut akan digunakan bagi penguat kendalian yang akan dibangunkan ini. Persaman matematik ini akan memberikan anggaran parameter litar penguat kendalian daripada spesifikasi litar penguat yang umum.

Matlamat utama rekabentuk adalah untuk mendapatkan nisbah W/L bagi penguat kendalian daripada prestasi yang dikehendaki. Ia akan tercapai dengan menghubungkaitkan nisbah W/L dengan parameter g_m. Persamaan yang terbentuk adalah seperti dibawah:

$$g_m = \sqrt{2K_n \frac{W}{L} \frac{I_{ss}}{2}}$$

diberi

$$\text{W/L} = \frac{g_m}{2K_n \frac{I_{ss}}{2}}$$

Justeru itu, bagi mendapatkan nisbah W/L, persamaan di atas digunakan dan dinyatakan di dalam jadual dibawah:

Transistor	Nisbah W/L
M_1, M_2	10.8µ : 0.18µ
M_4, M_5	10 : 1
M_6, M_7	60µ : 0.18µ
M_8, M_9	60 : 1
M_{10}, M_{11}	12.6:1
M_{14}-M_{17}	1:1
$M_{18,}$ M_{19}	10:1

Saiz transistor yang telah dikira, akan disimulasi dengan menggunakan perisian SPICE untuk mendapatkan prestasi yang dikehendaki. Jika sekiranya saiz transistor tidak menepati atau mengoptimumkan prestasi litar, ia akan diubah atau digantikan dengan nisbah W/L yang lain, yang mana bersesuaian dengan prestasi litar penyelidikan ini.

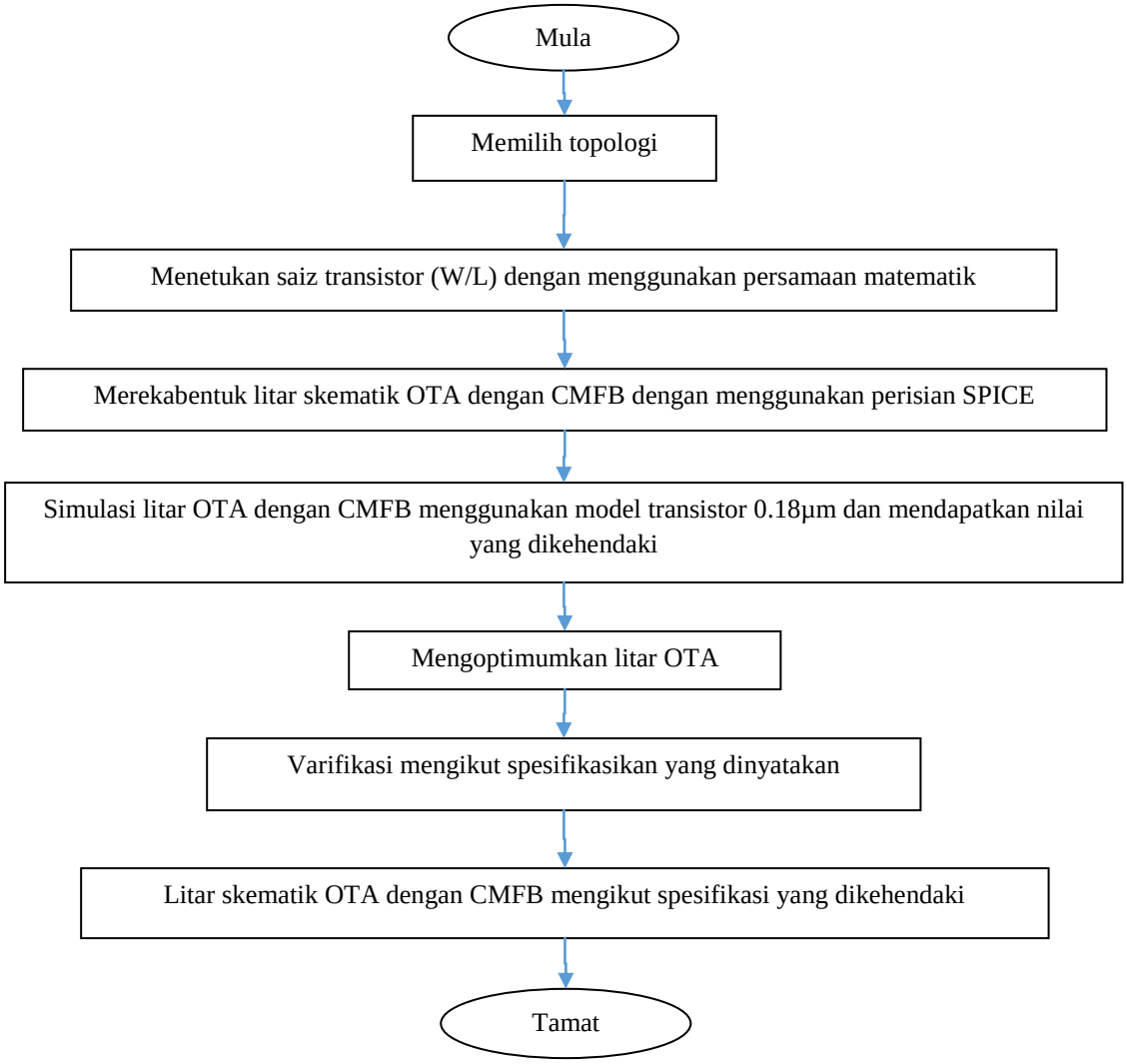
5.5 MENGOPTIMUMKAN LITAR DENGAN MENGUBAH SAIZ TRANSISTOR (W/L)

Mengoptimumkan litar ini dengan mengubah nisbah saiz transistor bagi mendapatkan prestasi yang lebih rasional, contohnya apabila nisbah W/L kecil dan dapat memberi nilai prestasi yang sama dengan mengunakan nisbah W/L yang besar. Maka nilai nisbah W/L yang kecil akan diambilkira dalam penggunaannya di dalam litar penyelidikan. Ini adalah kerana apabila melibatkan nisbah yang kecil, ia akan menggunakan faktor ruang kawasan yang lebih kecil, kerana penggunaan komponen transistor yang kecil semasa proses fabrikasi litar bersepadu.

5.6 SIMULASI TERAKHIR

Membuat simulasi terakhir, bagi mendapatkan semua prestasi di dalam litar menepati spesifikasi yang dikehendaki.

5.7 KERANGKA OPERASI



Rajah 3: Kerangka Operasi Kajian

6.0 KEPUTUSAN DAN PERBINCANGAN

6.1 PENGENALAN

Terdapat beberapa analisis dan pencirian yang telah dilakukan dalam penyelidikan ini. Antara perisian yang digunakan dalam membuat analisis penyelidikan adalah perisian Spice Simulator. Kesemua analisis yang dibuat adalah menjadi penentuukuran bagi mendapatkan prestasi yang akan memenuhi spesifikasi yang dikehendaki.

6.2 ANALISIS PENGUJIAN SAIZ TRANSISTOR (W/L)

Bagi mendapatkan nilai setiap saiz transistor yang digunakan didalam litar penyelidikan ini, beberapa kaedah telah digunapakai iaitu kaedah menggunakan model matematik dan kaedah cuba jaya. Apabila saiz transistor ini telah dikenalpasti, ia akan di masukkan pada setiap transistor mengikut jenisnya dan jika sekiranya simulasi telah dijalankan dan didapati saiz transistor tidak memberikan prestasi yang dikehendaki, justeru itu, saiz transistor hendaklah ditukar dan digantikan dengan nilai yang baru.

6.2.1 PENGUJIAN SAIZ TRANSISTOR (W/L) BAGI M_1 DAN M_2

$G_{m\,1} = \omega_0\ C_L = (10\text{Mhz})(1\text{pF}) = 10\mu$

$$W/L = \frac{g_m^{\,2}}{2\,k_n\,(I_{SS}/2)} \quad ; \text{ dimana } k_{n\,(n)} = 171\mu A/V^2,\ I_{ss} = 10\mu A$$

$$= \frac{(10\mu)^2}{2\,(171\mu)(10\mu/2)}$$

$$= 58.5\text{m} \approx 60\text{m}$$

$W/L = 10.8\mu : 0.18\mu$

6.2.3 PENGUJIAN SAIZ TRANSISTOR (W/L) BAGI M_6 DAN M_7

$G_{m\,6} = \omega_0\ C_L \tan(PM)$

$= (10\text{Mhz})(1\text{pF})(\tan 45^0)$

$= 10\mu$

$$W/L = \frac{g_m^{\,2}}{2\,k_n\,(I_{SS}/2)} \quad ; \text{ dimana } k_{n\,(p)} = -37\mu A/V^2,\ I_{ss} = 10\mu A$$

$$= \frac{(10\mu)^2}{2\,(37\mu)(10\mu/2)}$$

$$= 270\text{m}$$

$W/L = 60\mu : 0.18\mu$

6.2.4 PENGUJIAN SAIZ TRANSISTOR (W/L) BAGI M_8 DAN M_9

$$W/L = \frac{g_m^{\,2}}{2\,k_n\,(I_{SS}/2)} \quad ; \text{ dimana } k_{n\,(n)} = 171\mu A/V^2,\ I_{ss} = 10\mu A$$

$$= \frac{(-3.19\text{e-}4)^2}{2\,(171\mu)\,(10\mu/2)} \quad g_{m8} = -3.19\text{e-}4$$

$$= 59.5 \approx 60$$

6.2.5 PENGUJIAN SAIZ TRANSISTOR (W/L) BAGI M_4, M_5 M_{10} M_{11} M_{14}-M_{17} M_{18} DAN M_{19}

Bagi saiz transistor (W/L) M_4, M_5, M_{10}, M_{11}, $M_{14\text{-}17}$, M_{18} dan M_{19} ini, kaedah cuba jaya telah digunapakai di dalam litar penyelidikan. Saiz transistor ini akan disesuaikan ke atas litar bagi mendapatkan prestasi dan sekaligus mencapai spesifikasi yang dikehendaki.

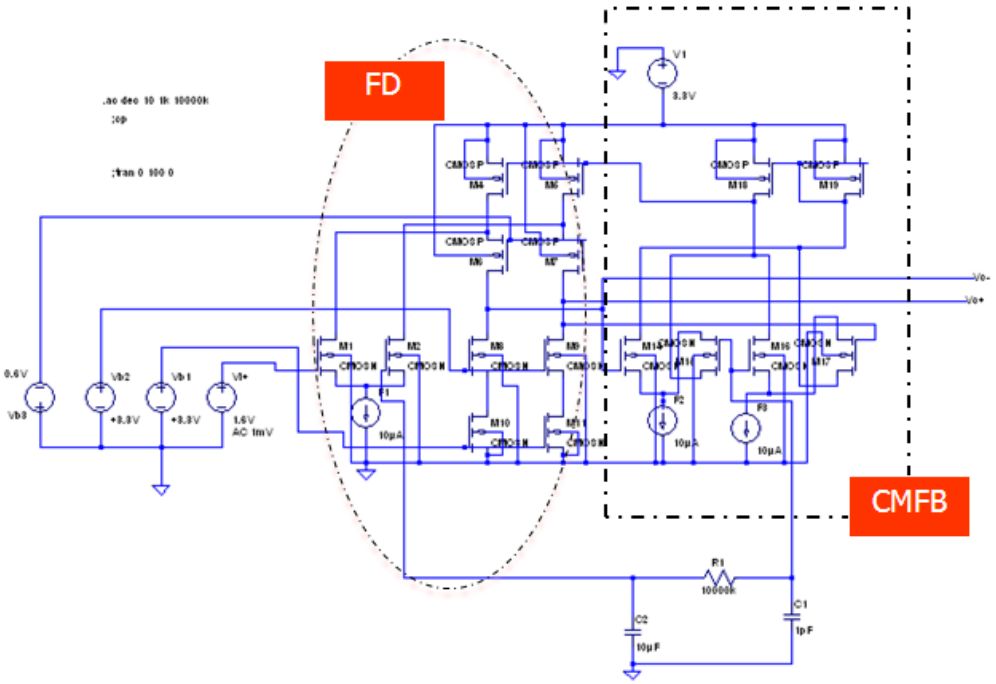
6.2.6 PENGHASILAN SAIZ TRANSISTOR BAGI SETIAP TRANSISTOR DALAM BENTUK NISBAH W/L

Berikut adalah senarai saiz transistor (W/L) bagi setiap transistor yang digunakan di dalam litar penyelidikan. Setiap transistor di gandingkan berpasangan dan mempunyai fungsi yang berbeza bagi setiap pasangan

Jadual 1: Nisbah W/L Bagi Setiap Transistor

Transistor	Nisbah W/L	Fungsi
M_1, M_2	10.8µ : 0.18µ	Pemacu masukan transistor
M_4, M_5	10 : 1	Punca Arus (Current Source)
M_6, M_7	60µ : 0.18µ	Transistor folded-cascode
M_8, M_9	60 : 1	Transistor folded-cascode
M_{10}, M_{11}	12.6:1	Transistor folded-cascode
M_{14}-M_{17}	1:1	Pasangan Pembezaan (differential pair)
$M_{18,}$ M_{19}	10:1	Current Mirror load

6.2.7 ANALISIS LITAR PEMBEZAAN PENUH PENGUAT KENDALIAN TRANSKONDUKTAN (OTA) DENGAN RANGKAIAN SUAPBALIK RAGAM SEPUNYA (CMFB)



Rajah 4: Gambarajah Litar Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) Dengan Rangkaian Suapbalik Ragam Sepunya (CMFB)

Rajah 4 menunjukkan gambarajah Litar Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) Dengan Rangkaian Suapbalik Ragam Sepunya (CMFB) yang sedang dibangunkan bagi tujuan penyelidikan ini. Litar ini mempunyai beberapa komponen iaitu 16 transistor yang terdiri daripada 6 transistor CMOS (*Complimentary Metal Oxide Semiconductor*) jenis P, dan 10 transistor CMOS jenis N. Setiap transistor ini telah ditetapkan nisbah W/L dan fungsi yang berlainan. Litar ini juga mempunyai 4 bekalan voltan DC (arus terus) dan 1 bekalan voltan yang mempunyai 2 punca iaitu DC dan AC (arus ulang alik). Seterusnya litar ini juga memerlukan 3 bekalan arus yang ideal, yang setiap satunya mempunyai nilai arus yang sama iaitu 10µA. Juga terdapat 2 kapasitor (1pF 10pF) dan 1 perintang (R1 = 10MΩ) di dalam litar ini. Litar penyelidikan ini telah disimulasi dengan menggunakan model transistor 0.18µm.

6.2.8 ANALISIS ISYARAT KECIL (AC ANALYSIS)

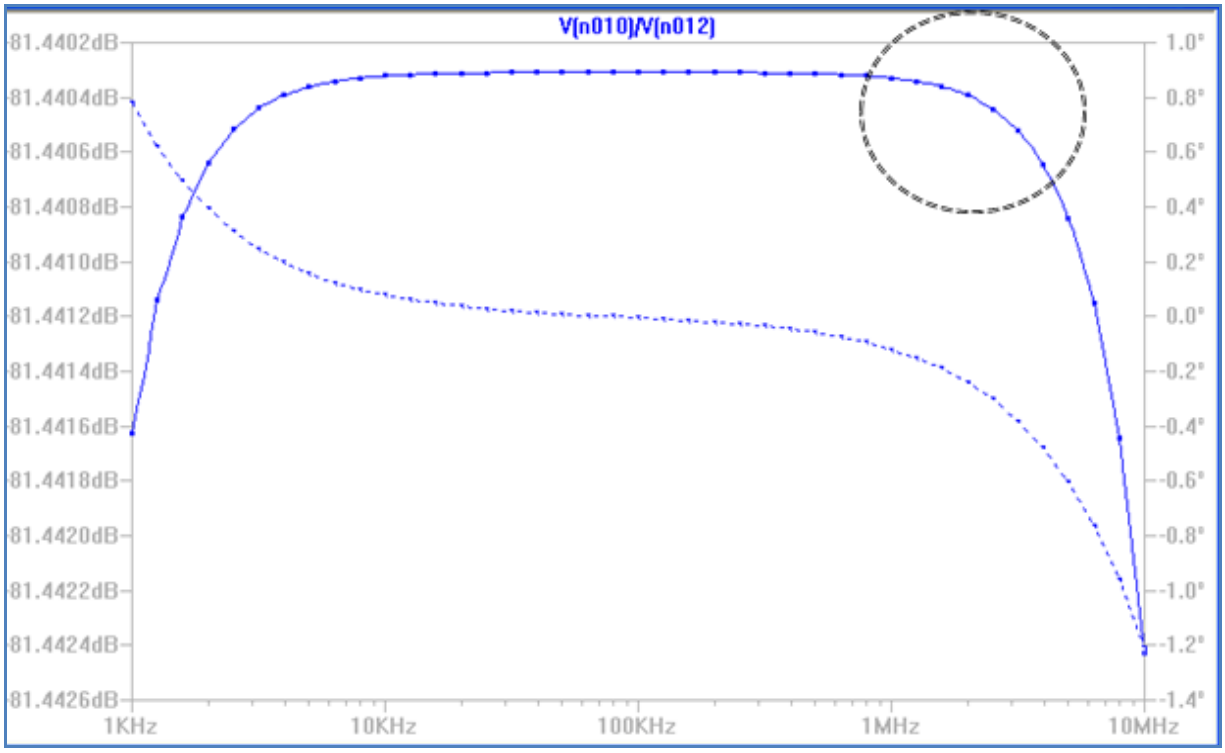
Analisis yang telah dijalankan ke atas litar penyelidikan ini adalah analisis isyarat kecil. Analisis ini di buat bagi mendapatkan isyarat keluaran bagi litar ini. Seterusnya gandaan kebezaan frekuensi rendah, gandaan kebezaan lebarjalur produk dan phase margin. Setiap satunya telah dianalisis bagi mendapatkan prestasi berdasarkan spesifikasi yang diperlukan.

6.2.8.1 GANDAAN KEBEZAAN FREKUENSI RENDAH

Rajah 5 menunjukkan analisis yang dijalankan ke atas litar bagi mendapatkan gandaan kebezaan frekuensi rendah. Berikut adalah formula mendapatkan gandaan ini,

$$\text{Gandaan kebezaan Frekuensi Rendah} = \frac{\text{Isyarat Keluaran } (V_{out})}{\text{Isyarat Masukan } (V_{in})}$$

$$= \text{-81.44dB (dari graf)}$$



Rajah 5: Gambarajah Dapatan Gandaan Kebezaan Frekuensi Rendah

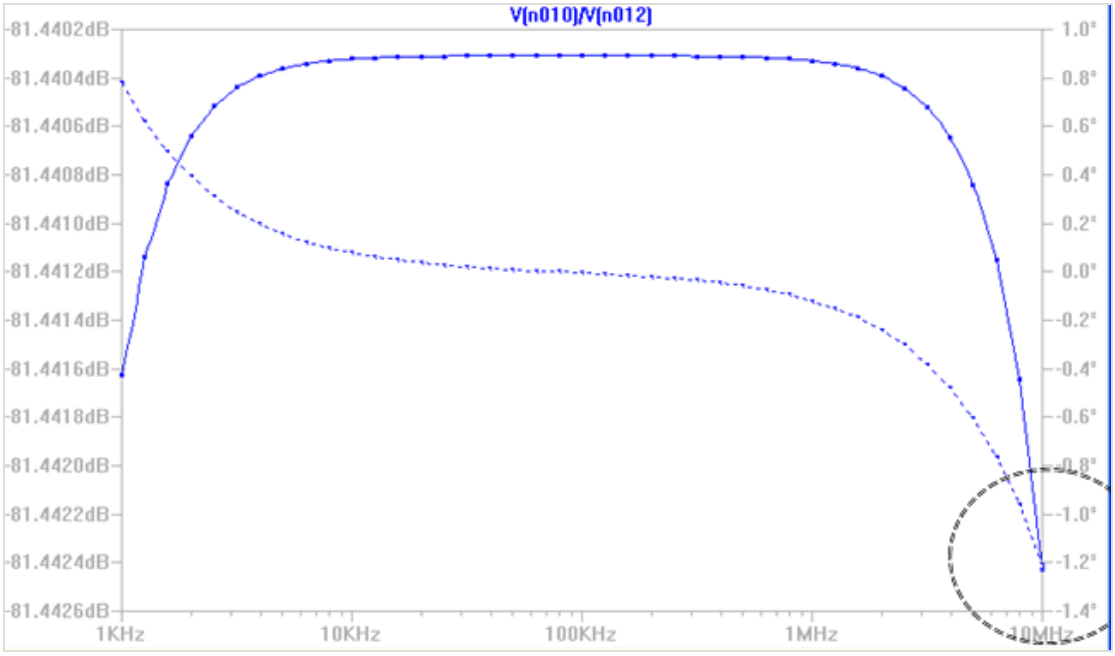
6.2.8.2 GANDAAN KEBEZAAN LEBARJALUR PRODUK

Rajah 6 menunjukkan analisis yang dijalankan keatas litar bagi mendapatkan gandaan kebezaan lebarjalur produk. Berikut adalah formula mendapatkan gandaan ini,

$$\text{Gandaan kebezaan Lebarjalur Produk} = \frac{\text{Isyarat Keluaran } (V_{out})}{\text{Isyarat Masukan } (V_{in})}$$

$$= \text{-10Mhz (dari graf)}$$

Nilai yang diambil daripada graf adalah semasa isyarat memotong paksi x.

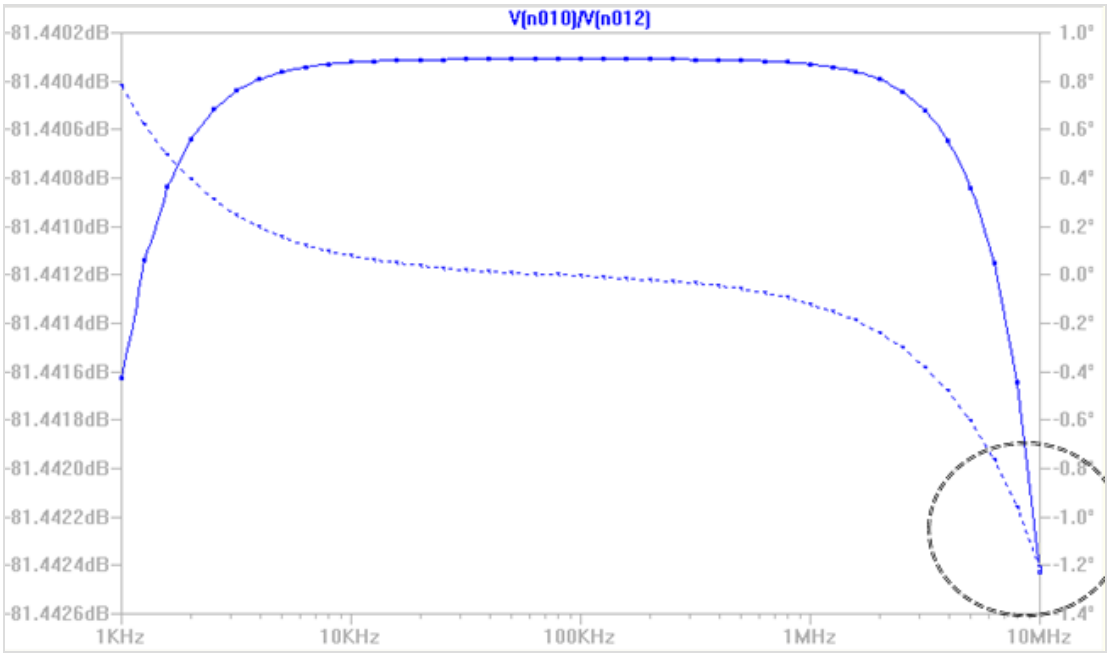


Rajah 6: Gambarajah Dapatan Gandaan Kebezaan Lebarjalur produk

6.2.8.3 JIDAR FASA

Rajah 7 menunjukkan analisis yang dijalankan ke atas litar bagi mendapatkan jidar fasa. Berikut adalah formula mendapatkan nilai ini,

$$\text{Jidar Fasa} = 180^0 - (-1.2^0)$$
$$= 181.2^0$$



Rajah 7: Gambarajah Dapatan Jidar Fasa

6.2.8.4 ANALISIS MENGGUNAKAN SPICE ERROR LOG

Analisis ini dijalankan adalah bertujuan untuk melihat keseluruhan prestasi bagi setiap transistor yang digunakan di dalam litar penyelidikan ini. Analisis ini juga dapat menentukan konduktan keluaran (output *conductance)* bagi setiap transistor untuk mendapatkan gandaan transkonduktan (gm). Analisis Spice Error Log adalah seperti dalam lampiran D.

7.0 KESIMPULAN

Dalam penyelidikan ini, Litar Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) Dengan Rangkaian Suapbalik Ragam Sepunya (CMFB) telah berjaya di hasilkan. Litar penyelidikan ini dihasilkan dengan menggunakan perisian Spice Simulator. Perisian ini digunakan bagi merekabentuk dan membuat simulasi ke atas litar. Keseluruhan komponen yang digunakan di dalam litar adalah terdiri daripada 16 transistor , 6 transistor CMOS (*Complimentary Metal Oxide Semiconductor*) jenis P, dan 10 transistor CMOS jenis N. Setiap transistor ini telah ditetapkan nisbah W/L dan fungsi yang berlainan. Litar ini juga mempunyai 4 bekalan voltan DC (arus terus) dan 1 bekalan voltan yang mempunyai 2 punca iaitu DC dan AC (arus ulang alik). Seterusnya litar ini juga memerlukan 3 bekalan arus yang ideal, yang setiap satunya mempunyai nilai arus yang sama iaitu 10µA. Juga terdapat 2 kapasitor (1pF 10pF) dan 1 perintang (R1 = 10MΩ) di dalam litar ini.

Pencirian saiz transistor bagi litar penyelidikan ini adalah dengan menggunakan model matematik dan kaedah cuba jaya. Setiap transistor di dalam litar ini adalah dalam keadaan berpasangan dan mempunyai fungsi yang berlainan. Oleh yang demikian, antara fungsi setiap pasangan transistor adalah pemacu masukan transistor (M_1, M_2), punca arus (current *source)* (M_4, M_5), Transistor folded-cascode (M_6, M_7, M_8, M_9, M_{10}, M_{11}, dan M_{14}-M_{17}).

Oleh yang demikian, di dalam penyelidikan ini beberapa analisis telah dijalankan bagi mendapatkan prestasi yang dikehendaki mengikut spesifikasi yang ditentukan. Analisis tersebut terdiri daripada analisis isyarat kecil (*AC analysis*) yang dapat menentukan prestasi gandaan kebezaan frekuensi rendah, gandaan kebezaan lebarjalur produk dan phase margin bagi litar penyelidikan ini. Isyarat yang diperlukan bagi analisis ini adalah isyarat keluaran (V_{out}) dibahagikan dengan isyarat masukan (V_{in}). Dapatan hasil dari analisis ini, nilai prestasi gandaan kebezaan frekuensi rendah adalah bernilai -81.44dB dan nilai prestasi bagi gandaan kebezaan lebarjalur produk adalah sebanyak -10Mhz. Manakala nilai prestasi bagi jidar fasa (*phase margin*) telah diperolehi sebanyak 181.2^0.

Pencirian ke atas prestasi setiap transistor telah dianalisis dengan menggunakan analisis Spice Error Log. Dengan menggunakan analisis ini, pelbagai parameter dapat dikenalpasti antaranya nilai arus (I_d), voltan (V_{gs}, V_{ds}, V_{bs}, V_{th}, V_{dsat}) , gandaan transkonduktan (g_m, g_{mb}) dan konduktan keluaran (g_{ds})

Kesimpulannya, daripada penyelidikan dan analisis yang telah dijalankan, objektif penyelidikan telah tercapai. Walaubagaimanapun spesifikasi bagi setiap prestasi yang dikehendaki tidak berjaya diperolehi. Ini adalah kerana litar penyelidikan yang direkabentuk dan dibangunkan tidak dapat memberi prestasi yang dikehendaki berikutan nilai saiz transistor (W/L) yang diberikan tidak memenuhi keseimbangan perjalanan atau prestasi litar. Masalah pincangan (biasing) mungkin juga berlaku berikutan penggunaan punca arus ideal di dalam litar penyelidikan.

7.1 CADANGAN KAJIAN MASA HADAPAN

Bagi menghasilkan dan menambahbaik Litar Pembezaan Penuh Penguat Kendalian Transkonduktan (OTA) Dengan Rangkaian Suapbalik Ragam Sepunya (CMFB) ini pada masa akan datang, beberapa elemen perlu diambilkira bagi memastikan prestasi litar mencapai objektif dan spesifikasi yang dikehendaki. Antara elemen yang perlu dititikberatkan adalah masalah pincangan. Jika sekiranya di dalam litar menggunakan punca arus ideal, masalah ini pasti akan berlaku dan cuba untuk mengelakkan dari menggunakan punca arus ideal dalam litar. Seterusnya saiz transistor (W/L) yang ditetapkan mestilah berupaya menghasilkan prestasi yang dikehendaki. Prestasi yang mantap adalah bergantung kepada saiz transistor (W/L) yang digunakan di dalam litar. Cadangan terakhir bagi mendapatkan spesifikasi yang dikehendaki adalah dengan menggunakan kaedah Algoritma Genetic (genetic *Algorithm*). Perisian ini dapat menganalisis prestasi yang dikehendaki secara automatik dan mudah digunakan.

8.0 RUJUKAN

[1] Azniza Binti Zainul, Membangunkan tahap manal makmal matematik bagi meningkatkan tahap pemahaman konsep matematik dalam proses pengajaran dan pembelajaran statistic kejuruteraan, KUITTHO, Tesis Sarjana. 2004

[2] Geiger, R.L and Sanchez Sinencio, E. 1985. Active filter design using operational transconductance amplifiers : a tutorial. IEEE Circuit Devices Magazines. 2(1) : 20-32

[3] Kumar, R, Research Methodology 1999: A Step by step guide for beginners, London Sage, Publications Ltd

[4] Mallya, S.M and Nevin, J.H. 1989. Design procedures for a fully differential folded-cascode CMOS OP-Amp. IEEE J Solid-state Circuit and Systems. 24(6) : 1737-1740

[5] Sanchez-Sinencio, E and Silva-Martinez, J. CMOS transconductance amplifier, architectures and active filters : a tutorial. :1-12.

[6] Sanchez-Sinencio, E 1988. Generation Of Continuous Time Two Integrator Loop OTA Filter Structure. IEEE Transaction On Circuit And System. 35(8) : 1-11

[7] Sendra/Smith, Microelectronic Circuits Fifth Edition 2004, Oxford University Press.

[8] Van Petegham, P.M and Duque-Carrillo, J.F. 1990. A General description of CMFB in Fully Differential Amplifiers. Circuits and Systems, IEEE International Symposium. 1-3 May 1990 . 4 : 320-312

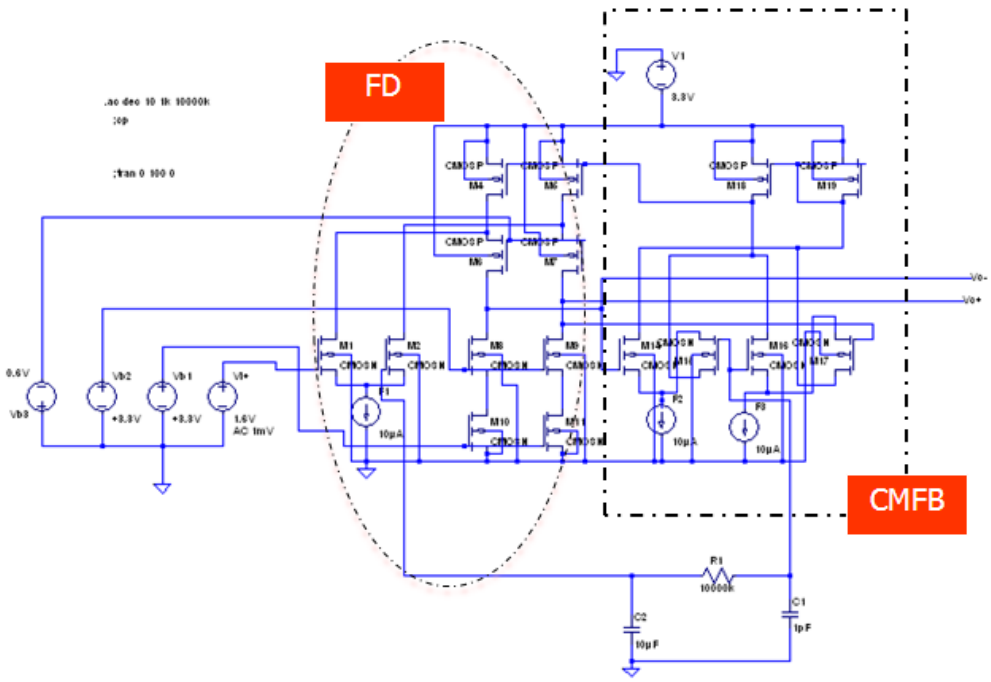
[9] Wai-Kai Chen, Principal and Application In Engineering Series, Analog Circuit and Devices, CRC Press LLC, 2003.

[10] Wai-Kai Chen, The VLSI Handbook, 2000, CRC Press LLC,.

[11] Weirsma, W. Research Method In Education : An Introduction, 2000, United State Ally and Bacon.

LAMPIRAN

A. LITAR PEMBEZAAN PENUH PENGUAT KENDALIAN TRANSKONDUKTAN (OTA) DENGAN RANGKAIAN SUAPBALIK RAGAM SEPUNYA (CMFB)

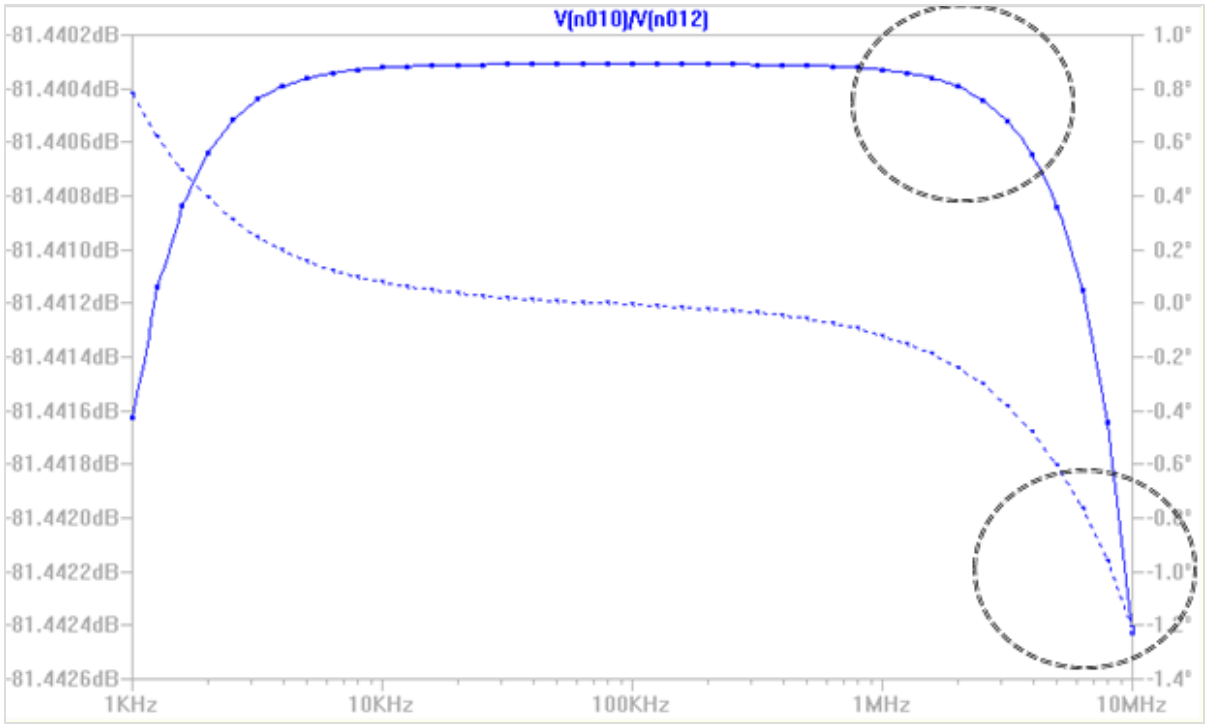


B. MODEL TRANSISTOR 0.18µm

```
* DATE: May 21/09
* LOT: T92Y                WAF: 9103
* Temperature_parameters=Default
.MODEL CMOSN NMOS ( LEVEL   = 49
+VERSION = 3.1          TNOM    = 27            TOX     = 4.1E-9
+XJ      = 1E-7         NCH     = 2.3549E17     VTH0    = 0.3694303
+K1      = 0.5789116    K2      = 1.110723E-3   K3      = 1E-3
+K3B     = 0.0297124    W0      = 1E-7          NLX     = 2.037748E-7
+DVT0W   = 0            DVT1W   = 0             DVT2W   = 0
+DVT0    = 1.2953626    DVT1    = 0.3421545     DVT2    = 0.0395588
+U0      = 293.1687573  UA      = -1.21942E-9   UB      = 2.325738E-18
+UC      = 7.061289E-11 VSAT    = 1.676164E5    A0      = 2
+AGS     = 0.4764546    B0      = 1.617101E-7   B1      = 5E-6
+KETA    = -0.0138552   A1      = 1.09168E-3    A2      = 0.3303025
+RDSW    = 105.6133217  PRWG    = 0.5           PRWB    = -0.2
+WR      = 1            WINT    = 2.885735E-9   LINT    = 1.715622E-8
+XL      = 0            XW      = -1E-8         DWG     = 2.754317E-9
+DWB     = -3.690793E-9 VOFF    = -0.0948017    NFACTOR = 2.1860065
+CIT     = 0            CDSC    = 2.4E-4        CDSCD   = 0
+CDSCB   = 0            ETA0    = 2.665034E-3   ETAB    = 6.028975E-5
+DSUB    = 0.0442223    PCLM    = 1.746064      PDIBLC1 = 0.3258185
+PDIBLC2 = 2.701992E-3  PDIBLCB = -0.1          DROUT   = 0.9787232
+PSCBE1  = 4.494778E10  PSCBE2  = 3.672074E-8   PVAG    = 0.0122755
+DELTA   = 0.01         RSH     = 7             MOBMOD  = 1
+PRT     = 0            UTE     = -1.5          KT1     = -0.11
+KT1L    = 0            KT2     = 0.022         UA1     = 4.31E-9
+UB1     = -7.61E-18    UC1     = -5.6E-11      AT      = 3.3E4
+WL      = 0            WLN     = 1             WW      = 0
+WWN     = 1            WWL     = 0             LL      = 0
+LLN     = 1            LW      = 0             LWN     = 1
+LWL     = 0            CAPMOD  = 2             XPART   = 0.5
+CGDO    = 8.58E-10     CGSO    = 8.58E-10      CGBO    = 1E-12
+CJ      = 9.471097E-4  PB      = 0.8           MJ      = 0.3726161
+CJSW    = 1.905901E-10 PBSW    = 0.8           MJSW    = 0.1369758
+CJSWG   = 3.3E-10      PBSWG   = 0.8           MJSWG   = 0.1369758
+CF      = 0            PVTH0   = -5.105777E-3  PRDSW   = -1.1011726
+PK2     = 2.247806E-3  WKETA   = -5.071892E-3  LKETA   = 5.324922E-4
+PU0     = -4.0206081   PUA     = -4.48232E-11  PUB     = 5.018589E-24
+PVSAT   = 2E3          PETA0   = 1E-4          PKETA   = -2.090695E-3 )
*
.MODEL CMOSP PMOS ( LEVEL   = 49
+VERSION = 3.1          TNOM    = 27            TOX     = 4.1E-9
+XJ      = 1E-7         NCH     = 4.1589E17     VTH0    = -0.3823437
+K1      = 0.5722049    K2      = 0.0219717     K3      = 0.1576753
+K3B     = 4.2763642    W0      = 1E-6          NLX     = 1.104212E-7
+DVT0W   = 0            DVT1W   = 0             DVT2W   = 0
+DVT0    = 0.6234839    DVT1    = 0.2479255     DVT2    = 0.1
+U0      = 109.4682454  UA      = 1.31646E-9    UB      = 1E-21
+UC      = -1E-10       VSAT    = 1.054892E5    A0      = 1.5796859
+AGS     = 0.3115024    B0      = 4.729297E-7   B1      = 1.446715E-6
+KETA    = 0.0298609    A1      = 0.3886886     A2      = 0.4010376
+RDSW    = 199.1594405  PRWG    = 0.5           PRWB    = -0.4947034
+WR      = 1            WINT    = 0             LINT    = 2.93948E-8
+XL      = 0            XW      = -1E-8         DWG     = -1.998034E-8
+DWB     = -2.481453E-9 VOFF    = -0.0935653    NFACTOR = 2
+CIT     = 0            CDSC    = 2.4E-4        CDSCD   = 0
+CDSCB   = 0            ETA0    = 3.515392E-4   ETAB    = -4.804338E-4
+DSUB    = 1.215087E-5  PCLM    = 0.96422       PDIBLC1 = 3.026627E-3
```

```
+PDIBLC2 = -1E-5        PDIBLCB = -1E-3        DROUT   = 1.117016E-4
+PSCBE1  = 7.999986E10  PSCBE2  = 8.271897E-10 PVAG    = 0.0190118
+DELTA   = 0.01         RSH     = 8.1          MOBMOD  = 1
+PRT     = 0           UTE     = -1.5         KT1     = -0.11
+KT1L    = 0           KT2     = 0.022        UA1     = 4.31E-9
+UB1     = -7.61E-18    UC1     = -5.6E-11     AT      = 3.3E4
+WL      = 0           WLN     = 1            WW      = 0
+WWN     = 1           WWL     = 0            LL      = 0
+LLN     = 1           LW      = 0            LWN     = 1
+LWL     = 0           CAPMOD  = 2            XPART   = 0.5
+CGDO    = 7.82E-10     CGSO    = 7.82E-10     CGBO    = 1E-12
+CJ      = 1.214428E-3  PB      = 0.8461606    MJ      = 0.4192076
+CJSW    = 2.165642E-10 PBSW    = 0.8          MJSW    = 0.3202874
+CJSWG   = 4.22E-10     PBSWG   = 0.8          MJSWG   = 0.3202874
+CF      = 0           PVTH0   = 5.167913E-4  PRDSW   = 9.5068821
+PK2     = 1.095907E-3  WKETA   = 0.0133232    LKETA   = -3.648003E-3
+PU0     = -1.0674346   PUA     = -4.30826E-11 PUB     = 1E-21
+PVSAT   = 50          PETA0   = 1E-4         PKETA   = -1.822724E-3  )
*
```

C. ANALISIS ISYARAT KELUARAN



D. ANALISIS SPICE ERROR LOG

SPICE Error Log: C:\Program Files\LTC\LTspiceIV\Draft3A.log

```
Semiconductor Device Operating Points:
                          --- BSIM3 MOSFETS ---
Name:          m19           m18           m7            m6            m5
Model:       cmosp         cmosp         cmosp         cmosp         cmosp
Id:       4.65e+00      4.65e+00      3.49e+00      3.49e+00      2.33e+00
Vgs:      1.95e+00      1.95e+00      1.35e+00      1.35e+00      1.95e+00
Vds:      1.95e+00      1.95e+00      3.00e-01      3.00e-01      1.35e+00
Vbs:      0.00e+00      0.00e+00     -1.35e+00     -1.35e+00      0.00e+00
Vth:     -5.73e-02     -5.72e-02     -2.06e-01     -2.06e-01     -1.20e-01
Vdsat:   -3.16e-02     -3.16e-02     -3.33e-02     -3.33e-02     -2.92e-02
Gm:       2.04e-06      2.04e-06      7.93e-15      7.93e-15      2.74e-12
Gds:      3.15e-12      3.15e-12      1.53e-16      1.54e-16      1.09e-17
Gmb       1.72e-07      1.72e-07      2.00e-15      2.00e-15      5.70e-13
Cbd:      0.00e+00      0.00e+00      0.00e+00      0.00e+00      0.00e+00
Cbs:      0.00e+00      0.00e+00      0.00e+00      0.00e+00      0.00e+00
Cgsov:    7.82e-09      7.82e-09      4.69e-14      4.69e-14      7.82e-09
Cgdov:    7.82e-09      7.82e-09      4.69e-14      4.69e-14      7.82e-09
Cgbov:    1.00e-12      1.00e-12      1.21e-19      1.21e-19      1.00e-12
dQgdVgb:  4.57e-02      4.58e-02      1.55e-13      1.55e-13      7.41e-02
dQgdVdb: -5.26e-08     -5.26e-08     -4.69e-14     -4.69e-14     -7.82e-09
dQgdVsb: -4.31e-02     -4.31e-02     -1.01e-13     -1.01e-13     -6.24e-02
dQddVgb: -6.92e-03     -6.93e-03     -4.69e-14     -4.69e-14     -1.44e-08
dQddVdb:  5.03e-08      5.03e-08      4.69e-14      4.69e-14      7.82e-09
dQddVsb:  7.66e-03      7.66e-03      3.16e-25      3.16e-25      8.06e-09
dQbdVgb: -3.19e-02     -3.19e-02     -6.12e-14     -6.12e-14     -7.41e-02
dQbdVdb: -4.01e-08     -4.01e-08     -2.66e-28     -2.67e-28     -8.20e-14
dQbdVsb:  2.78e-02      2.78e-02      5.37e-14      5.37e-14      6.24e-02
```

SPICE Error Log: C:\Program Files\LTC\LTspiceIV\Draft3A.log

```
Name:          m4            m17           m16           m15           m14
Model:       cmosp         cmosn         cmosn         cmosn         cmosn
Id:       2.33e+00     -2.32e+00     -2.32e+00     -2.32e+00     -2.32e+00
Vgs:      1.95e+00     -1.06e+00      5.88e-01      5.88e-01     -1.06e+00
Vds:      1.35e+00     -7.62e-01     -7.62e-01     -7.62e-01     -7.62e-01
Vbs:      0.00e+00      5.88e-01      5.88e-01      5.88e-01      5.88e-01
Vth:     -1.20e-01      1.32e-01      1.32e-01      1.32e-01      1.32e-01
Vdsat:   -2.92e-02      2.40e-02      8.48e-01      8.48e-01      2.40e-02
Gm:       2.76e-12      1.53e-10      2.21e-04      2.21e-04      1.53e-10
Gds:      1.10e-17      3.22e-15      3.77e-05      3.77e-05      3.22e-15
Gmb       5.75e-13      2.05e-11      8.92e-06      8.92e-06      2.05e-11
Cbd:      0.00e+00      0.00e+00      0.00e+00      0.00e+00      0.00e+00
Cbs:      0.00e+00      0.00e+00      0.00e+00      0.00e+00      0.00e+00
Cgsov:    7.82e-09      8.58e-10      8.58e-10      8.58e-10      8.58e-10
Cgdov:    7.82e-09      8.58e-10      8.58e-10      8.58e-10      8.58e-10
Cgbov:    1.00e-12      1.00e-12      1.00e-12      1.00e-12      1.00e-12
dQgdVgb:  7.41e-02      4.94e-03      7.21e-03      7.21e-03      4.94e-03
dQgdVdb: -7.82e-09     -8.68e-10     -1.10e-04     -1.10e-04     -8.68e-10
dQgdVsb: -6.24e-02     -4.19e-03     -7.38e-03     -7.38e-03     -4.19e-03
dQddVgb: -1.44e-08     -1.51e-07     -2.87e-03     -2.87e-03     -1.51e-07
dQddVdb:  7.82e-09      8.69e-10      1.19e-04      1.19e-04      8.69e-10
dQddVsb:  8.14e-09      1.75e-07      3.03e-03      3.03e-03      1.75e-07
dQbdVgb: -7.41e-02     -4.93e-03     -1.47e-03     -1.47e-03     -4.93e-03
dQbdVdb: -8.27e-14     -1.14e-11     -1.28e-04     -1.28e-04     -1.14e-11
dQbdVsb:  6.24e-02      4.19e-03      1.32e-03      1.32e-03      4.19e-03
```

SPICE Error Log: C:\Program Files\LTC\LTspiceIV\Draft3A.log

Name:	m11	m10	m9	m8	m2
Model:	cmosn	cmosn	cmosn	cmosn	cmosn
Id:	-2.16e-03	-2.16e-03	-3.49e+00	-3.49e+00	-4.65e+00
Vgs:	3.30e+00	3.30e+00	3.72e+00	3.72e+00	7.12e-01
Vds:	-4.23e-01	-4.23e-01	-1.23e+00	-1.23e+00	-1.24e+00
Vbs:	0.00e+00	0.00e+00	4.23e-01	4.23e-01	7.12e-01
Vth:	2.63e-01	2.63e-01	1.05e-01	1.05e-01	2.59e-01
Vdsat:	7.05e+00	7.05e+00	8.97e+01	8.97e+01	3.94e-01
Gm:	-1.63e-04	-1.63e-04	-3.19e-04	-3.19e-04	4.10e-03
Gds:	4.95e-03	4.95e-03	1.75e-03	1.75e-03	4.26e-04
Gmb	2.74e-04	2.74e-04	4.15e-05	4.15e-05	-4.99e-05
Cbd:	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Cbs:	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Cgsov:	1.08e-08	1.08e-08	4.03e-09	4.03e-09	9.26e-15
Cgdov:	1.08e-08	1.08e-08	4.03e-09	4.03e-09	9.26e-15
Cgbov:	1.00e-12	1.00e-12	1.00e-12	1.00e-12	1.46e-19
dQgdVgb:	1.06e-01	1.06e-01	3.85e-02	3.85e-02	3.04e-14
dQgdVdb:	-4.77e-02	-4.77e-02	-1.29e-02	-1.29e-02	-9.22e-15
dQgdVsb:	-6.06e-02	-6.06e-02	-2.69e-02	-2.69e-02	-2.15e-14
dQddVgb:	-5.27e-02	-5.27e-02	-1.86e-02	-1.86e-02	-1.37e-14
dQddVdb:	4.27e-02	4.27e-02	1.47e-02	1.47e-02	9.24e-15
dQddVsb:	1.68e-02	1.68e-02	2.25e-03	2.25e-03	4.68e-15
dQbdVgb:	-3.82e-04	-3.82e-04	-1.37e-03	-1.37e-03	-3.07e-15
dQbdVdb:	-3.77e-02	-3.77e-02	-1.65e-02	-1.65e-02	-6.30e-18
dQbdVsb:	2.70e-02	2.70e-02	2.24e-02	2.24e-02	2.89e-15

SPICE Error Log: C:\Program Files\LTC\LTspiceIV\Draft3A.log

Name:	m1
Model:	cmosn
Id:	-4.66e+00
Vgs:	2.31e+00
Vds:	-1.24e+00
Vbs:	7.12e-01
Vth:	2.58e-01
Vdsat:	8.40e-01
Gm:	2.36e-03
Gds:	1.90e-03
Gmb	-9.98e-05
Cbd:	0.00e+00
Cbs:	0.00e+00
Cgsov:	8.58e-15
Cgdov:	8.58e-15
Cgbov:	1.46e-19
dQgdVgb:	2.82e-14
dQgdVdb:	-8.70e-15
dQgdVsb:	-2.01e-14
dQddVgb:	-1.28e-14
dQddVdb:	8.82e-15
dQddVsb:	4.12e-15
dQbdVgb:	-2.70e-15
dQbdVdb:	-3.74e-16
dQbdVsb:	3.26e-15

E02: Electrical Bleeding System

Muslihah binti Saman [1], Mohd Hisham bin Abd Jalil [2] , Mohd Sopian bin Ibrahim [3], Kamaruddin bin Masri@Shaárani [4]
Institut Latihan Perindustrian Pasir Gudang, Johor

[1]*muslihah@ilppg.gov.my*

Abstrak

'Electrical Bleeding System' direka khas bagi menyelesaikan masalah kesukaran membuat proses 'bleeding' melalui cara konvensional. Sistem konvensional melibatkan dua orang pekerja untuk mengepam pedal minyak berkali-kali dan seorang pekerja lagi memberi arahan sambil membuat kerja bleeding (jujusan) pada kereta. Permasalahan dan kerumitan proses 'bleeding' secara konvensional pada sistem brek dan 'clutch' merupakan faktor utama terhasilnya projek ini. Ianya beroperasi apabila satu suis elektrik dapat mengawal motor pump 12VDC yang akan menyedut bendalir dalam tabung bekalan bendalir melalui 'clutch sleeve brake', 'master brake' dan terus ke tabung brek sehingga bendalir baru akan menolak bendalir lama keluar melalui tabung bendalir secara konsep 'reverse flow'. 'Reverse Flow' adalah konsep tekanan yang akan tolak minyak dari bawah hingga naik ke tabung bendalir [1]. Setelah diuji keberkesanannya, projek ini mampu melakukan kerja-kerja 'bleeding' secara bersendirian, menjimatkan kos minyak dan buruh tanpa perlu melibatkan ramai tenaga buruh, langkah kerja yang sedikit dengan masa yang agak pantas. Malahan sistem ini telah diakui keberkesanannya oleh kumpulan pelajar separuh masa (PERHEBAT) yang bertugas dibahagian penyelenggaraan di PULADA, Ulu Tiram dan pakar pengajar Bengkel Automotif kerana ia mampu mengatasi masalah kesukaran membuat sistem bleeding sekaligus dapat menyelesaikan angin dalam sistem.

***Kata Kunci** : bleeding, clutch, brek, reverse flow, pedal minyak*

1.0 Pengenalan

Sistem brek merupakan satu sistem keselamatan yang penting bagi sesebuah kenderaan. Brek yang dipasang pada kenderaan adalah bertujuan untuk memberhentikan atau memperlahankan kenderaan daripada terus bergerak apabila diperlukan. Operasi sistem brek biasanya menjadi satu aspek yang paling penting bagi setiap pemandu untuk diambil perhatian serius. Silinder induk disambungkan ke pedal brek yang diinjak oleh pemandu bagi memaksa bendalir dikenakan tekanan pada setiap pepasangan brek roda. Oleh itu, keupayaan sistem brek memainkan peranan penting dalam pemanduan kenderaan bermotor. Umumnya terdapat dua jenis sistem brek yang digunakan pada kenderaan, iaitu sistem brek hidraulik dan sistem brek mekanikal. Walaubagaimanapun kebanyakan kenderaan masa kini menggunakan teknologi sistem brek hidraulik kerana kuasa pemberhentiannya lebih baik daripada brek mekanikal. Perkembangan teknologi terkini mendorong kami untuk mencipta satu sistem *bleeding* yang menggunakan tenaga elektrik secara *reverse flow.* Sistem ini telah diuji dan digunapakai sebagai sistem penjujusan oleh responden dari *Pasukan 21 Wksp Arti (PERHEBAT)* dan diaplikasi di dalam modul amali sistem *bleeding* di dibengkel Automotif ILP Pasir Gudang.

1.1 Pernyataan Masalah

Bleeding pada sistem brek adalah *flushing* keluar minyak brek lama secara total dan menggantikannya dengan minyak brek baru. Ini adalah perlu kerana, semasa proses *bleeding* sistem brek mengandungi cecair yang tidak boleh dimampatkan, manakala gelembung udara dari gas mampat (air bubbles) turut hadir dalam sistem tersebut dan keadaan ini akan mengurangkan tekanan hidraulik yang boleh dibangunkan dalam sistem tersebut. Kaedah yang sama digunakan untuk *bleeding system* ialah kaedah penyingkiran, di mana cecair yang lama diganti dengan cecair yang baru dan melibatkan penyelenggaraan.
Gelembung udara mungkin telah memasuki sistem ketika pembaikan dilakukan, kerana kebocoran atau kerana tahap ketahanan menjadi terlalu rendah. Udara harus dibuang kerana ianya mempunyai tekanan dan membolehkan pedal brek ditekan dengan baik dan setelah beberapa tahun, tidak hairanlah terdapat minyak brek yang dicemari sebanyak 3%. Walau apa jenis minyak yang digunakan, sekiranya pengguna tidak menukar minyak brek sehingga enam atau tujuh tahun tidak maka minyak brek turut dicemari sehingga 7 hingga 8% udara.

Melalui pembacaan dari operator manual untuk membuang minyak brek yang telah dicemari air, ianya perlu diganti secara berkala kerana minyak brek DOT 3 dan 4 adalah berasaskan *Glycol* dan menyerap kelembapan dari masa ke masa. Hal ini boleh terjadi samada pada kenderaan yang bergerak 30,000 batu (lebih kuang 50000km) atau hanya disimpan di garaj kerana penceramaran ke atas minyak brek lebih dipengaruhi oleh faktor masa dan kelembapan selain jarak pemanduan (milage) [2]. Sistem brek hidraulik mestilah dijujus apabila sesuatu paip sambungan ditanggalkan atau dimasuki angin. Ia perlu dilakukan atas beberapa sebab :

- Apabila berlaku kerosakan pada *brake master clutch pump/sleeve*
- Pelarasan setiap lebih kurang 30000km-40000km.
- Berlaku kebocoran pada *system breake* atau *clutch*

1.2 Objektif

Permasalahan dan kerumitan langkah kerja secara konvensional untuk membuat bleeding pada *system brake dan clutch* merupakan faktor utama *Electrical Bleeding System* dicipta. Projek ini membenarkan kerja-kerja bleeding dilakukan secara bersendirian dengan langkah kerja yang sedikit dan masa yang agak pantas dan mampu menjimatkan kos pembelian minyak akibat penyingkiran minyak lama yang telah tercemar. Sistem brek hydraulik mestilah dijujus bila sesuatu paip sambungan ditanggalkan atau dimasuki angin. Objektif utama kajian adalah untuk :

- Mencipta alat penjujusan yang menggunakan konsep *reverse flow.*
- Mewujudkan alat penjujusan *brake* yang lebih efektif dan efisyen.
- Mencipta satu alat perenggu khas untuk membuat penjujusan.

2.0 Metodologi Kajian

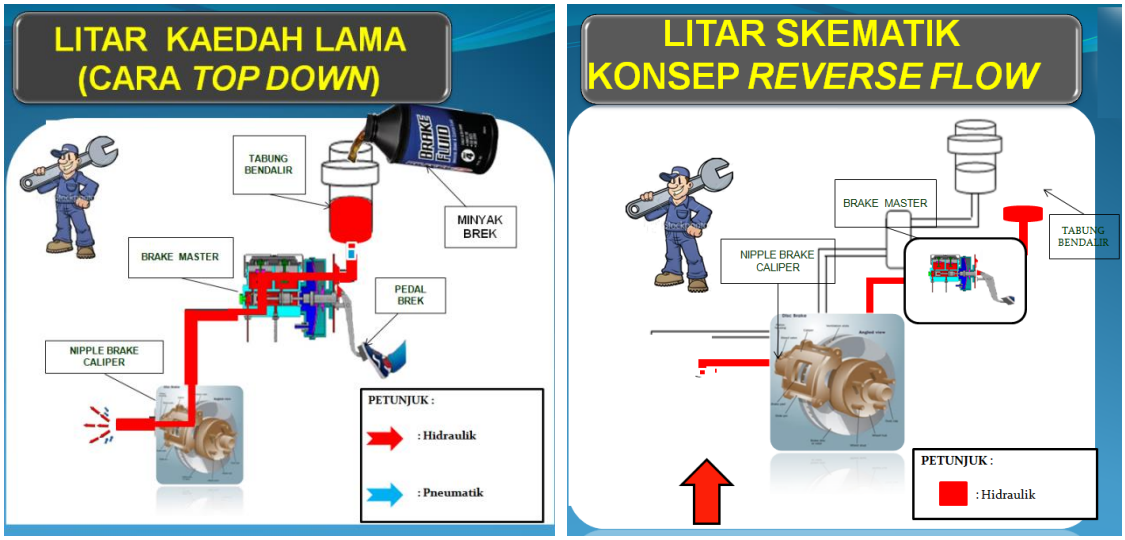
Cara pelaksanaan adalah bermula dengan demonstrasi langkah-langkah melaksanakan sistem bleeding menggunakan beberapa kaedah konvensional yang melibatkan pressure dan operasi bleeding secara manual. Seterusnya, demonstrasi sistem bleeding menggunakan alat penjujusan berkawalan elektrik yang dinamakan Electrical Bleeding System yang melibatkan bekalan elektrik dari suis kawalan dihidupkan untuk menggerakkan motor 12VDC yang beroperasi untuk memasukkan minyak baru dan menyedut minyak lama secara reversed flow. Perbandingan langkah kerja melalui carta alir, ukuran masa untuk menyelesaikan sistem bleeding akan diambil dan keberkesanan projek terhadap objektif utama kajian akan direkodkan dan dianalisa ke dalam graf di fasa Keputusan dan Perbincangan.

3.0 Keputusan dan Perbincangan

Hasil kajiselidik dan demonstrasi uji cuba terhadap responden pelajar separuh masa (PERHEBAT) yang bertugas dalam pasukan Pasukan 21 Wksp Arti jelas menunjukkan alat penjujusan yang dinamakan Electrical Bleeding System adalah berkesan dan selamat digunakan. Faedah-faedah yang dititik beratkan adalah dari segi faktor Penjimatan Kos Bendalir, Penjimatan Masa Operasi, Penjimatan Tenaga Kerja dan Penjimatan Kos Upah.

Perbandingan langkah kerja secara konvensional (top down) dan Electrical Bleeding System (reverse flow) ditunjukkan dalam Rajah 1 dibawah. Manakala data-data melalui carta alir perbandingan langkah kerja tersebut telah dianalisa dari segi penggunaan dan penjimatan yang terhasil seperti yang tertera dalam Jadual 1.

Rajah 1: Perbandingan Langkah Kerja pada Sistem *Bleeding*



Jadual 1: Perbandingan Langkah Kerja pada Sistem *Bleeding*

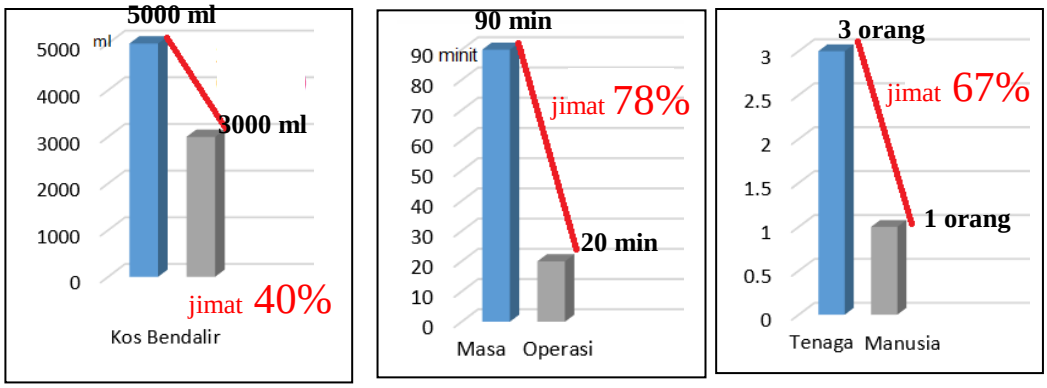
CARA MANUAL (BIASA)	SISTEM ANGIN (PNUEMATIC)	ELECTRICAL BLEEDING SYSTEM
Perlu 2 x pekerja	Seorang pekerja	Seorang pekerja
Perlu menjerit pam dan tahan	Tidak perlu menjerit	Tidak perlu menjerit
Perlu menuang bendalir berkali-kali	Tidak perlu	Tidak perlu
Perlu mengepam brek berkali-kali	Tidak perlu	Tidak perlu
Membuka *nipple brake calipper* untuk mengeluarkan minyak lama.	Tidak perlu	Tidak perlu
Tidak memerlukan bantuan alatan lain	Memerlukan *air pressure*	Tidak memerlukan bantuan alatan lain

Pengkaji juga telah membuat penilaian dan analisa ke dalam bentuk jadual dan graf di atas pencapaian hasil projek. Jadual 2 menunjukkan Pengunaan Minyak Bendalir, Masa Operasi dan Sumber Manusia sebelum dan selepas pembangunan projek terhadap 2 model kenderaan utama iaitu Trak 3 Tan DRB Hicom dan Land Rover. Keputusan kajian dari data tersebut, menunjukkan terdapat penjimatan terhadap penggunaan minyak bendalir, masa dan sumber manusia bagi kedua-dua jenis kenderaan setelah penggunaan *Electrical Bleeding System.*

Jadual 2: Pengunaan Minyak Bendalir, Masa Operasi dan Sumber Manusia

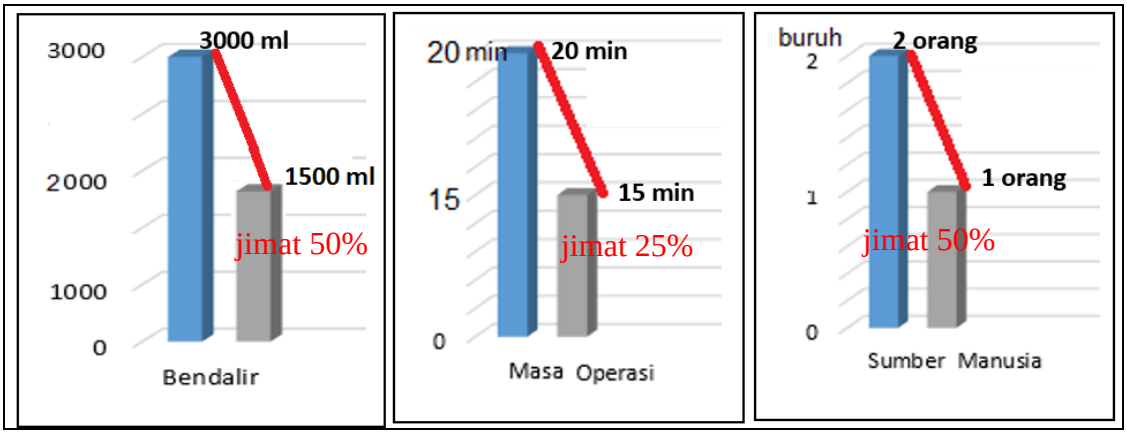
SISTEM	TRAK 3 TAN DRB HICOM (1 buah)			LAND ROVER (1 buah)		
	Sebelum Projek	Selepas Projek	Jimat	Sebelum Projek	Selepas Projek	Jimat
Minyak Bendalir	5000 ml (5 botol)	3000 ml (3 botol)	**2000 ml (2 botol)**	3000 ml (3 botol)	1500 ml (1.5 botol)	**500 ml (1.5 botol)**
Masa Operasi	90 minit	20 minit	**70 min**	20 minit	15 minit	**5 minit**
Sumber Manusia	3	1	**2**	2	1	**1**

Rajah 2: Peratusan Penjimatan Penggunaan Bendalir, Masa dan Buruh bagi sebuah Trak 3



Rajah 2 menunjukkan analisa terhadap peratusan penjimatan terhadap sebuah Trak 3 Tan DRB Hicom. Penjumatan sebanyak 40% terhadap kos bendalir, 78% terhadap masa yang diambil bagi menyelesaikan proses *bleeding* dan 67% penglibatan sumber manusia. Keputusan ini menunjukkan penggunaan *Electrical Bleeding System* sebagai alat penjujusan *break* dan *clutch* adalah efektif dan berkesan kerana mampu mengurangkan kos penyelenggaaan kenderaan tersebut.

Rajah 3: Peratusan Penjimatan Penggunaan Bendalir, Masa dan Buruh bagi sebuah Land Rover



Rajah 3 menunjukkan analisa terhadap peratusan penjimatan terhadap sebuah Land Rover. Penjumatan sebanyak 50% terhadap kos bendalir, 25% terhadap masa yang diambil bagi menyelesaikan proses *bleeding* dan 50% penglibatan sumber manusia. Keputusan ini menunjukkan penggunaan *Electrical Bleeding System* sebagai alat penjujusan *break* dan *clutch* adalah efektif dan berkesan kerana mampu mengurangkan kos penyelenggaaan kenderaan tersebut.

Jadual 4 menunjukkan perbandingan terhadap kos minyak bendalir dan kos sumber manusia sebelum dan selepas perlaksanaan projek terhadap sebuah kenderaan jenis Trak 3 Tan DRB Hicom dan Land Rover. Hasil kajian mendapati, terdapat penjimatan yang ketara terhadap kos minyak bendalir bagi Trak 3 DRB Hicom dan Land Rover masing-masing adalah sebanyak **RM59.60** dan **RM45.00.** Manakala pejimatan terhadap kos sumber manusia masing-masing sebanyak **RM125.80** dan **RM17.75**.

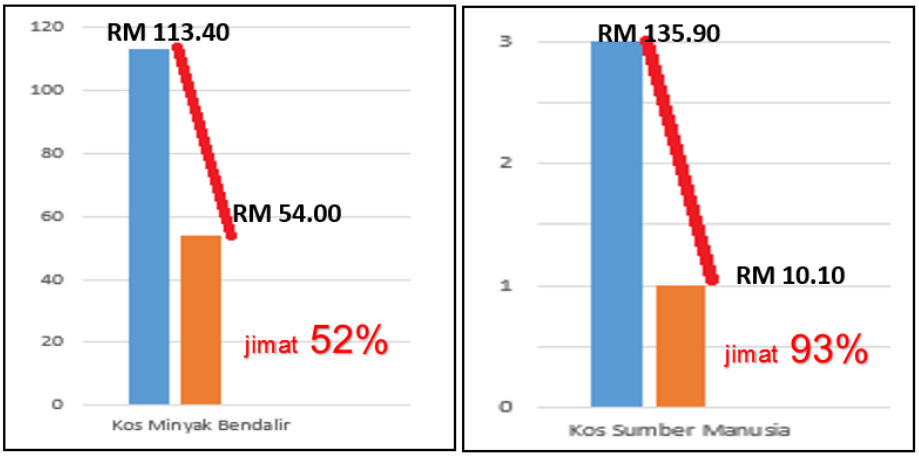
Jadual 4: Penjimatan Kos Minyak Bendalir, Masa Operasi dan Sumber Manusia

SISTEM	TRAK 3 TAN DRB HICOM (1 buah)			LAND ROVER (1 buah)		
	Sebelum Projek (RM)	Selepas Projek (RM)	**Jimat (RM)**	Sebelum Projek (RM)	Selepas Projek (RM)	**Jimat (RM)**
Kos Minyak Bendalir	113.40	54.00	**59.60**	72.00	27.00	**45.00**
Kos Sumber Manusia	135.90	10.10	**125.80**	20.20	7.55	**17.75**

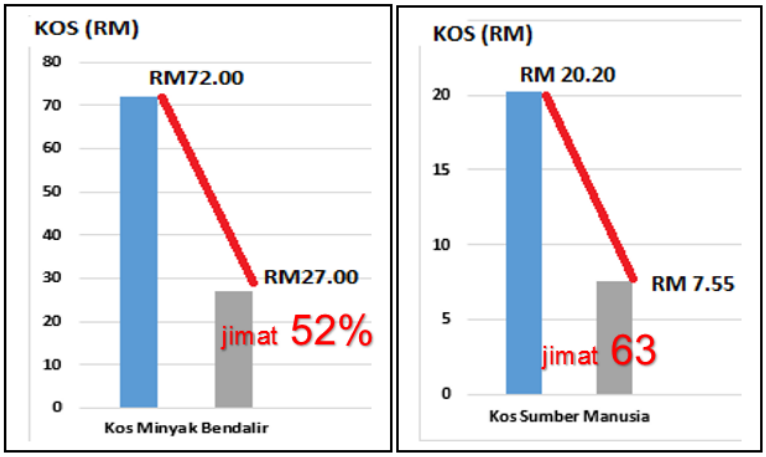
** Kos Sumber Manusia = [Masa Operasi x (RM30.20 per jam seorang pekerja)]*

Rajah 4 dan Rajah 5 menunjukkan peratusan penjimatan kos terhadap kedua-dua model kenderaan yang diuji. Penjimatan terhadap kos minyak bendalir bagi Trak 3 Tan DRB Hicom ialah sebanyak RM59.40 (52%) manakala penjimatan terhadap kos upah ialah sebanyak RM12.65 (93%). Manakala bagi kenderaan model Land Rover, penjimatan terhadap kos minyak bendalir ialah sebanyak RM45.00 (63%) manakala penjimatan terhadap kos upah ialah sebanyak RM12.65 (63%).

Rajah 4: Penjimatan terhadap kos sistem brek bagi sebuah Trak 3 Tan DRB Hicom



Rajah 5: Penjimatan terhadap kos sistem brek bagi sebuah Land Rover



Jadual 5 adalah hasil analisa berdasarkan rekod perlaksanaan pembaikan ke atas 18 buah trak 3 tan dan 23 buah Land Rover mulai 2 Jan – 30 April 2013. Sebanyak RM2170.00 kesan dari penjimatan kos minyak brek, RM2740.25 kos upah, 144900 minit masa yang terlibat dan penjimatan terhadap 49 sumber manusia kesan dari penggunaan *Electrical Bleeding System.* Keputusan ini juga telah diplotkan ke dalam Rajah 6 dibawah.

Jadual 5: Kesan Penjimatan Keseluruhan terhadap Perlaksanaan Electrical Bleeding System.

PENJIMATAN (41 BUAH KENDERAAN)	TRAK 3 TAN		LAND ROVER		JUMLAH KESELURUHAN
	PENGIRAAN	JUMLAH	PENGIRAAN	JUMLAH	
KOS MINYAK BREK	18 x RM59.60	RM1072.80	23 X RM45	RM1035.00	
		RM1072.80		RM1035.00	RM 2170.00
KOS UPAH	18 x 125.80	RM225.000	23xRM17.75	RM408.25	
		RM1297.00		RM1443.25	RM 2740.25
MASA	18 x 70	1260 minit	23 x 5	115 minit	
		1260 minit		115 minit	144900 minit
SUMBER MANUSIA	18 x 2	26 orang	23 x 1	23 orang	
		26 buruh		23 buruh	49 buruh

5.0 Kesimpulan

Pembangunan projek *Electrical Bleeding System* melalui kajian ini telah memberi kesan positif kerana mampu memberi penjimatan terhadap keseluruhan faktor yang diukur selari dengan pencapaian objektif. Keputusan dan hasil kajian terhadap rekod perlaksanaan pembaikan sebuah kenderaan model Trak 3 Tan DRB Hicom dan Land Rover sebelum dan selepas perlaksanaan projek jelas menunjukkan bahawa penggunaan motor elektrik 12VDC sebagai sistem kawalan utama untuk proses *bleeding* adalah efektif dan berkesan. Manakala analisa ke atas 18 buah trak 3 tan dan 23 buah Land Rover turut menggambarkan penjimatan ketara terhadap kos penyelenggaraan kenderaan di jabatan tersebut.

Projek *Electrical Bleeding System* yang direka ini bukan sahaja mampu memberi faedah positif terhadap individu dan jabatan malahan membenarkan individu membuat proses *bleeding* bersendirian dan dimana-mana jua. Diharapkan projek berinovasi ini mampu meningkatkan produktiviti pekerja dan memajukan industri negara disamping dapat menjimatkan kos keseluruhan penyelenggaraan minyak brek dan *clutch.*

6.0 Rujukan

[1] March 2, 1954 E. D. WILKERSON 2,670,874 Hydraulic Brake System Bleeding And Filling Apparatus Filed Oct. 12, 1948.

[2] Erjavec, Jack (2004). *Automotive Technology: A Systems Approach*, Delmar Cengage Learning. ISBN 1-4018-4831-1.

[3] *Brake for use on vehicles*. Boughton Edward Bishop 1929-07-16.

E04: Carbon Dioxide Testing and Monitoring Via SMS

Suhailae bt. Moridan[1]
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

suhailae@jtm.gov.my

Abstract

This study was conducted to develop a tool to measure and monitor the condition of CO_2 concentration level for indoor air quality. Arduino UNO was used as controller system for the entire process while GSM technology used as a medium for SMS delivery system. This project is divided into three parts. MQ-5 analog sensor was used to measure a CO_2 concentration level. The processing modules are responding to the operations to activate an indicator and alert notification. While the monitoring module responds sending text messaging using the SMS text service to those concerned. Taking into account the permissible concentration level of CO_2 recommended by ASHRAE and DOSH, a guide designed to classify the condition of the quality of the CO_2 concentration level. The actual measurement of CO_2 concentration level and short message will be classified for "very good", "good" and "not good" condition with the activation of indicator and alert notification. Therefore, with the development of this project, the monitoring system for CO_2 concentration level can be carried out more effectively and adopted to ensure the user's comfort.

Keywords: *CO_2 concentration level, CO_2 testing & monitoring, Indoor Air Quality, MQ-5 Analog Sensor*

1.0 Introduction

Carbon Dioxide (CO_2) is the natural gas produced by human respirations, human activities like fuel and coal burning and decaying vegetation process into the air environment. Carbon dioxide is non- flammable, odourless and colourless gas which is heavier than the air. The permissible concentration level of carbon dioxide is about 1000 ppm recommended by *Deputy of Occupational Safety and Health* (DOSH) and *American Society of Heating, Refrigerating and Air- Conditioning Engineers* (ASHRAE) regulation [1].

The indoor air known as indoor environment is the air or environment inside the building or confined closed room or space such as the classroom, office, shopping centre and others. While the Indoor Air Quality (IAQ) is defined as indoor air within building occupied at least one hour by people varying in state of health. The human health, comfort and their abilities of work are influence by the quality of air environment. The quantities of air in the building should be adequately ventilated. The fresh air from the outside must circulated into the building efficiently to maintain the air quality. The measured of carbon dioxide is served as an indication of insufficient circulation of air changes in the work environment in the building.

2.0 Background

In the building, there may have a natural ventilation or mechanical ventilation such as air- condition and fan to maintain the air quality. The qualities for IAQ included the quality of humidity, air temperature, the circulation of fresh air and the control of air pollutants from inside or outside of the building. The most common concern about the air quality is the health and safety of the people inside the building. Common causes of IAQ problems are influenced by the amount of the occupants and times spent inside the building. In the other hand, the chemical reaction between the furnishing and building material and the improper ventilation maintenance also affect the air quality.

IAQ problem only will be noticed after several hours in that environment and only disappear after they leave the room. There is no scientific evidence shows the health problem is associated to poor indoor air quality. Sometimes the health problem is not from the air environment but, based on the human health conditions. There are two separate health effect of major indoor air contaminants:
Sick Building Syndrome.
Building Related Sickness.

2.1 Sick Building Syndrome

The term of "sick building syndrome" means occupant who suffers from this disorder may experience the illness symptoms at least two week or more but healed after leaving the room. The specific causes is unknown but affected the body condition. The syndrome describes the symptoms that occurring together [3]. The condition causes health discomfort which is associated with the period of occupancy in the room such as headache, dizziness, poor concentration, dermatitis, dryness and irritation of eyes, nose and throat.

There are difficulties in measuring the association between non-specific symptoms and the indoor environment such as lighting levels, workload stress. Thus, the poor indoor air quality is contributing factor to the occurrence of symptoms in air-conditioned rooms than rooms with natural ventilation system.

CO_2 inhalation will distracted the body and physiological system on respiration, the central nervous and the cardiovascular system if exposed in an extended period of time. Many of CO_2 studies suggest that to minimize the sick building syndrome symptom with reducing the indoor CO_2 concentration levels below than 800 ppm [4].

2.2 Building- Related Illness

The term of "building- related illness" means the clinically illness directly influence from the poor indoor environment and poor ventilation system, known as aetiology, allergic reaction and infection often documented by psychical signs. The causes of this symptom are influenced by biological, chemical reaction, management, psychological and psychosomatic factors. The illness is occurring for a certain period and the symptom is not healed after leaving the room

There can be three different types of possible data transmission, which are transmission from a device to the coordinator, transmission from the coordinator to the device and transmission between any two devices. In a star topology only the first two transmission techniques are possible. Transmission between any two devices is not supported, where as in a peer-to peer network all the three types of transmissions are possible.

3.0 Relationship between Carbon Dioxide and Indoor Air Quality (IAQ)

Before the construction of the real project, the relationship between the carbon dioxide and Indoor Air Quality should be fully understand without compromising the rules have been proposed by *Malaysia Deputy of Occupational Safety and Health* (DOSH) and *American Society of Heating, Refrigerating and Air- Conditioning Engineers* (ASHRAE) regulation to activate the indicator alert for the change carbon dioxide concentration in air. Both regulations stated that the permissible of carbon dioxide concentration level is about 1000 ppm. More than 1000 ppm considered no good indoor air quality. The best carbon dioxide concentration level indoor room is less than 800 ppm.

Therefore, by using this permissible concentration value, the traffic light indicator (RED, YELLOW, GREEN) will be activated based on the condition the air quality indoor room (refer Table1).

Table 1: Relationship between CO_2 Concentration Level and Condition for IAQ

Colour	Concentration level (ppm)	Condition
RED	≥ 1000	NO GOOD
YELLOW	$800 \leq CO_2 < 1000$	GOOD
GREEN	< 800	VERY GOOD

4.0 Project Overview

The main purpose of this project is to measure the carbon dioxide concentration level indoor room and give the indicator and alert notification system. There are three main parts in this project as follows:

i. Testing module
   Measure the CO_2 concentration level by MQ-5 analog sensor and display the CO_2 concentration level on LCD display.
ii. Processing module
   Arduino UNO as main controller react the analog input from the MQ-5 analog sensor to give output signal for indicator and alert notification by using lamp, buzzer and fan.
iii. Monitoring module
   Every stage CO_2 concentration level indicates different SMS. Arduino UNO as controller give a signal processing for sending a notification SMS to in charge person.

5.0 Results and Discussions

The experiment result of this project comes from the actual testing on site by using this project prototype. The main purpose is to assess this prototype abilities and performance do observation and taking a sample data for analysis purposes. This project prototype was tested to determine its functionality before the actual test.

5.1 Experimental Result

The operation for this project is starting when the supply is been activated from USB cable connection. The CO_2 sensor will start to measure for the indoor room. The real CO_2 concentration level reading and the status will appear on LCD display. The display will change every time the CO_2 concentration level reading in the air is change. The CO_2 concentration level reading are rated for others three stage condition which is whether the CO_2 concentration level indoor room is in "Very Good", "Good" or "Not Good" condition. The experimental result can be summarized in Table 2 and displayed in Figure A.1, A.2 and A.3.

Table 2: Experimental Result and Unit Conversion for "Carbon Dioxide Testing and Monitoring via SMS"

Colour	Condition	Indicator Alert	SMS Status
RED	NO GOOD	Buzzer/ Fan 2 ON	*"status Not Good ≥ 1000 ppm"*
AMBER	GOOD	Fan 1 ON	*"status Good > 800 ppm"*
GREEN	VERY GOOD	Buzzer/ Fan OFF	*"status Good < 800 ppm"*

5.1.1 Threshold for MQ-5 Analog Sensor Signal

MQ- 5 analog sensor will be activated when the supply 5VDC is given. The signal output will trigger the output given toward the Arduino UNO as an input for the next process. Given analog pin for Arduino UNO is activated with 5VDC supply only. Therefore the expected value at pin 3 of MQ-5 analog sensor will give the value within 5VDC too. The test measurements were performed at room temperature to measure the value of this threshold. The actual voltage value from the MQ-5 analog sensor for Arduino UNO board for each condition in this project can be summarized in Table 3.

Measuring Voltage = *39 mV*
CO_2 reading = *31 ppm*

Therefore; 1 *ppm* = $\frac{39 \times 10^{-3}}{31}$

= ***12.6 mV***

Table 3: Unit Conversion for CO_2 Concentration Level and Condition for IAQ

Colour	Raw Voltage (V)	Concentration level (ppm)	Condition
RED	1.26	≥ 1000	NO GOOD
AMBER	1.0 ≤ V< 1.26	800 ≤ CO_2 < 1000	GOOD
GREEN	1.0	< 800	VERY GOOD

5.2 On site Experiment Result Analysis

There are two different closed rooms as location site to be chosen which is in the classroom in seminar room and others in the office. In making the observation and testing guided by some methods that have been used from previous study. For example the testing conducted in the Industrial Electronic (IE) Department office took about one hour. Each measurement at an interval of 5 minutes and took two days to complete. Others, the testing for classroom in seminar room took place about two hours only for one day. The readings were taken at an interval for 5 minutes. Both rooms are approximately at the same area about 31' x 29' square. The device is placed about 0.75 m from floor and measured at desk- level.

5.2.1 Industrial Electronic Office Department

The tests carried out on 9 to 10 December 2014 in the morning about 9.00 am until 10.00 am on sunny day and it is equipped with air conditioning. The office department is the highest ranked at level 3. Figure A.4 shows the project prototype placed in that room. There are about six people in that room during the testing day. According to the graph in Figure A.5 at IE office department for the first day shows us that the CO_2 concentration level is increased proportionally with the number of people who were in the room. The movement or activities in the classroom do not influenced the measurement. The value of initial reading for CO_2 concentration level was 400 ppm.

While for the second day testing, the initial reading was at 400 ppm and rising up to 405 ppm after the 5 minutes test. The CO_2 concentration level reading continues to increase to 410 ppm after 10 minutes testing and continues to increase until 415 ppm after 10 minutes later. The cause of the increasing value of CO_2 concentration reading is attributable to the effects of activities drive off pigeons. After 40 minutes tests, the reading of CO_2 concentration level start decrease to 405 ppm because of the room change (open door and window) and then the reading value returned to the value of 410 ppm and remain until the end of the test run.

5.2.2 Classroom at Seminar Room Zamrud

This experiment project study also done in the morning about two hours, start from 9.00 am until 11.00 am in sunny day on 12 December 2014. The room is equipped with the air conditioning system. This seminar room is situated at the ground floor at administrative buildings. There are about 15 peoples in that room. The experiment conducted for the student open- university master class during lecturing time. Figure A.6 shows the project prototype placed in that room during the actual testing. From the graph in Figure A.7, shows us that the initial reading for CO The initial reading for CO_2 concentration level was at 568 ppm and increased proportionally with time and the number of people who were in the room on certain period until the reading of CO_2 concentration level reach 680 ppm after 40 minutes.

The CO_2 concentration level value does not change much until one hour has passed. After one hour the reading increases up to 698 ppm. From the observation found that the students lose focus and concentration feel sleepy because of the long period of lecture time without the room change (open or close door) influence the increasing of CO_2 concentration level in the classroom. The air-conditioners as the indoor environment also contribute to the incremental factor of CO_2 gas in the class. After 1 hour and 30 minutes lecture time, it found that the concentration level of CO_2 reduced rated to 680 ppm until the end of this testing time because they start focusing try to solve the given question.

5.2.3 Comparison between CO_2 Average Concentrations Level with the Number of People Indoor Room

For this comparison, there are two different data that have been used for this analysis. One of them is the average of CO2 concentration level in IE office department for two days within six people in hot weather. The room is equipped with the air conditioning system in that room with different situation where one of the testing days the external air pollution interfere the study. Others is a relevant number of people and CO2 average concentration level between IE office department and seminar room Zamrud with different amount of people there. Figure A.8 shown that the first day testing, the average of CO_2 concentration level value is about 401.15 ppm while there is about 408.46 ppm for the second day. Therefore, the average for two days testing tell us that the concentration level of CO_2 on the second day of test experience an increase about 7.31 ppm or about 1.82% from the normal day. Hence, to achieve an ideal IAQ, one mechanism control must be executed to ensure the circulation of fresh air and the control of air pollutants from outside of the building. This place arguably meets the good air quality refer to the content of CO_2 concentration level which is recommended by DOSH and ASHRAE at 800 ppm.

Figure A.9 shows us that the average of CO_2 concentration level in IE office department is about 401.15 ppm for six people, while the average of CO_2 concentration level in seminar room Zamrud is about 662.15 ppm with a total of 14 persons in there. If the reference for the good air quality refers to the content of CO_2 concentration level which is recommended by DOSH and ASHRAE at 800 ppm, found both of these places have a very good air quality. We can infer that the CO_2 concentration level will increase proportionately with the number of people in the room. The reading of average of CO_2 concentration value differences for these two places amounted to 261 ppm or about 39.42%.

6.0 Conclusion

The CO2 testing and monitoring is described as the integrated new technology system that offering indication for IAQ and ease for ventilation maintenance program. By using CO2 testing and monitoring for the real time indicate new form of technique and guideline to improve the IAQ, safety and health procedures inside the building.

Although, there are many equipment for measuring the CO2 concentration level in the market, nevertheless only a few people aware about the impact of CO2 concentration level indoor room. The measurement instrument is standalone and others come with monitoring system but do not offer the real time monitoring information alert system.

Through the construction of this project, the CO2 concentration level can be measured on real time monitoring. This project was equipped with alerts and notification indicator for awareness of the level of CO2 concentration level recommended by DOSH and ASHRAE by sending SMS to those responsible in respect of the safety of the air quality in the room. From the experiment functionality test, found that this project prototype work meets all the objectives of targeted. While for the actual testing, were concluded that the movement or activities in the room are not influence the measurement. However, each time when the room changes (open door) the measurements are affected. The number of people and the ventilation system that have been used and improper ventilation maintenance also will influent the results and the indoor room air quality.

7.0 References

[1] Department of Safety and Health (2010). *Code of Practice on Indoor Air Quality*. Malaysia: DOSH (Department of Safety and Health)

[2] Cooper, G. (2002). *Air- Conditioning America: Engineers and the Controlled Environment, 1900-1960* (No. 23). JHU Press.

[3] Bas, E. (2004). *Indoor Air Quality: A Guide for Facility Managers*. The Fairmont Press Inc.

[4] Campbell-Lendrum, D., and Corvalán, C. (2007). Climate Change and Developing- Country Cities: Implications for Environmental Health and Equity. *Journal of Urban Health*, *84*(1), 109-117.

[5] Gładyszewska-Fiedoruk, K. (2010). Concentration of Carbon Dioxide Measured in University Classrooms. *Budownictwo i Inżynieria Środowiska*, *1*, 117-121.

[6] Pacurar, C., and Cernazanu, C. A study of CO_2 Influence on Student Activity in Classroom.

[7] Vora, S. B., Tiwari, M., and Singh, J. (2012). CO_2 Monitoring System from Remote Location using GSM, GPS and Concept of MODBUS. *International Journal of Computer Applications*, *57* (20).

[8] Hossain, M. K., Haque, S. M., and Bhattacharyya, S. (2013). GSM based Wireless Sensor Network to Measure Global Warming, Humidity and CO_2. *International Journal of Computer Applications*, *76*.

[9] Barrett, S. F. (2012). Arduino Microcontroller: Processing for Everyone! *Synthesis Lectures on Digital Circuits and Systems*, *7*(2), 1-371.

[10] Banzi, M. (2009). *Getting Started with Arduino*. O'Reilly Media, Inc.

[11] http://www.chicoree.fr/w/Arduino_sur_ATmega328P

[12] Stroustrup, B. (2013). *The C++ Programming Language.* Pearson Education.

[13] Sardana, S. (2012). *Handbook on C++ Language*. Laxmi Publications.

[14] Rhee, M. Y. (2009). *Mobile Communication Systems and Security*. John Wiley & Sons

[15] Trosby, F., Holley, K., and Harris, I. (2010). *Short Message Service (SMS): The Creation of Personal Global Text Messaging*. F. Hillebrand (Ed.). John Wiley & Sons.

[16] Hamill, L., and Lasen, A. (Eds.). (2005). *Mobile World: Past, Present and Future*. Springer.

[17] Maras, M. H. (2014). *Computer Forensics*. Jones & Bartlett Publishers

[18] Burbank, J. L., Andrusenko, J., Everett, J. S., and Kasch, W. T. (2013). *Wireless Networking: Understanding Internetworking Challenges*. John Wiley & Sons.

[19] http://www.dfrobot.com/ wiki/ index.php?title= Analog_Gas_Sensor (MQ5) _ (SKU:SEN0130)

[20] http://www.gsmarena.com/nokia_1200-1976.php

APPENDICES

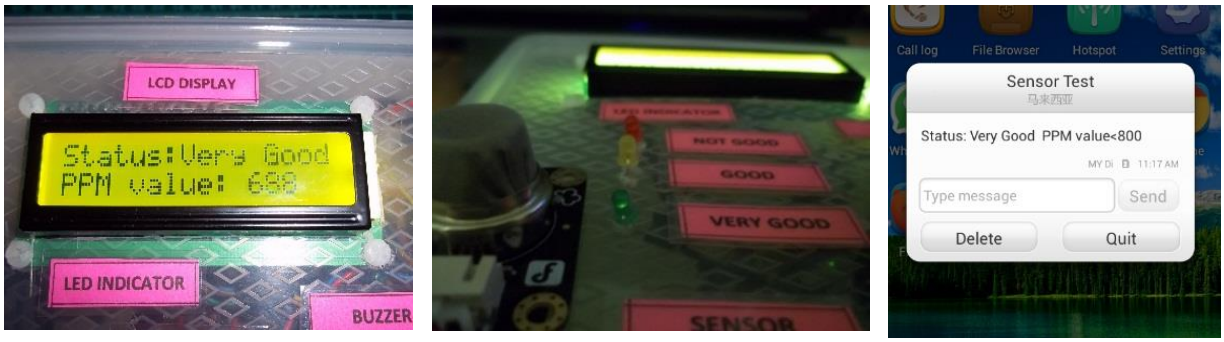


Figure A.1: The Result for *"Very Good"* Condition CO_2 Concentration Level Testing

Figure A.2: The Result for *"Good"* Condition CO_2 Concentration Level Testing

Figure A.3: The Result for *"Not Good"* Condition CO_2 Concentration Level Testing

Figure A.4: Prototype Placed During Testing in IE Office Department

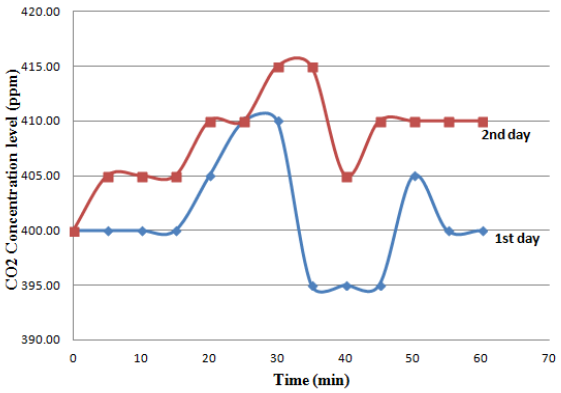


Figure A.5: Graph CO_2 Concentration Level Reading in IE Office Department

Figure A.6: Prototype Placed During Testing in Seminar Room Zamrud

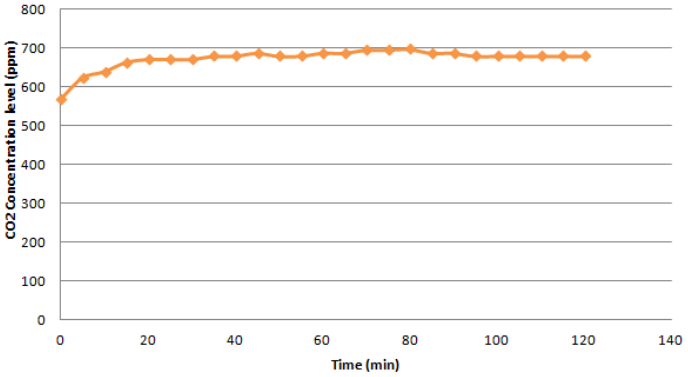


Figure A.7: Graph CO_2 Concentration Level Reading in Seminar Room Zamrud

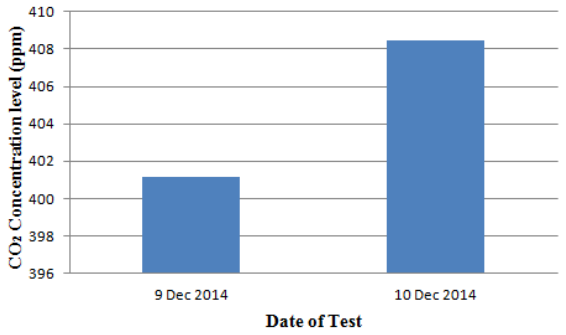


Figure A.8: Graph Comparison between Average CO_2 Concentration Levels in IE Office Department

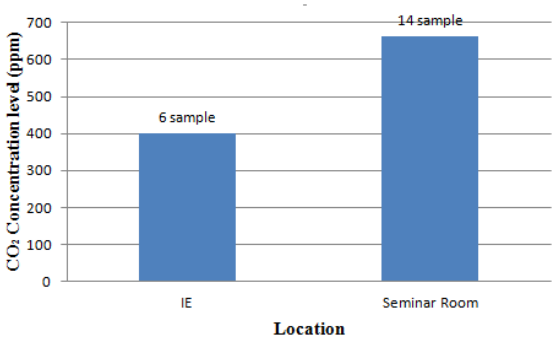


Figure A.9: Graph Comparison between CO_2 Average Concentration Level with the Number of People in IE Office Department and Seminar Room Zamrud

E05: Pembinaan Sistem Penerima Radio Melalui Serakan Meteor

Aidayu Delaila Binti Dahlan[1]
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

[1]*aidayu.jtm@1govuc.gov.my*

Abstrak

Abstrak ini membincangkan pembinan item penerima isyarat radio yang diterima dari satu kedudukan yang jauh, hasil dari pemantulan oleh plasma meteor. Model matematik digunakan untuk menganggar ciri-ciri isyarat yang bakal diterima dengan membuat beberapa andaian sesuai. Isyarat yang diterima banyak bergantung kepada jarak dan faktor pelemahan di sepanjang perambatannya dan ciri-ciri meteor itu sendiri. Isyarat dari stesen pemancar Sultan Ismail, Larkin, Johor Bahru (1°30'U, 103°43'T) pada aras laut, dipilih untuk dicerap setelah mengambil kira beberapa faktor antaranya nilai frekuensi yang dipancarkan dan kedudukan stesen tersebut. Sebuah antena Yagi lima elemen dibina dan sebuah penguat antena digunakan untuk membantu menguatkan isyarat yang diterima. Ujian dilakukan pada stesen ini dengan menggunakan radio penerima biasa yang mempunyai julat FM. Taburan meteor diramalkan dengan bantuan perisian OH5IY. Manakala perisian Yagimax 2.0 digunakan untuk membantu dalam merekabentuk antena.

1.0 Pengenalan

Setiap hari berjuta-juta meteor memasuki ruang atmosfera bumi di seluruh dunia. Sesetengah dari nya mempunyai tenaga yang cukup kuat untuk mengion bila berlakunya pengeseran dengan molekul-molekul gas yang terampai di ruang atmosfera dan membentuk ekor meteor yang terdiri dari plasma elektron. Kejadian ini berlaku pada ketinggian 100 hingga 120 km dari permukaan bumi. Ekor meteor yang terdiri dari plasma elektron ini, berupaya untuk memantulkan gelombang radio dan membenarkan komunikasi di luar garis nampak iaitu hingga mencapai 1800 kilometer dari pemancar. Sifat meteor yang dapat memantulkan gelombang radio ini memberikan pilihan terbaik untuk membolehkan satu isyarat diterima dari satu jarak yang sangat jauh dengan kos yang sangat murah berbanding dengan penggunaan satelit. Matlamat utama projek ini adalah membina sebuah stesen penerima isyarat radio yang dipantulkan dari pembentukan ekor tarian meteor ini. Isyarat radio tersebut berpunca dari stesen pemancaran Sultan Ismail di Larkin, Johor Bahru yang memancarkan isyarat radio modulasi frekuensi (FM). Stesen ini terletak di koordinat (1º30'U,103º43'T) pada aras laut. Stesen yang dibangunkan di fakulti kejuruteraan Universiti Kebangsaan Malaysia ini pula mempunyai koordinat (2º52'U,101º45'T) pada aras laut. Oleh itu jarak lurus antara dua kedudukan ini adalah dalam linkungan 300 km. Jarak ini terlalu jauh untuk suatu gelombang radio merambat secara lurus kepada penerima.

2.0 Pengenalpastian Masalah

Masalah utama yang dihadapi oleh perambat gelombang radio ini ialah, keadaan bentuk muka bumi di pertengahan laluannya yang terdiri dari kawasan-kawasan berbukit-bukau yang menyebabkan isyarat yang merambat melemah akibat biasan oleh tanah tinggi tersebut. Selain dari itu, kelengkungan muka bumi tidak memungkinkan isyarat tersebut diterima secara lurus dari pemancarnya. Oleh itu, melalui pantulan oleh plasma meteor, isyarat ini mempunyai peluang yang tinggi untuk diterima di stesen penerima. Walau bagaimanapun, isyarat tersebut hanya datang pada arah-arah tertentu sahaja iaitu dari arah di mana meteor terbentuk. Oleh itu, radio penerima biasa yang menggunakan antena eka-kutub mempunyai kemungkinan yang sangat rendah untuk menerima isyarat tersebut dengan baik. Untuk mengatasi masalah ini sebuah antena Yagi digunakan kerana ia mempunyai berkearahan yang tinggi, mudah dibina dan murah. Antena ini akan digunakan untuk menggantikan antena eka-kutub pada penerima.

3.0 Stesen Pemancar

Setiap stesen radio FM akan diperuntukan satu jalur frekuensi selebar 200kHz bagi tujuan penyiarannya. Kebanyakan stesen-stesen penyiaran kini, lebih cenderung untuk menggunakan isyarat FM bagi tujuan penghantaran isyarat yang mereka siarkan kerana:

i. Kurang hingar
ii. Kepekaan penerima lebih tinggi
iii. Kualiti bunyi yang diterima adalah lebih baik
iv. Kehilangan kuasa yang rendah

Plasma meteor terbentuk, memantulkan frekuensi pada julat frekuensi lampau tinggi (VHF) iaitu diantara 30-300 MHz. Untuk mengkaji kesan pembentukan plasma meteor ke atas isyarat radio, sebuah penerima mestilah dibina pada satu jarak yang melewati keupayaan sesuatu isyarat dari stesen pemancar untuk merambat. Rambatan suatu isyarat adalah terhad disebabkan oleh beberapa faktor iaitu:

i. Faktor bentuk muka bumi
ii. Jarak dan kelengkungan muka bumi

3.1 Menganggar Jarak Perambatan Gelombang

Sebelum model matematik dibuat, anggaran jarak perambatan gelombang dilakukan. Anggaran dilakukan scara geometri dengan beberapa andaian :

i. Isyarat datang pada sudut Θ=45º dari kesan penerima
ii. Meteor terbentuk di ketinggian h=100km

3.2 Kesan Kehilangan Terhadap Jarak

Secara am nya, kehilangan penghantaran pada satu perhubungan radio diantara pemancar dan penerima ditakrifkan sebagai nisbah di antara kuasa yang dipancarkan oleh pemancar terhadap kuasa yang diterima di penerima. Kehilangan bukan sahaja disebabkan oleh jarak perambatan sesuatu gelombang radio, tetapi juga disebabkan faktor-faktor lain, diantaranya ialah kehilangan di talian penghantaran, kehilangan disebabkan ketidaksepadanan, bisingan dan beberapa faktor lain. Tetapi dalam sistem ini, kehilangan oleh jarak paling banyak mempengaruhi kehilangan penghantarannya. Oleh kerana perambatan isyarat dipengaruhi oleh pantulan meteor, keadaan meteor perlu diambil kira. Oleh itu persamaan 3.1 digunakan.

$$\text{Kehilangan} = \frac{G_t G_r \lambda^3 q^2 re^2}{16\pi^2 L_1 L_2 (L_1 + L_2)} \qquad (3.1)$$

Dengan :
G_t = Gandaan Pemancar = 3.28
G_r = Gandaan Penerima = 10
λ = Panjang gelombang isyarat yang dicerap = 2.8 meter
q = Ketumpatan plasma meteor = 10^{14} (e / m^2)

Pemalar re = 2.818×10^{-15}
L_1 = jarak antara penerima dan meteor (kilometer)
L_2 = jarak antara pemancar dan meteor (kilometer)

Untuk menggunakan persamaan 2.5 beberapa andaian perlu dibuat supaya kerja-kerja pengiraan lebih mudah dilakukan. Andaian yang dibuat ialah :

i. Plasma terbentuk di ketinggian h = 100km
ii. Gandaan penerima G_r = 10
iii. Pantulan pada meteor tanpa kehilangan,
dengan sekali pantulan Γ = 1.
Kehilangan hanya dipengaruhi oleh jarak.
iv. Isyarat yang terpantul datang pada sudut Θ= 45º
v. Kelengkungan muka bumi diabaikan (bentuk muka bumi dianggap rata)

Isyarat yang dipantulkan oleh meteor akan dipantulkan semula ke muka bumi pada sudut-sudut tertentu bergantung kepada ketinggian meteor yang terbentuk. Jadi antena yang digunakan seeloknya dari jenis antena berkearahan tinggi supaya kuasa yang dipantulkan dapat diterima secara maksimum di penerima. Oleh itu antena mestilah diarahkan tepat pada arah isyarat yang dipantulkan. Satu sudut yang optimum perlu dianggarkan di penerima supaya keperluan ini dipenuhi.

3.3 Menganggar Sudut Kecondongan Antena

Kecondongan antena yang sesuai adalah perlu supaya antena dapat diarahkan pada arah dimana kehilangan dipenerima adalah minimum dan dengan iniia dapat dianggarkan dengan lebih tepat. Model matematik untuk menganggarkan kecondongan antena yang optimum dan nilai kehilangan yang lebih tepat adalah seperti persamaan 3.2.

$$\text{Kehilangan} = \frac{G_t\, G_r\, \lambda^3 q^2 re^2}{16\pi^2 L_1 L_2 (L_1 + L_2)(1 - \sin^2(t))} \quad (3.2)$$

Dengan :
G_t = Gandaan Pemancar = 3.28
G_r = Gandaan Penerima = 10
λ = Panjang gelombang isyarat yang dicerap = 2.8 meter
q = Ketumpatan plasma meteor = 10^{14} (e / m^2)
Pemalar re = 2.818 x 10^{-15}
L_1 = jarak antara penerima dan meteor (kilometer)
L_2 = jarak antara pemancar dan meteor (kilometer)
t = sudut pantulan pada meteor

Kiraan dibuat dengan andaian :
i. Pantulan dimeteor tanpa kehilangan dengan pekali pantulan $\Gamma = 1$, dan kehilangan dipengaruhi oleh jarak perambatan gelombang radio.
ii. Kelengkungan muka bumi diabaikan (bentuk muka bumi dianggap rata)

Selain dari kehilangan yang dianggarkan di penerima, kekuatan medan isyarat di penerima perlu juga dicari untuk menganggarkan kekuatan sebenar isyarat yang diterima. Dengan cara ini dapat diketahui sama ada kepekaan penerima mampu mengesan kehadiran isyarat tersebut.

3.3.1 Sistem Pencerapan

Hasil kaji selidik yang dibuat, antena Yagi dapat memenuhi keperluan ini. Antara faktor lain yang menjadikan antena ini sesuai ialah kos pembinaannya. Antena Yagi hanya memerlukan rod-rod aluminium untuk membinanya. Ianya mudah diapati dan murah. Selain daripada itu, antena ini lebioh mudah untuk dibina dan direkabentuk, kerana ia agak ringkas. Faktor yang terpenting ialah ciri antena ini yang mampu bekerja pada frekuensi yang tinggi, pada julat Frekuensi Lampau Tinggi VHF (Very High Frekuensi), dan menghasilkan corak sinaran pancar hujung yang sangat diperlukan dalam komunikasi menggunakan pantulan meteor.

Antena Yagi telah dihasilkan oleh Shintaro Uda di Tohoku University di Sendai, Jepun pada tahun 1926, dan hasil kajiannya telah ditulis dalam bahasa Jepun dan diterbitkan di negara itu pada 1926 dan 1927. Kemudian tulisan ini diterjemahkan di dalam bahasa Inggeris oleh Professor H. Yagi pada tahun 1928 dan kemudiannya ia diperkenalkan di seluruh dunia. Antara parameter-parameter utama yang perlu diketahui dalam pembinaan antena ialah corak sinaran, kekutuban, gandaan dan gelangan masukannya

3.3.2 Merekabentuk Antena Yagi

Untuk merekabentuk antena Yagi dan menghasilkan gandaan 10 dBi Jadual 3.1 dirujuk.

Jadual 3.1 Gandaan antena mengikut jumlah elemen yang digunakan.

Jumlah Elemen	Gandaan dBi
3	7
4	9
5	10.5
8	12

Daripada Jadual 3.1 didapati, antena Yagi dengan lima elemen dapat memenuhi keperluan awal sistem. Tetapi sistem ini boleh menggunakan elemen yang lebih banyak untuk mendapatkan gandaan yang lebih tinggi. Untuk mendapatkan corak sinaran pancar hujung, elemen-elemen antena pada arah sinaran mestilah bersaiz lebih pendek dari elemen pemandu. Elemen pemandu adalah resonan dengan separuh panjang gelombang (λ/2, biasanya antara 0.49λ hingga 0.5λ).3.3.3 Ukuran antena mengikut rekabentuk dan menggunakan YAGIMAX2.0

Jadual 3.2 Ukuran awal antena yang direkabentuk

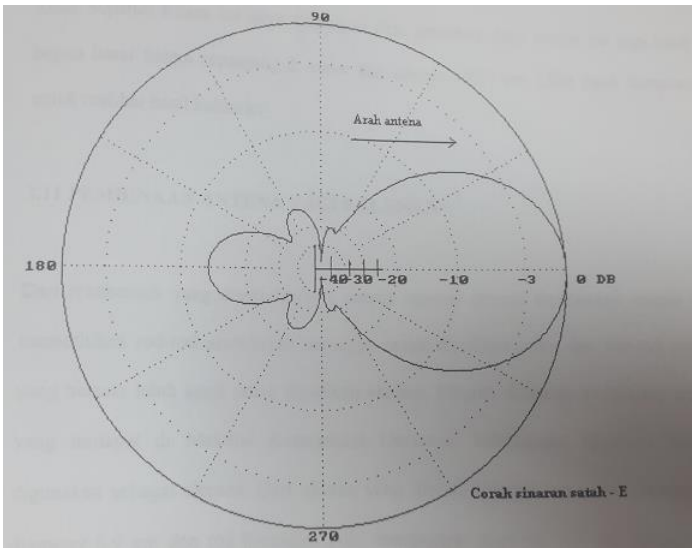
Elemen	Panjang (cm)	Jarak elemen dari pemantul (cm)	Diameter
Pemantul	150.7	0	0.9
Pemandu	139.5	70	0.9
Pengarah 1	124.0	154	0.9
Pengarah 2	124.0	238	0.9
Pengarah 3	124.0	322	0.9

Ukuran ini kemudiannya dioptimumkan untuk mendapatkan gandaan dan corak sinaran yang dikehendaki.

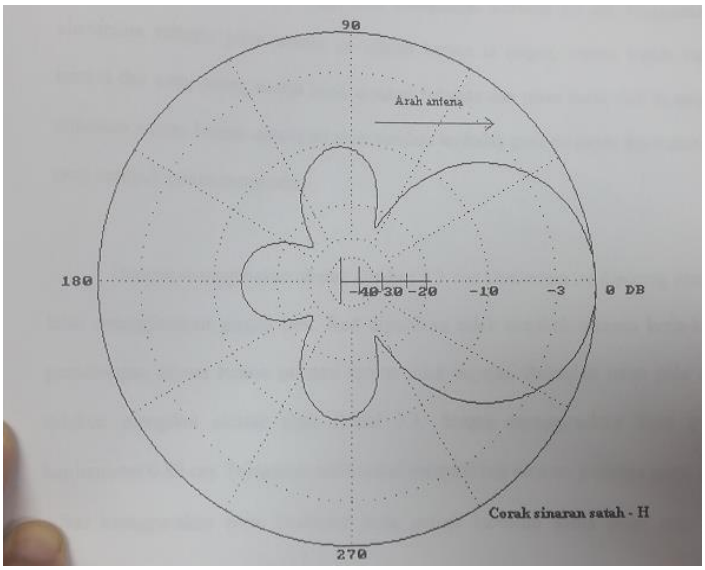
Jadual 3.3 Ukuran antena setelah dioptimumkan dengan YAGIMAX 2.0

Elemen	Panjang (cm)	Jarak elemen dari pemantul (cm)	Diameter
Pemantul	150.7	0.0	0.9
Pemandu	139.5	55.0	0.9
Pengarah 1	124.0	96.0	0.9
Pengarah 2	124.0	140.0	0.9
Pengarah 3	124.0	200.0	0.9

Berdasarkan masukan ini, corak sinaran antena dapat diperolehi bersama-sama dengan parameter yang lain/ dari parameter ini, spesifikasi antena yagi diperolehi. Corak sinaran antena yang direkabentuk adalah seperti Rajah 3.1 dan Rajah 3.2.



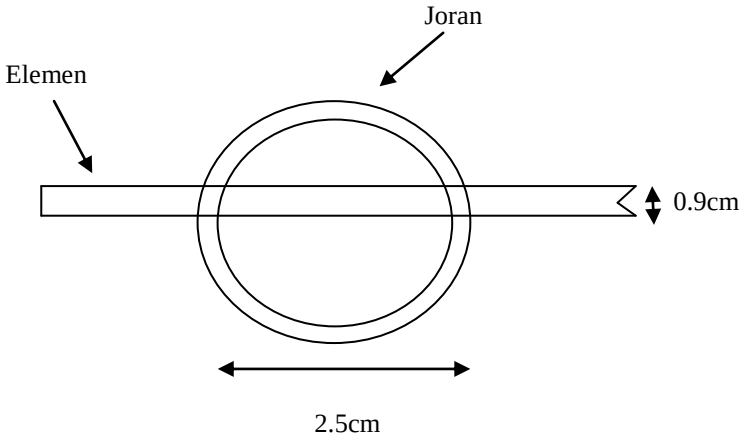
Rajah 3.1: Plot sinaran antena menggunakan YAGIMAX 2.0 (Corak Sinaran Satah-E)



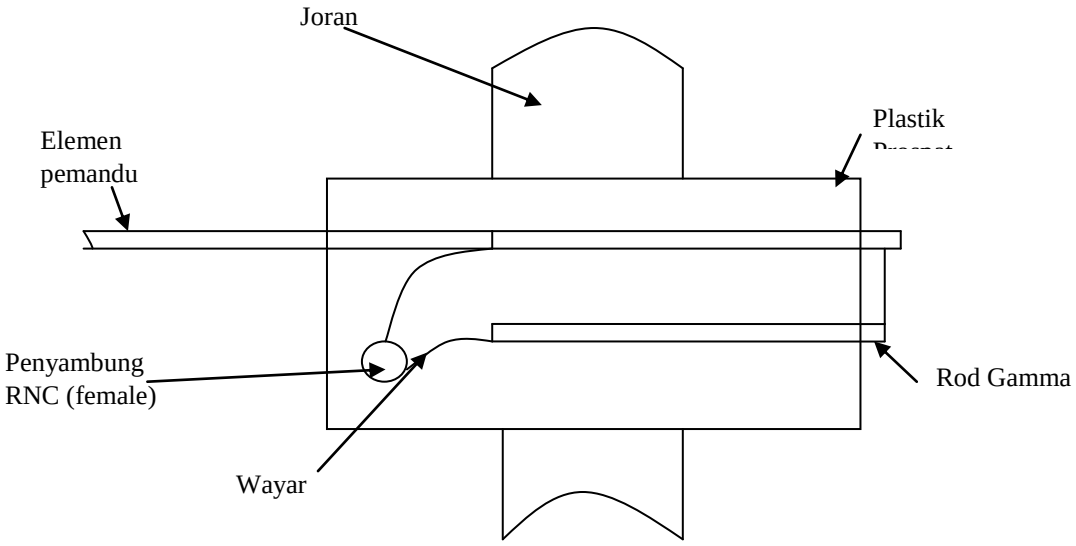
Rajah 3.2: Plot sinaran antena menggunakan YAGIMAX 2.0 (Corak Sinaran Satah-H)

4.0 Keputusan dan Pembinaan

Hasil dari rekabentuk yang disimulasikan, antena sebenar dapat dibina. Pembinaan antena ini memerlukan rod-rod aluminium berongga untuk dijadikan joran dan rod-rod padat yang bersaiz lebih kecil untuk dijadikan elemen. Ukuran diameter aluminium padat sesuai digunakan sebagai elemen. Penggunaan aluminium adalah kerana ianya ringan, lembut dan tahan karat.



Rajah 4.1: Pandangan hadapan antena



Rajah 4.2: Pemasangan di bahagian masukan antena

Untuk elemen di bahagian pemandu, lubang-lubang dibuat pada elemen tersebut menggunakan mata gerudi bersaiz 0.25cm. Tujuannya adalah untuk mengikat plastik pospat dengan menggunakan skru berdiameter 0.25cm. Dari keluaran YAGIMAX 2.0, galangan masukan diruang bebas bagi antena ini ialah 28.5 + j55.2 **Ω**, manakala kabel yang digunakan ialah dari siri RG58U yang bergalangan 50**Ω**, maka ruang untuk rod gamma bagi tujuan sepadanan gamma perlu disediakan atas plastik pospat tersebut. Sepadanan gamma adalah salah satu cara sepadanan galangan yang boleh digunakan sekiranya tiada sepadanan wujud anara masukan antena dan galangan kabel penghantaran.

4.1 Kiraan Sepadanan Gamma

Jejari elemen, a = 0.45 cm
Panjang Elemen Pemandu, l = 139.5 cm
Galangan ruangan bebas = 28.5 + j55.2 Ω (bacaan Yagimax)
Ruangan antara Elemen pemandu dan Rod Gamma, s = 2.5 cm
Diberi faktor pembahagian arus :-

$$\alpha = \ln(v) / (\ln(v) - \ln(u)) \quad (4.1)$$

dengan

$$u = a/a' \text{ dan } v = s/a' \quad (4.2)$$

dimana a = Jejari Elemen pemandu
a'= Jejari Rod Gamma

Dengan menggunakan jejari elemen yang sama saiz,

$u = 1$ dan $v = s / a' = 7.8$
$\alpha = \ln(v) / (\ln(v) - \ln(u)) = 1$

Nisbah langkah = $(1 + \alpha)^2 = 4$

Galangan ruang bebas

$Za = 28.5 + j55.2\Omega$
$Z_2 = (1 + \alpha)^2 (Za/2) = 4 (28.5 + j55.2\Omega) / 2 = 57.04 + 110.42\ j$

Galangan cirian yang disebabkan oleh Elemen Pemandu dan Rod Gamma Zo,
$Zo = 276\log_{10}(s / (aa')^{1/2}) = 247$
Z_2 yang dinormalkan, $Z_2 = (57.04 + 110.42\ j) / 247 = 0.23 + 0.45j$

Dari carta Smith atau kiraan secara matematik,
Lepasan (admittance) $1 / Z_2 = y_2 = 0.91 - 1.76j$
Dari carta Smith tempatkan Zs di 0 + 0j dan gerakkannya kearah penjana. Tujuannya adalah untuk mendapatkan Z_{in} dalam lingkungan 50Ω.
Jarak pergerakkan titik dari Zs adalah 0.227
Oleh itu, panjang rod gamma yang diperlukan ialah 63.5 cm.
Dari carta Smith ditentukan yang $y_g = 1 / z_g = -0.144j$

Oleh itu,

$y_{in} = y_g + y_2 = 0.9123 - 1.91j$
$1 / y_{in} = z_{in} = 0.2036 + 0.4263j$
$Z_{in} = 50.3 + 105.3j$

Untuk menghapuskan kesan khayal pada galangan masukan, nilai kapasitor yang perlu disambungkan secara seciri ialah,

$C = 1 / (2\ \pi f(\ 105.3))$
C = 14pF (Gunakan Kapasitor boleh laras) [7]

Dari kiraan yang dibuat, keperluan sepadanan gamma boleh dilihat pada Jadual 4.1

Jadual 4.1 Keperluan Sepadanan Gamma

Panjang rod gamma	63.5 cm
Nilai kapasitor yang digunakan	14 pF

4.2 Pengukuran Antena

Parameter antena diukur untuk membandingkannya dengan nilai simulasi dan untuk mengesahkan bahawa perkakasan yang dibina boleh bekerja dengan baik. Alatan yang digunakan untuk pengukuran parameter antena ini ialah:

i. Penjana isyarat ROHDE & SCHWARZ 100 KHz (+/- 1Hz)
ii. Penganalisis spektrum HEWLETT PACKARD 9KHz – 22 GHz
iii. Multimeter RADIO SHACK (*Auto Range Multimeter*)

4.3 Mengukur Galangan Masukan Antena

Pengukuran ini penting bagi memastikan galangan masukan antena dan talian penghantaran adalah sepadan. Kesepadanan yang wujud membolehkan kuasa diterima secara maksimum oleh antena dari pemancar dan dengan itu kesan kehilangan diminimumkan. Kaedah yang digunakan untuk mengukur nilai galangan ini ialah dengan menggunakan meter kuasa. Melalui kaedah ini, sebuah penjana isyarat dan meter kuasa digunakan. Konsep kerja kedah ini ialah, membandingkan kuasa yang dibekalkan kepada antena dengan kuasa yang dibalikkan dari antena. Nisbah antaranya akan menghasilkan Nisbah Voltan Gelombang Pegun (VSWR) bagi antena dengan talian penghantaran. Talian penghantaran yang digunakan adalah kabel RG58U (50 **Ω**).

4.4 Mengukur Gandaan Antena

Terdapat dua langkah utama yang perlu dilakukan untuk mengukur antena Yagi, iaitu mendapatkan nilai kekuatan isyarat bagi antena perbandingan, dan juga mendapatkan nilai kekuatan isyarat dipenerima apabila antena Yagi digunakan. Untuk mengukur kekuatan isyarat ini, satu kawasan yang agak lebar diperlukan. Ini adalah kerana jarak pemisahan antara pemancar dan penerima mestilah pada julat kawasan medan jauh (*far field*), atau lebih dikenali sebagai kawasan Frounhofer. Biasanya jarak yanag digunakan ialah $L \approx 6\lambda$ atau lebih. Dalam pengukuran ini, dua buah antena eka-kutub digunakan, iaitu dari jenis LARSEN LM/CM VHF sebagai antena perbandingan dan jarak pemisah L ialah 18 meter. Frekuensi 107.5 MHz dijanakan di penjana isyarat dan penganalisis isyarat disetkan untuk mengukur kekuatan medan pada frekuensi tersebut. Kemudian kekuatan untuk antena ekakutub diukur dibahagian penerima. Selepas itu, antena eka-kutub di bahagian penerima digantikan dengan antena Yagi. Antena Yagi diarahkan tepat kepada antena pemancar (eka-kutub), dan bacaan kekuatan medannya dicatat.

Dari ukuran yang dibuat:

- Kekuatan isyarat yang dipancarkan = 30 dBm
- Bacaan kekuatan medan penerima dengan antena ekakutub = -59 dBm
- Bacaan kekuatan medan penerima dengan antena Yagi = -51 dBm
- Oleh gandaan relatif antena Yagi lima elemen ini ialah = 8 dBi

Dari gandaan relatif yang diperoleh untuk antena Yagi ini, didapati ianya menghampiri nilai objektif, 10 dBi dan nilai simulasi, 10.46 dBi. Oleh itu, boleh dianggapkan yang antena Yagi hampir mencapai objektif. Terdapat ralat sebanyak 20%, dari nilai simulasi.

4.6 Mengukur Corak Sinaran Antena

Untuk memastikan corak sinaran antena Yagi yang dibina ini menghasilkan corak sinaran pancar hujung satu kaedah pengukuran digunakan. Corak radiasi ini diukur supaya perbandingan dengan nilai simulasi boleh dilakukan dan secara tidak langsung ia akan dapat memberi gambaran jelas bahawa antena ini dapat berfungsi dengan baik.

Antena Yagi yang diukur ditempatkan di atas kaki pemutar yang membolehkannya diputarkan pada sudut 360º. Jarak pemisahan antara antena pemancar dan penerima ialah $L \approx 6\ \lambda$. Dalam ukuran ini jarak yang digunakan ialah 18 meter iaitu ia terletak dalam kawasan medan jauh. Kemudian penjana isyarat dijanakan pada frekuensi janaan 107.5 MHz dan penganalisis spektrum disetkan untuk mengukur kekuatan medan pada frekuensi tersebut.

Jadual 4.2 Bacaan Kekuatan Isyarat pada Setiap Satah Secara Ukuran.

SUDUT PUTARAN	SATAH – E (dBm)	SATAH – H (dBm)
0	- 50	- 57
15	- 51	- 58
30	- 55	- 60
45	- 57	- 67
60	- 55	- 62
75	- 55	- 63
90	- 59	- 69
105	- 70	- 63
120	- 67	- 63
135	- 61	- 69
150	- 60	- 77
165	- 62	- 74
180	- 61	- 71

Jadual 4.3: Perbandingan ukuran parameter antena dengan simulasi dengan menggunakan perisian YAGIMAX2.0

Parameter	Simulasi	Ukuran
Gandaan	10.46 dBi	8 dBi
Nisbah Hadapan ke Belakang	13.9 dB	11 dB
Lebar Sinar Separuh Kuasa	46º Satah – E , 50º Satah - H	46º Satah – E , 60º Satah - H
Panjang	2 meter	2.05 meter
Galangan masukan	28.52 + j 55.21 Ω	50.3 Ω

Dari perbandingan tersebut, dapat dikatakan yang rekabentuk antena yang dibina adalah baik dan menghampiri rekabentuk secara simulasi. Oleh itu sebahagian dari sistem pencerapan ini sudah berjaya dibina.

5.0 Pencerapan Isyarat Radio

Pencerapan isyarat dengan menggunakan sistem penerima radio sangat popular digunakan oleh para amatur radio, untuk mencerap kehadiran meteor. Ini kerana dengan menggunakan kaedah ini, meteor dapat dicerap pada waktu siang dan malam. Sekiranya pencerapan menggunakan kaedah melihat, pencerapan hanya dapat melakukannya pada waktu siang sahaja. Satu lagi kelebihan cara pencerapan ini ialah, sistem ini tidak memerlukan si pencerap sentiasa berada disisi sistem kerana isyarat boleh dirakamkan dengan menggunakan pita perakam.

5.1 Pemasangan Sistem Penerima

Antena dipasangkan di satu kawasan lapang, di bahagian luar Makmal Komunikasi Fakulti Kejuruteraan Universiti Kebangsaan Malaysia. Jarak antara antena dan makmal ialah dalam linkungan 10 meter. Antena ini disokong oleh tiang yang diperbuat dari logam supaya ia lebih tahan bebanan dan tidak mudah patah sekiranya berlaku tiupan angin kencang. Tiang yang digunakan tidak terlalu tinggi, supaya berat antena dapat ditampung dengan baik dan tidak menyebabkannya membengkok. Tiang besi berbentuk L digunakan dengan panjang 2.5 meter. Tiang tersebut ditanam pada kedalaman 30 sentimeter dari permukaan tanah dan disetiap sisinya disokong dengan kayu agar ia lebih tahan tiupan angin.

Dengan menggunakan kompas, sudut 125º kearah tenggara diperolehi. Sudut tersebut mengarah ke Johor Bahru, dan dengan sudut tersebut antena akan diarahkan. Satu lagi logam berbentuk L yang lebih pendek (30 cm) telah digunakan untuk mencantumkan antena pada tiang utama, dan dengan ini antena boleh dicondongkan pada sudut yang dikehendaki. Dalam projek ini, antena dicondongkan pada sudut 65º dari ufuk.

Dengan menggunakan kabel RG58U (50Ω), sepanjang 15 meter yang disetiap hujungnya telah ditamatkan dengan penyambung (*BNC male*), bahagian masukan antena disambungkan kepada masukan pra-penguat. Pada masukan antena dan masukan pra-penguat, penyambung (BNC female) digunakan. Penggunaan penyambunug ini adalah untuk memastikan sambungan tersambung dengan baik. Keluaran dari pra-penguat disambungkan terus ke masukan antena radio.

5.2 Mencerap Isyarat

Percubaan mencerap isyarat yang dipantulkan oleh plasma meteor dilakukan selama dua malam, selepas kerja-kerja pemasangan selesai.

Tempat	: Makmal Komunikasi Fakulti Kejuruteraan UKM
Tarikh	: 12 hingga 13 Januari 2007
Masa	: 10 malam hingga 6 pagi
Kaedah	: mendengar dan merakam
Keadaan cuaca	: 12 / 1 / 2007 – hujan dan berpetir
	13 / 1 / 2007 – hujan dan berpetir

Hasil dari pencerapan yang dilakukan, didapati pada hari pertama (12 / 1 / 2007), tidak terdapat sebarang penerimaan isyarat yang dirakamkan. Terdapat gangguan sekejap-sekejap oleh stesen pemancar yang tidak diketahui. Gangguan hanya tamat pada kira-kira pukul 3.30 pagi. Gangguan tersebut bukan pantulan isyarat oleh meteor kerana setiap gangguan mengambil masa 2 hingga 5 minit, dan ini bukan ciri isyarat yang dipantulkan oleh meteor yang mana biasanya hanya mengambil masa dalam lingkungan milisaat. Pada hari kedua pencerapan (13 / 1 / 2007), keadaan cuaca tidak begitu baik dengan hujan dan berpetir. Keluaran radio mengeluarkan bunyi yang agak kuat semasa petir berlaku.

6.0 Kesimpulan

Sebuah sistem penerima isyarat melalui serakan meteor telah dapat dibina. Sistem ini terdiri daripada antena Yagi dan sebuah radio untuk menala isyarat. Antena Yagi yang dibina mempunyai ciri-ciri yang menghampiri ukuran secara simulasi yang menggunakan perisian YAGIMAX 2.0. Walaupun begitu, penambahbaikan masih diperlukan untuk mendapatkan ciri-ciri antena yang lebih baik. Percubaan pencerapan tidak berjaya mencerap isyarat yang dipantulkan oleh meteor. Ini adalah berkemungkinan beberapa faktor, antaranya masa pencerapan yang tidak sesuai dan kebarangkalian kehadiran meteor adalah kecil.

7.0. Rujukan

[1] George zay., 1997 Observing Technique-Radio International meteor Organisation mamber:chapter 5

[2] Schilling; Donald L.Meteor Burst Communications:Theory and Practise 1993:John Willey & Sons

[3] Warren L.Stutzman; Gary A. Theile. Antena Theory and design. Edisi 2. John Wiley

[4] Balanis Constatine.,1982 Antenna Theory Analysis and Design. Edisi 3. Harper & Row

[5] Gary M.Miller., 1993.Modern Electronic Communications Edisi 4. Prantice Hall international.Inc

E06: Development of Cost Effective PLC Training Kit by Using Arduino Platform (PLCduino)

Mohd Safit Bin Mohd Samsudin[1], Mohd Azri Bin Akhiak[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

[1]safit.jtm@1govuc.gov.my

Abstract

Kebolehan, kemahiran dan pengalaman dalam menggunakan Programmable Logic Controller (PLC) sebagai pengawal mesin mempunyai permintaan yang tinggi oleh industri. Pengajaran dan pembelajaran PLC ini biasanya disampaikan dengan bantuan peralatan kit latihan. Kit ini umumnya terdiri daripada PLC yang digabungkan dengan suis sebagai alat masukan (input) dan lampu sebagai alat keluaran (output). Namun kos memiliki kit latihan PLC adalah cukup mahal dan PLC itu sendiri mendominasi jumlah keseluruhan kos. Dalam projek ini, satu penyelesaian bagi mengatasi masalah ini dicadangkan dengan memperkenalkan peralatan kit latihan PLCduino. Pada dasarnya sistem ini menggunakan rajah tangga sebagai bahasa pengaturcaraan dan Arduino platform sebagai perkakasan pengawal. Set arahan rajah tangga secara automatik ditukar kepada bahasa Arduino dengan penggunaan perisian LDuino manakala syarat masukan atau keluaran PLC menggunakan beberapa komponen geganti. Sistem ini diharapkan mampu memberikan prestasi yang sama seperti sebuah PLC standard dengan kos yang lebih murah lebih kurang sebanyak 50 peratus.

***Kata Kunci**: PLCduino, LDuino, PLC, Arduino*

1.0 Pengenalan

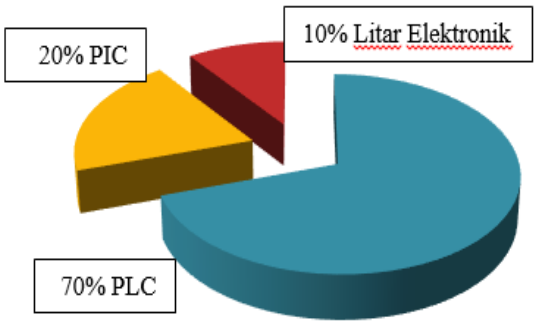
Kemajuan ilmu pengetahuan dan teknologi telah mendorong manusia untuk berusaha mengatasi segala permasalahan yang timbul di sekitarnya serta meringankan pekerjaan yang ada. Salah satunya dunia perindustrian yang tidak hanya berperanan dalam satu bidang sahaja, melainkan disegenap bidang kehidupan manusia. Banyak perkara yang mungkin ketika ini memerlukan penyelesaian permasalahan dimana ianya mengkehendaki perbelanjaan wang, waktu, tenaga yang amat banyak untuk menyelesaikannya. Dengan adanya kemajuan teknologi pada masa ini, permasalahan tersebut dapat dikurangkan seminimum mungkin. Salah satu contohnya pada alat PLC yang dapat dibina dengan sesederhana mungkin dengan memanfaatkan mikro pengawal sebagai komponen utamanya.

2.0 Latar Belakang

Di antara faktor awal yang mengwujudkan rekaan dan pembangunan sistem kawalan PLCduino adalah seperti berikut :

- Keperluan kos yang murah
- Mudah diaturcarakan
- Pengawal yang mudah dikawal
- Sistem pendawaian yang ringkas dan mudah
- Lebih kecil dan keboleharapan yang tinggi
- Binaannya ringkas dan penyelenggaraanya murah

2.0 Kajian Lapangan



Hasil penelitian yang dijalankan dari tahun 2010 hingga 2013 didapati pelajar (peringkat diploma dan sijil) lebih gemar menggunakan PLC sebagai peranti pengawal pada projek akhir mereka. Kajian menunjukkan;

- 70% pelajar memilih PLC (PLC Nais, Omron, dan lain-lain)
- 20% pelajar memilih mikro pengawal (PIC16F877, Arduino dan lain-lain)
- 10% pelajar memilih sistem elektronik (litar pengawal, papan litar geganti dan sebagainya)

Hal ini kerana PLC mempunyai kelebihan seperti:

- Mudah dibuat pengubahsuiaan aturcaranya.
- Rekabentuk sistem kawalan mudah diubah dengan menggunakan perisian.
- Aplikasi kawalan yang meluas.
- Kebolehharapannya tinggi.
- Ketahanan kepada masalah persekitaran proses (suhu, lembapan, ketidakstabilan voltan dan hingar) yang baik.

Manakala PIC mempunyai kelebihan seperti;

- Kos pembuatan yang murah
- Kecekapan untuk menjalankan arahan atau program yang telah diprogramkan.
- Kemudahan untuk menaiktaraf pengawal mikro dan perisian.
- Alat ganti senang diperolehi jika berlaku kerosakan bagi tujuan pembaikan atau penggantian IC.
- Jumlah masukan/keluaran (I/O) yang banyak dan flexible.
- Kebolehan pengawal mikro untuk kegunaan aplikasi analog dan digital.

3.1 Kajian Ilmiah Terdahulu

Banyak kajian terdahulu yang dijalankan bagi mengurangkan kos pembinaan PLC serta mempermudahkan kaedah penggunaan PLC tersebut.

- Burhan, I., Talib, S. dan Azman, A.A. (March 2012) telah berjaya merekabentuk PLC training kit bagi tujuan pembelajaran. Walau bagaimana pun PLC training kit ini masih menggunakan PLC Omron, Siemens dan Nais sebagai pengawal.
- A F Kheiralla, Osama Siddig, Ahmed A Elhaj Mokhtar, Montasir Esameldeen, (June 2012). Dengan menggunakan PLC (Siemens STEP7-224XP) mereka telah merekabentuk sebuah PLC workbench dengan kos sebanyak USD 1600.
- Zaimi Bin Ahmad (March 2005). Beliau telah merekacipta suatu pengawal mikro lampu isyarat yang beroperasi berdasarkan aliran trafik semasa. Beliau menggunakan PIC 16F877 sebagai peranti pengawal dan PIC Basic Pro sebagai bahasa aturcara.
- Chong Kok Hee (April 2009). Projek ini menggunakan kawalan mikro untuk membanyakkan input atau output bagi PLC Omron CJ1GCPU42H. Ianya bertujuan supaya dapat mengurangkan kos tanpa mengubah asal unsur dan fungsi bagi PLC yang sedang digunakan.
- Mohd Shahrin Bin Darmin (May 2008). Projek ini mempunyai persamaan seperti projek di atas di mana 2 unit pengawal (PLC dan PIC) digabungkan bagi memperbanyakkan keluaran (expension).
- Dr. Wesley B. Williams P.E (June 2013). Bagi mengurangkan kos pembelajaran PLC secara pratikal beliau mencadangkan penggunaan perisian I-Trilogi digunakan bagi membina ladder diagram. Simulasi dari ladder diagram yang dibina boleh dijalankan menggunakan perisian Labview. Manakala peranti pengawai Arduino digunakan sebagai perkakasan pengawal mikro.

4.0 Penyataan Masalah

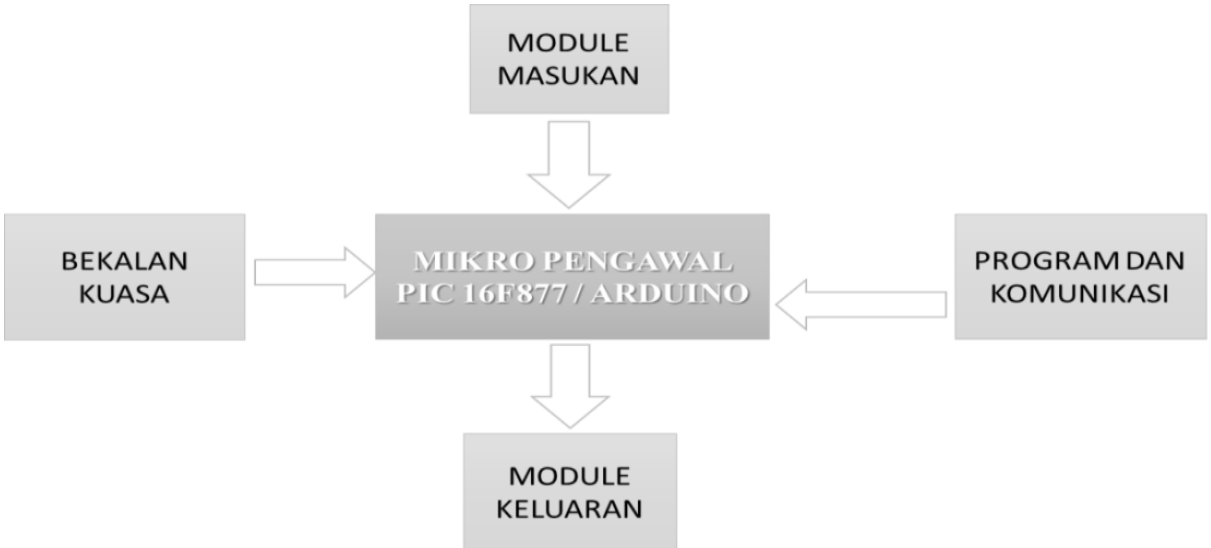
Walaupun PLC lebih gemar digunakan oleh pelajar, tetapi kos untuk membeli PLC adalah lebih mahal jika dibandingkan dengan PIC. Sebagai contoh; PLC jenis Nais dengan 32 I/O berharga lebih kurang RM1070 manakala PIC SK40C dengan 32 I/O berharga lebih kurang RM100. Perbezaan kos melebihi 10 kali ganda. Permasalahan lain yang dihadapi apabila jumlah input melebihi jumlah output ataupun sebaliknya. Contohnya jika nilai input dikehendaki 17 manakala output yang diperlukan hanya 2 port sedangkan PLC tersebut mempunyai 32 I/O iaitu 16 Input dan 16 Output. 1 unit PLC expension diperlukan lagi bagi mengisi 1 port input yang tidak mencukupi sedangkan terdapat 14 output yang masih tidak digunakan. Harga 1 unit PLC expension biasanya menyamai harga sebuah PLC utama.

Kajian ilmiah terdahulu yang dijalankan masih tertumpu bagi memperbanyakkan masukan dan keluaran PLC dengan menambah PIC sebagai peranti keluaran dan masukan. Masalah mengantaramuka PLC dan PIC ini masih menjadi isu yang besar dan perlu diperbaiki. Gabungan ini akan menyebabkan masalah baru timbul, dimana PLC menggunakan 24V dan PIC pula menggunakan 5V sebagai sumber bekalan kuasa, isyarat masukan dan keluaran. Masalah mengkomunikasi perisian PIC (seperti C, C++ dan *microcode*) dengan PLC (seperti *ladder diagram*, *function block* dan *sequence flow chart*) memerlukan sistem integrasi yang boleh membaca arahan dari kedua-dua peranti PLC dan PIC.

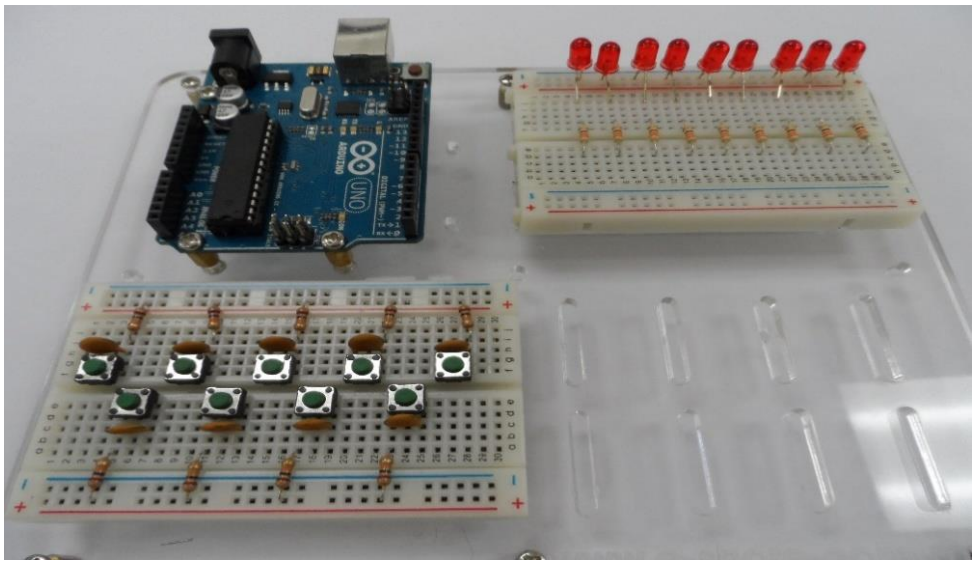
5.0 Kaedah Pembelajaran

Kaedah pembelajaran pada masa ini, pelajar perlu mempelajari subjek-subjek seperti PLC, Microcontroller, pengaturcaraan C atau C++, litar elektronik, electro-pneumatik dan sebagainya. Pembelajaran ini dijalankan dari peringkat sijil hinggalah ke ijazah. Kemampuan pelajar untuk menggunakan microcontroller menjadi sukar kerana tidak ke semua subjek tersebut diajar diperingkat sijil lagi. Kelemahan paling ketara ialah subjek-subjek tersebut diajar secara berasingan dan tidak dikaitkan secara terus antara setiap subjek. Kos penyediaan peralatan pengajaran juga tinggi kerana pihak institut perlu menyediakan makmal-makmal tertentu.

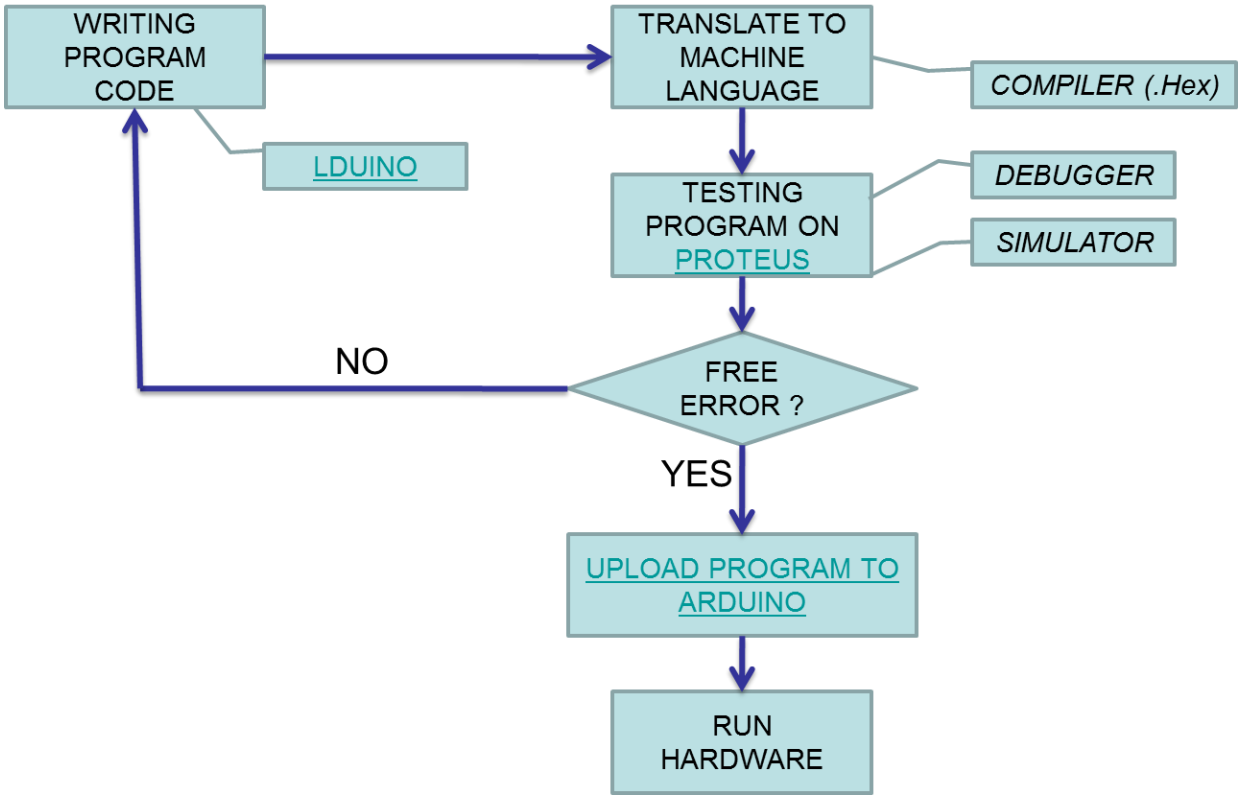
Kaedah pembelajaran PLCmikro dan PLCduino ini membolehkan pelajar mempelajari PLC dan microcontroller pada masa yang sama. Ianya membolehkan microcontroller di programkan menggunakan ladder diagram, di mana pelajar tidak perlu mengetahui pengaturcaraan C dan C++. Ini akan membolehkan pelajar mempelajari penggunaan microcontroller di peringkat awal (sijil) lagi. PLCmikro dan PLCduino ini mempunyai asas yang sama seperti sebuah PLC. Rajah 1 menunjukkan asas binaan sebuah PLC, PLCmikro dan PLCduino.



Rajah 1: Rajah blok asas



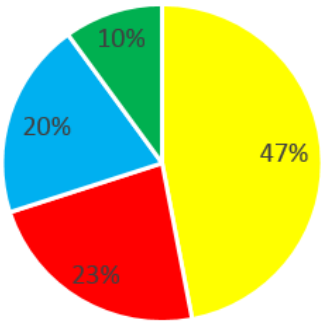
Rajah 2: Kit Permulaan (Starter Kit)



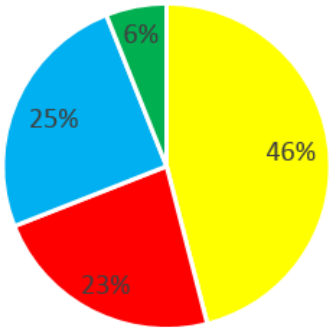
Rajah 3: Kendalian Carta Alir PLCduino

6.0 Keputusan Kajian

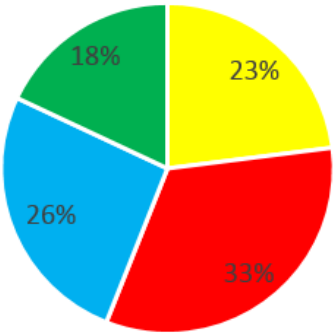
Modul yang telah dibina merupakan satu inisatif untuk membangunkan modal insan tenaga pengajar ILJTM dalam bidang instrumentasi sejajar dengan hala tuju Negara dalam melahirkan sumber manusia yang mahir berpengetahuan, dinamik dan berketerampilan. Perubahan teknologi yang pantas memerlukan latihan yang berterusan dalam membentuk kemahiran, pengetahuan dan sikap yang sesuai kepada tenaga pengajar / pegawai latihan kemahiran ILJTM. Graf di bawah memaparkan hasil yang di dapati dari kaji selidik yang telah dijalankan.



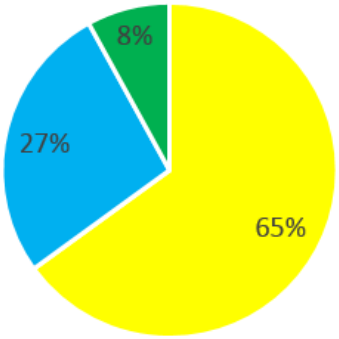
PLCduino lebih baik dari PLC



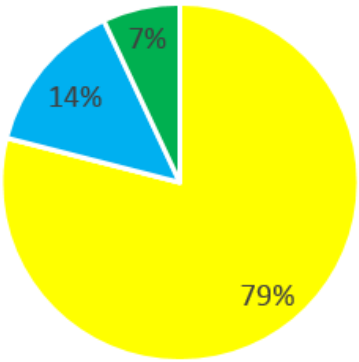
LDuino lebih mudah berbanding PLC programming



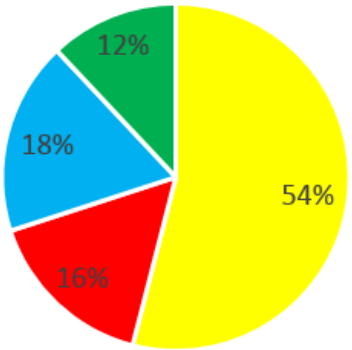
PLCduino lebih senang dipelajari berbanding PLC



Aturcara LDuino lebih mudah berbanding Bahasa peringkat tingg



Pelajar mendapati projek ini bermanafaat



Harga PLC yang mahal adalah penyebab penggunakan bertukar kepada PLCduino

Rajah 4: Kaji Selidik

Kesan kepada industri didapati hampir 70% hingga 80% industri perkilangan terutamanya industri automasi di negara ini menggunakan PLC secara meluas. Kebanyakkan para jurutera dan juruteknik mahir menggunakan PLC dengan kaedah pembinaan ladder diagram. Memperkenalkan mikro pengawal dengan bahasa pengaturcaraan seperti C, C++, Basic Language dan sebagainya amat sukar kerana perlu melatih mereka dalam jangka masa yang panjang. Penggunaan PLCmikro dan PLCduino ini dapat mengatasi masalah tersebut. Dengan hanya latihan dan pendedahan yang minima mereka mudah memahami konsep PLCmikro dan PLCdunio ini.

7.0 Kesimpulan

PLCmikro atau PLCduino boleh digunakan sebagai alat pengajaran dalam pembelajaran teknologi kejuruteraan elektrik secara khusus. Didalamnya terkandung kejuruteraan mekanikal seperti sistem pneumatik, kejuruteraan elektrik/elektronik seperti sistem litar geganti input dan output, kejuruteraan perisian seperti penggunaan perisian LDmicro, dan kejuruteraan automasi seperti sistem kawalan electro-pneumatik.

Kajian juga menunjukkan peningkatan minat dalam kalangan pelajar di peringkat rendah bermula daripada kolej vokasional (Tingkatan 4 dan 5) hinggalah ke peringkat diploma untuk menggunakan PIC atau Arduino sebagai peranti kawalan.

Pengembangan sistem PLCmikro dan PLCduino ini bukan sahaja membolehkan pelajar mempelajari asas kefungsian PLC tetapi pada masa yang sama pelajar juga dapat mempelajari kefungsian mikro pengawal. Ianya juga merupakan langkah pertama dalam usaha untuk menghasilkan PLC buatan Malaysia.

8.0 Rujukan

[1] Chong Kok Hee (April 2009). Expansion Of Input / Output PLC Omron CJ1GCPU42H Using PIC. Thesis (Universiti Technical Malaysia Malacca).

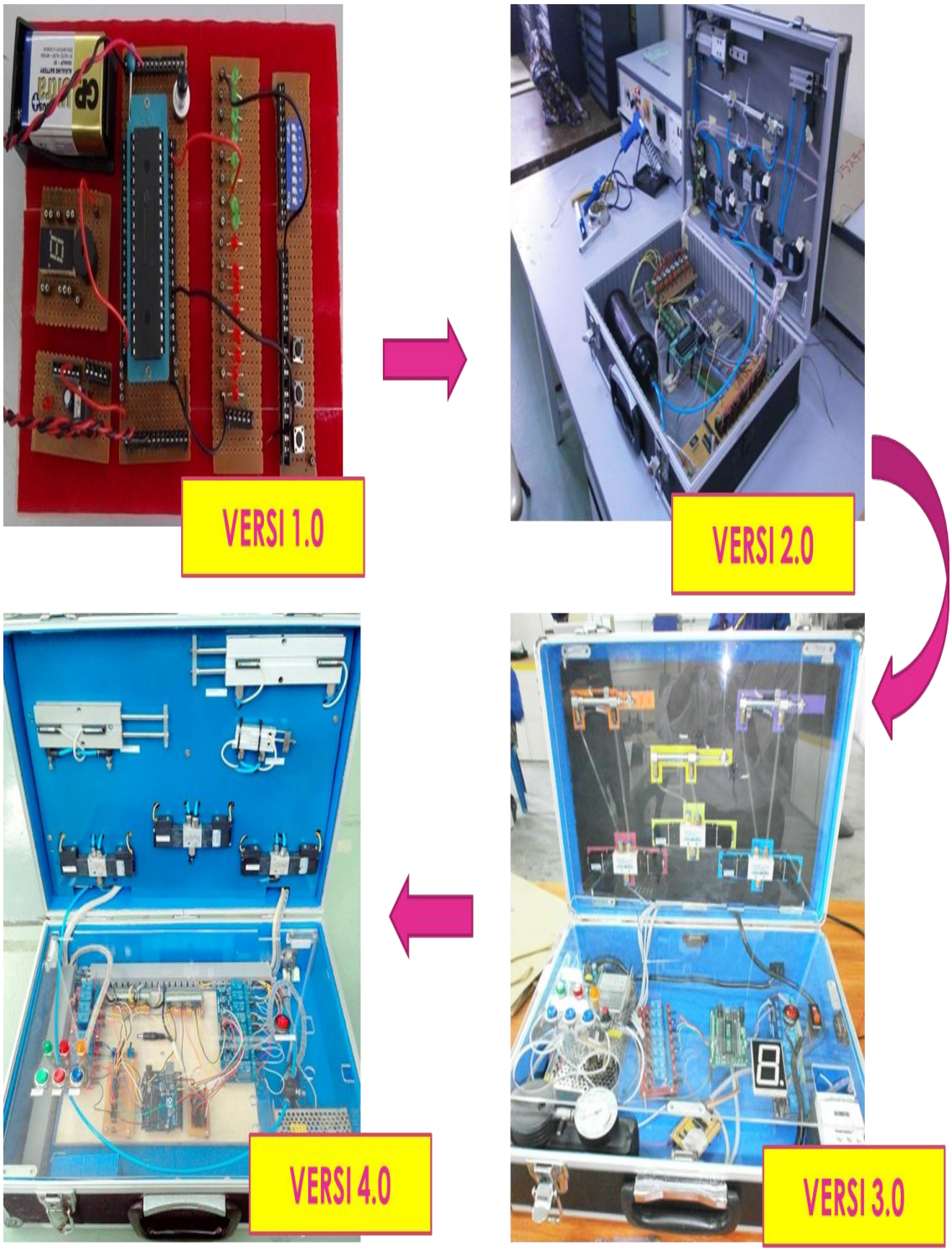
[2] Zaimi Bin Ahmad (March 2005). Designing A Traffic Light Controller Using PIC 16F877. Thesis (Kolej Universiti Teknikal Kebangsaan Malaysia).

[3] Mohd Shahrin Bin Darmin (May 2008). Inexpensive PLC Output Port Expansion Using Microcontroller. Thesis (Universiti Technical Malaysia Malacca).

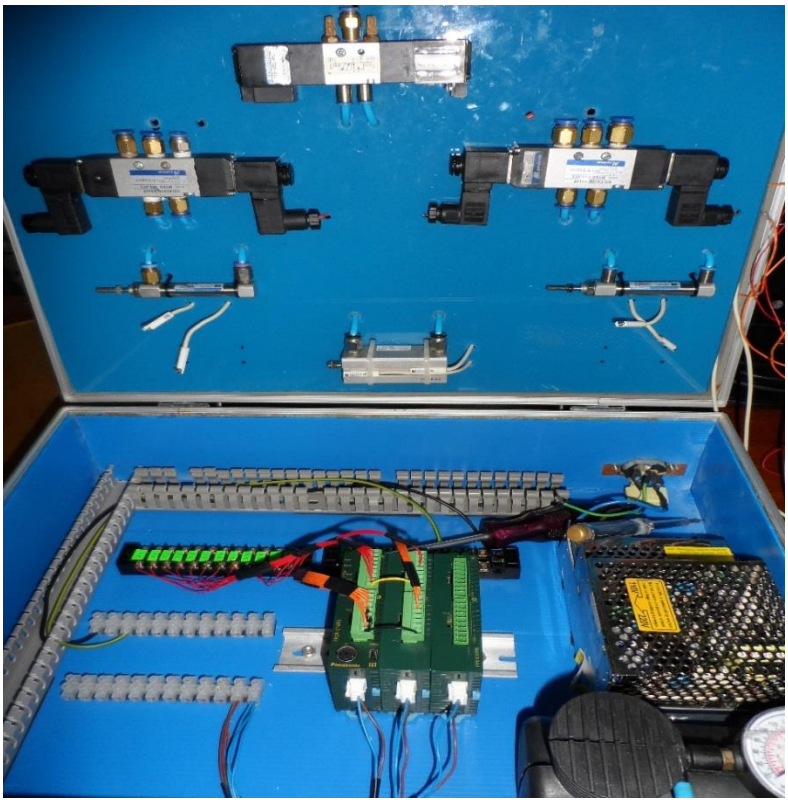
[4] Dr. Wesley B. Williams P.E (June 2013). LabVIEW and Arduino as a getway to PLC programming. 120th ASEE Annual Conference. Paper ID #6767.

[5] Mohd Safit. Thesis Sarjana Kejuruteraan Elektrik (Mekatronik), UTHM Johor, January 2015, Development Of Cost Effective PLC Training Kit By Using Arduino Platform (PLCduino)

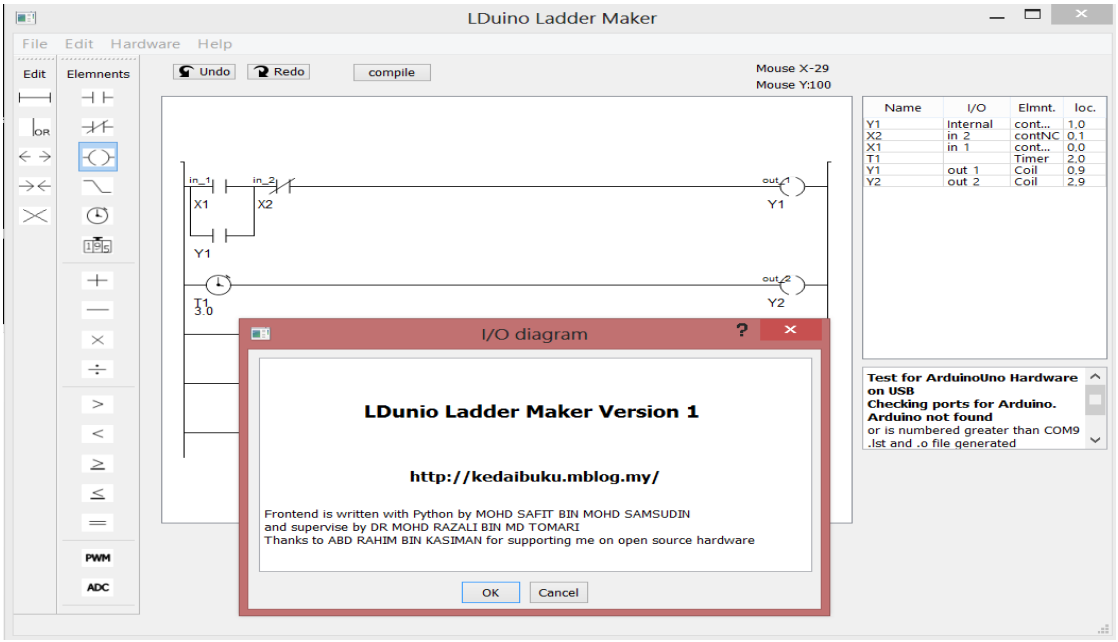
LAMPIRAN



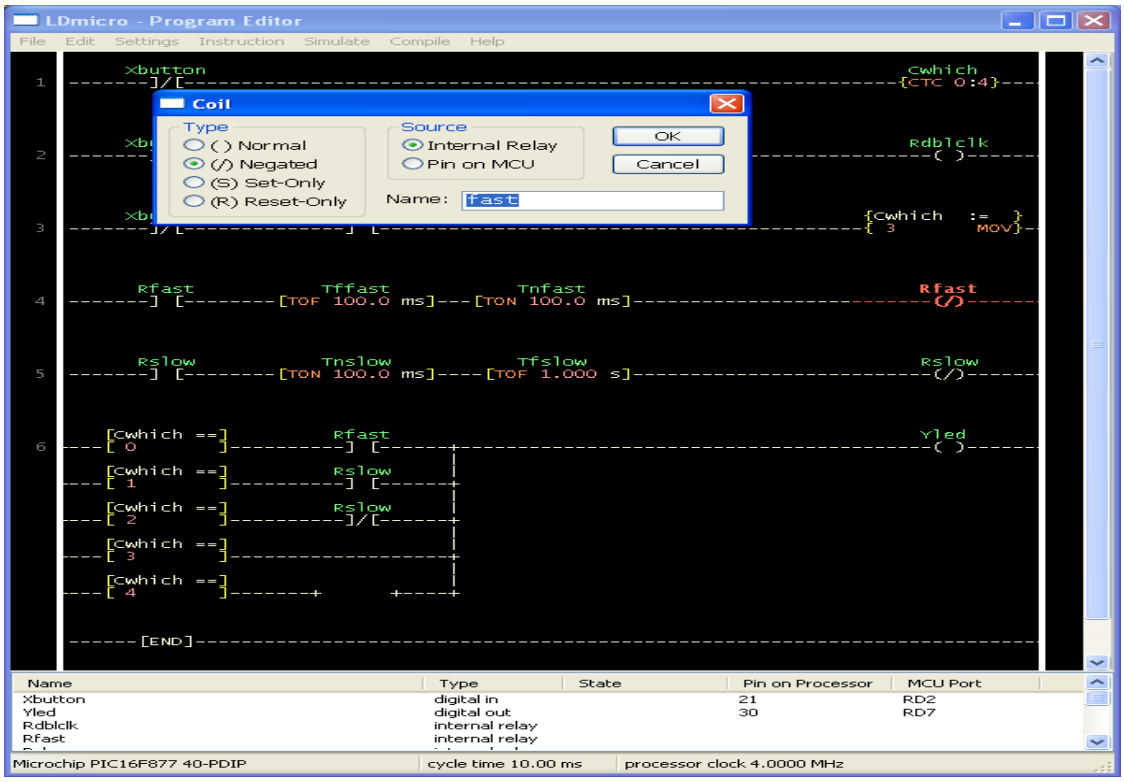
Gambar 1: Evolusi Peralatan Pendidikan PLCmicro dan PLCduino Yang Dibangunkan.



Gambar 2: Peralatan Pendidikan PLC yang dibangunkan bagi tujuan perbandingan



Gambar 3: Perisian LDuino.



Gambar 4: Perisian LDmicro.

Gambar 5: Perbandingan harga

E07: Performance Analysis of Gas Discharge Tube (GDT) at Telecommunication Drop Wire Termination System

Mohamad Hatta Mohamed Nor
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka

m_hatta.jtm@1govuc.gov.my

Abstracts:

The major role of lightning protection system such as gas discharge tube (GDT) at drop wire termination line is to secure the telecommunication and electronics equipment from both direct and indirect lightning overvoltage surge by intercepting flashes, reducing the impulse voltage level and guiding their currents to ground. Based on data recorded by Telekom Malaysia Berhad (TM) from July until September 2013 there are about 3747 cases of distribution points, drop wire termination line and customer internal wiring faults due to lightning overvoltage surge activities. These lightning issues contribute major problems to telecommunication utility company and their subscribers due to telecommunication line breakdown. The objectives of this project is to model, simulate, analyze and validate the lightning impulse generator based on IEC 60060-1 and also to model, simulate, analyze and validate the performance analysis of gas discharge tube (GDT) by testing their DC sparkover voltage, impulse sparkover, DC holdover voltage based on BS EN 61643 respectively. PSpice and Micro-Cap simulation software have used to simulate and analyze the effects of direct lightning strike to both protected and unprotected drop wire termination line. From results obtained, the GDT has performed well and sustained to protect the drop wire termination from lightning overvoltage impulse and dangerous DC sparkover voltage. Existing lightning surge arrester at drop wire termination line can be modified and upgraded based on results obtained to minimize the line breakdown.

Keywords: *Lightning protection system, gas discharge tube (GDT), telecommunication drop wire*

1.0 Introduction

Lightning is one of nature's most powerful and destructive phenomena. Lightning discharges contain awesome amounts of electrical energy and have been measured from several thousand amps to over 200,000 amps. Even though a lightning discharge is of a very short duration, typically 200 microseconds, it is a very real cause of damage and destruction [1].

The effects of a direct strike are obvious and immediately apparent such as transmission line damaged, buildings damaged, trees blown apart, personal injuries and even death. However, the secondary effects of lightning can caused overall performance of electronics systems severely affected by lightning induced transients and switching actions, which give rise to transient over voltages or surges. A reliable lightning protection scheme must encompass both structural lightning protection and transient over voltage (electronics systems) protection.

The major role of lightning protection is to secure a structure from lightning damage by intercepting flashes and guiding their currents to the ground. Since lightning tends to strike at the highest object in the vicinity, rods are typically placed at the apex of a structure and along its ridges; low-impedance copper conductor connects them to the ground. The isoceraunic map (lightning threats map) shown in Figure 1.1 will depict the number of lightning days per year where Malaysia stands as the world's number 2 lightning hotspot and with an average of 240 lightning days per annum which is about 40 strikes per square kilometer per year in year 2008 [1].

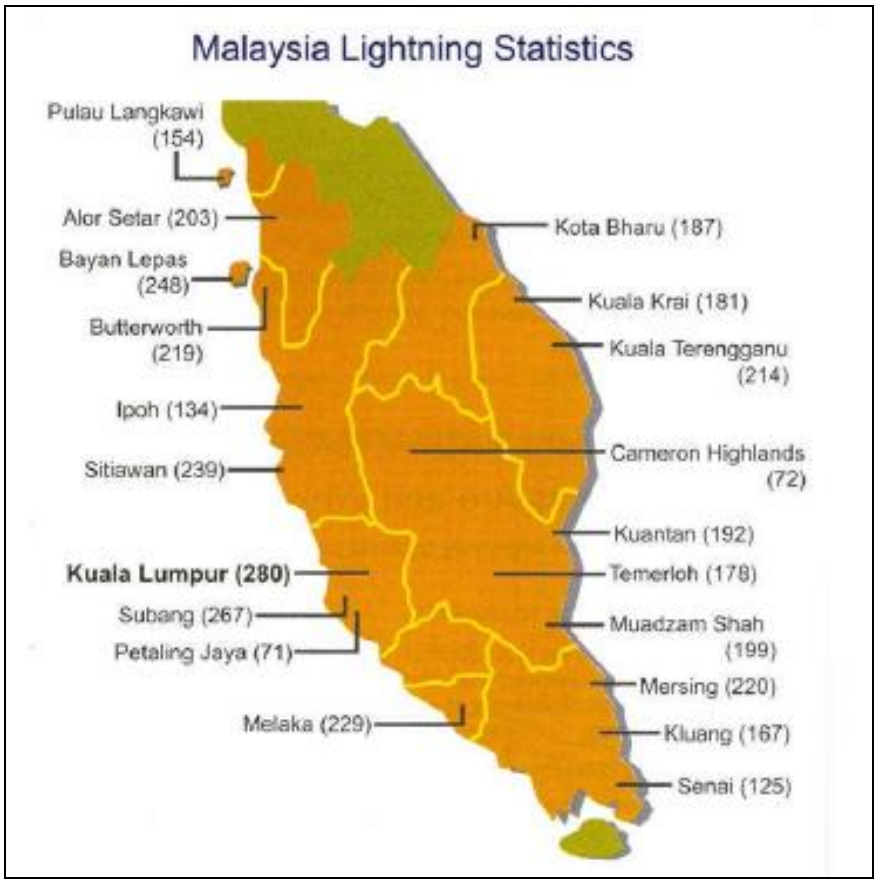


Figure 1: Malaysia Lightning Statistics Recorded by Jabatan Meteorologi Malaysia in year of 2008 [1].

2.0 Objective of project

The main objectives of this project are listed below:

1. To model the lightning impulse generator based on IEC 60060-1.
2. To model the DC sparkover voltage, impulse sparkover and DC holdover voltage based on BS EN 61643-311 standard.
3. To study, simulate, analyze and validate the effects of direct lightning strike to drop wire termination by using appropriate simulation software based on BS EN 61000-4-5 standard.
4. To study, simulate, analyze and validate the performance of existing gas discharge tube (GDT) by using appropriate simulation software based on BS EN 61643-311 standard.

3.0 Methodology

A project methodology is summarized into the flow chart as shown in Figure 3.1. The methodology of this project starts with modeling, simulating and analyzing the lightning impulse generator by PSpice simulation software based on BS61000-4-5 standard. After that, the performance analysis of gas discharge tube (GDT) is modeled, simulated and analyzed through Micro-Cap simulation software based on BS61643-311 standard. Three major criteria in performance analysis of gas discharge tube (GDT) have been taken into account, which are DC sparkover, impulse sparkover and DC holdover analysis.

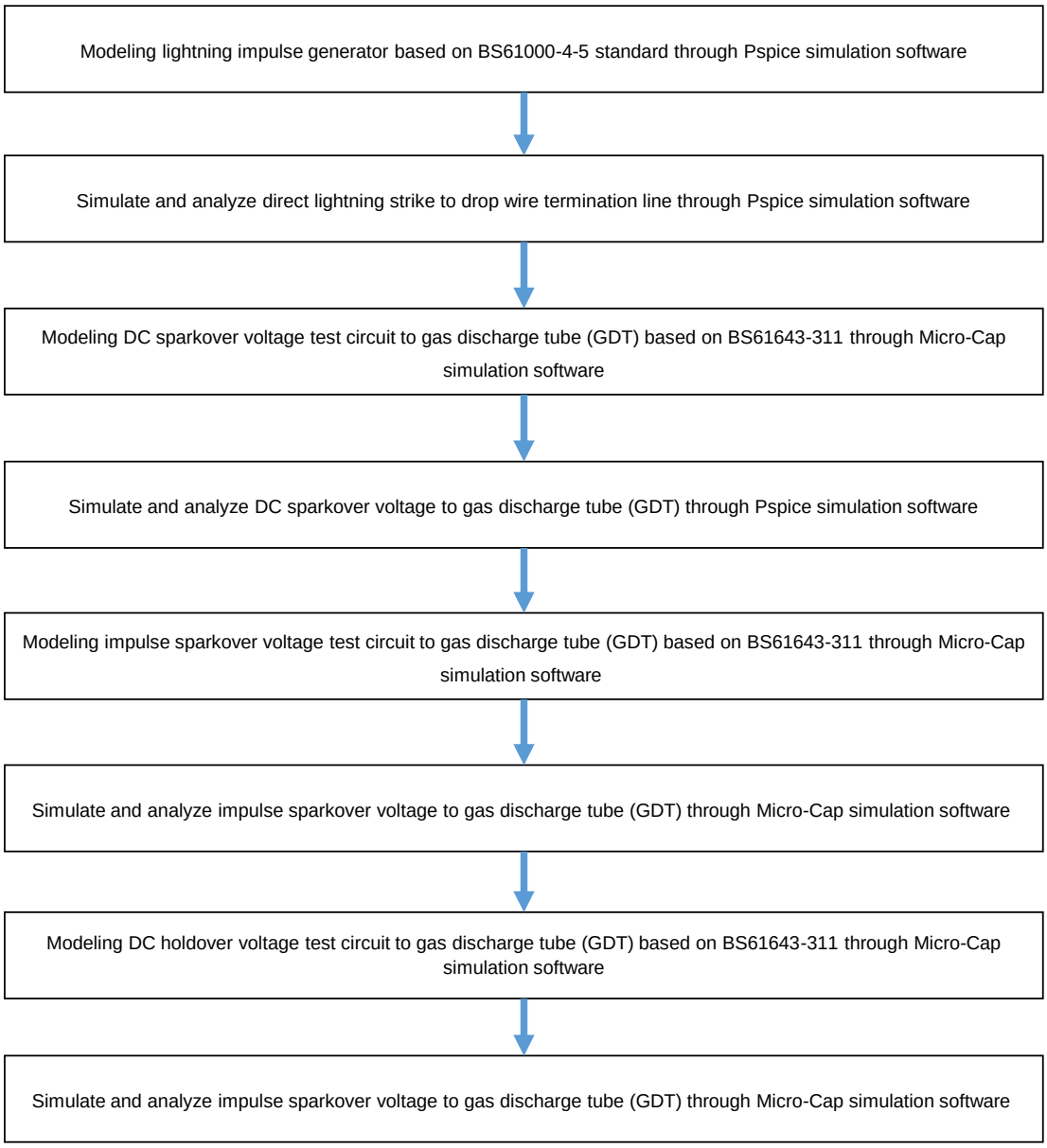


Figure 2: Summarized of project methodology in flow chart

4.0 Results

The effect of direct lightning strike to drop wire has been successful simulated, analyzed and validated by PSpice simulation software. Also, performance of gas discharge tube (GDT) has been simulated, analyzed and validated by Micro-Cap simulation software. Both protected and unprotected drop wire termination by GDT have been simulated, compared, analyzed and validated respectively. From results obtained, GDT has performed well and sustained to protect the drop wire termination line from lightning overvoltage impulse and dangerous DC sparkover voltage.

5.0 Conclusion

Direct lightning strike have been studied, modeled, simulated and validated by Psipce simulation software based on IEC 60060-1. From the results obtained the drop wire and devices such as telephone, modem and fax machine will be collapsed and damaged due to overvoltage lightning impulse. Performances of gas discharge tube (GDT) have been modeled, simulated, analyzed and validated by Micro-Cap simulation software based on BS EN 61643-311. From the results obtained there are clearly stated that's GDT can protect the drop wire termination line from lightning overvoltage surge and DC sparkover voltage. Both results between protected and unprotected drop wire termination line by GDT have been simulated and analyzed, and as a conclusion the GDT has performed well and sustained to protect the drop wire termination line from lightning impulse and DC sparkover voltage. Existing surge arrester at drop wire termination line can be modified and upgraded based on results obtained to minimize the telecommunication line breakdown due to lightning overvoltage surge and DC sparkover voltage activities.

6.0 References

[1] *Cawangan Kejuruteraan Elektrik* (2008). *Panduan Teknik Edisi ke 4*: Chapter 17, Lightning Protection, Surge Protection and Earthing System. [Brochure]. Jabatan Kerja Raya, Malaysia. JKR, 1-19.

[2] Ibrahim A. Metwell and Fridolin H. Heidler (2006). Lightning Transients in Low Voltage Installation inside Different Types of Class II LPS. Power Delivery, IEEE Transactions on (Volume: 24, Issue: 2). April 2009. IEEE, 930-938.

[3] Wii Xu, Yu LI and S.Cheng (2006). Research on Lightning Surge and Protection of Indoor Wiring. Power System Technology, 2006. PowerCon, 2006. International Conference. 22-26 Oct. 2006, IEEE, 1-7.

[4] G. Antonini, S. Cristina and A. Orlandi (1998). PEEC Modeling of LPS and Coupling to Coaxial Cables. Electromagnetic Compatibility, IEEE Transactions on (Volume: 40, Issue: 4). November 1998. IEEE, 481-491.

[5] Narjes Fallah, Chandima Gomes, Mohd Zainal Abidin Ab Kadir, Ghasem Nourirad, Mina Baojahmadi and Rebaz J. Ahmed (2013). Lightning Protection Techniques for Roof Top PV Systems, IEEE 7th International Power Engineering and Optimization Conference (PEOCO 2013). 3-4 June 2013. Langkawi, Malaysia. IEEE, 417-421.

[6] F. Mahtar, A.Ramli, W. R. Wan Abdullah and M. N. Isa (2007). Comparison Study of Usage as Grounding Electrode between Galvanized Iron and Copper with and without Earth Additive Filler. 2007 Asia Pacific Conference on Applied Electromagnetics Proceedings. 4-6 December 2007. Melaka, Malaysia. IEEE, 1-5.

[7] Keith Wallace, Lane Garrett and Shashi Patel (2006). Protective Grounding Methods and Requirements on Distribution Line Wood Pole Construction. Transmission & Distribution Construction, Operation, and Live Line Maintenance, 2006. ESMO 2006, IEEE 11th International Conference. 15-19 October 2006. IEEE, 1-6.

[8] Welson Bassi and Jorge M. Janiszewski (2003). Evaluation of Currents and Charges in Low-Voltage Surge Arresters due to Lightning Strikes, IEEE, 2003. IEEE Transactions and Power Delivery, Vol. 18, No.1. January 2003. IEEE 90 – 94.

[9] L. Pu, J. Deng, S. Qian, S. Gu and X. Cao (2012). A New Method to Study on Dist. Characterictics of CG Ligthning. High Voltage Engineering and Application (ICHVE), 2012 International Conference. 17-20 Sept. 2012. IEEE, 85 – 88.

[10] Zar Ni Tun (2008). Protection of Lightning Caused Interruptions on TL (2008). Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, 2008 5th International Conference (Volume: 2). 14-17 May 2008. IEEE, 909 – 912.

[11] K. Munukutla, V. Vittal, G. T. Heydt, D. Chipman and B. Keel (2010). A Practical Evaluation of Surge Arrester Placement for TL Lightning Protection, Power Delivery, IEEE Transactions (Volume: 25, Issue: 3). July 2010. IEEE, 1742 – 1748.

[12] J. Takami, T. Tsuboi, K. Yamamoto and S. Okabe (2013). Lightning Surge Characteristic on Inclined Incoming Line to Substation based on Reduced - Scale Model Experiment. Dielectrics and Electrical Insulation, IEEE Transactions on (Volume: 20, Issue: 3). June 2013. IEEE, 739 – 746.

[13] Ibrahim A.Metwally and Fridolin H. Heidler (2007). Comp. of Transient Overvoltages in LV Installations during Direct Strikes to Diff. LPS. Electromagnetic Compatibility, IEEE Transactions (Volume: 49, Issue: 3). August 2007. IEEE, 602 – 613.

[14] A. Tatematsu, K. Yamazaki, K. Miyajima and H. Motoyama (2013). Experimental Study of Lightning and Switching Surges-Induced Overvoltages in LV Control Circuits. Electromagnetic Compatibility (EMC EUROPE), 2013 International Symposium. 2-6 Sept. 2013. IEEE, 771 – 776.

[15] L. Yong, W. Haiyan and L. Gang. Study on Lightning Parameter of Transmission Line Porch Based on Lightning Location System (2010). Electrical Insulation (ISEI), Conference Record of the 2010 IEEE International Symposium. 6-9 June 2010. IEEE, 1 – 4.

[16] Thomas R. Brinner and Robert A. Durham (2010). Transient-Voltage Aspects of Grounding. Industry Applications, IEEE Transactions (Volume: 46, Issue: 5). Sept.-Oct. 2010. IEEE, 1796 – 1804.

[17] I. A. Metwally and F. Heidler (2007). Influence of Line Routing and Terminations on Transient Overvoltages in LV Power Installations. Electromagnetic Compatibility, 2007. EMC Zurich 2007. 18th International Zurich Symposium. 24-28 Sept. 2007. IEEE, 313 – 316.

[18] Ibrahim A. Metwally and Fridolin H. Heidler (2007). Enhancement of the SPD Residual Voltage at Apparatus Terminals in Low-Voltage. IEEE Transactions on Power System (Volume: 22, Issue: 4). October 2007. IEEE, 2207 – 2213.

[19] G. L. Amicucci, F. Fiamingo, Z. Flisowski, G.B. Lo Piparo and C. Mazzetti (2010). Surge Protective Devices for Low Voltage Systems: Practical Approach for the Protection Distance Evaluation. Power Tech, 2007 IEEE Lausanne. 1-5 July 2007. IEEE, 778 – 782.

[20] Akiyoshi Tatematsu, Kenichi Yamazaki, Kiyotomi Miyajima, and Hideki Motoyama (2013). Experimental Study of Lightning and Switching Surges-Induced Overvoltages in Low-Voltage Control Circuits. Electromagnetic Compatibility (EMC EUROPE), 2013 International Symposium. 2-6 Sept. 2013. IEEE, 771 – 776.

[21] H. Ahmad, M. R. M. Esa and F. K. Chew (2007). Dispersion of Standard and Non-Standard Lightning Current to Ground in a Telecommunication Building. Power Engineering Conference. IPEC 2007 International. 3-6 December 2007. IEEE, 207 – 212.

[22] International Electrotechnical Commission (2006). *I.E.C 60060-1*. Geneva: International Electrotechnical Commission.

[23] British Standards Institution (2013). *B.S. 61643-311*. London: British Standards Institution.

E08: Smart Vehicle Child Safety System

Marina S[1], Nur Hidayah A.G[2], Nik Mohd Akif N.Z[3], Fatin Amira T[4],
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

marina_sukor@jtm.gov.my[1]

Abstrak

Sejak kebelakangan ini banyak berlaku kes kematian kanak-kanak yang ditinggalkan lama di dalam kereta disebabkan oleh kecuaian ibu bapa. Kejadian sebegini telah terjadi berulang kali namun tidak dijadikan pengajaran oleh ibu bapa atau penjaga dalam memastikan keselamatan anak mereka. Smart Vehicle Child Safety System direka untuk menyelesaikan masalah yang berkaitan dengan mencipta peranti yang boleh berhubung ke telefon bimbit ibu bapa sekiranya kanak-kanak ditinggalkan lama di dalam kereta. Apabila ibu bapa mendapat panggilan telefon dari kenderaan, mereka akan membalas panggilan tersebut untuk membuka cermin tingkap kereta tanpa perlu memecahkannya. Motion sensor digunakan untuk mengesan pergerakkan kanak-kanak didalam kereta manakala pengawal PIC digunakan untuk mengawal pergerakkan cermin kereta setelah mendapat panggilan telefon.

Katakunci: *Motion sensor, PIC, keselamatan kereta.*

1.0 Pengenalan

Smart Vehicle Controlling System dibangunkan untuk menyelesaikan masalah yang berkaitan dengan kes kanak-kanak tertinggal di dalam kereta yang kerap berlaku di negara kita sejak akhir-akhir ini. Kejadian seumpama ini boleh mengakibatkan kematian akibat lemas kerana ditinggalkan terlalu lama di dalam kereta dalam keadaan cuaca yang amat panas. Dengan adanya pembangunan projek seumpama ini diharap dapat membantu masyarakat dalam berhadapan masalah seperti ini terutama kepada ibu bapa.

2.0 Objektif Projek

Objektif pembangunan projek antaranya adalah seperti dibawah:

a) Menyediakan satu sistem elektronik yang dapat memberitahu pengguna/ibubapa berkenaan kanak-kanak tertinggal didalam kereta.
b) Menyediakan satu sistem elektronik yang dapat menyelamatkan kanak-kanak yang lemas dalam kereta dalam waktu yang singkat.
c) Menyediakan satu sistem kenderaan yang ditinggalkan dalam keadaan selamat.

3.0 Latar Belakang

Kes ini sering berlaku akibat kecuaian ibu bapa yang meninggalkan anak mereka di dalam kenderaan tanpa sengaja. Sumber dari akhbar Berita Harian, 25 Ogos 2010 menyatakan "…satu kes di New Jersey, Amerika Syarikat, mahkamah memutuskan meninggalkan anak dalam kereta tanpa pengawasan orang dewasa, walaupun sebentar adalah satu penderaan atau kecuaian. Seseorang ibu bapa sebenarnya mengundang bahaya apabila meninggalkan anak yang masih kecil, walaupun sekejap. Terdapat risiko kereta dilarikan, anak diculik dan kemungkinan suhu dalam kereta berubah mendadak serta membahayakan kanak-kanak yang berada di dalamnya."

Oleh itu satu perbandingan sistem keselamatan sediada kenderaan dilakukan melalui kaedah pencambahan fikiran. Perbandingan sistem sebelum dan pengubahsuaian semasa adalah seperti Jadual 3.1

Jadual 3.1: Perbandingan projek

Sebelum (Sistem asal pada kereta)	Selepas (Penambahbaikan)
Hanya menggunakan kaedah kunci yang biasa atau manual	Kaedah membuka kunci kereta menggunakan telefon bimbit
Tiada penderia	Menggunakan sensor untuk mengesan pergerakkan manusia semasa kereta ditinggalkan.
Tidak dapat menghubungi pemilik kereta ketika keadaan kecemasan berlaku.	Pemilik kenderaan akan dihubungi secara automatik sekiranya berlaku kecemasan
Tiada kaedah alternatif untuk menyelamatkan kanak-kanak dan perlu memecahkan tingkap kereta.	Menyediakan kaedah alternatif supaya kanak-kanak dapat bernafas dan diselamatkan

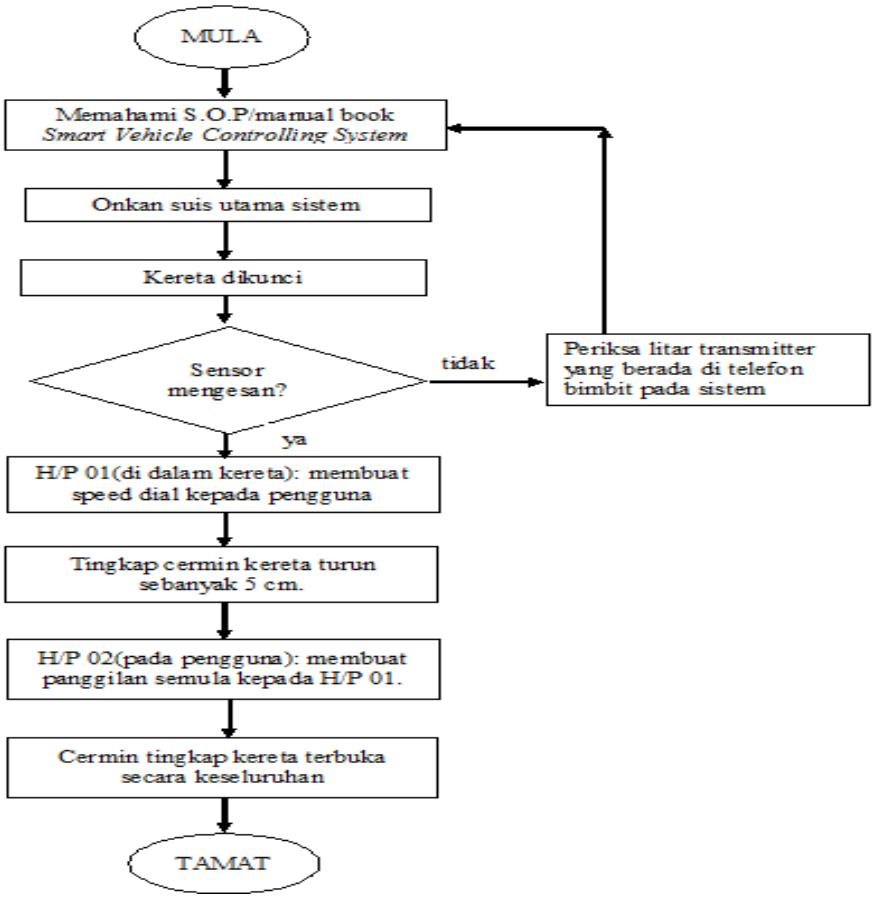
4.0 Pembangunan Sistem

Sistem yang telah dibangunkan akan beroperasi apabila suis utama diaktifkan dalam keadaan kereta berkunci. *Motion Sensor* akan berfungsi mengesan sebarang pergerakkan di dalam kereta ketika kereta ditinggalkan. Perkara ini merujuk kepada keadaan kanak-kanak yang meronta dan menangis ketika ditinggalkan dalam kenderaan. Apabila pergerakkan di kesan, litar *transmitter* di dalam kereta akan menghubungi telefon bimbit pengguna.

Apabila menerima panggilan, pengguna akan mendapat tahu ada keadaan kecemasan yang berlaku di dalam kereta. Pengguna akan terus ke tempat kereta ditinggalkan dan dalam masa yang sama, *motor power window* akan menurunkan tingkap supaya kanak-kanak dapat bernafas. Tingkap ditetapkan untuk turun sebanyak 5cm bertujuan membenarkan pengaliran udara dalam kereta. Sekiranya keadaan terdesak, pengguna boleh memilih untuk menurunkan keseluruhan tingkap kereta supaya kanak-kanak dapat diselamatkan oleh orang ramai sekiranya pengguna berada pada lokasi yang jauh dari kereta.

5.0 Metodologi

Sistem ini dibangunkan dengan gabungan 5 litar elektronik iaitu Litar *Power Supply*, Litar PIC 16F84A, Litar *Motion Sensor*, Litar *Motor Power Window* yang terdapat pada pintu kereta dan Litar *Transmitter & Receiver* yang berada di telefon bimbit. Litar *motion sensor* dijadikan sebagai masukan pada pengaturcaraan pada PIC 16F84A.Untuk peranti keluaran adalah telefon bimbit dan motor *power window*. Semua peranti ini akan beroperasi selepas mendapat isyarat daripada peranti masukan. Peranti masukan dan peranti keluaran akan bergabung untuk melancarkan operasi projek ini**.**

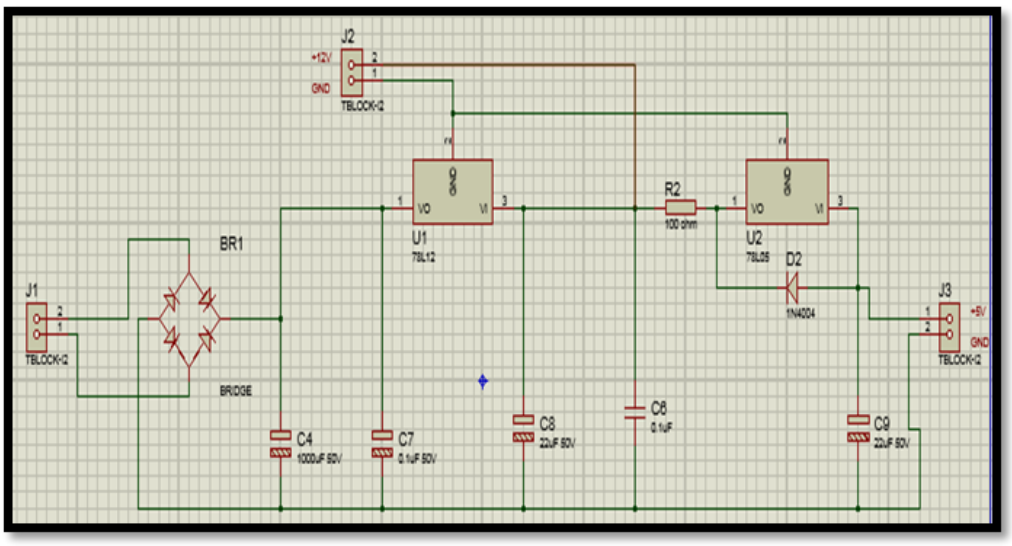


Rajah 1: Carta Alir penggunaan Sistem Keselamatan Kenderaan

6.0 Litar-litar yang digunakan.

6.1 Bekalan Kuasa

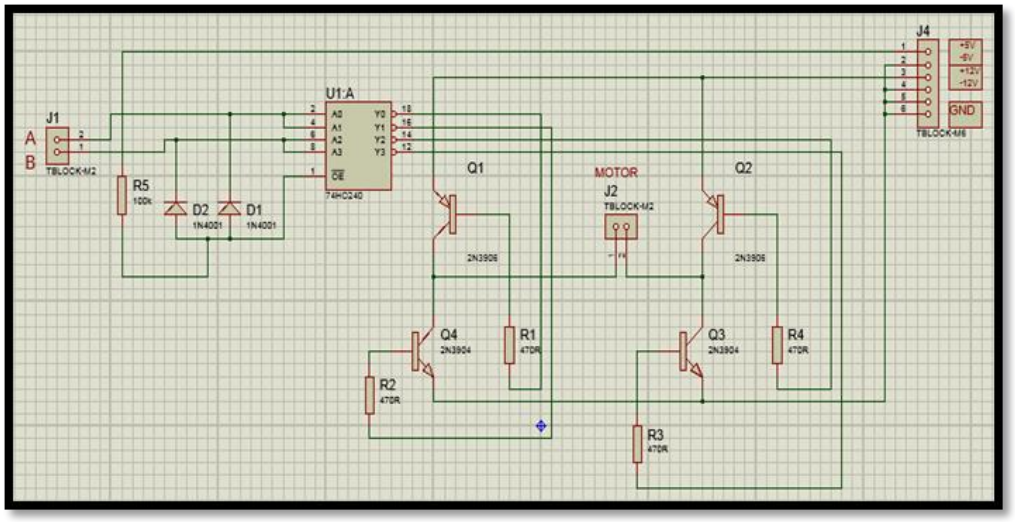
Digunakan sebagai bekalan kuasa untuk litar yang terlibat.



Rajah 2: Bekalan kuasa (12v & 5v) untuk litar yang digunakan

6.2 Motor power window

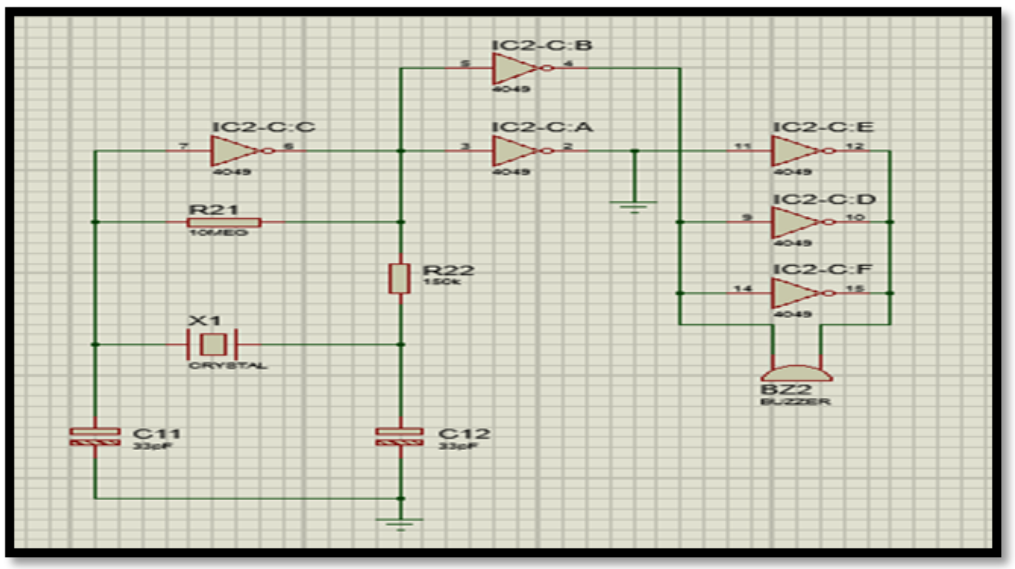
Digunakan untuk kawalan cermin tingkap kereta**.**



Rajah 3: Beroperasi sebagai keluaran selepas mendapat isyarat daripada PIC 18F84A

6.3 Transmitter

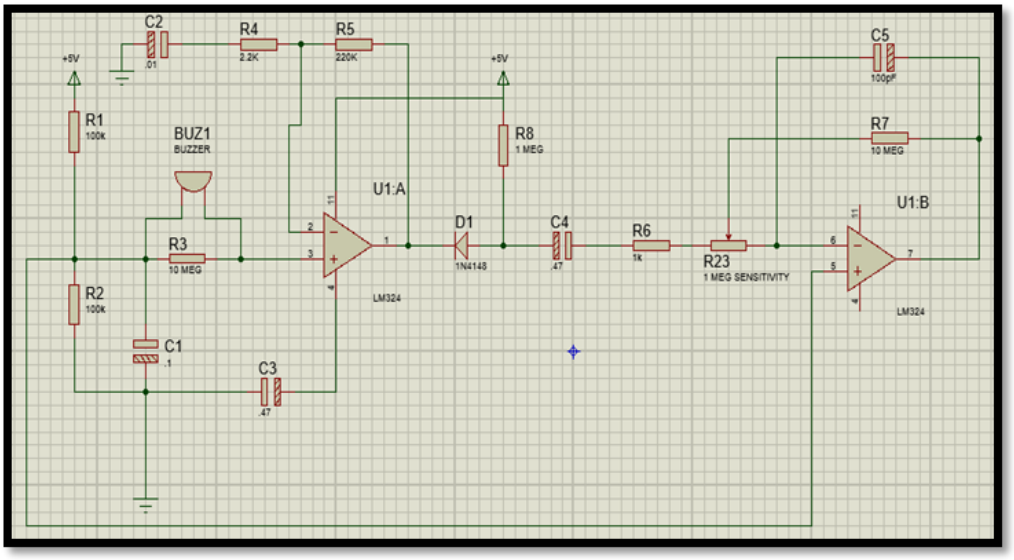
Sebagai penghantar isyarat kepada pengguna selepas mendapat isyarat daripada *motion sensor*.



Rajah 4: Di sambungkan ke butang nombor 3 di telefon bimbit pada sistem

6.4 Receiver

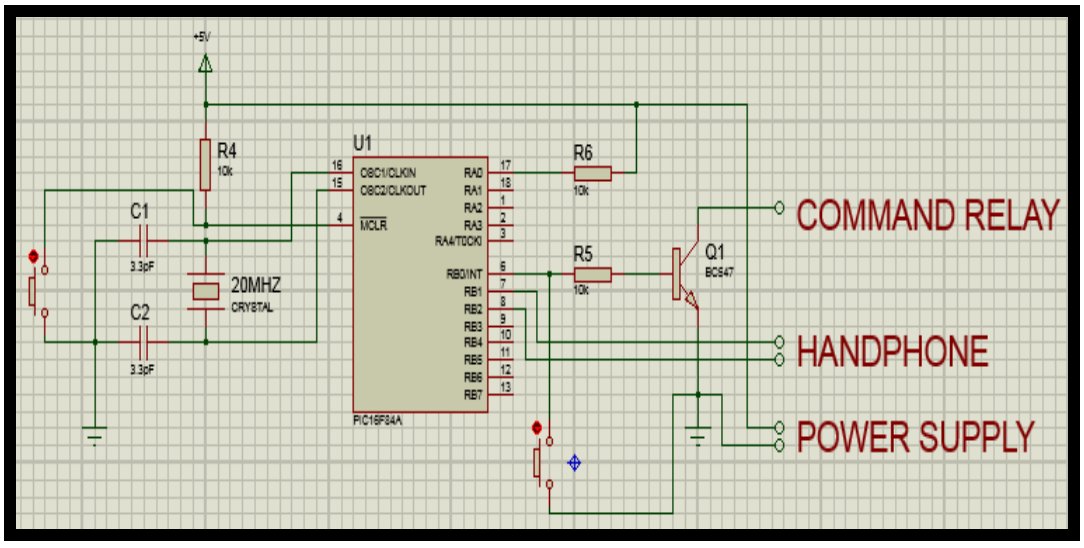
Penerima isyarat daripada pengguna apabila pengguna membuat panggilan semula ke telefon bimbit yang berada di dalam kereta.



Rajah 5: Beroperasi sebagai penerima panggilan dan membuka cermin tingkap keseluruhan

6.5 Litar PIC 16F84A

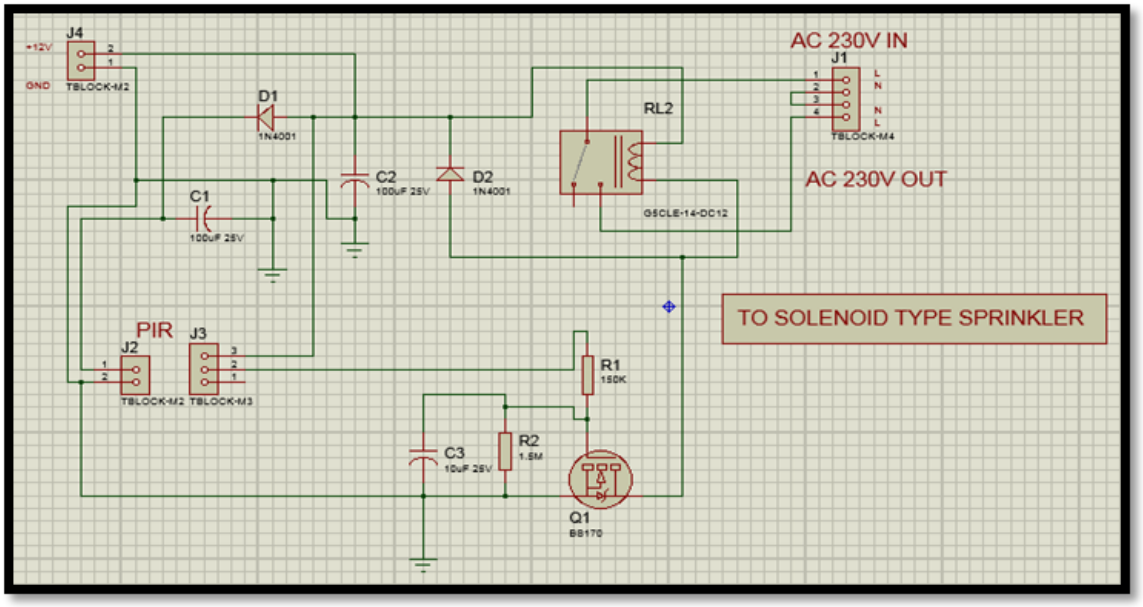
Sebagai pengawal keseluruhan litar serta komponen elektronik yang digunakan di dalam projek ini.



Rajah 6: Beroperasi sebagai pengawal masukan dan keluaran sistem

6.6 Litar motion sensor

Untuk mengesan pergerakkan di dalam kereta dan menghantar isyarat kepada litar *transmitter*.



Rajah 7: Untuk mengesan pergerakan

7.0 Keputusan

Jadual 7.1 menunjukkan hasil pengujian terhadap produk elektronik yang dibangunkankan.

Jadual 2: Keputusan keseluruhan projek

Bil	Input / output	Proses	Status
1.	Input ➢ Suis push button (butang kecemasan) ➢ Sensor	PIC 16F84A	Tingkap terbuka dalam 5 cm.
2.	Output ➢ Telefon bimbit (transmitter) ➢ Telefon bimbit (receiver) ➢ Relay forward ➢ Relar reverse		Tingkap akan terbuka sepenuhnya.

8.0 Kesimpulan

Sistem ini dapat membantu pengguna dari pelbagai aspek antaranya dari aspek kewangan, keselamatan, menjimatkan masa, menyelamatkan nyawa orang yang tersayang dan kenderaan apabila berlaku kes-kes kecuaian seperti di atas. Projek ini di bangunkan adalah untuk memudahkan pengguna menjalankan aktiviti seharian dan beroperasi sebagai '*reminder*' sekiranya berlaku perkara-perkara buruk yang tidak dirancang.

9.0 Cadangan Penambahbaikan

Antara cadangan penambahbaikan yang boleh dilaksanakan pada masa akan datang adalah seperti dibawah.

- Boleh mengunci kereta dengan menggunakan telefon bimbit tanpa perlu ada *remote* kereta.
- Boleh menerima isyarat panggilan dan video bagi melihat paparan imej di dalam kereta, bukan sekadar panggilan biasa atau SMS sahaja.
- Mampu mengesan suara bayi di dalam kereta yang terhad pergerakkannya.

Dengan adanya penambahbaikan ini dapat meningkatkan kualiti produk yang dihasilkan.

10.0 Rujukan

[1] Roslina.S.(2004). Elektrik dan Elektronik (Edisi ke-3). Dewan Bahasa & Pustaka. Kuala Lumpur.

[2] D.R.Malcom (2007). Asas Elektronik (Edisi ke-2). Terjemahan Universiti Teknologi Malaysia, Skudai, Johor.

[3] https://www.futurelec.com/PIR_Sensors.shtml

[4] http://akizukidenshi.com/download/PIC16F84A.pdf

[5] http://www.ideatahunakhir.blogspot.com

E10: Development on DC Grass Cutter

Hezry Bin Abd Ghafar[1], Mohd Rauf Bin Ali Khan[2], Rupizani Binti Jusoh[3]
Institut Latihan Perindustrian Mersing, Johor Darul Takzim

hezry.jtm@1govuc.gov.my[1], mohdrauf.jtm@1govuc.gov.my[2], rupizanijusoh@gmail.com[3]

Abstrak

Idea dalam projek pembangunan DC Grass Cutter adalah merekacipta satu produk yang dapat menggantikan mesin rumput konvesional dengan satu mesin yang lebih efektif, tidak menggunakan sebarang bahan api serta mesin yang boleh mengurangkan kos penyelenggaraan bulanan dan tahunan. Produk ini direka dengan menjadikan tenaga solar sebagai punca bekalan kuasa produk. Mesin rumput yang sedia ada kini menggunakan bahan api dan ianya adalah satu penyumbang kepada pencemaran udara dan pemanasan global bumi. Dengan terciptanya produk ini, ianya dapat membantu ekosistem bumi dan penyumbang kepada penggunaan teknologi tenaga solar dalam ekosistem manusia. Dengan penggunaan teknologi solar sebagai bekalan kuasa kepada produk yang dicipta, ianya dapat mengurangkan penggunaan bahan api kepada 0% kerana produk ini 100% menggunakan bekalan kuasa bateri sepenuhnya. Dengan penggunaan 0% bahan api, kos bahan api dikurangkan kepada hampir 100%, ianya juga mengurangkan kos penyelenggaraan bulanan dan seterusnya kos penyelenggaraan tahunan kepada hampir 80% hingga 90% terhadap produk yang dibina ini.

Kata kunci: *DC grass cutter, tenaga solar, bateri.*

1.0 Pengenalan

Dalam era globalisasi masa kini, pelbagai kemudahan dicipta bagi memudahkan sesuatu tugas atau kerja. Lantaran itu, pembaharuan haruslah dilakukan seiring dengan kehendak masyarakat yang sentiasa inginkan kemudahan yang cepat dan berkualiti. Di Malaysia, kerja-kerja pemotongan rumput sering kelihatan seperti di tepi-tepi jalan oleh pihak berwajib bertujuan untuk memperindahkan persekitaran di sesebuah tempat selain di rumah-rumah persendirian untuk menjadikan halaman rumah sentiasa bersih. Jika dilihat dari sudut kos yang diperlukan bagi seseorang untuk menjalankan kerja-kerja pemotongan rumput, bahan yang utama ialah bahan bakar iaitu petrol. Sumber ini adalah sumber yang semakin lama semakin sedikit ditelan zaman berikutan ia adalah sumber yang tidak dapat dikitar semula dan penggunaannya yang meluas oleh segenap lapisan masyarakat. Penggunaan mesin rumput juga akan mencemarkan alam sekitar dengan asap dan bunyi yang dihasilkan setiap kali kerja-kerja pemotongan rumput dijalankan. Bagi mereka yang menjadikan memotong rumput ini sebagai sumber rezeki, mereka harus berdepan dengan masalah kesihatan seperti sakit belakang. Terdapat kesan yang tidak baik terhadap postur tubuh seseorang apabila menggunakan mesin rumput secara berterusan atau agak lama. Mereka sering mengalami kesakitan belakang badan kerana bebanan ke atas tulang belakang oleh mesin tersebut.

Berikutan daripada beberapa perkara ini dan Malaysia terletak di kawasan garisan khatulistiwa iaitu menerima cahaya matahari hampir sepanjang tahun, suatu inovasi telah dicipta iaitu *DC Grass Cutter* bagi memberi alternatif dan impak yang baik kepada pengguna dengan berkonsepkan tenaga solar.

2.0 Objektif

Terdapat tiga objektif bagi penghasilan produk ini:

1. Menghasilkan mesin rumput yang dapat mengurangkan kos. Kos bahan bakar seperti petrol tidak diperlukan setiap kali ingin memotong rumput.
2. Menghasilkan mesin rumput yang mesra alam iaitu tidak mencemarkan alam sekitar dan pencemaran bunyi.
3. Memperbaiki struktur tubuh pengguna semasa kerja memotong rumput dijalankan.

3.0 Fungsi Projek

Produk ini direka dengan fungsi berikut:

1. Bateri nanogel 12V adalah komponen utama yang digunakan bagi menggantikan bahan bakar untuk menghidupkan motor *DC Grass Cutter*.
2. *DC Grass Cutter* ini dapat dikendalikan dengan menekan suis pada handle sebelah kanan dan motor dapat berfungsi dengan kelajuan maksimum 3000rpm untuk memulakan kerja-kerja memotong rumput.

4.0 Kebaikan dan Potensi Komersil

Antara kebaikan produk ini adalah menghasilkan mesin rumput yang mesra alam, tiada pencemaran udara dan bunyi dihasilkan daripada *DC Grass Cutter* ini. Selain itu ia juga menggunakan tenaga solar bagi mengecas semula bateri. Bateri nanogel 12V ini dapat bertahan selama 45 minit tanpa henti dalam melakukan kerja-kerja pemotongan rumput.

Dengan perkembangan teknologi solar kini, *DC Grass Cutter* ini dapat dikomersilkan dan akan memenuhi citarasa pengguna dengan mengambil kira kos bahan mentah dan kos tenaga yang semakin meningkat. Walaupun telah terdapat mesin rumput yang menggunakan solar tetapi *DC Grass Cutter* yang dicipta ini lebih praktikal dan lebih baik digunakan.

5.0 Metodologi Projek

Bahan-bahan dan peralatan yang digunakan untuk menghasilkan projek adalah seperti di bawah:

- Motor DC 12 volt
- Bateri DC 12 volt
- Photovoltaic 10 Wp
- Solar Charger Controller
- Trimmer Line
- String Trimmer Disc
- Digital Voltmeter
- Pelbagai Jenis Skru
- Suis
- Paip Stainless Steel 2 inch
- Cable 2.5mm

Pembaharuan yang telah dilakukan ke atas *DC Grass Cutter* ini adalah dari segi penggunaan tenaga solar berbanding penggunaan bahan bakar. Bateri yang digunakan adalah berkapasiti 12V 9AH/10HR ini dapat dicas semula menggunakan panel solar. Dengan menyambungkan sahaja terminal positif dan negatif pada kabel di bateri, bateri akan dicas semula. Tempoh untuk bateri ini dicas penuh adalah bergantung pada keterikan cahaya matahari, yang mana kebiasaannya ialah 4 jam iaitu antara 11 pagi hingga 3 petang.

Pengubahsuaian yang telah dilakukan terhadap *DC Grass Cutter* ini adalah lebih ringan iaitu 5 kg sahaja berbanding mesin rumput biasa yang berat lebih kurang 15kg. Bahan utama yang digunakan untuk menghasilkan *DC Grass Cutter* ialah *stainless steel* yang membuatkan ia lebih ringan. *DC Grass Cutter* ini mempunyai dua pemegang iaitu di kanan dan kiri bagi memudahkan pengguna mengendalikan nya. Apabila ditekan suis, motor akan berfungsi dan kerja-kerja pemotongan boleh dilakukan sama seperti mesin rumput konvensional. *DC Grass Cutter* ini memberi keselesaan kepada pengguna kerana span yang lembut telah dijadikan pengalas tangan pengguna. Dari segi keselamatan pula, terdapat penghadang dibahagian bawah supaya dapat mengelakkan batu atau rumput berterbangan terkena muka pengguna.

6.0 Gambarajah Projek

Rajah 1: DC grass cutter dari bahagian hadapan

Rajah 2: *DC Grass Cutter* dengan tempat penyimpanan dan assesori

7.0 Analisa Projek

Jadual 1: Kadar masa pengecasan bateri.

Kadar masa (menggunakan panel solar 20W)	Kaedah mengecas bateri 12 V
8 Jam (8am-4pm) Waktu puncak pancaran matahari = 4 jam (11am-3pm)	Menggunakan panel solar 10WP

Jadual 2: Perbandingan berat pemotong rumput

Jenis pemotong rumput	Berat (Kg)
Konvensional	10 Kg
DC Grass Cutter	5 Kg

Jadual 3: Perbandingan kadar boleh dengar

Jenis pemotong rumput	Kadar boleh dengar (dB)
Konvensional	85 -125
DC Grass Cutter	70 - 90

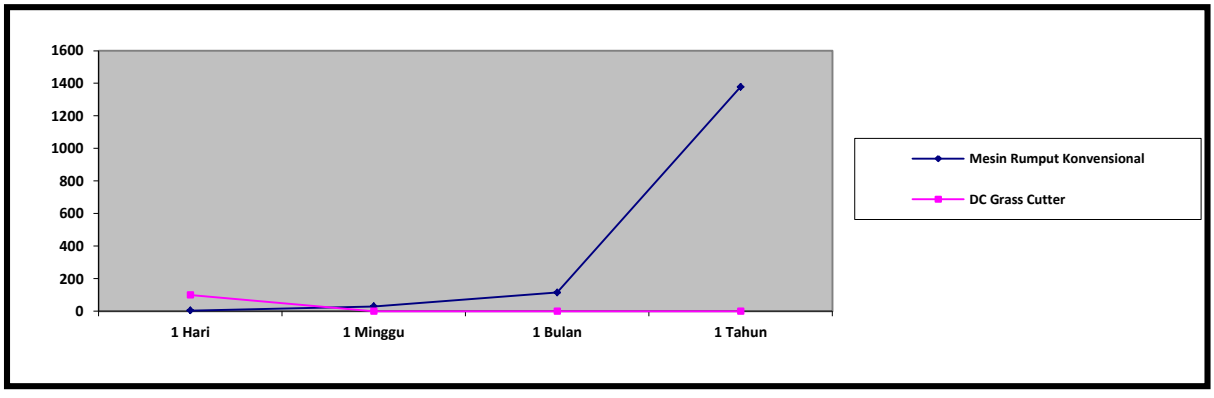
Jadual 4: DC Grass Cutter

Kadar masa	Penggunaan sumber kuasa
30 -45 minute	Bateri 12V

Jadual 5: Perbandingan penggunaan bekalan kuasa/Bekalan bahan bakar

Masa	1 hari	1 Minggu	1 Bulan	1 Tahun
Mesin Rumput Konvensional	RM 4.10	RM 28.70	RM 114.80	RM1137.60
DC Grass Cutter	RM 100.00	RM 0	RM 0	RM 0

** Berdasarkan Penggunaan Minyak 2 liter untuk 1 Hari penggunaan Mesin Rumput Konvensional.



Rajah 3: Graf perbandingan penggunaan bekalan

8.0 Kesimpulan

Penggunaan mesin rumput amat penting lebih-lebih lagi bagi kontraktor-kontraktor dalam sektor landskap dan pembersihan. Jika dibandingkan penggunaan bahan api dan bekalan kuasa bateri yang digunakan, *DC Grass Cutter* adalah satu alat inovasi yang lebih efektif dalam penggunaan seharian. Kita tidak boleh ketepikan apa yang DC Grass Cutter mampu lakukan dalam kehidupan seharian malah produk inovasi yang telah dicipta ini dapat memberikan impak yang baik pada golongan peniaga mahupun golongan pengguna kecil di negara ini.

Manusia sekarang mahukan produk atau peralatan yang tidak mendatangkan sebarang kemudaratan serta peralatan yang mesra pengguna dan mudah digunakan. Dengan adanya DC Grass Cutter ini dihasilkan, ia dapat digunakan oleh semua lapisan masyarakat kerana keadaaan realistiknya adalah mudah dibawa serta mudah dikendalikan dan ianya juga tidak mendatangkan sebarang bahaya jika ia tidak digunakan. Ini bermakna Mesin *DC Grass Cutter* tidak terdedah dengan bahan bakar yang bahaya.

Oleh itu, produk ini amat memenuhi segala kretiria produk yang selamat digunakan serta mampu mengurangkan kos penggunaan dan penyelengaraan hampir kepada 90%.

E11: Development on 3S Generator

Mohd Rauf Bin Ali Khan[1], Mohd Syahrulnizam Bin Razali[2], Hezry Bin Abd Ghafar [3]
Institut Latihan Perindustrian Mersing, Johor Darul Takzim

Mohdrauf.jtm@1govuc.gov.my[1], syahrulnizam.jtm@1govuc.gov.my[2], hezry.jtm@1govuc.gov.my[3]

Abstract

"3S Generator" is a project that is innovating from the existing products, namely portable generator. The existing portable generator is using diesel or petrol fuel to operating the engine generator. The existing portable generator is also a equipment that emits smoke and powerful sound when operating. With this, the project "3S Generator " is producing a new product that has the same machine operation but does not use any fuel to operate the product. "3S Generator" also uses the solar technology as well as the power supply of batteries to generate the equipment. This innovation machine is produce to reduce operating sound equipment with 70% quieter than the existing generator and will not produce any smoke when operating. For commercial purposes, "3S Generator" can be commercialized overcome existing generator because it does not use fuel as well just have annual maintenance. With that, it can save on fuel costs and maintenance costs.

***Keywords**: 3S Generator, solar technology, battery.*

1.0 Introduction

In today's globalized world, a truly created to facilitate a task or job. Thus, the reform should be carried out in line with the will of the people who always want a quick and quality facilities. In Malaysia, the use of portable generators for everyday use and is used by traders night market traders are very diverse. Thus arises the idea to replace the existing portable generator to a generator that does not use gasoline as a fuel source to turn on the generator. As we know, oil is a resource that fewer and fewer over time as it is a resource that can not be recycled and its widespread use by the entire community. The use of existing portable generator is polluting the environment with smoke and noise generated every time the generator is used. With innovative products are created by our users easier to use the "3S generator" is. And what is meant by "3S Generator" This is Self Sustain Solar Generator.

2.0 Objectives

There are three revenue objectives for this product:

1. Generate Generator that does not use any fuel, diesel and petrol.
2. Reduce the environmental pollution that is not happening emissions and noise.
3. Eliminating fuel costs and reduces maintenance costs

3.0 Functionality Project

The product was created as above:

1. Battery 12V Nanogel is a major component used as a source of Power Supply.
2. The project applied the 'standalone solar system' in which direct current is converted to alternating current by an inverter.
3. Solar Systems will supply voltage of 12V to 12V Battery Nanogel Solar as power supply and battery charging voltage of 12V to 12V Nanogel.
4. Nanogel 12V battery will supply 12V DC to AC inverter to convert 12VDC to 240VAC.
5. The Inverter 240VAC, 240VAC it will supply it to the Motor 240VAC to 230VAC Motor This allows moving and twisting. This motor will be connected to the alternator using Belting and it will move the alternator.
6. This alternator will convert mechanical energy to electrical energy is 12VDC and it is used and serves to recharge the batteries 12 VDC.

4.0 Advantages and Commercialize Potential

Among the advantages of this product are:

1. Replacing the existing Portable Generator.
2. No Fuel Costs and can reduce monthly and annual maintenance costs.
3. Do not use any electricity and only depends on the Solar System entirely.
4. Easy and safe to use.
5. Can turn all electrical equipment 240VAC.

"3S Generator" can be commercialized overcome existing generator because it does not use fuel as well just have annual maintenance. With that, it can save on fuel costs and maintenance costs.

5.0 Project Methodology

List of the project equipment is as listed:

- Battery DC 12 volt
- Photovoltaic 10 Wp
- Inverter
- Socket 13A
- Wall socket outlet
- On off switch
- Main switch
- Alternator
- Belting
- AC Motor
- ELCB
- MCB

6.0 Project Figure

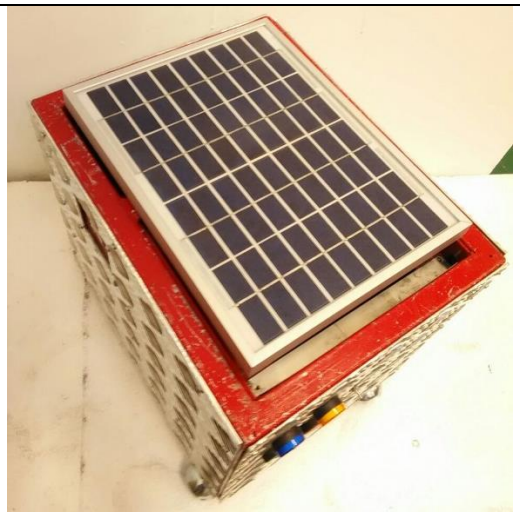
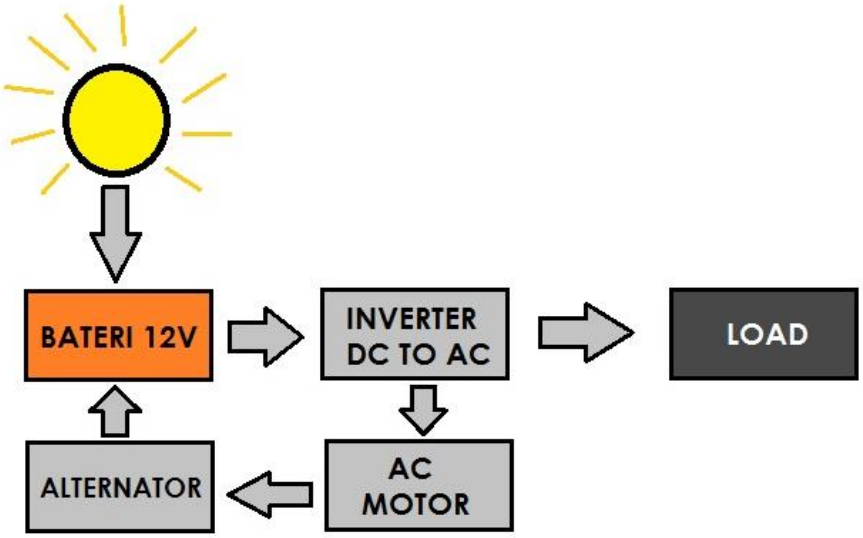


Figure 1: Project Figure

Picture 2: Block Diagram

7.0 Project Analysis



8.0 Summary

Use Protable Generator is very important especially for traders night market traders in Malaysia. If we compare the fuel consumption and battery power supply is used, 3S Generator is a tool for more effective innovation in everyday use. We can not ignore what 3S Generator can do in everyday life and even product innovation that have been created, it can have a good impact on the business community as well as small consumer group in the country. The human condition are now demanding products or equipment which do not cause any harm to the equipment user friendly and easy to use. Generator 3S With this, it can be used by all ages as realistic conditions is easy to carry and easy to operate and it does not cause any harm if it is not used. This means 3S Generator fuel is not exposed to the hazard. Therefore, these products meet all kretiria very safe product to use and able to reduce the cost of use and maintenance of close to 90%.

E12: The Effect of Electromagnetic Force (EMF) Radiation at Mobile Phone Base Station

Norhafniza Binti Mohamed[1], Rafidah Ab Aziz[2], Nur Azmiera Ariffin[3], Rohjihan Abd Jalil[4]
Institut Latihan Perindustrian Mersing (ILP) Johor

norhafniza.jtm@1govuc.gov.my[1]

Abstract

The aim of this research is to investigate the effect of electromagnetic force (EMF) radiation at mobile phone base station specifically towards the environment. Research was implemented on three mobile phone base stations around Johor. This research is concerned with the effect of electromagnetic force (EMF) radiation toward health issues and life expectancy on electrical and electronic equipment. Data for this research were collected from one set of questionnaire that related with thirty respondents health's background and their awareness about electromagnetic force (EMF) radiation. At the second part, the collected data were analyzed using the Statistic Package Social Science (SPSS) software to get the result. Beside that we also conducted an observation to survey on electrical and electronic equipment of life expectancy. These data prove that electromagnetic force (EMF) radiation at mobile phone base station does not affect human health as well as life span of electrical and electronic equipment.

Keywords: electromagnetic force (EMF), radiation, health, life expectancy of electrical and electronic equipment

1.0 Introduction

Nowadays, million peoples in the world using cell phone or smart phone as a communication tool. As this telecommunication technologies growth, the more mobile base station tower had been built to connect to a mobile phone. Mobile phone base stations are the nodes of mobile network. Every base stations provides a closely defined area – the radio cell – with reception. In Malaysia, nine network operators have acquired mobile communications licenses and they currently operates about 10,000 mobile phone base stations. These provides mobile communication services to some 42 million subscribers. Because of so many telecommunication towers erected, general public is more concerned about the radiation occur from the mobile phone base station rather than their mobile phones and/or devices. Besides, scientist worldwide also concerned about the potential health risks associated with the use of this device. Even small adverse effects on health could have major public health implications. Moreover, radio frequency is an abstract subject and is not easily understood by people. The term radiation often conjures fear and scare. A tremendous amount of publicity generated in the mass media has also caused great concern among members of the public. This research are focus on the survey of people involved with the mobile phone base station area in term of their health background and knowledge about safety of EMF exposure. Also the connection between the life expectancy of electrical and electronic equipment.

2.0 Background

Electromagnetic (EM) radiation is a form of energy that is all around us and takes many forms, such as radio waves, microwaves, X-rays and gamma rays. Sunlight is also a form of EM energy, but visible light is only a small portion of the EM spectrum, which contains a broad range of electromagnetic wavelengths. The electromagnetic force is a special force that affects everything in the universe because (like gravity) it has an infinite range. It has the ability to attract and repel charges. Since material in solid and liquid forms are made of charges having a unique order, they, too, may be manipulated by this force. It is also responsible for giving things strength, shape, and hardness. The electromagnetic force can be generated by three types of fields known as the electrostatic field, magnetostatic field, and the electromagnetic field. EM radiation is created when an atomic particle, such as an electron, is accelerated by an electric field, causing it to move.
The movement produces oscillating electric and magnetic fields, which travel at right angles to each other in a bundle of light energy called a photon. Photons travel in harmonic waves at the fastest speed possible in the universe: 186,282 miles per second (299,792,458 meters per second) in a vacuum, also known as the speed of light. The waves have certain characteristics, given as frequency, wavelength or energy [1]

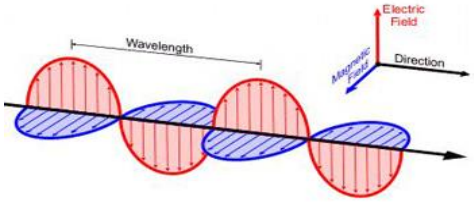


Figure 1: The Electromagnetic Waves

Figure 1 illustrates the electromagnetic are formed when electrical field (show in red arrows) couples with magnetic field (show in blue arrows) Magnetic and electric fields of an electromagnetic wave are perpendicular to each other and to the direction of the wave.

EM radiation spans an enormous range of wavelengths and frequencies. This range is known as the electromagnetic spectrum. The EM spectrum is generally divided into seven regions, in order of decreasing wavelength and increasing energy and frequency.

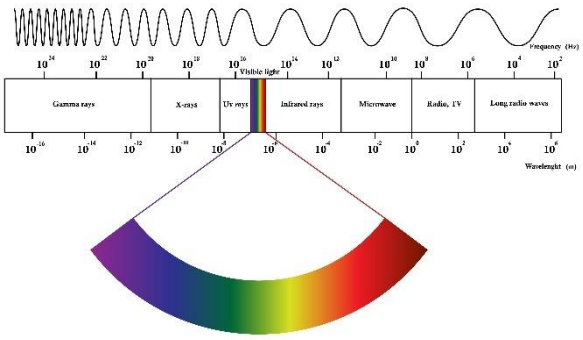


Figure 2: The Electromagnetic Spectrum

3.0 Radiation

Radiation is electromagnetic in nature, i.e., it consists of waves of electric and magnetic energy moving together through space at the speed of light. We live in a radiation world and are exposed to both natural and man-made radiation. Every second of our life, we are exposed to all forms of radiation such as ultraviolet light from the sun and radio waves from radio and television broadcasts. When we go for a chest x-ray examination, we are exposed to x-rays. There are two types of radiation i.e., ionizing and non-ionizing radiation. Ionizing radiation contains enough energy to cause ionization. Ionization is a process by which electrons are stripped from atoms and molecules. Its interaction with matter can change chemical reactions in the body that leads to damage in biological tissues including effects on DNA **(**deoxyribonucleic acid**)** – the genetic material. Gamma rays and x-rays are two forms of ionizing radiation. While Non-ionizing does not have sufficient energy to cause ionization in living matter. It causes some heating effect, but usually not enough to cause any kind of long-term damage to tissues. Radio frequency energy, visible light and microwave radiation are considered non-ionizing. For the same strength, ionizing radiation is more capable of causing health effects than non-ionizing radiation due to the ionization process.[2]

In this report, the respondent's data was collected at the area of mobile phone base station located at Jemaluang, Kota Tinggi and Johor Bahru. Mobile phone base stations are also known as base transceiver stations or telecommunications structures. They are low-power, multi-channel two-way radios. Antennas, which produce radio frequency radiation, are mounted on either transmission towers or roof-mounted structures. These structures need to be of a certain height in order to have a wider coverage. A mobile phone communicate to a nearby base station. From that base station the phone call goes into the regular fixed-line phone system [3].

4.0 Methodology

4.1 Study Population

A study was conducted among 30 respondents living near three selected mobile phone base stations in Johor. Among the respondents were 5 Telekom Malaysia workers involved directly with mobile phone base station maintenance. Other respondents were residents at the study sites.

The eligibility criteria included adult people of both sexes, living or working near a mobile phone base station and able to provide written or spoken informed consent. A total of 33 people were approached with 3 refusals mentioning lack of time and not interested in the study with a response rate of 91%.

Table 1: Number of Respondents According to Selected Mobile Phone Base Station

No of area	Location of Mobile Phone Base Station	Total of respondents
1	Mersing	12
2	Kota Tinggi	12
3	Jemaluang	6

4.2 Data Collection

Data were collected from in person interview using a structured questionnaire. The questionnaire was pretested in the fields and after necessary omission, addition and language editing, used for data collection. Data were collected on demographic characteristics, self-reported health problems, knowledge and awareness about the electromagnetic force (EMF) and the radiation effect towards health and electronics device.

Each respondents was asked if they noticed any recent changes of the following symptoms: headache, falling or dizzy when standing up, sexual problems, trouble eating well, sleeping problems, fainted, tiredness or fatigue. Respondents were also interviewed about the effectiveness using electrical and electronic equipment in their house. The respondents were informed regarding the objective of the study and that participating in the study is voluntary and confidential.

4.3 Data Analysis

The collected data were checked, edited and verified to exclude any error or inconsistency. Data was coded and entered into an excel sheet. Data editing and analysis were done manually and using specific statistical software SPSS.

5.0 Results

5.1 Sociodemographic Profile

Data was collected from adults aged 25 years and above. The mean age of the respondents was 35.2 years. Out of 30 respondents, the majority 14 (46.7%) was in the age group 31-35 years, 6 respondents (20%) were in 25–30 years age group, and the rest were in other age groups. Most of the respondents 11 (36.7%) reported to be working/ living in the current residence for 3–5 years duration. The mean duration of working/ living in current residence is 4.77 years. Most of respondents were married (83.3%) and 92% of them have children (Table 2).

Table 2: Sociodemographic characteristics of the (n = 30) respondents.

Variables	Number	Percentage
Male	19	63.3
Female	11	36.7
Age group (years)		
26 – 30	6	20.0
31 – 35	14	46.7
36 – 40	4	13.3
41 – 45	3	10.0
46 – 50	3	10.0
51 – 55	0	0.0
56 – 60	0	0.0
Duration of working/ living in current residence (years)		
0 – 2	7	23.3
3 – 5	11	36.7
6 – 8	8	26.7
≥ 9	4	13.3
Race		
Malay	23	76.7
Chinese	4	13.3
Indian	3	10.0
Marital Status		
Married	25	83.3
Unmarried	5	16.7
Number Of Children		
0	7	23.3
1 – 2	13	43.3
3 – 4	8	26.7
≥ 5	2	6.7

5.2 Self-reported Health Problems

During the past three weeks respondents experienced problems such as tiredness (33.33%), headache (20%), sexual problems (10%), sleeping problems (10%), eating problems (3.33%) and none of the respondents has fainted. However, these effects were not ruled out by taking personal history of any existing previous medical conditions or diseases (Figure 3).

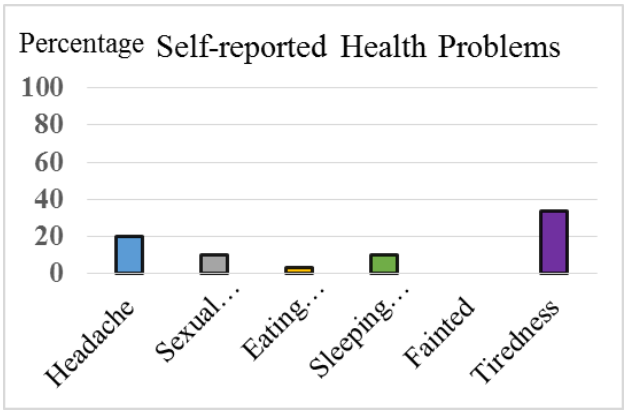


Figure 3: Self-reported Health Problems

5.3 Awareness and Knowledge of Electromagnetic Force (EMF) Radiation

Respondents demonstrated (51%) at minimum good level of EMF radiation awareness and (60%) at minimum good level of EMF radiation knowledge. Only (13%) has poor awareness towards EMF radiation and (30%) have poor knowledge of EMF radiation. The details of each level of awareness and knowledge are shown in Figure 4.

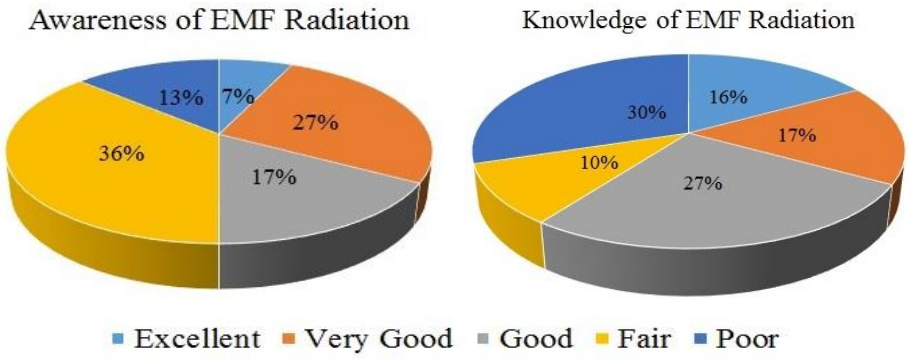


Figure 4: Awareness and Knowledge of Electromagnetic Force (EMF) Radiation

5.4 Electrical & Electronics Equipment Problems

From our study, 14 respondents were not face any problems with the electrical & electronic equipment while 16 respondents were experience problems on the electrical & electronic equipment such as virus attack their laptop, the performance of pc and smartphone is slow and hand phone battery weak after use.

6.0 Discussions

The results of our study shows that awareness and knowledge of EMF radiation is at very satisfactory level as almost half of the respondents had a minimum of "good" level of awareness and knowledge. Study also shows that less than one third of the respondents had health problems and about 30% had tiredness issues which is not consider as health problems. Respondents were selected from various types of occupation and background from an engineer to a housewife. The widespread usage of mobile phone in today's world has helped everybody to at least know the existence of radiation. Furthermore, 100% respondents verified that the functionality problems of their electronics devices are based on many factors of technical specification including electronic parts and common pc problems. The study shows that the life span of electronic devices were not affected by the radiation of electromagnetic force.

7.0 Conclusion

From the results of our study, we conclude that electromagnetic force (EMF) radiation at mobile phone base station does not affect human health as well as life span on electrical and electronic equipment. However, the health problems reported cannot be ignored and should be considered as a public health concern. For future study it is recommended to investigate and measure the frequency, distance and duration of exposure from mobile phone base station.

8.0 References

[1] Wayne Tomasi, "Electronic Communication Systems, Fundamentals Through Advanced", Fifth Edition, Prentice Hall, 2004

[2] William H.Hayrt, Jr, John A. Buck, "Engineering Electromagnetics", Seventh Edition, Mc Graw Hill Higher Education, 2006

[3] Professor Ng Kwan Hoong, "Radiation, Mobile Phones, Base Stations and Your Health", Malaysian Communications and Multimedia Commission, September 2003

[4 http://www.who.int/peh-emf/en/

[5] http://articles.mercola.com/sites/articles/archive/2011/02/16/raising-awareness-about-electromagnetic-pollution.aspx

E13: Sparring Kickboxing Machine

Nik Mohd Farid Bin Nik Hassan[1], Nasiruddin Bin Sadan[2]
Bahagian Teknologi Instrumentasi, Jabatan Elektrik & Elektronik
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

Nikmohdfarid@jtm.gov.my
Nasiruddin@jtm.gov.my

Abstract

Pada masa kini, sukan tinju (kickboxing) semakin mendapat sambutan di kalangan remaja Malaysia. Banyak sekolah telah menubuhkan kelab kickboxing untuk dijadikan sebahagian aktiviti kokurikulum pelajar. Di peringkat kebangsaan sukan kickboxing ini semakin berkembang pesat,dan mendapat tempat di mata dunia. Justeru itu, ***Sparring Kickboxing Machine*** *ini dicipta untuk membantu memudahkan lagi proses latihan tinju. Objektif utama pembangunan projek ini adalah bagi memudahkan seorang peninju berlatih mengelak serangan dari musuh dan meningkatkan daya fokus peninju terhadap jangkaan serangan yang akan diberikan oleh musuh. Dengan terciptanya projek ini, peninju boleh berlatih pada bila-bila masa tanpa memerlukan rakan tinju (sparring partner) yang lazimnya diperlukan dalam sesuatu latihan. Selain itu, terdapat 3 pilihan tahap serangan yang telah diprogramkan bagi aras kesukaran yang berbeza. Kelebihan utama mesin ini adalah ia mempunyai pilihan 3 mod kawalan samaada secara automatik, manual dan sistem kawalan menggunakan telefon pintar android.*

Keywords: *Kickboxing, Android, P.L.C, GSM Relay*

1.0 Pengenalan

Sukan tinju ataupun *Kickboxing* lazimnya dimainkan oleh 2 orang pemain dimana mereka berlawan tinju dan mengutip mata berdasarkan peraturan yang ditetapkan. Sukan ini tidak boleh dimainkan oleh seorang peserta dan ia haruslah berpasangan. Jadi begitu jugalah fenomenanya semasa sesi latihan. Peninju agak sukar untuk berlatih seorang diri untuk memantapkan lagi kemahiran dan teknik yang dipelajari. Justeru itu, mesin ini direka khas untuk membantu sesi latihan bagi seorang yang bergelar peninju. Mesin ini boleh mengambil alih tugas seorang rakan tinju *(sparring partner)* dengan menjalankan fungsi yang sama seperti seorang peninju. Selain dari membantu peninju dari segi menajamkan daya fokus, peninju juga boleh melakukan serangan balas *(counter-attack)* kerana terdapat 2 unit panel penahan yang dipasang pada mesin ini yang boleh menampung serangan yang diberikan oleh peninju.

Mesin ini digerakkan oleh sistem pneumatik yang bertindak sebagai mekanisma utama penggerak kepada *actuator cylinder* manakala turutan pergerakannya dikawal oleh Programmable Logic Controller (P.L.C) yang telah diprogramkan. Disamping itu, GSM Relay digunakan untuk mengawal pilihan tahap kesukaran serangan hanya dengan menggunakan telefon bimbit.

2.0 Objektif

Antara objektif utama perlaksanaan projek ini adalah:

i. Untuk membantu peninju berlatih tanpa rakan tinju *(sparring partner).*
ii. Untuk menajamkan daya fokus peninju terhadap serangan pihak lawan.
iii. Sebagai laithan fizikal bagi peninju melakukan serangan balas (*counter-attack*)

3.0 Metadologi Projek

3.1 Sistem dan Perkakasan

3.1.1 Sistem Pneumatik

Sistem pneumatik adalah sistem utama yang digunakan untuk menggerakkan mesin tinju ini. Ia terdiri daripada pemampat *(compressor)* yang bertindak untuk membekalkan angin mampat kepada sistem sehingga tekanan *6 Bar.*

Rajah 1: Pemampat mudah alih

Double Acting Cylinder pula digunakan sebagai mekanisma yang menyerupai lengan seorang peninju. Ia boleh keluar dan masuk daripada silinder apabila angin mampat dibekalkan kepadanya.

Rajah 2: Double Acting Cylinder

Pneumatic Valve adalah alat yang dingunakan untuk mengawal masukan dan keluaran angin kepada actuatpr cylinder. Apabila bekalan kuasa 24 V.dc diberikan kepadanya, injap akan terbuka dan angin akan dilepaskan kepada *actuator cylinder*.

Rajah 3: Pneumatic Valve

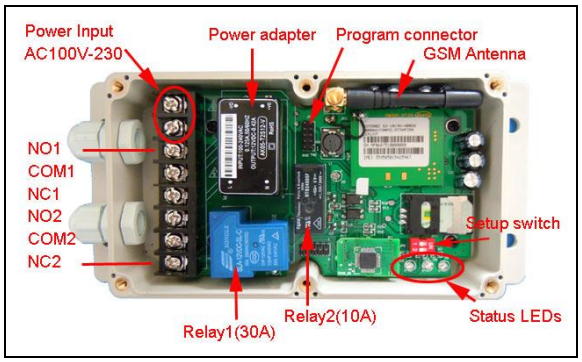
3.1.2 Programmable Logic Controller (P.L.C)

Programmable Logic Controller (P.L.C) digunakan sebagai pengawal bagi pergerakkan keluar masuk *actuator cylinder*. Turutan pergerakkan ketiga – tiga actuator cylinder telah diprogramkan ke dalam PLC menggunakan bahasa pengaturcaraan rajah tangga *(Ladder Diagram).* Dengan itu, pengguna tidak dapat menjangka tujahan yang akan dikeluarkan oleh *actuator cylinder* kerana tiga tahap serangan telah diprogramkan dimana setiap tahap mempunyai turutan dan tahap kelajuan yang berbeza.

Rajah 4: Programmable Logic Controller (P.L.C)

3.1.3 Global System for Mobile Communications (GSM) Relay

Global System for Mobile Communication (GSM) Relay adalah satu peranti yang boleh menghubungkan dengan telefon bimbit pengguna. Peranti ini dipasang pada projek ini untuk mengawal input bagi PLC. Sekiranya input diaktifkan dari jarak jauh menggunakan telefon bimbit, mesin akan beroperasi mengikut tahap pilihan input yang dipilih.



Rajah 5: Binaan dalaman GSM Relay

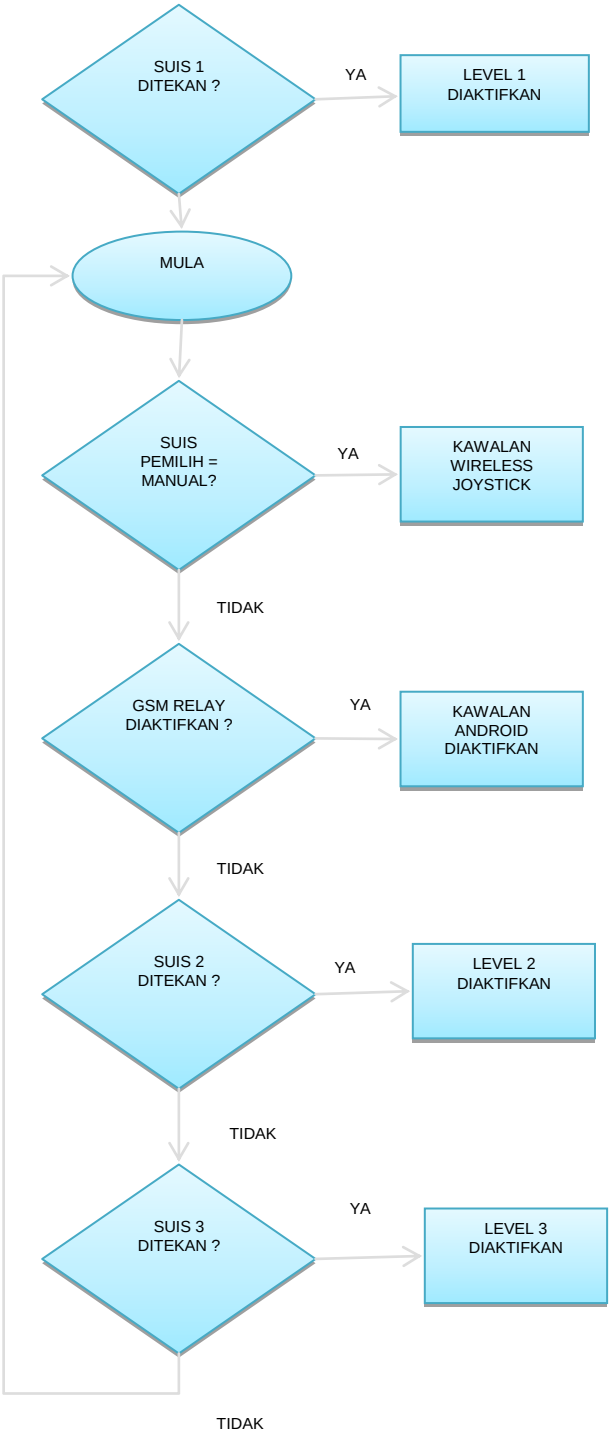
3.1.4 Wireless Joystick

Wireless Joystick digunakan bagi mod kawalan manual. Dengan ini, rakan tinju boleh berlawan dengan peninju tanpa menggunakan kekuatan fizikal. Mereka hanya perlu mengawal pergerakkan dengan menggunakan *joystick* sahaja. Oleh itu, sesiapa sahaja boleh berlawan dengan peninju walaupun tidak mempunyai kemahiran dan kekuatan fizikal.

Rajah 6: Wireless Joystick Transmitter dan Reciever Module

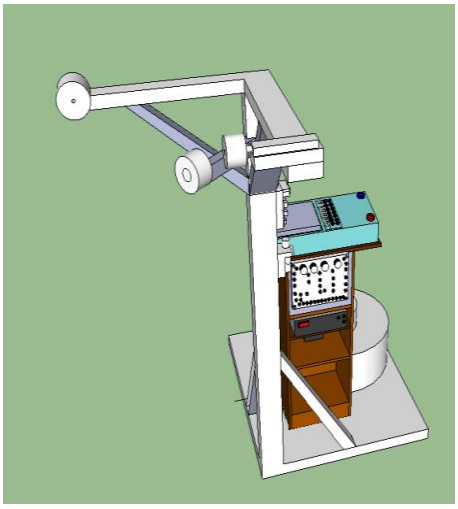
3.2 Prinsip Operasi

3.2.1 Carta Alir



Rajah 7: Gambarajah carta alir kendalian projek

3.2.3 Rekabentuk



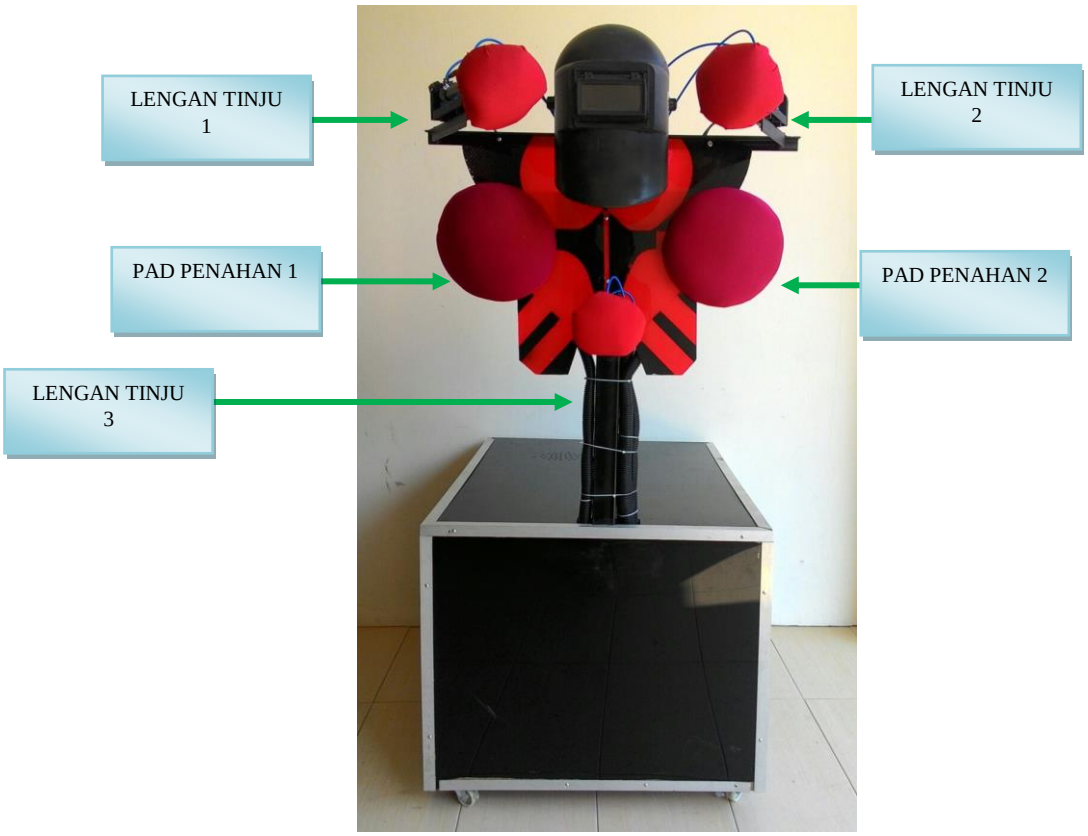
Rajah 8: Lakaran awal rekabentuk projek

4.0 Keputusan dan Analisis

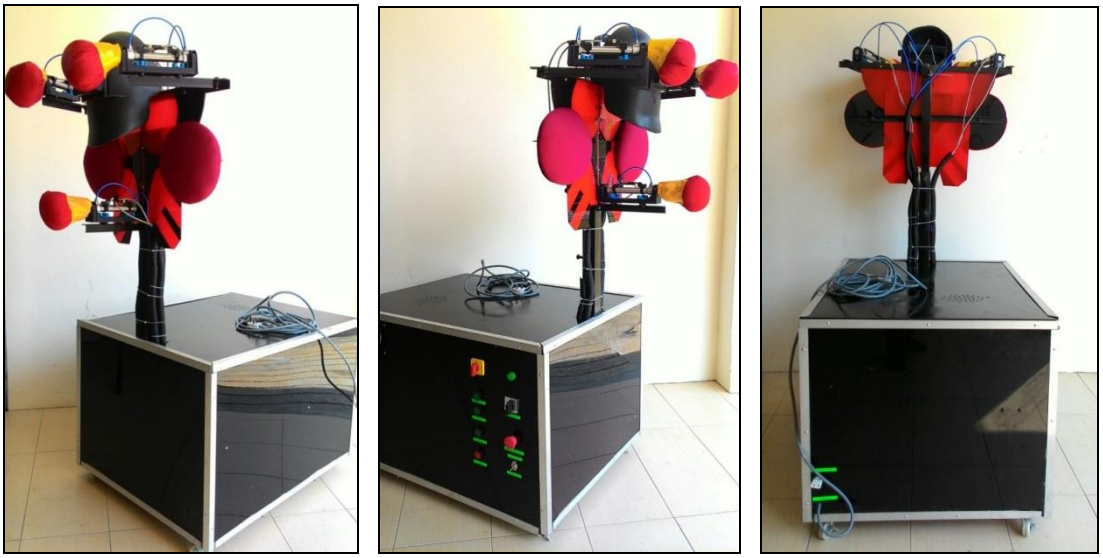
4.1 Mod Kawalan

1) Mod Automatik	- Untuk mod ini, 3 tahap serangan telah diprogramkan menggunakan PLC i. **Tahap 1** – pergerakkan 2 *actuator cylinder*, pergerakan dengan kelajuan perlahan ii. **Tahap 2** – pergerakkan 3 *actuator cylinder*, pergerakkan dengan kelajuan sederhana iii. **Tahap 3** – pergerakkan 3 *actuator cylinder*, pergerakkan dengan kelajuan tinggi
2) Mod Manual	- Untuk mod ini, rakan yang mengendalikan joystick bebas menbuat sebarang pergerakkan dengan menekan butang yang telah ditetapkan pada *joystick*
3) Mod Android	- Untuk mod ini, rakan tinju boleh memilih diantara 3 tahap serangan ini tanpa menekan butang pada mesin, kawalan hanya dilakukan menggunakan telefon pintar dengan aplikasi android.  **Rajah 9: Paparan aplikasi android**

4.2 Hasil Rekabentuk



Rajah 10: Gambar keseluruhan projek



Rajah 11: Pandangan sisi dan Pandangan belakang

4.3 Kelebihan projek

Projek ini sememangnya mempunyai banyak kelebihan yang amat berguna dan bermanafaat. Diantara kelebihan projek ini adalah:

i. Satu-satunya mesin yang dicipta untuk membantu latihan tinju dan belum ada mesin seumpama ini pernah dicipta.
ii. Sesiapa sahaja boleh manjadi rakan tinju walaupun tiada kemahiran dan kekuatan fizikal untuk bertinju.
iii. Mempunyai 3 pilihan tahap kesukaran serangan yang boleh dipilih.
iv. Menggunakan teknologi terkini dalam kawalan secara jarak jauh menggunakan android dan *wireless joystick.*

5.0 Kesimpulan

Secara keseluruhannya, objektif utama pembangunan projek ini tercapai. Dengan terciptanya mesin ini, ia benar-benar dapat membantu peninju dalam menjalankan latihan. Tahap daya fokus peninju juga dapat ditingkatkan apabila menggunakan mesin ini. Selain itu, aplikasi teknologi terkini juga membuatkan projek ini lebih bernilai komersil. Diharap dengan adanya projek ini, ia dapat digunakan untuk meningkatkan tahap pencapaian sukan tinju di Malaysia khususnya dan di dunia amnya.

6.0 Rujukan

[1] Advanced Microcontroller Corporation: **“ What is Programmable Logic Controller?”,** http://www.amci.com/tutorials/tutorials-what-is-programmable-logic-controller.asp

[2] Maximum Integrated: **“ Introduction to Programmable Logic Controller ”,**

http://www.maximintegrated.com/en/app-notes/index.mvp/id/4701

[3] “ Cytron Technology”, www.cytron.com.my

[4] “Home-Arduino”, www.arduino.cc/

[5] “What is pneumatic?”, http://www.nfpa.com/fluidpower/whatispneumatics.aspx

E14: Kesan Penggunaan Kit Pengujian Contactor dan Auxillary Contact terhadap Minat Pelajar sebagai Alat dan Bahan Bantuan Mengajar

Muslihah binti Saman [1], Mohd Hisham bin Abd Jalil [2], Mohd J Sen bin Alias[3], Kamaruddin bin Masri@Shaárani [4]

Institut Latihan Perindustrian Pasir Gudang, Johor

Abstrak

Kursus Elektrik yang dijalankan dibawah Institut Latihan Kemahiran Awam dan Swasta merupakan salah satu bidang yang banyak menyumbang kepada tenaga mahir berkompetenan tinggi seiring dengan matlamat dan keperluan negara. Kursus ini turut dilengkapi dengan Sijil Kemahiran Malaysia (SKM), Sijil Kekompetenan Voltan Rendah dan Voltan Tinggi yang dikeluarkan oleh Suruhanjaya Tenaga (ST). Modul Kawalan Motor Elektrik Satu Fasa dan Tiga Fasa merupakan salah satu modul yang menjadi syarat bagi melayakkan seseorang mendapat sijil SKM dan sijil ST [1]. Modul ini melibatkan penggunaan 'contactor' dan 'auxillary contact' sebagai komponen utama yang bertindak sebagai suis penghidup sesebuah motor elektrik. Matlamat utama projek ini dibangunkan adalah untuk mendorong pelajar supaya lebih berminat untuk membuat pengujian melalui alat dan bahan bantuan mengajar (ABBM) yang dinamakan ***Kit Pengujian Contactor dan Auxillary Contact*** *dengan cara yang lebih pantas dan amat mudah, hanya dengan menekan sebuah suis ujian keterusan terhadap* ***'coil', litar pengeluaran (T1, T2 dan T3)*** *termasuk* ***semua 'contact normally open dan normally closed'*** *melalui LED yang dipasang dapat diketahui. Pengujian secara konvensional menggunakan multimeter agak menyukarkan dan memakan masa yang panjang. Keadaan ini menjadi punca pelajar mengabaikan kerja-kerja pengujian, malah masalah renjatan elektrik akibat menggunakan komponen rosak dan tidak selamat boleh berlaku [2]. Projek ini telah disahkan keberkesanannya oleh pakar elektrik dari kalangan pengajar berkompeten dan jurutera yang telah menggunakannya.*

Kata Kunci : *contactor, auxillary contact, motor, multimeter, ujian keterusan.*

1.0 Pengenalan

Penggunaan alat dan bahan bantuan mengajar (ABBM) yang sesuai amat penting terutamanya matapelajaran teknikal. Pembelajaran teknikal khususnya jurusan kejuruteraan seperti bidang elektrik dijalankan secara praktikal, penggunaan simulasi, h*ands-on*, projek, kaedah penyelesaian masalah dan contoh penyelesaian yang banyak adalah penting untuk meningkatkan pemahaman dan pengalaman pelajar (Mok, 2000). Terdapat pelbagai cara yang digunakan oleh setiap pensyarah untuk menghasilkan satu proses pengajaran dan pembelajaran yang berkesan. Salah satu cara yang amat penting adalah melalui ABBM. ABBM boleh menimbulkan rangsangan dan keinginan pelajar untuk mengetahui dan mengaplikasi sesuatu pelajaran dengan kaedah yang lebih menarik, mudah dan berkesan.

Modul Kawalan Motor Elektrik adalah bermatlamat untuk memperkukuh dan mengembangkan pengetahuan, pemahaman, pengaplikasian serta menganalisis teori dan terampil dalam bidang amali kawalan motor elektrik satu fasa dan tiga fasa. Ia merangkumi konsep asas kawalan motor, fungsi kawalan motor, jenis-jenis kawalan motor, alat pandu, komponen kawalan, litar-litar kawalan motor, pemula voltan penuh dan kurangan, penyenggaraan dan pembaikan [3]. Melalui matapelajaran ini pelajar dapat mengaplikasi pengetahuan dan kemahiran kawalan motor a.u satu fasa dan tiga fasa dalam bidang elektrik dan elektronik dan menganalisis dan merancang keperluan pendidikan menggunakan pengetahuan kemahiran dalam proses merekacipta projek. Selain daripada itu, pelajar akan berkebolehan mengembangkan dan memahami litar-litar kawalan motor elektrik, menyambung, memasang dan mengujilari pemula-pemula kawalan motor serta berkemahiran menyenggara dan membaiki kerosakan pemula-pemula motor satu fasa dan tiga fasa.

1.1 Pernyataan Masalah

Pengujian atau pemeriksaan terhadap peralatan dan komponen elektrik yang terlibat dalam pendawaian motor elektrik amat dititikberatkan kepada semua pendawai sebelum ia digunakan. Namun begitu aspek keselamatan ini telah diabaikan oleh hampir semua pelajar. Pengkaji mendapati, pelajar hanya menguji *contactor* dan *auxillary contact* apabila motor elektrik yang telah siap di pasang tidak berfungsi atau rosak. Punca-punca masalah mengapa pelajar mengabaikan kerja-kerja pengujian komponen ini sebelum digunakan adalah seperti dibawah :

a) Kaedah pengujian agak rumit.
b) Kaedah pengujian memakan masa yang panjang.
c) Kaedah pengujian kurang berkesan berikutan hasil pengujian yang tidak dapat diketahui dengan jelas.
d) Pelajar kurang berminat kerana kaedah pengujian kurang interaktif.

Masalah ini telah mendapat perhatian dan mendorong pengkaji untuk mencipta ABMM yang dinamakan **Kit Pengujian *Contactor* dan *Auxillary Contact***. Pendawaian yang melibatkan lebih dari satu motor akan melibatkan lebih banyak *contactor* dan *auxillary contact*, maka proses pengujian menggunakan multimeter akan mengambil masa yang lebih panjang. Justeru, pembangunan kit pengujian yang mampu menarik minat pelajar dan dapat memudahkan kaedah pengujian terhadap komponen tersebut adalah wajar dibina bagi membantu proses pengajaran dan pembelajaran bagi mata pelajaran kawalan motor elektrik.

1.2 Objektif Kajian

Kajian ini dijalankan adalah untuk membangunkan Kit Pengujian *Contactor* dan *Auxillary Contact* sebagai ABMM adalah untuk menarik minat pelajar untuk menguji komponen tersebut sebelum membuat pendawaian agar aspek keselamatan seperti renjatan elektrik dapat dielakkan akibat menggunakan komponen yang rosak. Objektif utama kajian adalah seperti dibawah :

a) Mengenalpasti kelemahan pelajar terhadap konsep pengujian keterusan terhadap *Contactor* dan *Auxillary Contact* dalam Modul Kawalan Motor Elektrik.
b) Membangunkan Kit Pengajaran berbentuk suatu alat pengujian terhadap *Contactor* dan *Auxillary Contact* sebagai ABMM.
c) Menguji kebolehgunaan, kebolehfungsian dan rekabentuk alat penguji.

2.0 Metodologi Kajian

Kaedah kajian dilakukan menggunakan dua kaedah iaitu **kajian serta analisis dan kajiselidik**. Kajiselidik pertama dilakukan bersama pelajar di Bengkel Elektrik ILP Pasir Gudang yang terdiri dari pelajar lepasan SPM dan pelajar separuh masa yang telah bekerja sebagai juruteknik, penyelia dan jurutera dari kawasan Pasir Gudang.

2.1 Perlaksanaan keseluruhan kajian

Fasa pertama bagi menjalankan kajian ini ialah mencari dan mengumpul maklumat daripada pelbagai sumber termasuklah buku, jurnal, laman web, tesis dan artikel. Setiap sumber dianalisis dengan teliti dan permasalahan dapat dikenalpasti. Pengkaji telah menjalankan temu bual tidak berstruktur bagi mengenalpasti punca masalah sebenar. Fasa kedua dalam perlaksanaan kajian ini adalah merekabentuk ABMM. Pengkaji menggunakan Model ADDIE sebagai panduan dalam merekabentuk kit pengajaran tersebut. Segala maklumat yang telah dianalisis daripada fasa pertama digunakan oleh pengkaji untuk menjana idea bagi merekabentuk kit pengajaran yang mempunyai ciri-ciri yang dapat membantu proses pengajaran dan pembelajaran dengan lebih berkesan.

Langkah seterusnya adalah mengenalpasti dan menyenarai semua keperluan bagi membangunkan kit tersebut. Lakaran projek termasuk rekabentuk litar untuk menguji semua *normally open contact* dan *normally closed contact* haruslah dilakukan untuk memberi gambaran jelas tentang rekabentuk kit pengajaran yang dibangunkan. Setelah mendapat rekabentuk yang sesuai, proses pembinaan kit tersebut dijalankan.

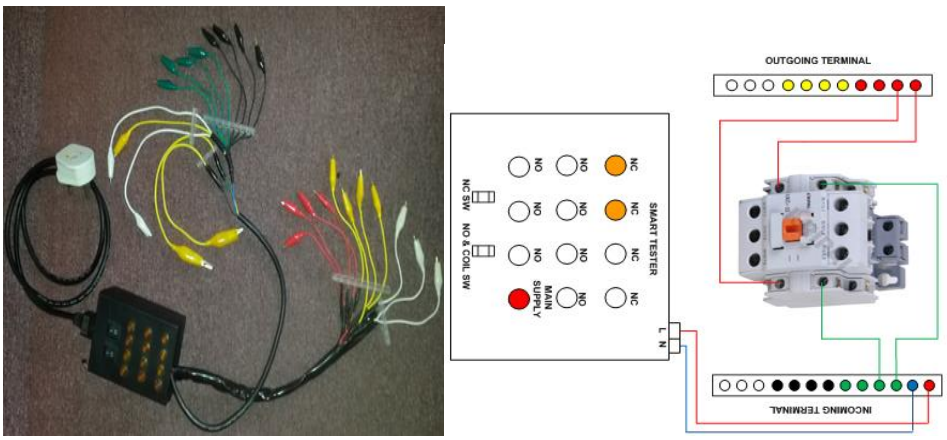
Setelah kit dibina dan diuji fungsinya, langkah seterusnya ialah membangunkan prosedur latihan kepada pelajar supaya mereka dapat menggunakan kit tersebut dengan mudah dan betul. Fasa ketiga dimana pengkaji telah menguji dan menilai keberkesanan kit pengajaran tersebut terhadap pelajar seperti yang telah dinyatakan dalam persampelan dan populasi di dalam bab ini. Kaedah yang digunakan adalah kaedah tinjauan untuk mendapatkan maklumbalas dari pelajar termasuk pengajar berkompeten tinggi.

2.2 Pelaksanaan Kit Alat Pengujian *Contactor* dan *Auxillary Contact*

Cara pelaksanaan adalah bermula dengan penerangan pensyarah terhadap kepentingan membuat pengujian keterusan terhadap semua contactor dan auxillary contactor sebelum membuat pemasangan. Proses pengujian pada mulanya dilakukan secara konvensional menggunakan multimeter. Semua contact NO dan NC diuji keterusannya. Seterusnya pengajar memperkenalkan kit pengajaran yang dicipta. Pensyarah menguji keseluruhan contactor dan auxillary contact dan hasil ujian keterusan bagi semua contact NO dan NC dapat dilihat melalui 'indicator PENGUJI' dengan jelas. Sekiranya salah satu contact rosak, indicator tersebut tidak ON. Kaedah pengujian menggunakan ABMM akan diterangkan kepada pelajar dengan tujuan menarik minat pelajar supaya sentiasa membuat pengujian untuk mematuhi aspek keselamatan pelajar yang membuat pendawaian motor elektrik 3 fasa.

3.0 Keputusan dan perbincangan

Rekabentuk produk yang dihasilkan adalah ringkas, namun idea untuk menarik minat pelajar untuk membuat pengujian sebelum menggunakan komponen tersebut telah mendapat sambutan yang amat menggalakkan. Gambar sebenar produk yang siap di ujicuba sebagai ABBM beserta buku panduan pengguna telah diberi pengiktirafan oleh jabatan seperti rajah 1.



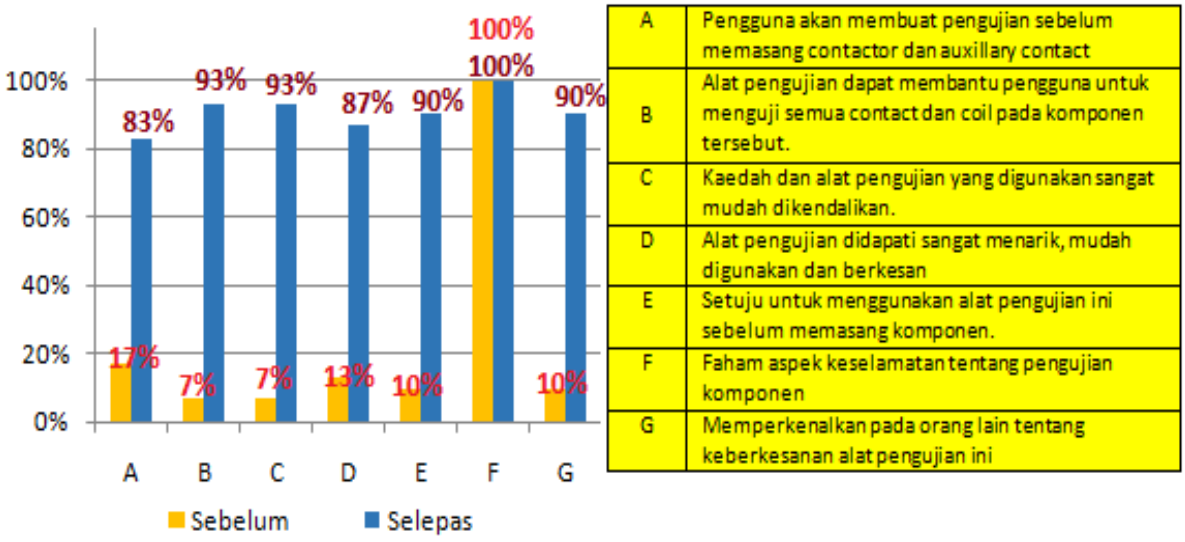
Rajah 1 : Kit Pengujian beserta Manual Panduan Pengguna

Beberapa analisis data telah dibuat melalui 30 sampel berbentuk borang soal selidik yang melibatkan responden dari golongan pelajar dan pengajar di Bengkel Elektrik. Kajiselidik keberkesanan projek telah diambil sebelum dan selepas projek dihasilkan dan perbandingan terhadap keputusan kajian telah menunjukkan hasil yang positif.

Hasil kajian mendapati, sebanyak 90% responden berpuas hati dan bersetuju untuk menggunakan Kit Pengajaran yang dicipta sebagai alat uji berbanding kaedah konvensional. Manakala ABBM ini juga diakui mudah digunakan dan dapat menarik minat responden untuk menggunakannya memandangkan peratusan hasil kajian dalam Rajah 2 adalah amat memberangsangkan.

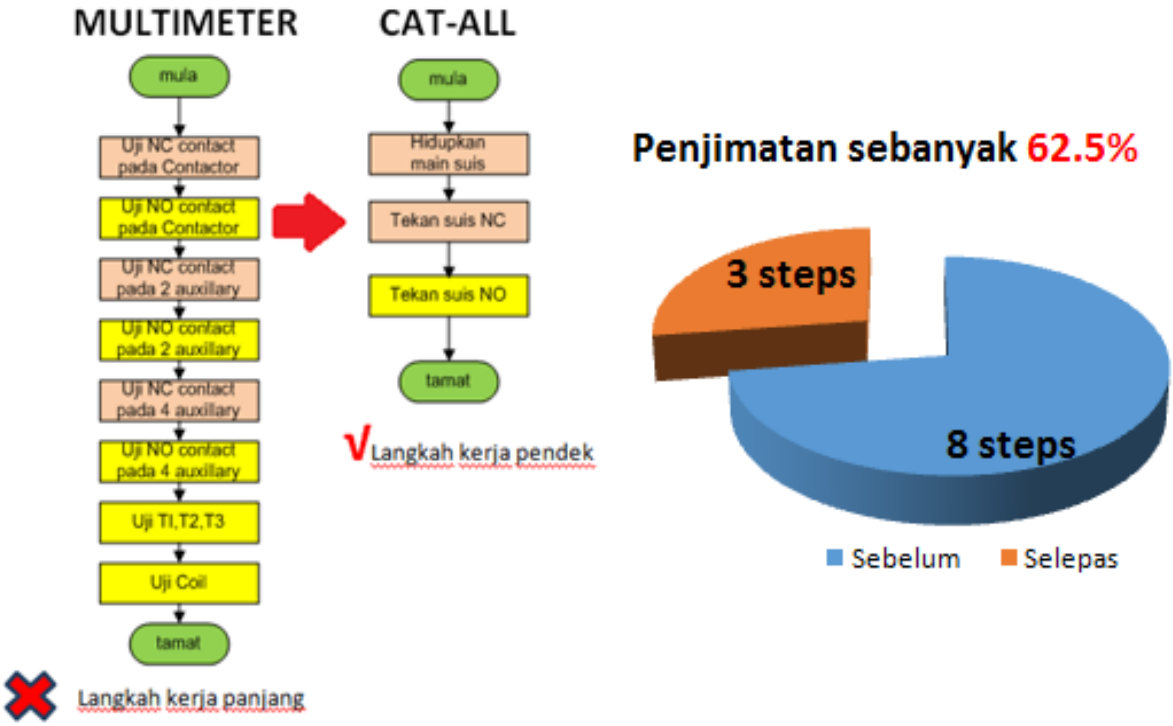
Jadual 1: Keputusan kajiselidik sebelum dan selepas penggunaan ABMM

BIL	Isu	Keputusan		Keputusan (%)	
		Sebelum	Selepas	Sebelum	Selepas
1	Pengguna akan membuat pengujian sebelum memasang contactor dan auxillary contact	5	25	17%	83%
2	Alat pengujian dapat membantu pengguna untuk menguji semua contact dan coil pada komponen tersebut.	2	28	7%	93%
3	Kaedah dan alat pengujian yang digunakan sangat mudah dikendalikan.	2	28	7%	93%
4	Alat pengujian didapati sangat menarik, mudah digunakan dan berkesan	4	26	13%	87%
5	Setuju untuk menggunakan alat pengujian ini sebelum memasang komponen.	3	27	10%	90%
6	Faham aspek keselamatan tentang pengujian komponen	30	30	100%	100%
7	Memperkenalkan pada orang lain tentang keberkesanan alat pengujian ini	3	27	10%	90%



Rajah 2 : Graf perbandingan sebelum dan selepas penggunaan ABBM

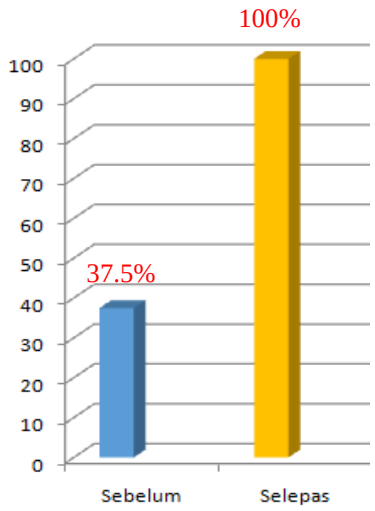
Sebanyak 93% responden berpendapat bahawa kaedah dan alat pengujian yang dicipta amat mudah dikendalikan. Manakala perincian keputusan dari aspek penjimatan masa sebanyak 62.5% dapat dibuktikan melalui carta alir dan carta pai dalam Rajah 3.



Rajah 3 : Carta Alir dan Carta Pai Perbandingan Langkah Kerja

Rajah 4 menunjukkan keputusan ujian keterusan menggunakan ABBM adalah 100%, manakala hanya 37.5% sahaja yang dapat dilakukan melalui kaedah sedia ada.

MULTIMETER	ABBM
√ NC pada contactor	√NC pada contactor
✖ NO pada contactor	√NO pada contactor
√ NC pada 2 auxillary	√NC pada2 auxillary
✖ NOpada 2 auxillary	√NOpada2 auxillary
√ NC pada 4 auxillary	√NC pada 4 auxillary
✖ NO pada 4 auxillary	√NO pada 4 auxillary
✖ Litar pengeluaran (T1,T2, T3)	√Litar Pengeluaran (T1, T2, T3)
✖ ACTIVATE COIL	√ACTIVATE COIL
3/8 * 100 = 37.5	**8/8 * 100 = 100%**



Rajah 4 : Keputusan terhadap Meningkatkan jumlah pengujian keterusan terhadap semua *contact*

4.0 Kesimpulan

Kajian ini telah membuktikan bahawa penggunaan Kit Pengujian *Contactor* dan *Auxillary Contact* memberikan kesan yang positif terhadap pencapaian pelajar di dalam modul Kawalan Motor Elektrik. Selain daripada itu, kajian ini juga menerapkan dua aspek utama iaitu pengetahuan konseptual iaitu teori dan pembelajaran melalui pengalaman iaitu latihan praktikal. Projek ini secara tidak langsung mampu menyelesaikan masalah didalam membuat pengujian keterusan dengan lebih cepat dan efisyen.

Produk ini telah dipertandingkan pada 25hb Febuari 2014 diperingkat jabatan dan mendapat **JOHAN** kategori teknikal. Pencapaian pingat **PERAK dalam Pertandingan CITEC** peringkat ILJTM di ILP Kuala Lumpur tahun lepas juga membuktikan produk ini boleh dipasarkan. Untuk meneruskan cabaran inovasi, kami telah membuat penyeragaman prosedur pengujian *contactor dan auxillary contact* kepada semua pelajar di ILP Pasir Gudang khususnya di Bengkel Elektrik, Penjaga Elektrik Voltan Rendah A0 dan Kebanyakan Bengkel lain seperti Bengkel Mekanik Industri, Elektronik Industri, Instrument Perindustrian yang kebanyakkannya membuat pendawaian motor menggunakan contactor dan auxillary dan seterusnya diseragamkan di seluruh ILJTM diseluruh Malaysia. Dengan sokongan pihak pengurusan, kami akan meneruskan usaha bagi membantu pelajar-pelajar untuk terus menambah baik sehingga mampu dipatenkan. Insyaallah.

Kesimpulan dari hasil analisis dan perbincangan yang dibuat, jelaslah bahawa pelajar memperakui penggunaan ABBM tersebut dapat membantu dan menarik minat mereka untuk membuat pengujian keterusan sebelum membuat pendawaian, Selain itu projek ini turut memberi impak kepada bahagian pengurusan dalam menjimatkan kos bahanguna habis untuk membeli bahan dan peralatan latihan berbentuk alat bantuan mengajar. Kit ini telah diperakui keberkesanannya oleh pengajar dan pekerja mahir yang mempunyai berkompeten tinggi yang telahpun menggunakannya.

5.0 Rujukan

[1] Buku Garis Panduan Pendawaian Elektrik Suruhanjaya Tenaga, Edisi 2008, pp 41-43.

[2] Standard MS IEC 60364:2003 ‘Electrical Installation of Building – Guide to MS IEC 60364.

[3] Gagne, P, Holt, Rinehart dan Winston (1976) The Condition of Learning. NY. Ibrahim Mamat (1993). Kepimpinan Sekolah : Teori dan Praktis. Kuala Lumpur : Kumpulan Budiman Sdn. Bhd.

[4] Yahya b. Emat (1984). Kawalan Motor Elektrik : Kuala Lumpur : Adabi Sdn. Bhd.

[5] Saharudin Busri (2009). Definisi dan Penghasilan Reka Bentuk. Reka Menjana Inovasi (1). Ms 3

[6] Contactor Testing by Using PLC – Research Public Journals. Retrieved on 27th April 2015 on www.researchpublish.com

[7] The Basic of Contactors, Paul Frank, PRIMEDIA Workplace Learning (1999). Retrieved on 7th Mei 2015

[8] Journal of Engineering Technology (JET), Vol. 2

E15: Home Integrated System for Surveillances and Automation using NFC Technology

Nasiruddin Bin Sadan[1], Mohd Affidi Bin Sidek[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Kemaman, Terengganu

nasiruddin@jtm.gov.my
affidi.sidek@jtm.gov.my

Abstrak

Dewasa ini, perkembangan teknologi semakin pesat dengan tercetusnya idea dan ciptaan yang dihasilkan. Namun tidak dinafikan, dengan kemajuan teknologi ini manusia juga semakin hilang pertimbangan diri, jenayah semakin meningkat dan antaranya adalah jenayah pecah rumah. Justeru itu, projek ini dibangunkan untuk mengawal kejadian ini daripada berleluasa. Sistem pengawasan ini menggunakan litar kawalan kamera yang berupaya merakam pergerakan objek yang kemudiannya akan dihantar terus kepada telefon bimbit pengguna untuk makluman dan tindakan selanjutnya. Apabila menerima imej, pengguna boleh bertindak untuk mengaktifkan penggera, menghidupkan lampu atau mengaktifkan 'autolock door'. Selain dari tujuan pemantauan, sistem bersepadu ini adalah gabungan bersama kawalan automasi iaitu satu ciri-ciri yang biasa ada bagi rumah pintar (Smarthome). Sistem automasi ini membolehkan pengguna mengawal kelengkapan rumah seperti mengawal perkakasan elektrik sekiranya pengguna tiada dirumah hanya dengan mengimbas pada Near Field Communication (NFC) tag menggunakan telefon bimbit. NFC adalah teknologi terkini dimana setiap data atau maklumat disimpan didalam tag dan pengguna boleh mengaktifkan atau menyahaktifkan arahan yang diperlukan hanya dengan sekali imbasan tag pada NFC reader ataupun menggunakan telefon bimbit yang dilengkapi dengan fungsi NFC. Dengan terhasilnya projek ini, sistem pemantauan rumah dapat dilakukan dengan lebih efisen disamping dapat mewujudkan satu sistem kawalan rumah yang pintar.

***Kata Kunci** : Near Field Communication (NFC), Surveillances, Automation*

1.0 Pengenalan

Menjelang tahun 2020, Negara kita kini sedang menuju untuk mencapai status sebuah negara maju, seiring dengan itu, kemajuan teknologi dan inovasi menjadi antara tonggak utama negara demi mencapai wawasan tersebut. Namun tidak dinafikan, manusia kini juga semakin hilang nilai-nilai kemanusian. Jenayah semakin berleluasa, tanpa mengira waktu, tempat dan mangsanya. Saban hari kita dikejutkan dengan kejadian-kejadian jenayah di media elektronik dan media cetak. Kita semakin hari merasakan semakin tidak selamat. Malahan berada dalam rumah sendiri pun belum menjamin keselamatan kerana dengan adanya jenayah samun, pecah rumah dan seumpamanya. Menurut statistik yang dikeluarkan oleh Polis Diraja Malaysia di antara tahun 2005 hingga 2013 seperti jadual 1 di bawah, jenayah pecah rumah adalah penyumbang kes yang tertinggi dicatatkan untuk sepanjang tempoh tersebut.

Jadual 1: Statistik indeks jenayah di Malaysia bagi tahun 2005 – 2013

KESALAHAN	TAHUN 2005	TAHUN 2006	TAHUN 2007	TAHUN 2008	TAHUN 2009	TAHUN 2010	TAHUN 2011	TAHUN 2012	TAHUN 2013	JA
JENAYAH KEKERASAN :										
BUNUH	497	606	590	654	601	568	530	602	627	
ROGOL	1,887	2,454	3,176	3,494	3,840	3,693	3,270	2,964	2,718	
SAMUN BERKAWAN BERS/API	40	67	75	182	815	1,809	318	110	98	
SAMUN BERKAWAN TANPA BERS/API	1,842	2,723	7,093	21,804	23,722	15,809	16,084	16,738	16,647	
SAMUN BERSENJATAPI	317	248	197	76	155	309	52	17	21	
SAMUN TANPA S/API	13,210	19,467	17,235	4,959	4,862	3,834	3,871	3,275	3,565	
MENCEDERAKAN	4,246	5,843	6,793	6,648	8,370	8,111	6,537	6,244	5,699	
JUMLAH	**22,039**	**31,408**	**35,159**	**37,817**	**42,365**	**34,133**	**30,662**	**29,950**	**29,375**	
JENAYAH HARTABENDA :										
CURI	34,317	42,472	44,646	41,215	40,864	36,406	30,502	24,299	21,405	
CURI MOTOKAR	9,711	11,154	12,428	15,198	14,222	15,290	16,110	16,196	16,733	
CURI MOTOSIKAL	51,709	65,462	67,606	67,359	61,394	54,557	50,896	51,259	49,133	
CURI VAN/LORI/J'BERAT	5,507	6,338	5,047	6,263	5,524	4,774	4,472	4,526	4,981	
CURI RAGUT	9,617	11,074	11,106	8,205	9,739	5,950	3,453	2,500	2,118	
PECAH RUMAH DAN CURI	24,465	28,872	33,590	35,588	38,570	35,052	30,200	24,939	23,317	
JUMLAH	**135,326**	**165,372**	**174,423**	**173,828**	**170,313**	**152,029**	**135,633**	**123,719**	**117,687**	
JUMLAH JENAYAH INDEKS	**157,365**	**196,780**	**209,582**	**211,645**	**212,678**	**186,162**	**166,295**	**153,669**	**147,062**	

Justeru itu, sebagai salah satu langkah mengatasi masalah ini, satu projek inovasi telah dicipta khusus untuk membantu meningkatkan kawalan keselamatan terhadap rumah kediaman. Disamping itu, projek ini juga mempunyai dwi-fungsi yang utama kerana selain bertujuan untuk sistem pemantauan rumah, ia dilengkali dengan sistem automasi yang menghubungkan peralatan rumah seperti lampu, kipas dan peralatan elektrik dimana pengguna boleh mengaktifan pada bila-bila masa dan dimana jua dengan menggunakan *Near Field Communication (NFC) t*ag ataupun telefon pintar.

NFC merupakan satu teknologi terkini dimana ia adalah perkongsian data antara medium aktif dan medium pasif. Dengan itu, komunikasi akan berlaku ialah diantara peranti pintar seperti telefon pintar (medium aktif) dan medium seperti kad ataupun tag (medium pasif) apabila sistem ini diaktifkan. Selain itu, antara kegunaan lain teknologi NFC adalah seperti berikut:

i. Pembayaran Mobile *(e-wallet)*
ii. Perkongsian data tanpa wayar (wireless)
iii. NFC tag
iv. Mendapatkan informasi
v. Transit dan Boarding Pass

2.0 Objektif

Antara objektif utama perlaksanaan projek ini adalah:

i. Untuk meningkatkan sistem keselamatan dirumah dengan sistem kawalan kamera litar tertutup yang mengesan kehadiran penceroboh
ii. Untuk tindakan susulan sekiranya berlaku kecurian seperti mengaktifkan sistem kunci automatik.
iii. Sebagai sistem kawalan automasi bagi peralatan rumah
iv. Sebagai aplikasi bagi teknologi *Near Field Communication* yang terkini
v. Untuk memudahkan urusan seharian manusia

3.0 Metadologi Projek

3.1 Sistem dan Perkakasan

3.1.1 Wireless IP Camera

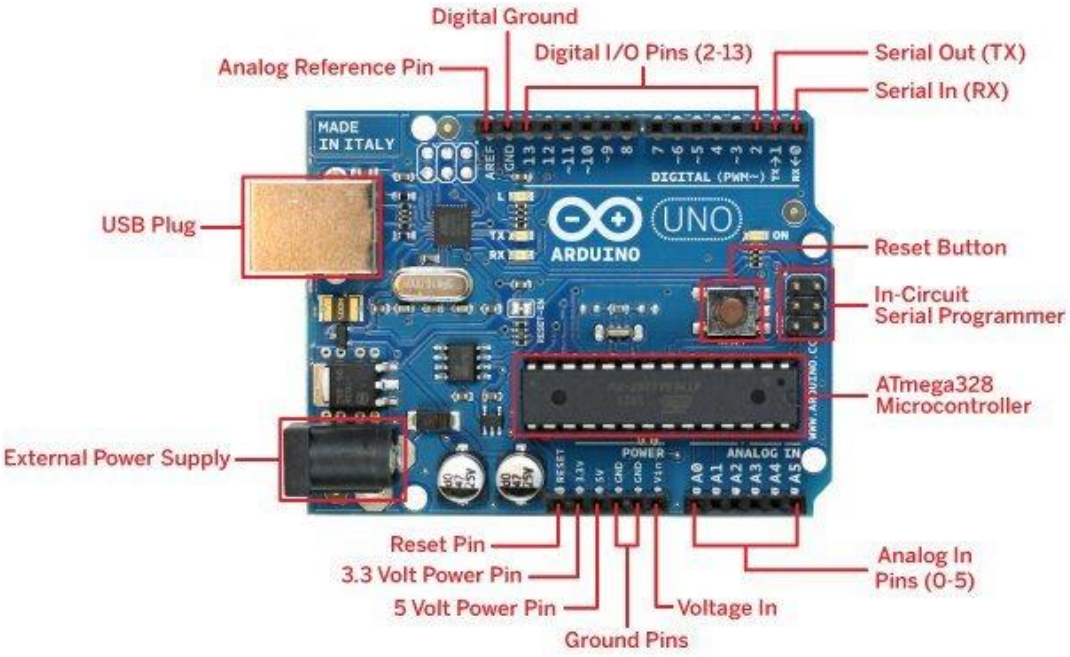
Wireless IP Camera mereupakan peranti utama yang digunakan sebagai sistem pemantauan bagi projek ini. Kamera litar tertutup ini dilengkapi dengan sistem pengesan pergerakan (motion sensor) yang akan diaktifkan apabila mengesan kehadiran objek bergerak seperti pencuri atau penceroboh. Kamera ini akan disambungkan dalam satu rangkaian internet dan gambar imej yang dirakam akan dihantar terus kepada telefon bimbit pemilik untuk maklumat dan tindakan selanjutnya.

Rajah 1: FOSCAM Wireless IP Camera

Rajah 2: Konfigurasi bagi penyambungan IP Camera

3.1.2 Arduino Board

Arduino Board merupakan papan pembangunan *(development board)* yang menggunakan mikropengawal jenis ATMEGA sebagai peranti utama pengawalnya. Modul ini dilengkapi dengan sebahagian pin input dan output yang boleh digunakan untuk mengawal litar keluaran yang lain berdasarkan aplikasi tertentu.



Rajah 3: Papan pembangunan Arduino

Spesifikasi:

Microcontroller :	ATmega328
Operating Voltage :	5V
Input Voltage :	7-12V
Input Voltage (limits) :	6-20V
Digital I/O Pins :	14 (of which 6 provide PWM output)
Analog Input Pins :	6
DC Current per I/O Pin :	40 mA
Clock Speed :	16 MHz

3.1.3 NFC Shield

Near Field Communication (NFC) shield merupakan satu peranti tambahan yang disambungkan kepada papan pembangunan Arduino. Fungsi utama *NFC shield* ini adalah untuk mengesan *NFC tag* sekiranya diimbas pada permukaan shield tersebut. Setiap tag yang berbeza akan menghantar isyarat data yang berbeza. Data ini digunakan sebagai input bagi mengawal sistem automasi seperti menghidupkan dan mematikan lampu atau peralatan elektrik yang lain.

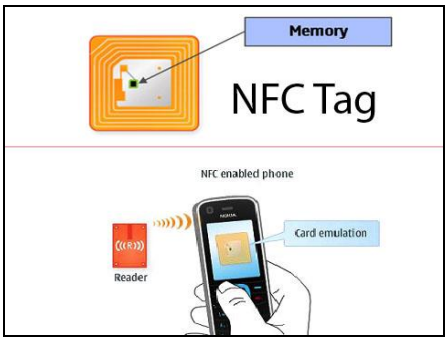
Rajah 4: Near Field Communication (NFC) Shield

3.1.4 NFC Tag

Dengan menggunakan NFC tag, kitaran penghantaran data yang berlaku adalah seperti berikut:

- Kad yang mempunyai cip memori NFC (kad ini juga dikenali sebagai NFC Tag ataupun NFC Smart Poster) merupakan kad yang dikuasakan oleh medan magnet. Ia tidak memerlukan sebagai bateri untuk menggerakkan operasinya. Bergantung kepada jenis memorinya sama ada data di dalamnya boleh dipadamkan/ditulis semula atau tidak.
- Peranti pintar yang merupakan medium aktif akan memancarkan gelombang radio untuk berkomunikasi dengan NFC Tag. Gelombang yang dipancarkan akan mengaktifkan NFC Tag tersebut.
- NFC Tag yang menerima gelombang radio itu akan berinteraksi dengan peranti pintar dan seterusnya menghantar data yang diminta oleh peranti pintar.

Ciri-ciri berkenaan ialah perkongsian data lebih perlahan jika dibandingkan dengan Bluetooth, jarak antara dua peranti mestilah teramat dekat (kurang dari 4 cm), namun ia menggunakan tenaga yang kurang dan juga ia tidak memerlukan sebarang pengesahan berkata-laluan (authentication code) ataupun pairing process. Hanya pastikan sahaja 2 peranti pintar berada pada satu jarak yang dekat, aktifkan NFC dan penghantara data boleh dilakukan.



Rajah 5: Simbol bagi NFC Tag **Rajah 6: Imbasan NFC Tag menggunakan telefon pintar**

3.1.5 Ethernet Shield

Ethernet shield adalah satu papan papan tambahan yang disambungkan kepada papan pembangunan Arduino. Ia digunakan untuk menghubungkan kepada capaian internet ataupun *rangkaian dalaman (local network.* Dengan ini, pengguna boleh mengakses sistem ini dimana jua mereka berada menggunakan internet. Pengguna juga bebas untuk mengaktifkan atau menyahaktifkan apa jua peranti hanya menggunakan telefon bimbit yang diungkan kepada sistem ini menggunakan capaian internet.

Rajah 7: Ethernet Shield

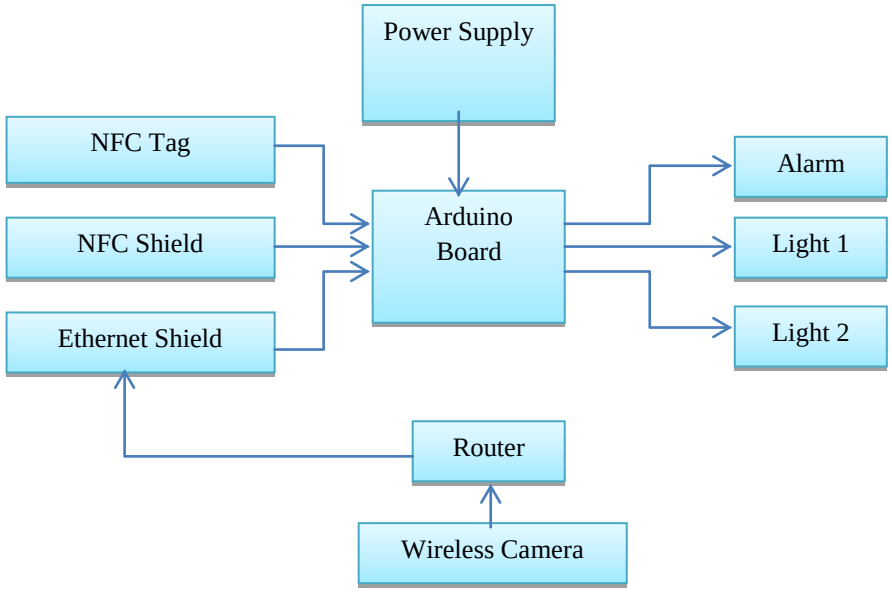
3.1.6 Solenoid Lock

Solenoid lock merupakan satu peranti eletronik yang menggunakan prinsip aruhan elektromagnetik. Apabila bekalan kuasa diberikan kepada gegelung yang dililit pada teras besi, aruhan elektromagnetik akan terhasil seterusnya akan menarik teras besi keluar atau masuk. Solenoid lock ini digunakan untuk mengunci pintu atau tingkap secara automatik menggunakan sistem kawalan automasi yang telah diprogramkan. Apabila penceroboh dikesan memecah m asuk ke dalam rumah, pengguna boleh mengaktifkan sitem autolock ini dan penceroboh akan terkunci di dalam rumah dan tidak boleh melarikan diri.

Rajah 8: Solenoid Lock

3.2 Prinsip Operasi

Sistem ini menggabungkan peranti masukan seperti *NFC shield* dan *Ethernet shield* kepada papan pembangunan Arduino. Segala bentuk arahan dan tindakan telah diprogramkan kedalam *microcontroller* yang ada pada Arduino. Keluaran yang terhasil boleh dikawal sepenunya oleh pengguna samaada menggunakan komputer ataupun telefon bimbit.



Rajah 9 : Rajah blok sistem keseluruhan

3.3 Pembangunan Projek

Pembangunan yang utama bagi projek ini adalah sistem pendawaian dan pembangunan model bangunan rumah.

Rajah 10: Pendawaian pada papan panel

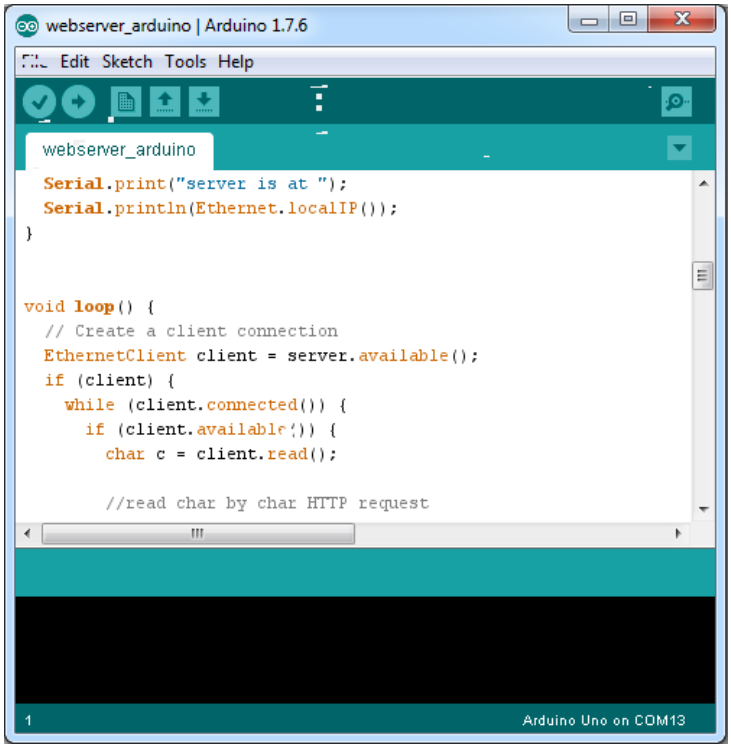
Rajah 11: Pembangunan model rumah

Rajah 12: NFC tag

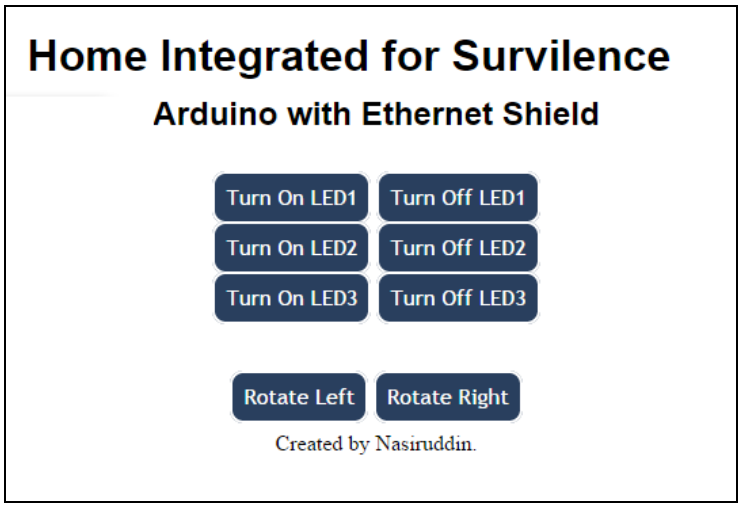
4.0 Keputusan dan Analisis

4.1 Network Configuration

Sistem ini menggunakan medium internet untuk menghubungkan antara sistem wireless camera, NFC teknologi dan pengguna. Dengan itu, pengguna boleh mengakses sistem hanya dengan menggunakan telefon pintar mereka walau dimana berada. Oleh itu, konfigurasi antara sistem dan rangkaian internet perlu dilakukan terlebih dahulu dengan menggunakan internet shield. Rajah berikut menunjukkan konfigurasi antara internet shield yang telah diprogramkan.



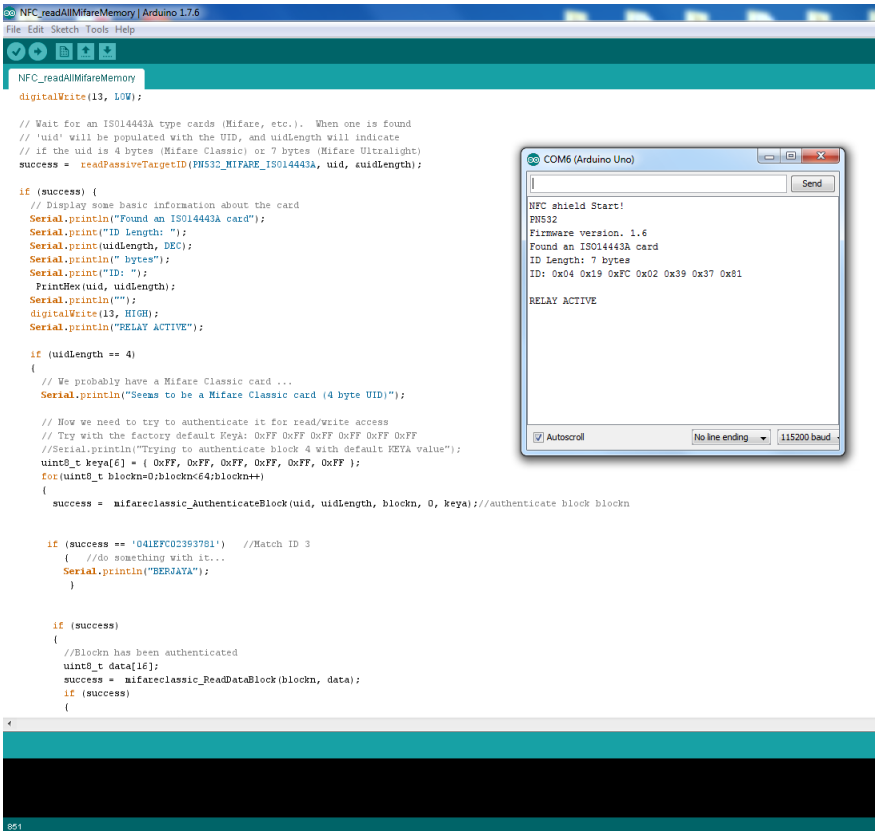
Rajah 13: Kod pengaturcaraan bagi konfigurasi internet browser



Rajah 14: Output bagi paparan web browser

4.2 Android and NFC Configuration

Rajah berikut menunjukkan kod pengaturcaraan bagi konfigurasi antara NFC shield dan Arduino board.



Rajah 15: Kod pengaturcaraan bagi NFC shield

Rajah 16: Tetapan masukan dan keluaran bagi NFC Shield

5.0 Kesimpulan

Apabila projek ini selesai sepenuhnya, dijangka ia dapat digunakan untuk meningkatkan tahap kawalan keselamatan ke atas rumah persendirian mahupun premis-premis awam. Selain itu, sistem kawalan pintar menggunakan teknologi NFC ini membolehkan pengguna mengawal sistem automasi di dalam rumah walau dimana jua mereka berada tanpa perlu berada dekat dengan peralatan tersebut.

6.0 Rujukan

[1] Gerai Cerdas: **" DFRduino Ethernet Shield",** www.geraicerdas.com/mikrokontroler/shield/dfrduino-ethernet-shield-detail

[2] Kompasiana: **" Fungsi NFC pada Smartphone",** http://www.kompasiana.com/dwikristiani/fungsi-nfc-padasmartphone

[3] "Cytron Technology", www.cytron.com.my

[4] "Home-Arduino", www.arduino.cc/

E16: Keys Protection System

Roshaizad Bin Ruslan[1], Letchumy[2]
Jabatan Elektrik & Elektronik
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka

Abstrak

Keys Protection System adalah satu projek yang direka bertujuan untuk mengesan kehilangan kunci serta pengguna terakhir yang bertanggungjawab mengambil kunci tersebut. Sistem ini akan berupaya mengesan pengguna yang bertanggungjawab samada ketika mengambil atau memulang kunci. Ia akan memaparkan maklumat kunci yang diambil serta maklumat pengguna itu sendiri yang diwakili dengan kod yang telah ditetapkan. Pengguna perlu menggunakan kad RFID yang dibekalkan bagi membuka kotak kekunci dan mengenalpasti identiti. Setelah kunci diambil maklumat tentang kunci tersebut dan identity pengguna akan terpapar pada seven segment display. Sistem ini dibangunkan menggunakan aplikasi dan pengaturcaraan arduino.

Kata Kunci : kad RFID, arduino, seven segment display

1.0 Pengenalan

Keys Protection System merupakan projek yang menggabungkan kejuruteraan elektrikal dan elektronik untuk menyelesaikan masalah berdasarkan keadaan sebenar. Kesukaran melakukan pemantauan terhadap pergerakan kunci bilik dan makmal di kawasan tempat kerja mencetuskan idea untuk menghasilkan projek ini.

Projek ini sebenarnya sebuah kotak penyimpanan kunci yang mampu dan berupaya mengesan pengguna terakhir, kedudukan kunci dan status kunci yang diambil. Pembangunan projek ini mengambil kira keadaan mesra pengguna, dimana penggunaannya tidak memerlukan keupayaan teknikal yang tinggi dan amat mudah difahami.

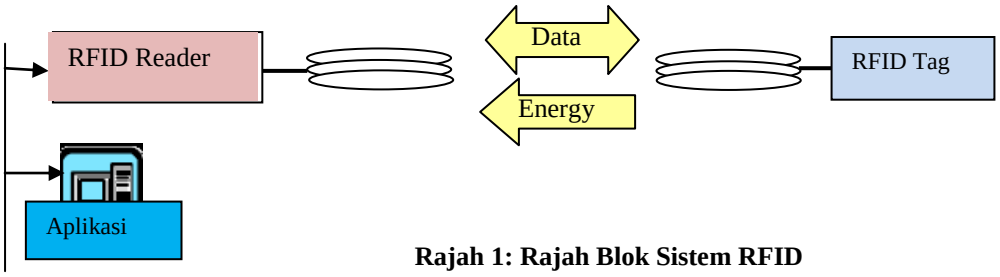
1.1 Latarbelakang Masalah

Pelbagai cara dan sistem bagi tujuan pemantauan pergerakan kunci sebelum ini masih gagal untuk mengelakkan daripada kes kehilangan kunci dan mengesan pegawai yang bertanggungjawab menggunakannya. Kaedah manual seperti merekod di dalam buku pergerakkan, meletakkan tanda nama pada kunci yang diambil nampaknya bukanlah satu cara yang berkesan kerana ia memerlukan displin yang tinggi kepada pengguna.

Risiko keselamatan yang terpaksa ditanggung dengan kes-kes kehilangan dan kecurian sebelum ini memerlukan satu penyelesaian khusus yang perlu dibuat. Berdasarkan keperluan dan kepentingan yang mendesak maka projek ini dipilih untuk dibangunkan. Satu kajian yang dilakukan diantara bulan Januari 2013 sehingga November 2013 menunjukkan penggunaan sistem yang digunapakai sebelum ini mempunyai banyak masalah. Berikut disenaraikan masalah yang dihadapi oleh pengguna menggunakan kaedah buku pergerakkan:

i. Pengguna tidak merekod peminjaman kunci di dalam buku pergerakan
ii. Berlaku kes kehilangan kunci
iii. Tidak diketahui pengguna yang bertanggungjawab jika beliau tidak merekod pergerakan kunci.
iv. Pemantauan pergerakan kunci sukar dilakukan dan memerlukan displin yang tinggi oleh para pengguna.

2.0 Kaedah Pembangunan Sistem

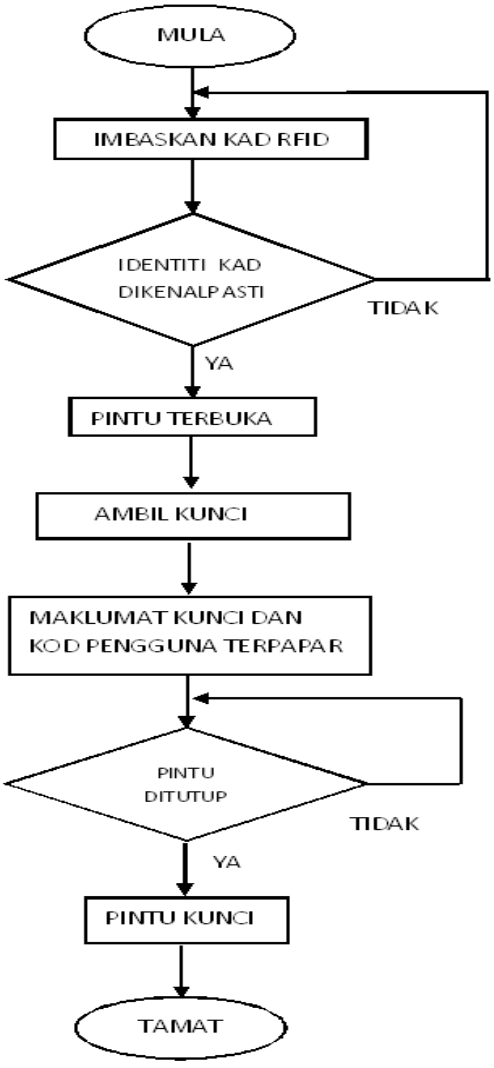


Rajah 1: Rajah Blok Sistem RFID

RFID bermaksud "*Radio- Frequency Identification*"**.** Tag RFID yang mempunyai identiti unik pada setiap kad akan dibaca oleh *RFID Reader.* Identiti pengguna akan diketahui dengan penggunaan Tag RFID ini. *RFID Reader* ini akan menghantar maklumat kepada aplikasi yang dibangunkan menggunakan pemproses jenis *Arduino. Arduino* ini diprogram untuk mengawal aplikasi sistem kunci automatik, paparan maklumat jenis kunci yang diambil dan identiti peminjam serta maklumat pemulangan kunci.

2.1 Cartalir pengunaan kotak kunci

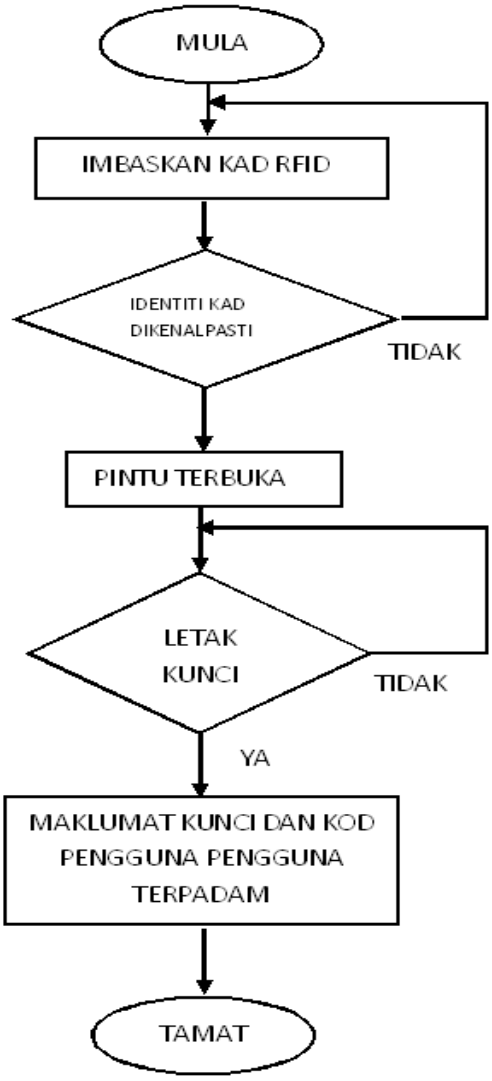
Pengambilan kunci:



Rajah 2a: Cartalir pengunaan kotak kunci (Pengambilan Kunci)

Pengguna akan mengimbas Tag RFID dan identiti pengguna akan dikenalpasti. Kunci pintu kotak akan terbuka secara automatik. Apabila pengguna mengambil kunci, maklumat kunci dan kod identiti pengguna akan terpapar. Maklumat ini akan kekal selagi kunci yang diambil tidak dipulangkan. Kunci pintu akan terkunci dengan sendiri apabila ia ditutup.

Pemulangan kunci:



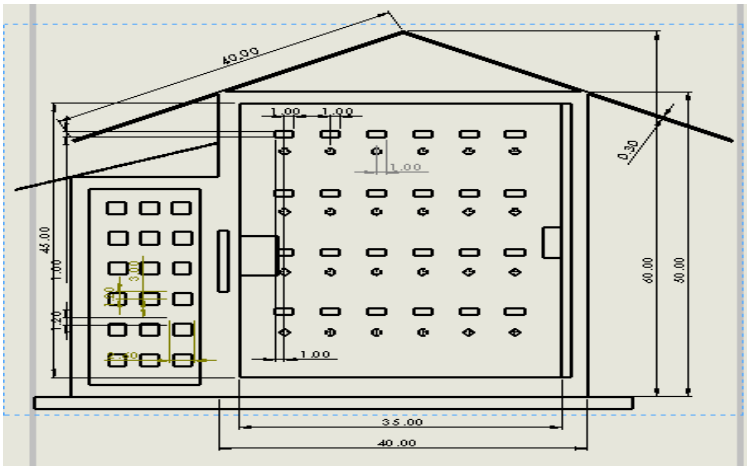
Rajah 2b: Cartalir pengunaan kotak kunci (Pemulangan Kunci)

Ketika pemulangan kunci, pengguna perlu menggunakan Tag RFID bagi pengesahan identiti. Pintu kotak kekunci akan terbuka secara automatik apabila pengguna dikenalpasti. Apabila kunci dikembalikan ke tempat asal maklumat kunci dan kod pengguna akan terpadam.

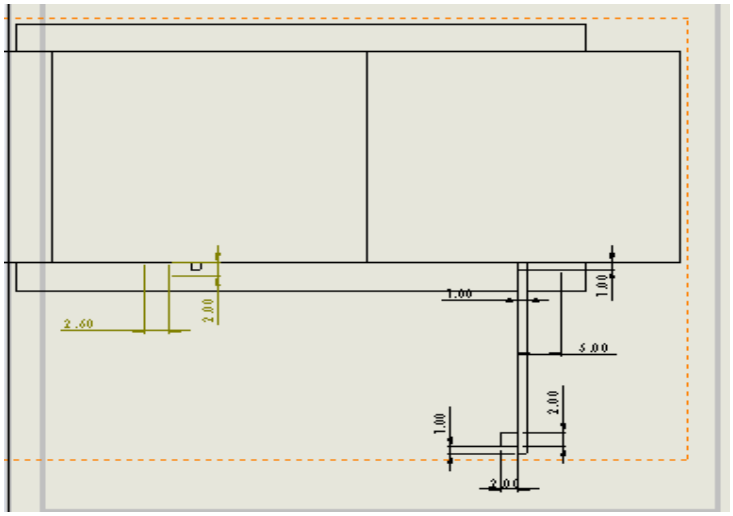
3.0 Rekabentuk Projek

Rekabentuk kotak kekunci ini diperbuat dari kayu dan mempunyai tempat letak kunci serta petunjuk paparan *seven segment display*.

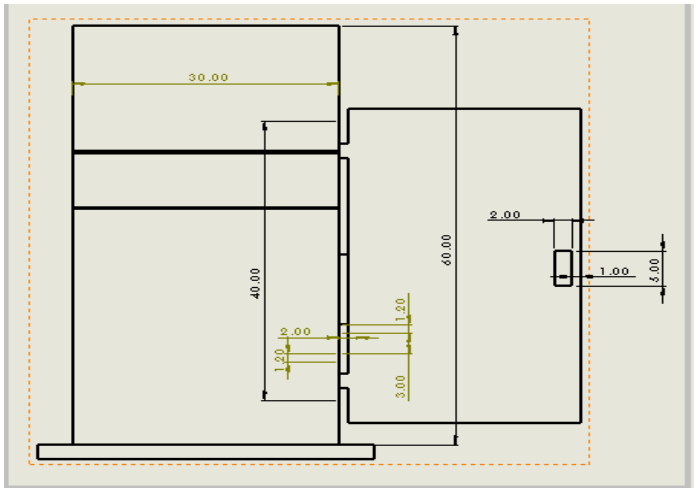
8.1 Rekabentuk mekanikal



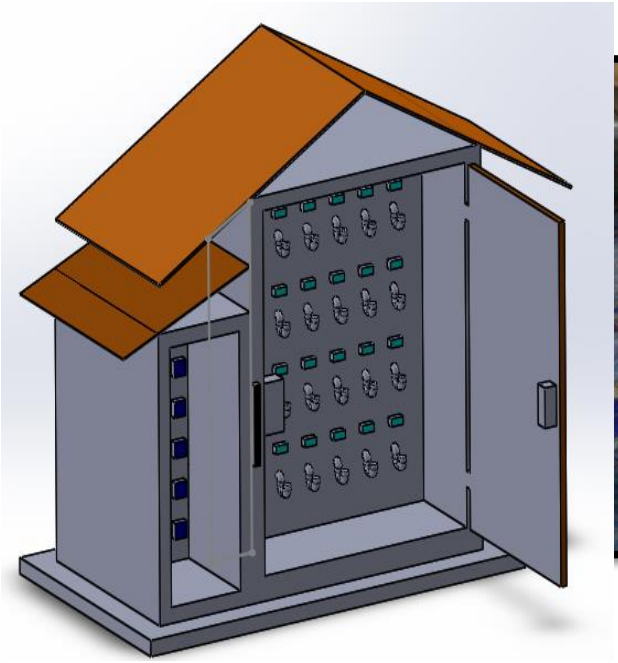
Rajah 3a : Pandangan hadapan



Rajah 3b :Pandangan atas



Rajah 3c : Pandangan sisi



Rajah 3d : Lukisan isometrik

Rajah 3e: Kotak Kekunci

Rajah 3f: Prototaip Keys Protection System

3.2 Pembangunan Aturcara

Ini adalah contoh aturcara yang dibangunkan menggunakan perisian Arduino bagi membangunkan projek ini.

KeyManagementControlV2

```
#define sevenSegLED(ucChar) \
((ucChar == '0') ? 0xFC : \
(ucChar == '1') ? 0x60 : \
(ucChar == '2') ? 0xDA : \
(ucChar == '3') ? 0xF2 : \
(ucChar == '4') ? 0x66 : \
(ucChar == '5') ? 0xB6 : \
(ucChar == '6') ? 0xBE : \
(ucChar == '7') ? 0xE0 : \
(ucChar == '8') ? 0xFE : \
(ucChar == '9') ? 0xF6 : \
(ucChar == ' ') ? 0x00 : ucChar);
```

Rajah 4: Aturcara Projek

Define menyatakan kaki 7segment sebagai output dalam penomboran hexadecimal

```
#include <EEPROM.h>

char buffer[12];
char id[12];
byte index=0;
boolean data_received = false;
byte number[16];
```

Rajah 5: Aturcara Projek

EPROM sebagai memori yang akan menyimpan data. Jika berlakunya bekalan kuasa terpupus, data yang disimpan tetap akan ada. Jadi nombor yang terpapar sebelum ini akan terpapar semula apabila kuasa dihidupkan semula dan ia tidak akan reset.

```
char numID[5][10] = {
{'0','0','0','3','5','3','3','7','7','6'},
{'0','0','0','8','1','5','8','1','7','3'},
{'0','0','0','8','1','5','8','0','2','5'},
{'0','0','0','8','1','6','2','8','2','6'},
{'0','0','0','8','1','6','2','8','7','9'}
```

Rajah 6: Aturcara Projek

Char num ID adalah tempat untuk menyatakan nombor yang akan di imbas oleh RFID, nombor ini terdapat pada kad RFID. Jika ingin membuat penambahan, masukkan no kad RFID yang lain pada *char num ID*.

Byte mempunyai satu program yang menyatakan tempat atau kaki pada *Arduino* yang akan mengeluarkan output yang telah ditetapkan pada aturcara.

```
pinMode(rst, OUTPUT);
pinMode(en, OUTPUT);
pinMode(latch, OUTPUT);
pinMode(sdat, OUTPUT);
pinMode(sclk, OUTPUT);
digitalWrite(rst,LOW);
delay(10);
digitalWrite(rst,HIGH);
digitalWrite(en,LOW);
digitalWrite(sclk,LOW);
digitalWrite(latch,HIGH);
digitalWrite(sdat,HIGH);
```

Rajah 7: Aturcara Projek

Kami menggunakan *code digital wire* kerana dalam sistem yang kami laksanakan. Kami telah menghubungan antara cip dengan cip (RFID), oleh itu data yang akan diterima oleh A*rduino* adalah dari signal bukanya suis.

```
void loop() {

 if(data_received == true)
 {

  data_received = false;

  for(byte idx=0;idx<5;idx++)
  {
    short error=0;
    //compare
    for(int i=0;i<10;i++)
    {
     if( numID[idx][i] != buffer[i+1]) error++;
    }

    if(error==0)
    {
      digitalWrite(relay1,HIGH);
```

Void loop yang kami gunakan bertujuan untuk memangil semula program. Misalnya selepas nombor yang telah terpapar mengeluarkan nombor 1. Apabila USB dimasukkan semula, nombor yang terpapar akan menjadi kosong semula.

4.0 Keputusan Dan Analisis

Setelah prototaip *Keys Protection System* ini siap dibangunkan satu ujian keberkesanan dilakukan di Bahagian Mekatronik. Projek ini mula dipasang pada Julai 2014. Ujian keberkesanan ini amat penting bagi memastikan masalah seperti berikut berjaya diatasi.

i. Pengguna tidak merekod peminjaman kunci didalam buku pergerakan
ii. Berlaku kes kehilangan kunci
iii. Tidak diketahui pengguna yang bertanggungjawab jika beliau tidak merekod pergerakan kunci.
iv. Pemantauan pergerakan kunci sukar dilakukan dan memerlukan displin yang tinggi oleh para pengguna.

Sehingga Mei 2015, hasil soal selidik dan pemantuan yang dilakukan mendapati semua masalah yang timbul sebelum ini berjaya diatasi sepenuhnya.

5.0 Perbincangan

Teknologi terpenting dalam pembangunan projek ini adalah pengunaan RFID. RFID bermaksud "*Radio-Frequency Identification*"**.** Singkatan ini secara amnya merujuk kepada satu sistem yang mengandungi tiga bahagian utama: *Tag* RFID, RFID *reader* dan aplikasinya. *Tag* RFID adalah peranti elektronik yang kecil direka menggunankan cip yang sangat kecil dan dikelilingi dengan antena. Cip kecil ini berupaya untuk membawa sejenis informasi berpandukan aplikasi. Selain itu cip ini juga berupaya untuk bertindak balas terhadap isyarat gelombang elektomagnet yang diterima melalui antena. Penggunaan peranti RFID adalah sama seperti bar kod atau strip magnet dibelakang kad kredit atau kad ATM,ia memiliki identiti tersendiri yang unik setiap satunya. Ini adalah sebab utama kenapa RFID dipilih dalam menentukan identity pengguna bagi projek ini.

Kaedah penggunaan sistem ini amat mudah dan mampu menentukan status individu yang menggunakan. Pemantuan yang minima keatas pergerakan kunci dapat dilakukan. Kes-kes kehilangan kunci juga dapat diatasi kerana para pengguna menyedari bahawa mereka akan dikesan dan bertanggungjawab keatas kunci yang dipinjam.

6.0 Kesimpulan

Hasil daripada ujian keberkesanan pengunaan yang dilakukan diantara Julai 2014 hingga Mei 2015 mendapati projek ini amat berjaya dilaksanakan. Namun begitu setelah ujian keberkesanan pengunaan dilakukan dapat diperhatikan sistem ini mempunyai kelemahan yang perlu diatasi jika ingin dikomersialkan iaitu:

i. Pembinaan Kotak Kekunci hendaklah daripada bahan yang kuat dan kukuh.
ii. Alat-alat kawalan dan elektronik haruslah ditingkatkan keboleharapan dengan pemilihan komponen dan kaedah etching PCB yang terbaik.

Antara penambahbaikan yang boleh dilakukan pada sistem ini adalah menaiktaraf sistem perekodan dengan pengguna mampu memantau dengan menggunakan computer dan mencetak semua pergerakan kunci dan individu yang bertanggungjawab.

7.0 Rujukan

[1] http://www.airqualitymonitoring.blogspot.com/2012/10/pic16f877a-microcontroller.html

[2] http://www.societyofrobots.com/images/sbs_voltage_regulator.JPG

[3] http://asyyshafiesmtmt.blogspot.com/2009/06/perintang.html

[4] http://www.microchip.com /from Sparkfun or Iteadstudio connected to Arduino-art3rfid1.htm

[5] http://en.wikipedia.org/wiki/.vibration sensor.htm

[6] http://www.cytron.com.my/usr_attachment/PR25_DD.pdf

E17: Smart Genetic Algorithm Controller

Ong Joo Hun[1]
Institut Latihan Perindustrian Arumugam Pillai Nibong Tebal, Pulau Pinang
Electrical & Electronic Department

ongjh188@ilpapnt.gov.my

Abstract

The objective of this project is to design, develop and optimize the performance of an industrial robotic arm in terms of its positioning and speed to perform any application. We will introduce Genetic Algorithm (GA) that able to look for the optimum sequences to solve its path planning via evolutionary solutions. GA will determine the best combinatorial paths in order to minimize the total motion of welding time in shortest travel distance. To develop this project, studies have been emphasized on the development of the Cartesian robot structure that include its kinematics and dynamics analysis, classification and configurations of the robots, modernized drive technology to perform motion planning, and sophisticated customized programming software to control and interfacing to the outside world / applications. For automating the path planning process, computational intelligence is considered the main and powerful methods to develop this robotics system. This project involves in developing a machine learning system that is capable of performing independent learning capability for a given tasks. The design and development of this project will involve two major sections. First section concerns about hardware construction, wiring and testing. Second section involves software design to control the movement of the robot for spot welding. The hardware design can be categorized into two sections; the electrical design and mechanical design. The electrical design involves wiring of control components such as control of stepper motor, input and output devices as well as **power supply** *and safety devices. The mechanical design will include mechanical parts fabrication. The software parts will include design of Graphical User Interface GUI simulator, GA optimization module and hardware / software integration. Finally, the developed genetic algorithm controller has been tested its functionality and implemented successfully in this Cartesian robot system to perform spot welding process compare to conventional control method used in industrial robotics applications.*

Keywords: *Genetic Algorithm (GA), Cartesian Robot*

1.0 Introduction

A Cartesian coordinate robot is an industrial robot whose one or more principal axes of control are linear. They move in a straight line rather than rotate. Among other advantages, this mechanical arrangement simplifies the robot control arm solution. Cartesian robots are being widely employed in industrial applications such as automobile spot welding or assembling lines that handle a variety of car models. In order to avoid the risk factor in spot welding application, various steps can be taken. One of the prominent methods is by substituting the human hands with the robotic arm in handling these dangerous and hazardous environments.

It is with these reasons that this study was conducted with the primary objective to design and develop a new low-cost, high-efficiency Cartesian robotic arm for application such as spot welding. A new evolutionary computation method using Genetic Algorithm (GA) to control and optimize the system performance in terms of its positioning and speed that would contribute towards encouraging a productive and quality process. GA operates on populations of candidate controllers, initially selected from some distribution. This population of candidate controller is repeatedly grown according to crossover, mutation and other GA operators and then culled according to the fitness function.

The competition between different companies regarding price and performance of the Cartesian robot and control system has been the most important motivation. In case of cost saving on robotics equipments, we have come out this solution to aware national interest in science and technology as this constitutes a prerequisite for an inventive society.

2.0 Problem Statement

The problem can be stated as: Given a Cartesian robot with a spot welding torch (laser head as replacement of torch), a set of known fixed coordinates with the initial and final configurations, find a coordinated motion plan for the laser head from its initial to final configuration, and optimizing the overall time taken for the laser head to perform spot welding application.

To give an idea of the complexity of the problem, let's consider a number of n coordination points and one origin points for the laser head fixed at positions (x_0, y_0). For this application, the search space is a discrete space and there are (*n*!) permutation scheme of the close routes or path that this robot has to go through. GA is relatively effective global search algorithm to find the best or approximate optimization solution for the shortest path and time in this problem.

The above mentioned problem is actually same as the well-known "Traveling Salesman Problem (TSP)" that of finding the shortest closed tour through a given set of cities visiting each city exactly once. The objective function is the sum of the Euclidian lengths of all edges among the salesman's route. The Euclidean distance between points *P* (p_1,p_2,…,p_n) and *Q* (q_1,q_2,…,q_n) in Euclidean n-space is defined as:

$$\sqrt{(p_1-q_1)^2+(p_2-q_2)^2+\ldots+(p_n-q_n)^2}=\sqrt{\sum_{i=1}^{n}(p_i-q_i)^2}$$

The developed Cartesian robot is scheduled of a route for the spot welder to perform welding on a work piece. In this robotic application, the "cities" are points to weld, and the "cost of travel" includes the time for retooling the robot (single machine job sequencing problem).

Thus, given a set of points C = {c_1, c_2, …,c_k}, for each pair (c_i, c_j), i≠j, let d(c_i, c_j) be the distance between point c_i and c_j. Solving the TSP entails finding a permutation π' of the points ($c_{\pi'(1)},\ldots,c_{\pi'(k)}$), such that

$$\sum_{i=1}^{k} d(c_{\pi'(i)},c_{\pi'(i+1)}) \le \sum_{i=1}^{k} d(c_{\pi(i)},c_{\pi(i+1)}) \qquad \forall \pi \neq \pi', (k+1) \equiv 1$$

The size of the solution space, *q* is given in equation 1.2 for *n* > 2, where *n* is the number of points. This is the number of Hamiltonian cycles in a complete graph of *n* nodes, that is, closed paths that visit all nodes exactly once.

$$q = \frac{1}{2}(n-1)!$$

For a laser head with *n* number of coordination points, the numbers of possible solutions / routes are *n*! where *n* = the number of points are given in Table 1. Therefore, an evolutionary solution such as genetic algorithm is introduced to optimize the performance and solve the path planning sequences problem in shortest time.

Table 1: Number of possible solutions

No. of Points (*n*)	Number of Solutions
5	120
10	3628800
50	3.04E+64

3.0 Overview of the Project

The optimization of the spot welding process is the task of finding the best combinational paths for spot welding through a given set of vertices. A method is presented to minimize the total motion time taken for spot welding operation. The method uses a coordination diagram and trajectories planner that can easily be implemented in the Cartesian robot as shown in Figure 1.

The development of the control system can be divided into standard spot welding program and an optimization program as illustrated in Figure 2. The standard spot welding software consists of a graphical user interface (GUI) where users can input objects data. The program is responsible to learn and store the data into the main database. The data includes vector coordinates and motion parameters such as speed, acceleration, welding delay and stopping delay. The main database can be extracted and used as for basic sequential spot welding. The optimization program consists of using the genetic algorithm. The data from the main database will be extracted and processed by the algorithm to form a GA database. From the GA database, the optimized welding operation can be done via the interface of the robot's controller.

Figure 1: Cartesian robot for spot welding application and the main controller

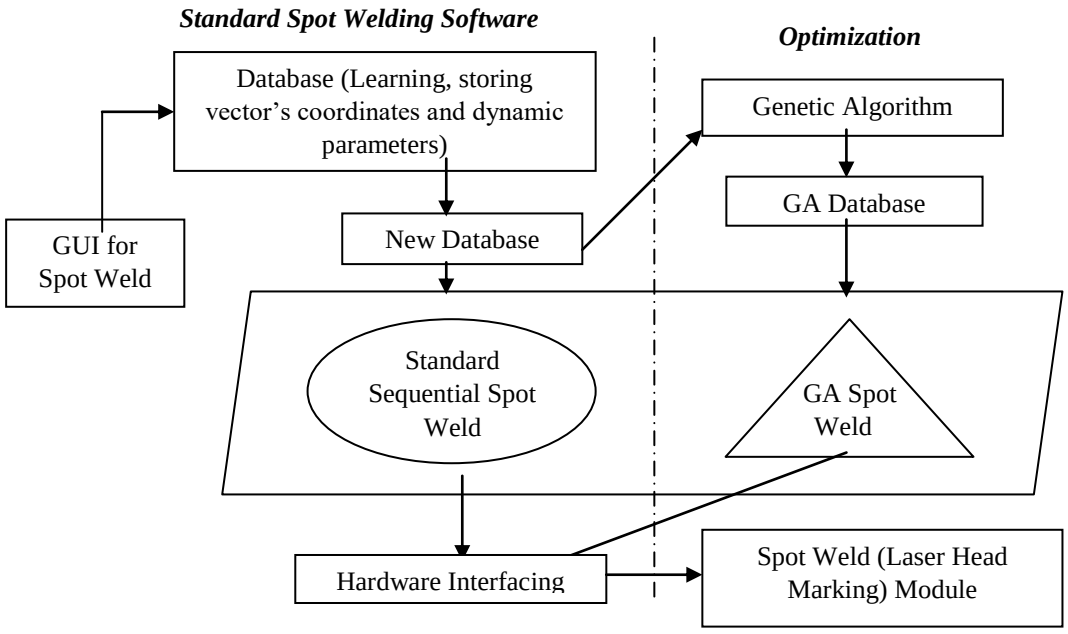


Figure 2: Block diagram of genetic algorithm controller for cartesian robot

4.0 Hardware Development

The hardware of the proposed system can be divided into electrical and mechanical sections. The electrical section consists of electrical protection system, power distribution system, I/O module, electro-pneumatic-based Z axis, stepper motor control and the main controller wiring. These include the design of schematic and wiring diagram for the robotic system. The mechanical section consists of lead screw drive system, jig and fixture module, and mechanical base. The electrical and mechanical module are designed and constructed stage by stage. Figure 3 shows the block diagram of the proposed Cartesian robot system.

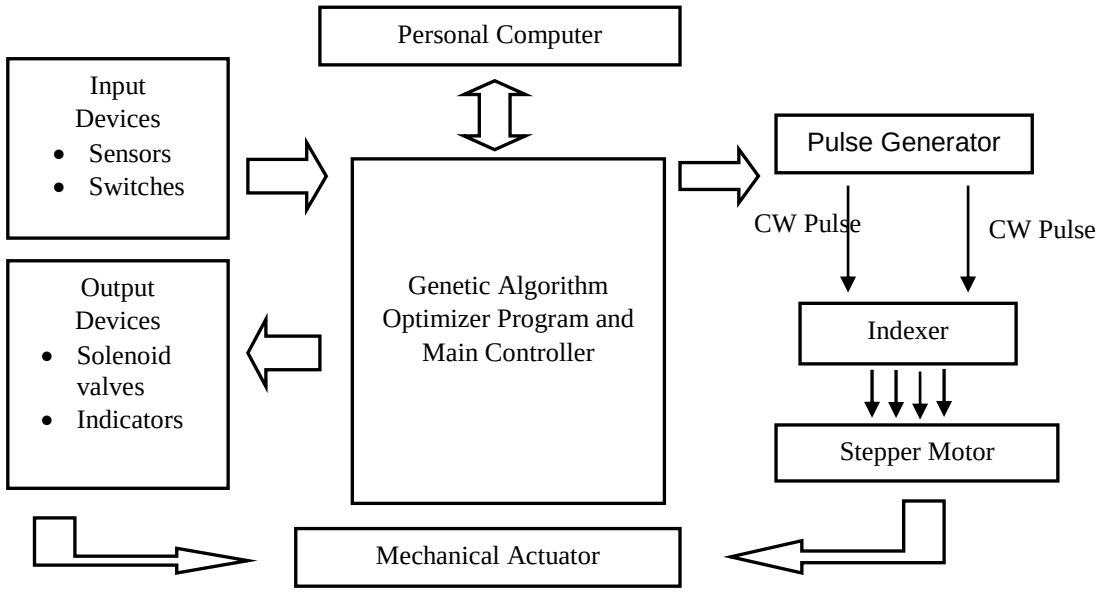


Figure 3: Block Diagram of the robotic system design

Two units of Parker Compumotor OEM750X micro stepping drive/controller are applied as the main controller for this project. The main functions of these controllers are feedback info analysis, data processing, actuation signals generation and operation sequencing etc. Table below shows the performance parameter of the driver.

Table 2: OEM750X micro stepping drive/controller's performance parameter

Parameter	**Specification**
Accuracy	±5 arc min (0.0833°) typical.
Repeatability	±5 arc sec (0.0014°) typical.
Resolution	16 selectable choices: 200, 400, 1000, 2000, 5000, 10000, 12800, 18000, 20000, 21600, 25000, 25400, 25600, 36000, 50000, 50800
Waveform	Selectable. Allows waveform shaping for optimum smoothness or relative accuracy. Pure sine; -4%, -6%, -8%, -10% 3rd harmonic.
Encoder A, B and Z Channel	Single-ended, active high; Logic Low = 0-0.8V; Logic High = 2.0-5.0V
Limits and Home Inputs	Logic High = 2.0–5.0V; Logic Low = 0–0.8V
2 Programmable Outputs	Logic Low = maximum of 0.44 V (sinks to 24 mA)
Motor Type	Two-phase hybrid permanent magnet, 1.8°
RS-232C Interface	9,600 baud rate, 8 data bits, 1 stop bit, no parity

5.0 Software Development

The process of developing the entire control system software can be divided into several major stages. These are simulation graphical user interface (GUI) package that consists of machine learning module and GUI control simulator, GA optimization module and hardware and software system integration. The final process involves troubleshooting and minor modifications to problems encountered and testing. Figure 4 shows the flow chart of the GA optimization main program while Figure 5 and Figure 6 show the GUI simulator in optimizing the Cartesian robot's path planning process and control.

The simulation package consists of a GUI where it links and directs the flow of the working process. It is a medium to allow interaction between the hardware, control system and database. In this simulation package, the input data would be stored and learned in the database. The data from the database can be extracted to be processed and executed via the hardware.

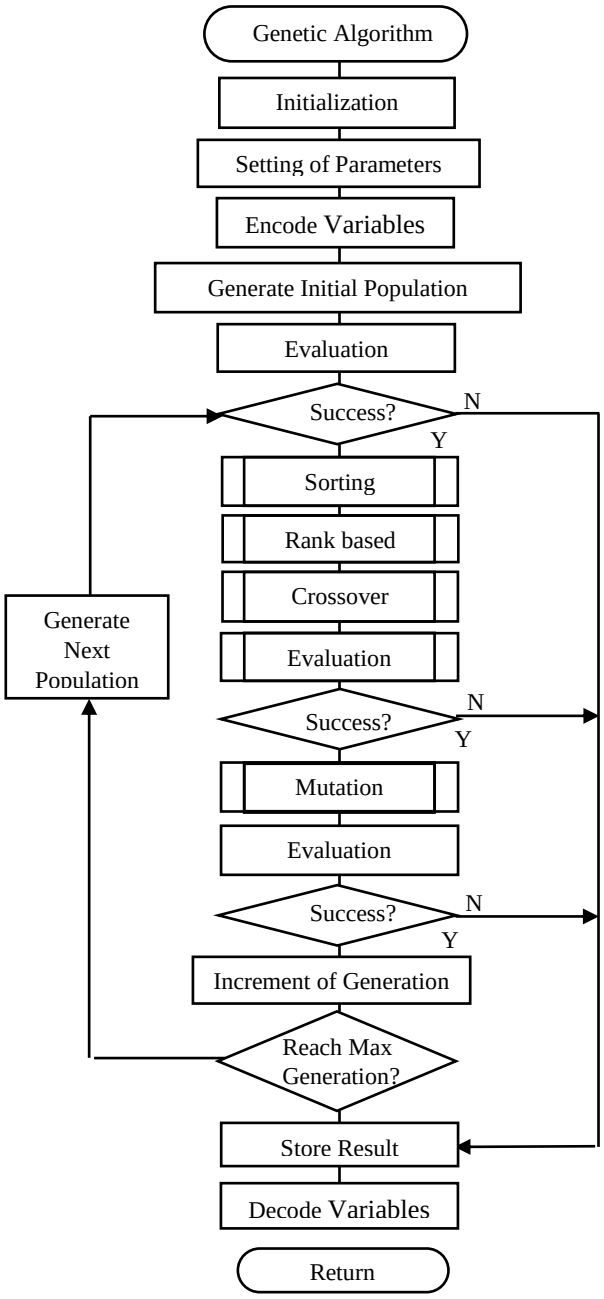


Figure 4: Genetic algorithm operation program

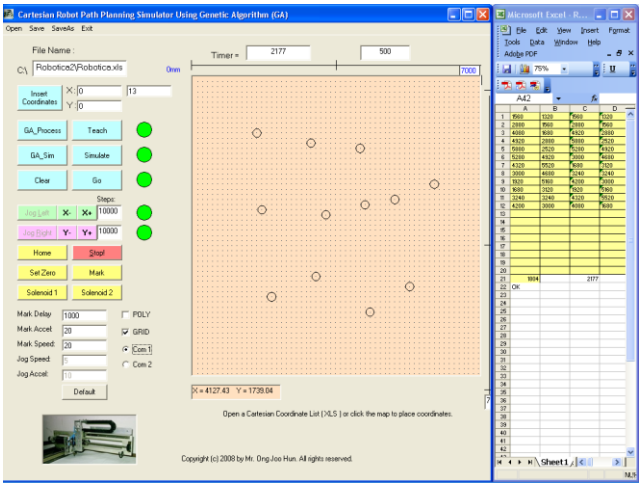


Figure 5: GUI Simulator for GA optimization in Cartesian robot system control (Ver. 1.0)

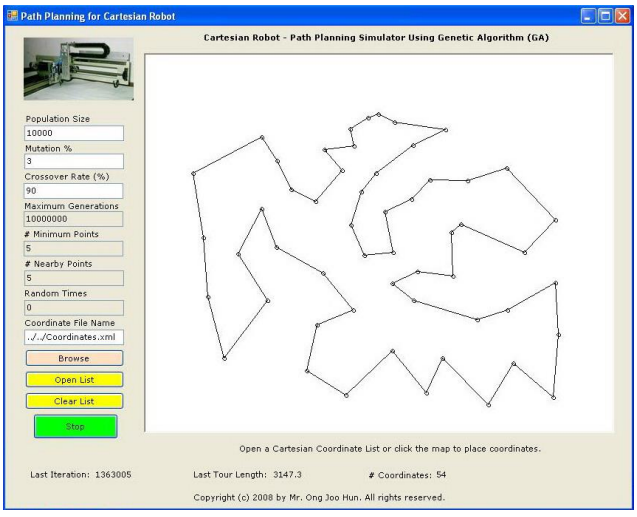


Figure 6: GUI Simulator for GA optimization in Cartesian robot system control (Ver. 2.0)

6.0 Results and Discussions

A test was conducted to compare the performance of a GA optimization and random solutions in terms of its total travel distance. The maximum generation was set to be 500, with the population size at 20 along with 90% crossover rate and a mutation rate of 1%. From the results shown in Figure 7 and Figure 8, it can be observed that the graph for GA achieve the shortest path and time for all points compare to the random search. This means that the fitness solution obtained by GA is better compare to random. This is because GA employs the evolutionary process in solving the problem. In each generation, fittest chromosomes (or solutions) are selected as the parents to produce the children (or new solutions) that inherited the strength of both parents. The offspring would then replace the worse chromosomes. Therefore the solution keeps improving.

On the other hand, in random search, the solution would not go through the evolution process as GA. The effect of GA compare to random can be observed more clearly when the number of maximum generation is reduced, in which only run for 200 generations.

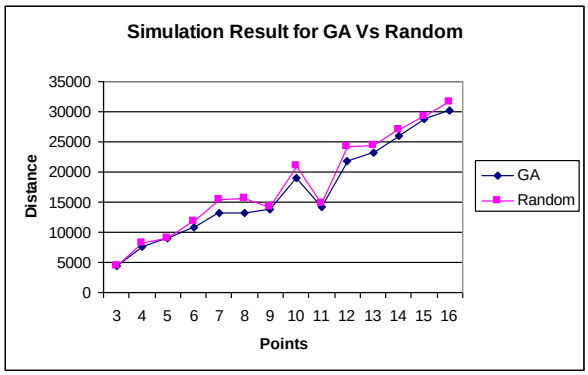


Figure 7: Distance comparison between GA and random

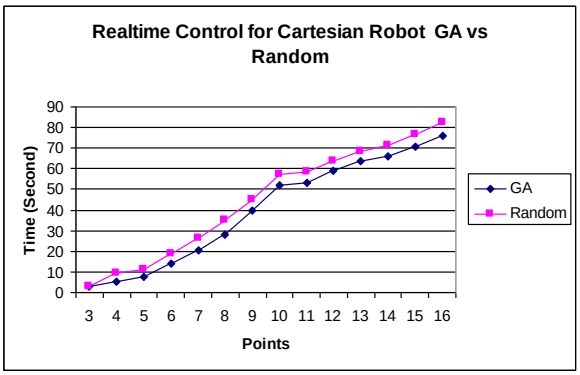


Figure 8: Real time control for GA and random

7.0 Conclusion

The genetic algorithm (GA) controller for Cartesian robotic system has successfully designed and developed for spot welding application. The objective of this project is successfully achieved that include hardware design of electrical and mechanical parts fabrication, GA optimization programming and customized GUI simulator and control system. The performance optimization of the path planning for the robot is based on the TSP algorithm. The simulation results indicate that the GA is able to find the shortest marking path for different types of objects topologies. GA is also better in both the ability and the speed to find optimal solution compared to random search. Therefore, GA should be applied instead of random search in order to obtain better results.

As a conclusion, we have solved a permutation problem in robot path planning by combining genetic algorithm programming. The adoption of this new technology and control system into the modern industrial robotics system will help to solve workflow problems, sophisticated machines and complexity manufacturing processes. It is vital for us to solve the related functionality issues and problems thus enhancing the efficiency of the applications.

8.0 References

[1] Baharin, I. B. (1989). *Robotics: Kinematics, Simulation and Artificial Intelligence*. Proceeding of First National Computer Science Conference. Volume 1, pp. 97-100, Kuala Lumpur, Malaysia.

[2] Bentley J. L. (1992). *Fast Algorithms for Geometric Traveling Salesman Problems*. ORSA Journal on Computing, (4):387-411.

[3] Beyer H. G. and Deb K. (2001). *On self-Adaptive Features in Real-Parameter Evolutionary Algorithms*, IEEE Transactions on Evolutionary Computation 5(3), pp. 250-270.

[4] Chryssolouris G. and Velusamy S. (2001). *Dynamic scheduling of manufacturing job shops using genetic algorithms*. Journal of Intelligent Manufacturing, vol.12, no.3, pp.281-293.

E18: E-Basic Electricity For Beginner

Siti Noormaizura Sarkam[1], Hafizah Mohamad Deli[2]
Jabatan Elektrik & Elektronik,
Institut Latihan Perindustrian Arumugam Pillai, Nibong Tebal

[1]*noormaizura@ilpapnt.gov.my*, [2]*hafizah@ilpapnt.gov.my*

Abstrak

Basic Electricity (Asas Elektrik; Kod: B01-01-02) merupakan salah satu modul yang wajib dipelajari oleh pelajar-pelajar jurusan Teknologi Elektrik 1 Fasa. Modul ini melibatkan 2 jam kredit dan merupakan asas utama bagi pembelajaran dalam bidang elektrik. Modul yang merangkumi pengenalan dan pengaplikasian Hukum Ohm, Hukum Kirchoff, sambungan litar, pengiraan jumlah beban, voltan, arus dan lain-lain. E-BasicElectricity ini dibangunkan bagi menginterpretasikan Kertas Penerangan bagi Modul 2 iaitu Basic Electricity (Asas Elektrik). Projek ini dibangunkan bagi mempertingkatkan kefahaman pelajar terhadap modul ini selain menunjukkan aplikasi Hukum Ohm, Hukum Kirchoff dan lain-lain pengiraan yang berkaitan, dapat menyelesaikan masalah pengiraan dengan mudah serta mendapat gambaran yang jelas mengenai modul ini. Projek yang menggunakan Microsoft Office sebagai pengantaramuka ini diharap dapat membantu pelajar dalam menguasai rumus-rumus, aplikasi dan penyelesaian masalah berkaitan modul ini. Projek ini juga dapat mengurangkan penggunaan kertas (paperless) kerana pelajar hanya perlu memuat turun Kertas Penerangan bagi Modul 2 ; B01-01-02; Basic Electricity.

Kata Kunci: *Hukum Ohm, litar, beban, voltan, arus*

1.0 Pengenalan

Sebelum seseorang pelajar dapat menguasai dan mahir dalam bidang elektrikal terutamanya kerja-kerja teknikal, seseorang pelajar itu seharusnya dapat menguasai bidang asas elektrik secara teoritikal bagi memastikan pepasangan atau kerja-kerja yang dilakukan tidak membahayakan kepada diri sendiri, peralatan dan juga pepasangan. Selain menitikberatkan soal penggunaan peralatan pelindungan keselamatan (PPE) seperti pemakaian yang sesuai, kasut keselamatan dan topi, pelajar juga harus mahir dalam membuat pengiraan sebelum sesuatu pepasangan dijalankan agar tidak terjadi litar pintas atau kebocoran litar yang boleh menyebabkan kecederaan atau kerosakan pad alat dan perkakasan.

Asas Elektrik diajar kepada pelajar Institusi Latihan Jabatan Tenaga Manusia (ILJTM) yang mengikuti Kursus Teknologi Elektrik di dalam modul Basic Electricity (B01-01-02). Antara ketrampilan yang diuji adalah kemahiran pelajar membuat pelbagai pengiraan yang melibatkan pelbagi jenis beban iaitu rintangan (Resistor) , pemuat (Capacitor) dan peraruh (Inductor). Pelajar ditentusahkan sebagai terampil sekiranya litar atau pendawaian disambung dengan betul.

2.0 Pernyataan Masalah

Kebiasaannya semasa proses pengajaran dan pembelajaran (PnP) , pengajar menyampaikan maklumat dan ilmu pengetahuan secara penerangan, penyampaian nota dan sesi soal jawab. Pemahaman teori pelajar dinilai berdasarkan tugasan, kuiz, ujian dan perbincangan kumpulan. Nota yang banyak diberikan kepada pelajar adakalanya tidak dapat difahami oleh pelajar kerana kebanyakan tugasan diberikan dalam bentuk pengiraan. Kepelbagaian bentuk soalan pengiraan dapat membantu pelajar meningkatkan kemahiran dan pemahaman mereka dalam modul ini.

Oleh itu, satu aplikasi komputer yang mudah dikendalikan, mempunyai tahap kebolehpercayaan yang tinggi serta mampu menjimatkan masa pengajaran diperlukan bagi meningkatkan produktiviti dan keberkesanan latihan. Hal ini penting agar proses pengajaran dan pembelajaran tidak tergendala dan dapat diselesaikan dalam tempoh masa yang ditetapkan selain memberi lebih masa kepada pelajar untuk melakukan latihan amali sekaligus memahami aplikasi pengiraan atau teori dalam kerja-kerja amali yang dijalankan. Selain itu, pelajar juga tidak perlu menggunakan banyak kertas kerana latihan atau tugasan dapat dilaksanakan menggunakan komputer.

3.0 Latar Belakang e-Basic Electricity for Beginner

Kajian literatur mendapati cara konvensional dalam mempelajari modul *Basic Electricity (B01-01-02)* agak susah difahami oleh para pelajar kerana pelajar generasi kini yang menceburkan diri dalam bidang kemahiran adalah golongan yang kurang berminat dengan pembacaan dan pemahaman nota. Mereka lebih mudah memahami sesuatu subjek atau modul yang melibatkan pengiraan dengan membuat latihan secara berulang-ulang atau aktiviti fizikal seperti yang dijalankan dalam sesi latihan amali.

e-Basic Electricity for Beginner yang dihasilkan hanya menggunakan Microsoft Office sebagai pengantaramuka membolehkan semua pelajar dapat menggunakan program ini tanpa perlu memuat turun aplikasi lain atau perisian lain. Program yang mudah ini juga dapat digunakan oleh semua peringkat umur mahupun lapisan masyarakat seperti pelajar sekolah rendah, menengah ataupun pelajar yang bukan berlatarbelakangkan bidang elektrikal.

4.0 Dapatan Kajian dan Perbincangan

Kajian mendapati pencapaian pelajar dalam memahami modul *Basic Electricity (B01-01-02)* dapat dipertingkatkan melalui penilaian yang dijalankan.

Jadual 1: Perbandingan keputusan penilaian purata 40 orang pelajar

Kaedah Penilaian	Konvensional	*e-Basic Electricity for Beginner*
Markah purata	50%	80%

Selain dapat digunakan untuk memahami aplikasi rumus-rumus dalam pembelajaran teori dalam pengajaran dan pembelajaran, *e-Basic Electricity for Beginner* dilihat berpotensi untuk digunakan oleh sesiapa sahaja yang terlibat di dalam kerja-kerja pemasangan elektrik. Penggunaan program ini juga dapat mengurangkan penggunaan kertas (*paperless*).

5.0 Kesimpulan

e-Basic Electricity for Beginner dapat membantu dan memudahkan pengguna amnya dan pelajar jurusan Teknologi Elektrik 1 Fasa khususnya untuk memahami dan menguasai modul *Basic Electricity (B01-01-02)*. Ia juga mempunyai nilai komersil untuk dikembangkan dan dipasarkan. Selain mudah digunakan, *e-Basic Electricity for Beginner* juga mampu meningkatkan produktiviti serta motivasi untuk belajar dan bekerja. Penambahbaikan boleh dilakukan dengan membangunkan program ini dalam bentuk aplikasi android.

6.0 Rujukan

[1] www.electricianinformationresource.com
[2] Kertas Penerangan Modul 2 B01-01-02 LE 1 , ILJTM
[3] www.electricianexampracticetests.com/

E19: Solar Powered Lawn Mower

Alwary Suhaimy Johari[1], Raja Muhammed Raja Daud[2],
Siti Noormaizura Sarkam[3]
Jabatan Elektrik & Elektronik,
Institut Latihan Perindustrian Arumugam Pillai, Nibong Tebal

alwary@ilpapnt.gov.my,raja_mohd@ilpapnt.gov.my,
noormaizura@ilpapnt.gov.my

Abstract:

According to the U.S. Environmental Protection Agency (EPA), lawn mowers (like snow blowers, chain saws, leaf blowers and similar gas-powered garden equipment) emit high levels of carbon monoxide; a colorless, odorless, poisonous gas. EPA claimed that the lawn mowers also emit hydrocarbons and nitrogen oxides, pollutants that contribute to the formation of ozone. While ozone occurs naturally in the upper atmosphere and shields the earth from harmful radiation, ozone at ground level is a noxious pollutant. Ground-level ozone impairs lung function, inhibits plant growth and is a key ingredient of smog. As a result, we created remote control solar-powered lawn mower to help cut down on air pollution, gas consumption and noise which sustainable, environmentally friendly way of maintaining one's lawn that can be use by anyone even though a children. By using remote control, kids especially will like it and indirectly enhanced them in helping their parents during gardening.

Keywords: remote control, sustainable, pollutants, environmentally friendly, lawn mower

1.0 Pengenalan

Mesin rumput adalah satu mesin yang menjadi keperluan dalam kehidupan masyarakat buat masa ini. Di sekeliling rumah, sekitar pejabat, tanah-tanah lapang, padang-padang permainan, taman-taman rekreasi dan pelbagai tempat lagi pasti ada rumput yang mana sebagai tumbuhan yang membesar dan bertambah bilangan dari masa ke semasa, perlulah adanya proses untuk memotong dan merapikan rumput tersebut. Untuk tujuan itu mesin rumput telah dicipta dalam perkembangan teknologi manusia. Pelbagai jenis mesin rumput telah dicipta, daripada zaman tiada teknologi manusia menggunakan pisau yang bengkok di hujung untuk memotong rumput. Seterusnya teknologi berkembang masnusia mencipta mesin rumput menggunakan enjin. Ada yang jenis dipegang dan dikawal dengan tangan dan ada yang ditolak ke hadapan untuk memotong rumput. Semuanya itu adalah untuk tujuan memotong rumput. Teknologi makin berkembang pelbagai mesin rumput telah dicipta dari menggunakan enjin kepada menggunakan bateri dan daripada dikendali secara manual kepada dikendali dengan kawalan radio dan sebagainya. Projek ini dijalankan untuk merealisasikan mesin rumput yang menggunakan kuasa solar sebagai penggerak dan kawalan sepenuhnya menggunakan kawalan radio.

2.0 Pernyataan Masalah

Mesin rumput konvensional menimbulkan pelbagai kesan dan masalah seperti berikut :

i) Bahan api untuk mesin rumput yang sentiasa berlaku kenaikan harga membebankan pengguna
ii) Kesusahan bagi pengguna yang tidak boleh terkena bahang matahari panas untuk memotong rumput
iii) Mesin rumput galas belakang dengan kuasa enjin menghasilkan bunyi yang bising yang boleh membawa kesan kepada pendengaran pengguna
iv) Mesin rumput galas belakang juga agak berat untuk digunakan secara berterusan beberapa jam bagi pekerja-pekerja cuci kawasan dan ia mungkin akan membawa kepada kesakitan tulang belakang dan pinggang

Oleh itu, Mesin Rumput Berkuasa Solar (*Solar Powered Lawn Mower*) yang mudah dikendalikan, mempunyai tahap kebolehpercayaan yang tinggi serta mampu menjimatkan masa penggunaan dicipta bagi meningkatkan produktiviti.

3.0 Latar Belakang Solar Powered Lawn Mower

Kajian literatur mendapati projek ini dapat :

- Meningkatkan daya kreativiti dan inovasi pelajar dan pengajar
- Mencuba untuk menghasilkan sesuatu yang berguna kepada masyarakat
- Menghasilkan *prototype* yang boleh berfungsi dengan baik
- Memahami setiap fungsi komponen yang digunakan dalam projek
- Meningkatkan pengalaman pelajar dalam kerja-kerja elektrikal dan mekanikal
- Memupuk daya saing dalam diri pelajar untuk mencapai apa yang dirancang
- Memupuk kerjasama dalam kumpulan dikalangan pelajar
- Mengenal erti kepuasan dari hasil bertungkus lumus berusaha keras

4.0 Dapatan Kajian dan Perbincangan

4.1 Mesin rumput sedia ada di pasaran

i) Menggunakan solar hanya untuk rotor pemotong tetapi masih perlu di tolak secara manual sekeliling padang.
ii) Dikawal sepenuhnya menggunakan radio tetapi masih menggunakan enjin untuk menggerakkan mesin dan memotong rumput.
iii) Ada yang diprogramkan secara bijak untuk memotong rumput dan pulang ke tempat asal untuk di cas bateri semula tetapi tidak menggunakan solar, masih lagi menggunakan sumber elektrik di rumah untuk mengecas semula bateri

4.2 Solar Powered Lawn Mower

i) Dengan menggunakan solar panel dan bateri sepenuhnya, pengguna dapat memotong rumput tanpa menggunakan walau setitik bahan api. Ini pasti amat menjimatkan pengguna. Solar Panel boleh bertahan 20 hingga 30 tahun pasti akan membuatkan pengguna teruja akan ketahanan penggunaannya.
ii) Mesin rumput yang dikendalikan sepenuhnya secara remot dari jarak jauh akan memudahkan pengguna yang tidak tahan dengan bahang matahari. Pengguna dapat duduk di bawah pokok atau di halaman rumah atau dari dalam rumah untuk mengawal mesin rumput dan ia dapat beroperasi dengan baik tanpa masalah.
iii) Dengan menggunakan sepenuhnya mesin rumput yang dapat dikawal dengan radio , pekerja tidak terbeban dengan masalah bunyi yang bising dari enjin dan juga beban berat yang perlu digalas di belakang.
iv) Pada masa yang sama ia akan mengurangkan kemungkinan kos rawatan yang akan timbul dengan pelbagai masalah kesihatan yang mungkin timbul.

5.0 Kesimpulan

Projek ini boleh dikembangkan dengan memasang sensor yang membolehkan mesin rumput bergerak sendiri tanpa kawalan secara radio. Ia akan bergerak untuk memotong rumput dan jika ada halangan ia akan mengubah haluan dengan sendiri. Ia akan diprogramkan untuk memotong rumput mengikut koordinat dan luas ruang dengan penetapan panjang dan lebar dari titik mula ia beroperasi. Penambahbaikan lain adalah menggunakan bahan-bahan yang lebih ringan dan mengubah rekaan menggunakan motor yang lebih kecil kuasanya untuk mengurangkan penggunaan tenaga. Dengan pengurangan beban bahan dan kuasa motor yang di gunakan maka saiz solar panel dapat dikurangkan, ini akan menjimatkan kos pembinaan mesin rumput ini.

6.0 Rujukan

[1] http://www.cytron.com.my/
[2] http://en.wikipedia.org
[3] http://www.cprogramming.com/

E20: Prototaip Sistem Amaran Kepala Air

Syamsul Halim Bin Wahab[1] , Fairuzana Binti Kamso[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Alor Gajah, Melaka
Jabatan Elektrik & Elektronik

syamsulh.jtm@1govuc.gov.my, fairuzana.jtm@1govuc.gov.my

Abstrak

Fenomena kepala air merupakan salah satu fenomena semulajadi yang masih tidak diketahui umum secara meluas. Boleh dikatakan semua kawasan air terjun berpontensi untuk berlakunya kepala air ini. Kebiasaannya, fenomena ini berpunca daripada hujan lebat yang berlaku di hulu sungai. Apabila hujan lebat, aliran air ini menjadi sangat deras dan seterusnya membawa kelodak, dedaun dan juga kayu balak yang boleh mengancam bahaya kepada pengunjung air terjun. Berikutan banyak kejadian yang telah berlaku, ADTEC Melaka telah membangunkan Prototaip Sistem Amaran Kepala Air bagi menangani masalah ini. Dengan ini, satu mekanisme pemberitahuan dibangunkan untuk memberi amaran awal mengenai paras air yang telah mencapai tahap kritikal.

Hasil kajian yang dijalankan, mekanisme pemberitahun yang sesuai adalah menggunakan sistem pesanan ringkas (SMS). Melalui sistem ini, penderia terapung diletakkan di bahagian atas air terjun, di mana ia akan mengesan paras air hampir mencapai keadaan kritikal. Apabila penderia diaktifkan, dua isyarat SMS akan dikeluarkan. Satu SMS adalah pemberitahuan kepada pengawal dan satu SMS lagi akan mengaktifkan sistem di bahagian bawah air terjun . Sistem di bahagian bawah air terjun akan membunyikan penggera (siren) untuk memberi amaran awal kepada pengunjung sekiranya berlaku kenaikan paras air secara mendadak. Dengan ini, ia memberi ruang kepada pengunjung untuk menyelamatkan diri. Projek ini dibangunkan untuk menghasilkan sistem amaran kepala air dengan kos yang lebih efektif berbanding dengan sistem yang sedia ada.

Kata Kunci : Kepala air, Sistem Pesanan Ringkas (SMS), Mekanisme Pemberitahuan, Penderia Terapung, Pengawal.

1.0 Pengenalan

Kepala air bermaksud punca aliran air secara semulajadi dalam kuantiti yang besar serta menghanyut segala sampah, kelodak dan pokok-pokok daripada hulu sungai atau air terjun ke sungai utama secara mengejut [4]. Lazimnya, ia berpunca daripada hujan lebat yang berlaku di hulu sungai. Kepala air cuma berlaku di sungai-sungai kecil dan ianya tidak bermusim. Fenomena 'kepala air' adalah sangat berbahaya dan tidak boleh dipandang ringan oleh semua pihak. Dengan ini, satu sistem amaran yang efisien perlu ada di setiap kawasan air terjun.

2.0 Latarbelakang

Sehingga kini, walaupun tiada statistik yang tepat, kadar kematian disebabkan fenomena kepala air di kawasan air terjun semakin meningkat. Masih ramai yang tidak mengetahui bagaimana fenomena kepala air ini boleh terjadi. Ini menjadikan orang ramai tidak peka akan keselamatan diri mereka. Antaranya boleh dilihat dalam berita-berita tempatan seperti yang ditunjukkan dalam Gambarajah 1.

Sebelum 'Kepala Air' Lalu　　Semasa 'Kepala Air' Lalu

3 beradik lemas di hutan lipur

> "Saya terkejut melihat 'kepala air' mengalir deras bersama objek yang kelihatan seperti manusia. Apabila diamati saya dapati ia seorang lelaki dan seorang perempuan dewasa bersama dua kanak-kanak terkapai-kapai minta tolong," kata Turiman Bostam, 40, saksi kejadian lemas mengorbankan tiga beradik perempuan, semalam.

Tiga sahabat ditemui maut

'Kalau umur aku panjang' umpama petanda tragedi lemas di kawasan perkelahan

INFO

Gambarajah 1: Berita berkenaan fenomena kepala air

Kajian dilakukan pada Stesen Siren Gemas di Negeri Sembilan mendapati terdapat beberapa masalah yang dialami oleh sistem siren sedia ada yang menyebabkan pengoperasiannya tidak efektif dan kurang sesuai [3]. Berikut adalah masalah tersebut.

i. **Bunyi siren tidak didengari**
Apabila berlakunya banjir, bunyi siren tidak didengari bagi penduduk yang tinggal berjauhan dari sistem siren ini. Maka amaran tidak dapat diketahui dengan segera yang boleh menyebabkan keadaan bahaya pada penduduk.

ii. **Bunyi siren terlalu kuat**
Bagi penduduk yang tinggal berdekatan dengan sistem siren ini pula, bunyi siren yang kuat apabila berlakunya banjir pula menyebabkan gangguan pendengaran kepada mereka.

iii. **Tiada perhubungan secara SMS dengan orang awam**
Perhubungan secara SMS dengan orang awam atau penjaga kawasan adalah penting bagi memastikan langkah berjaga-jaga dapat diambil dengan segera. Sistem sediaada terhad kepada bunyi siren sahaja.

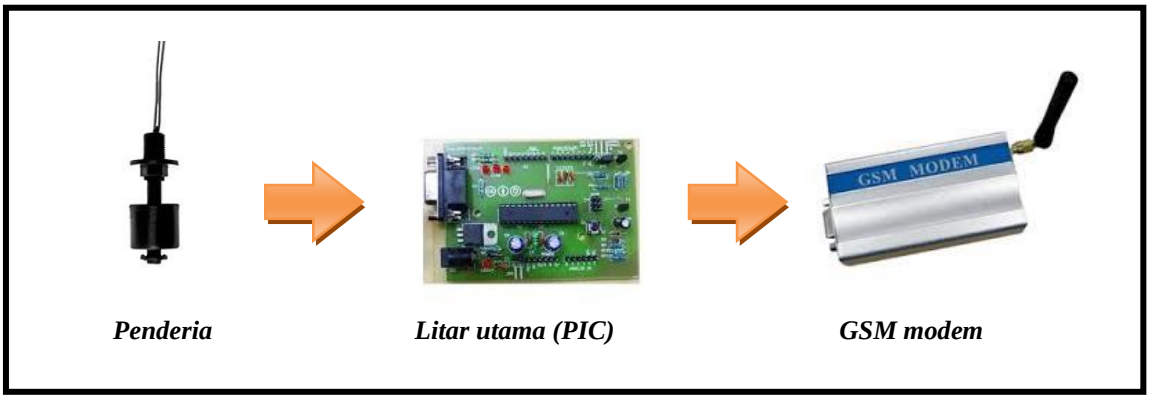
iv. **Kos pemasangan yang tinggi.**
Kos pembinaan dan pemasangan sistem yang agak tinggi sehingga mencecah ratusan ringgit menyebabkan sistem seperti ini tidak dapat dipasang di semua kawasan rekreasi air terjun yang kebiasaannya menghadapi fenomena kepala air yang amat membimbangkan kini.

3.0 Prototaip Sistem Amaran Kepala Air

Prototaip Sistem Amaran Kepala Air ini adalah satu sistem berdasarkan teknologi SMS [2] yang telah dibangunkan oleh Pusat Latihan Teknologi Tinggi (ADTEC) Melaka bertujuan untuk memaklumkan amaran awal kepada penjaga kawasan dan pengunjung terhadap kemungkinan berlakunya fenomena kepala air di kawasan rekreasi air terjun. Dengan adanya amaran awal yang dikeluarkan oleh sistem ini, penduduk dan pengunjung kawasan sekitar mempunyai tempoh masa yang mencukupi untuk mengambil tindakan yang sewajarnya dalam menyelamatkan diri, keluarga dan harta benda sekiranya berlaku aliran air deras atau lebih dikenali sebagai fenomena kepala air.

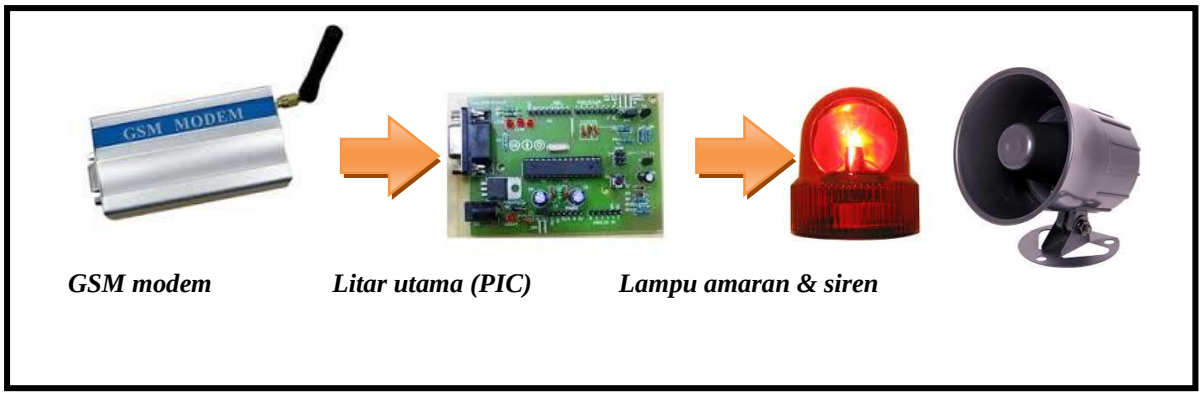
3.1 Rekabentuk Projek [1]

Tiga komponen utama di dalam sistem ini adalah penderia, litar utama yang menggunakan *Peripheral Interface Controller* (PIC) dan modem GSM (*Global System for Mobile*) yang menghantar SMS. PIC pada litar utama diprogramkan supaya boleh bertindak sebagai pengawal. Di bahagian sistem penghantar (rujuk Gambarajah 2), penderia akan mengesan paras air dan disambungkan kepada litar utama sebagai input. Kemudian, litar utama akan memberi arahan kepada modem GSM untuk menghantar SMS. Seterusnya, modem GSM akan menghantar SMS kepada dua penerima iaitu sistem penerima di bahagian bawah air terjun dan telefon selular penjaga kawasan yang bertanggungjawab.



Gambarajah 2: Sistem Penghantar

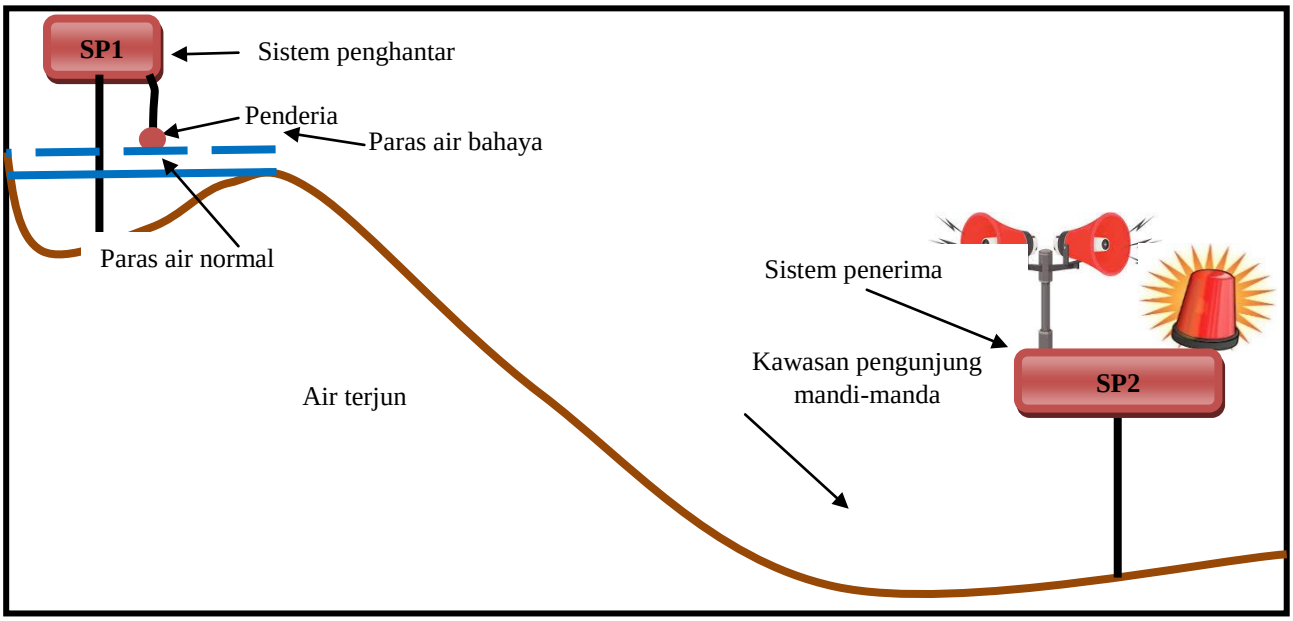
Di bahagian sistem penerima pula (rujuk Gambarajah 3), modem GSM akan menerima SMS yang dihantar oleh sistem penghantar tadi sebagai input. Kemudian, ia akan menghantar isyarat kepada litar utama, di mana litar utama akan memproses isyarat tersebut dan memberi arahan untuk menghidupkan lampu amaran dan siren sebagai output. Dengan ini, lampu amaran akan menyala dan siren akan berbunyi.



Gambarajah 3: Sistem Penerima

3.2 Penerangan Projek

Berdasarkan Gambarajah 4, apabila paras air naik mendadak di bahagian atas air terjun dan mengenai penderia, maka sistem penghantar (SP1) akan menghantar SMS (sistem pesanan ringkas) kepada sistem penerima (SP2) di bahagian bawah air terjun dan juga kepada penjaga kawasan air terjun tersebut. Ini bermakna sistem penghantar, SP1 perlu diletakkan di bahagian atas air terjun. Penderia akan diletakkan pada paras yang ditetapkan untuk mengesan kenaikan paras air yang dianggap berbahaya. Apabila sistem penerima (SP2) yang ditempatkan di bahagian bawah air terjun menerima SMS tersebut, ia akan menghantar isyarat kepada siren untuk berbunyi dan lampu amaran untuk menyala. SMS yang dihantar kepada penjaga kawasan air terjun tersebut juga akan membolehkan penjaga kawasan tersebut mengambil langkah yang sewajarnya untuk menyelamatkan pengunjung kawasan tersebut.



Gambarajah 4: Sistem Amaran Kepala Air dipasang di kawasan air terjun

3.3 Penerangan prototaip [1]

Prototaip yang dibangunkan (rujuk Gambarajah 5) menggunakan dua tangki bagi mewakili bahagian atas dan bawah air terjun. Bagi mewujudkan situasi aliran air seperti air terjun, sistem menggunakan pam air. Penderia magnetik digunakan di dalam sistem ini di mana satu paip dipasang secara menegak pada tangki. Kemudian, material yang akan dikesan dilekatkan pada pelampung dan diletakkan ke dalam paip tersebut. Apabila air naik, pelampung bersama material juga akan naik sehingga ke satu tahap yang akan mengaktifkan penderia magnetik. Bagi pengawal di dalam litar utama, PIC digunakan kerana kosnya yang murah. Ia diprogramkan menggunakan bahasa C.

Gambarajah 5: Prototaip Sistem Amaran Kepala Air

4.0 Kelebihan Projek

Kelebihan sistem ini adalah ia menggunakan SMS sebagai medium penghantaran isyarat amaran. Ini membolehkan sistem menghantar isyarat kepada jumlah penerima yang lebih banyak. Ini amat penting bagi kawasan air terjun rekreasi yang mempunyai beberapa tempat mandi. Sistem SMS juga tidak akan terpengaruh dengan faktor jarak [2]. Berbanding dengan sistem sedia ada seperti yang terdapat di Stesen Siren Gemas, ia menggunakan mekanisme *Radio Frequency Identification* (RFID) yang terbatas pada jarak tertentu [3].

5.0 Keputusan dan Perbincangan

Melalui ujian yang dilakukan didapati batang paip yang menempatkan material yang akan dikesan oleh penderia magnetik terlalu kecil. Ini menyukarkan air masuk dan menaikkan pelampung yang terdapat material tersebut. Langkah yang di ambil adalah menukar saiz batang paip yang lebih besar. Ujian yang dilakukan selepas pengubahsuaian dilakukan mendapati sistem penghantar berjaya menghantar SMS kepada sistem penerima dan seterusnya menghidupkan siren dan lampu. Walaupun begitu, penggunaan mekanisme batang paip dan penderia magnetik adalah kurang sesuai kerana kesukaran mengesan material pada pelampung. Bagi sistem sebenar, penggunaan penderia terapung atau penderia ultrabunyi adalah lebih baik.

5.1 Cadangan penambahbaikan

Antara cadangan penambahbaikan yang dicadangkan adalah seperti berikut:

- Menukar penderia kepada penderia yang lebih sesuai dan tahan lasak seperti penderia terapung atau penderia ultrabunyi.
- Membangunkan bekalan kuasa pada sistem yang menggunakan solar.
- Menambah sistem kamera untuk memantau paras air terjun di bahagian atas.

6.0 Kesimpulan

Dengan lebih 55 kawasan rekreasi air terjun di Malaysia, sistem ini dilihat mampu dipasarkan dengan mudah kerana kosnya yang murah dan menggunakan komponen yang sedia ada di pasaran disamping memberi pulangan yang lumayan. Pasaran sistem amaran kepala air masih lagi cair, dimana belum ada sistem yang murah, ringkas dan berkesan. Akhir sekali, adalah didapati projek ini mempunyai potensi untuk dimajukan dengan lebih lanjut dengan mengambil kira penambahbaikan yang perlu dilakukan dan boleh dipasang pada semua kawasan rekreasi air terjun bagi mengelakkan kehilangan nyawa akibat fenomena kepala air.

7.0 Rujukan

[1] Laporan Projek Prototaip Sistem Amaran Kepala Air

[2] Sistem pesanan ringkas (SMS) (Mohd Ali Atan, ISBN 9679389456)

[3] http://habinovasi.mampu.gov.my/laporan_inovasi/840-sistem-siren-amaran-banjir-menggunakan-network-radio-frequency-rfid.pdf (10 Ogos 2015, 9.00 am)

[4] https://terengganuoutdoorstore.wordpress.com/2013/01/22/fenomena-kepala-air/ (10 Ogos 2015, 8.00 am)

E22: Application of Microwave Bandpass Filter as a Sensor

Siti Nurul Ain Binti Jalani
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka

sitinurulainjalani@gmail.com.my

Abstract

This paper is mainly focused on development of microwave sensor by using bandpass filter principle. The reason of this paper is to develop the microwave sensor with knowledge about the potential of the microwave technique to implement practical microwave sensors. Microwave sensor, generally operate at microwave frequencies with frequencies between 300 MHz to 300 GHz. This paper developed microwave sensor based on principle of microstrip filter design because of the microstrip filter is filled with a material then produces a response frequency shift and a broadening of the curve compared to free space. The Microwave Office Simulator (MWO) is used to design the microstrip dimension of the filter sensor system. Besides that, MATLAB is used programmed for the sensor design. The main objective of this paper is to create a sensitivity of microstrip filter sensor for characterizing the quality of rice. The simulations results are compared with the available literature data. The end of this paper, the microstrip filter are sensitive with different type of rice which proven by the shifted of frequency is slightly different with different type of rice.

Keywords: *Bandpass filter, Microstrip filter, Microwave sensor*

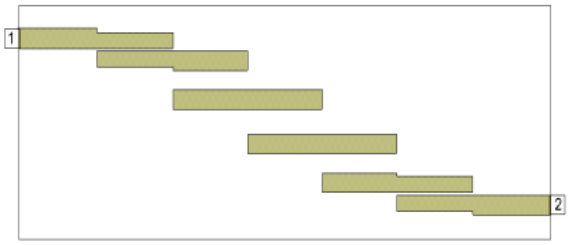
1.0 Introduction

Microwave sensors technology was originally developed in early 1960s, resulting in the first commercial sensors [1]. The application of microwave sensor are available everywhere and a lot of the materials properties can be measured using it. It is a sensor that operates in microwave frequency. Microwave is operated a 300MHz o 300GHz. The purpose of this paper is to develop a microwave sensor that can be used widely in the industrial application. There are several advantages in microwave sensor such as insensitive to environmental conditions; fast and it also does not affect the material under test. However it still has some disadvantages, whereby at the higher frequency, the electronic components are more expensive and microwave meters must be calibrated separately for different materials.

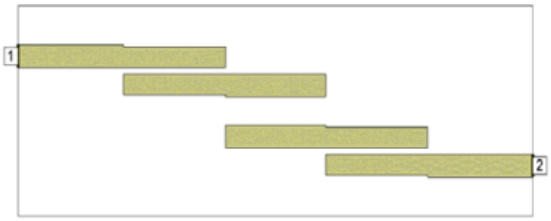
This paper developed a microwave sensor based on principles of microstrip filter design. The size and the arrangement of the coupled lines are based on resonant principle in order to obtain sensitive operation frequency range which can cover the ISM band [2]. Similarly, the measurement methods implement for this study sensor are reflection/transmission technique. The microwave office simulator is used to design the microstrip dimension of the filter sensor system. A part from that, MATLAB is the program used for the sensor design.

2.0 Design and Fabrication

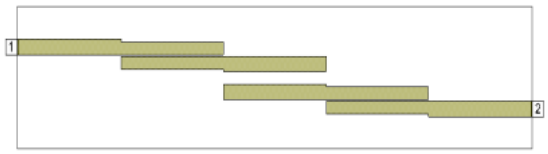
In this study, 2^{nd} and 4^{th} order bandpass filter sensors were constructed using low cost FR4 and RT/Duroid 5880 printer circuit board (PCB), respectively. All filter sensor were designed based on Butterworth routine and sketch by using AutoCAD software. Then, the drawing filter line was printed on act paper and attached on PCB using ironing technique. Finally, the PCB was etched and fabricated with acrylic sample holder as shown in Figure 1. The detail calculations for the filter physical dimensions are not described here, since it can be found in several literatures [3].



(a) The Microstrip Filter Design for 4th order FR4 Board



(b) The Microstrip Filter Design for 2nd order FR4 Board



(c) The Microstrip Filter Design for 2nd order RT/Duroid Board

Figure 1: Microstrip Filter Design wih Dimension

The dimension of microstrip line (width W, length L and size coupling gap S) and specificaions of the PCB substrate for each sensor are tabulated in Table 1.

Table 1: Dimensions for the Parallel Coupled Bandpass Filter Sensors

Substrate	Order	Dimensions								
		W1	W2	W3	L1	L2	L3	S1	S2	S3
FR4 $\varepsilon_r = 4.2$ $\tan \delta = 0.03$ $h = 1.6$ mm	2nd	2.7	3.0		16.5	16.2		0.8	3.6	
	4th	2.7	3.3	3.3	17.5	17.0	17.0	0.5	3.2	4.2
RT/Duroid $\varepsilon_r = 2.2$ $\tan \delta = 0.004$ $h = 0.787$ mm	2nd	2.0	2.3		22.1	22.0		0.3	2.0	

Measurement process is the process to test whether the filter are operated at the same result with simulation process or not. It is also to test whether the coupled line bandpass filter are sensitive with the material or not. So, for this study, the samples of rice are used to test the Bare given the different resonant frequency. The equipment used to test the filter sensor is E5071C ENA Series Network Analyzer.

Before do the measurement process, there have to calibrate he two port of Network Analyzer to ensure that there is no distortion or error during do the measurement. After the calibration done, the measurement process can be determined. Figure 2 shows the process to connect the filter sensor with the connector.

Figure 2: Air filled Sensor

After the measurement of filter sensor without any material, test the filter with the rice. Before that, the rice has to blend to ensure there is no gap between each other. Put the rice in the filter sensor and then see whether the resonant frequency is different with the filter sensor without the rice. Figure 3 shows the filter sensor with the rice. The type of rice has been used are Sakura Super Thai Brown Rice (sample 8), Sakura Super Basmathi Pakistan Rice (sample 9) and Giant Super Special Rice (sample 10).

Figure 3: Filter Sensor with the Sample of Rice

3.0 Results and Discussions

The results from the measurements for 4^{th} order and 2^{nd} order microstrip bandpass filter printed on FR4 board and 2^{nd} order microstrip bandpass filter printed on RT Duroid has been combined in one graph using MATLAB software. Figure 4 shows the configuration of microwave filter sensors.

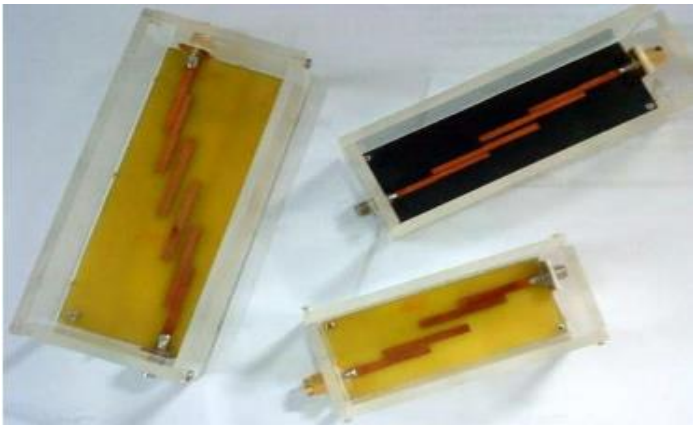


Figure 4: Configuration of Microwave Filter

Figure 5 and figure 6 shows the result for measurement results which is consist of reflection and transmission of the microstrip coupled line bandpass filter.

Figure 5 demonstrate the results for measurement of bandpass filter principle by using ENA Agilent Technologies which is S_{21} versus the frequency in GHz. From the observation, the 2^{nd} order bandpass filter printed on RT Duroid id the best result compared to FR4 board because it has low loss in comparison to other designed. The explanation behind it is because the S_{21} are approximately 0dB at the passband of transmission line. A part from that, the different sample of rice is given the different transmission line. The simulation result is quite similar to the measurement result in term of air.

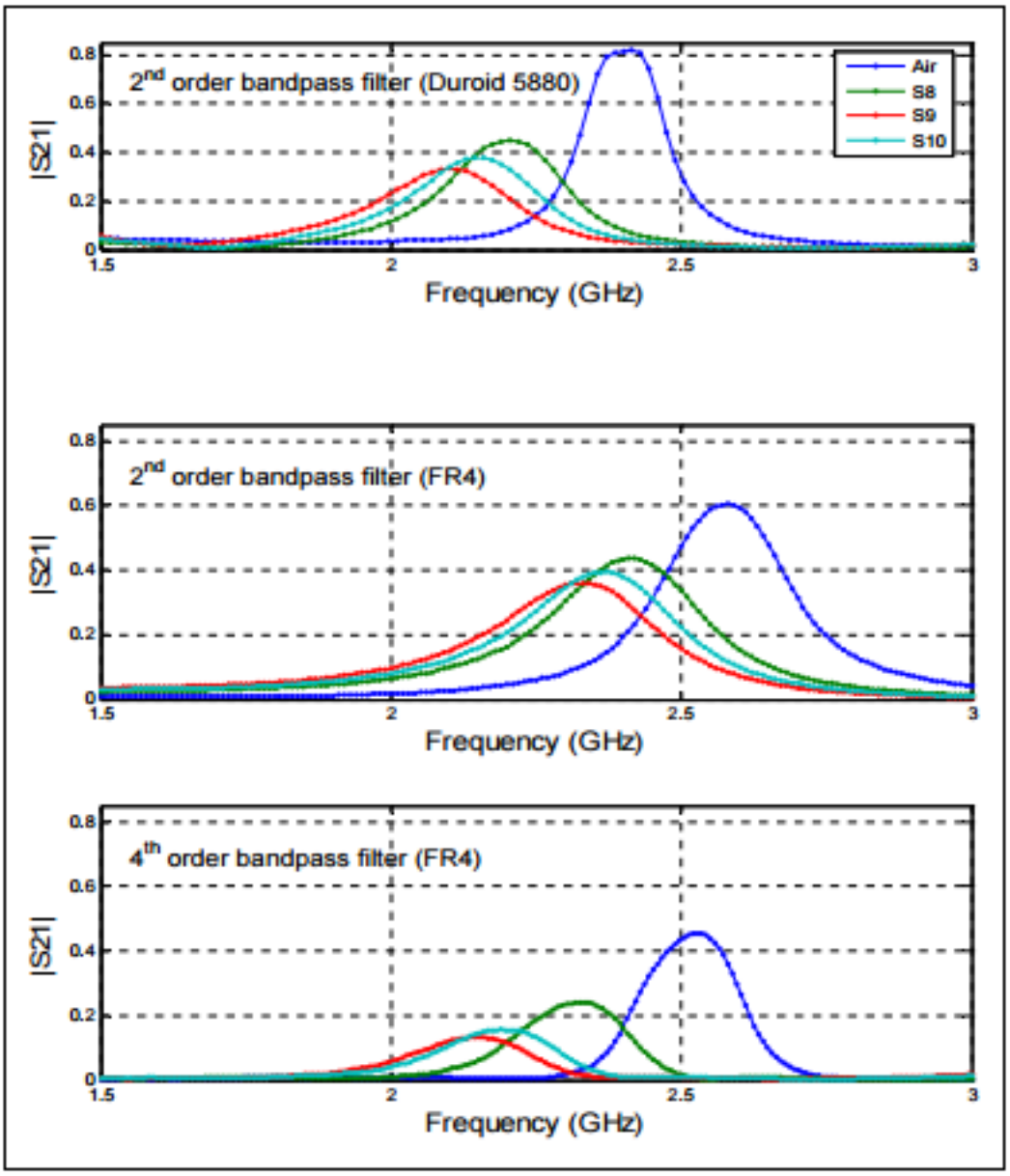


Figure 5: Transmission Line, S_{21} versus the Frequency (GHz)

The S8, S9 and S10 are referred to the different samples of rice whih is S8 is Sakura Super Thai Brown Rice, S9 is Sakura Super Basmathi Pakistan Rice and S10 is Giant Super Special Rice. Sample 8 is the lowest permittivity compare to other samples. Exactly, different of material or samples are given different of dielectric constant but for the rice the permittivity is not so much different even though there have many samples of rice. Therefore, it actually explains why the results for sample 8, sample 9 and sample 10 did not so much different between each other.

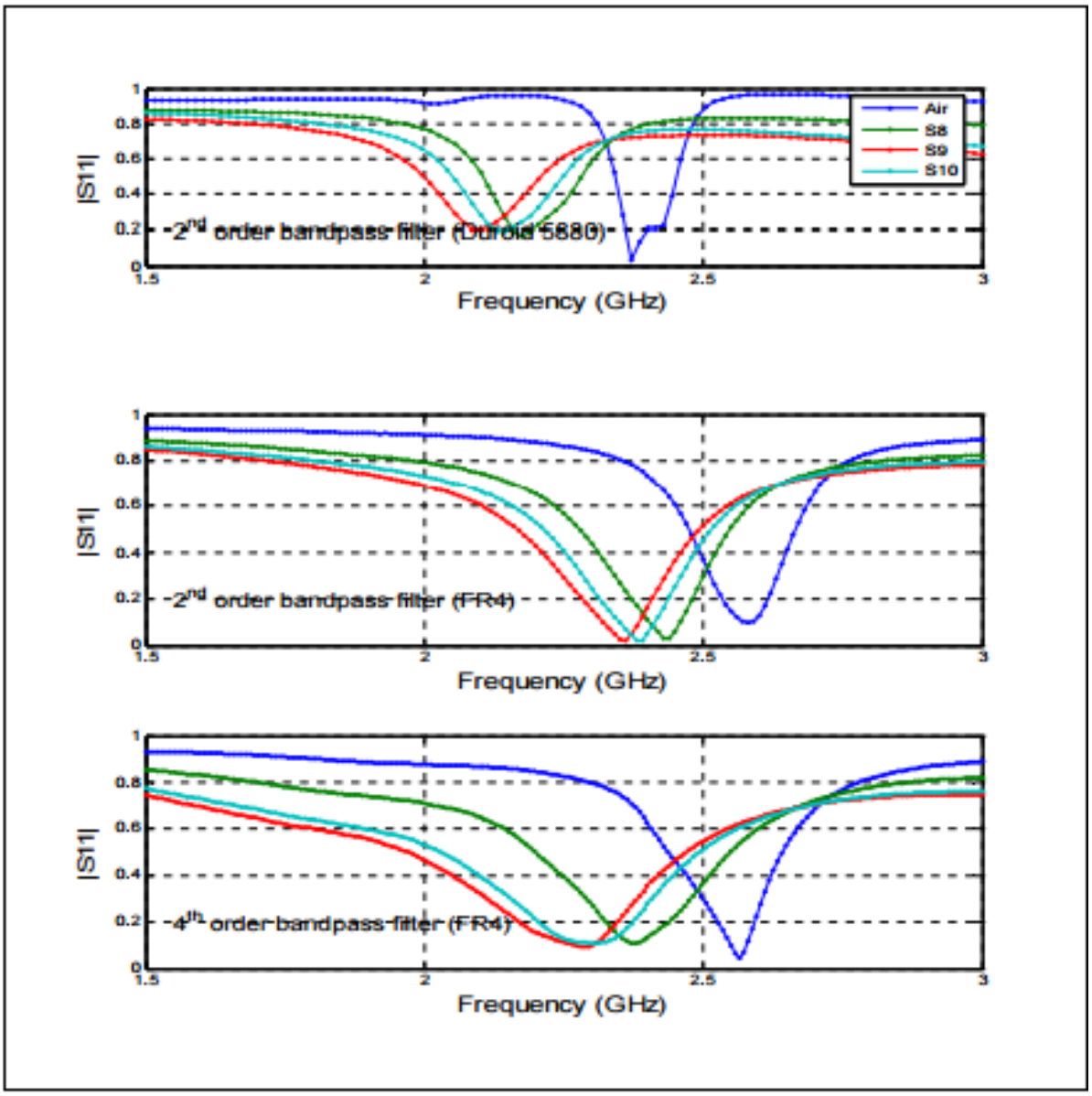


Figure 6: Reflection, S_{11} versus the Frequency (GHz)

Figure 6 reveal the results for return loss versus operating frequency. For the RT Duroid board, the simulation and measurement are quite similar which the resonant frequency at 2.46GHz but for the FR4 board, both of the design fallen at 2.6 GHz. Exactly, for the reflection for graph above shows that the three samples shows the quite same results. For FR4 board, for the lower order is better than high order in term of losses. The reason is more order is given more coupled between one lines to another. From the observation, it can be concluding that RT Duroid is the best material board to use and also the lower other is given less of losses. Besides that, the coupled line filter sensor is sensitive due to the samples of rice.

4.0 Conclusion

This study had developed microwave sensor using bandpass filter principle which are very important depends on the agriculture applications. Rice is the material that been used to create the sensitivity of microwave filter sensor in this paper. From the results, it can be conclude that microwave filter sensor is sensitive due to the samples of rice which is different samples of rice are given the different resonant frequency. Besides that, the simulation results are not so much different with the measurement results. From the observation, RT Duroid board is more sensitive compare to FR4 board even though RT Duroid is expensive than FR4 board

5.0 References

[1] M. Kent, "The use of strip-line configuration in microwave moisture measurement," Journal of Microwave Power and Electromagnetic Energy, vol. 7, pp. 185-193.

[2] Siti Nurul Ain Binti Jalani, "Design of Microwave Bandpass Filter Principle", Universiti Teknologi Malaysia, 2010

[3] You Kok Yeow[1] , Siti Nurul Ain Jalani[2] , Zulkifly Abbas[3] , and You Li Ling[4], 'Application of Bandpass Filter as a Sensor for Rice Characterization", Journal of Computer Application and Industrial Electronics, 2010

[4] K. Sarabandi, and E. S. Li, "Microstrip ring resonator for soil moisture measurements," IEEE Transactions on Geoscience and Remote Sensing, vol. 35, pp. 1223-1231, September 1997.

[5] Y. J. Zhang, and S. Okamura, "A density-independent method for high moisture content measurement using a microstrip transmission line," Journal of Microwave Power and Electromagnetic Energy, vol. 41, pp. 110-117, 2006.

[6] Mongia, Bahl, Bhartia and Hong, RF and Microwave CoupledLine Circuits, Actech House: NewYork, 2007.

E26: Friendly Digital Incubator

Noor Hairilfaiz Bin Mohammad[1], Banisrekha Binti Mohd Nawi[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Kulim

Abstrak

Inkubator adalah satu alat untuk menetaskan telur unggas seperti ayam, puyuh, itik, angsa dan lain-lain tanpa memerlukan induknya. Kebiasaannya inkubator moden yang ada di pasaran adalah mahal harganya. Inkubator yang dicipta untuk industri kecil pula bermodal rendah, menggunakan mentol sebagai alat pemanas dan thermostat sebagai pengawal suhu. Antara kelemahan inkubator ini ialah suhu semasa dalam inkubator tidak dapat dibaca dengan tepat dan inkubator tersebut hendaklah sentiasa dipantau untuk memastikan suhu dalam keadaan stabil. Oleh itu pengguna sentiasa berulang-alik ke lokasi inkubator untuk memastikan perkara tersebut. Dari segi kawalan suhu pula adalah kurang stabil kerana hanya satu thermostat yang mengawal semua mentol yang ada pada inkubator. Setiap mentol akan menyala dan padam serentak untuk stabilkan suhu.'Friendly Digital Incubator' atau 'FDI' adalah projek untuk menaiktaraf inkubator untuk industri kecil tanpa menjejaskan harga kos inkubator tersebut. Thermostat akan diganti dengan satu sistem digital yang mampu mengawal setiap mentol disamping memaparkan suhu semasa dalam inkubator tersebut. 'FDI' juga disertakan satu alat kawalan yang juga mampu memaparkan suhu semasa inkubator, menetapkan suhu inkubator dan mengeluarkan amaran jika terjadi masalah. Alat kawalan ini berkomunikasi dengan inkubator menggunakan gelombang radio untuk memudahkan pemantauan inkubator tanpa perlu ke tempat inkubator tersebut.

Kata Kunci : *Inkubator, RF, Unggas, Microcontroller, Kawalan suhu*

1.0 Pengenalan

Inkubator adalah satu alat pengeraman telur unggas untuk menggantikan pengeraman secara semulajadi. Inkubator ini penting kepada penternak unggas untuk mempercepatkan pembiakan ternakan mereka. Dalam penetasan telur, faktor yang penting ialah penjagaan suhu dan kelembapan. Suhu yang stabil menjamin peratusan kejayaan penetasan telur.

Inkubator secara amnya dapat dibahagikan kepada dua jenis. Inkubator manual dan inkubator automatic. Inkubator automatik mampu memusingkan telur pada jeda masa seperti yang ditetapkan. Manakala inkubator manual memerlukan penternak mengalihnya sendiri. Namun kedua-dua inkubator ini menggunakan thermostat beserta alat pemanas untuk mengawal suhu supaya sentiasa stabil. Inkubator juga tertutup supaya kelembapan yang tinggi dapat dikekalkan. Setiap telur unggas mempunyai masa penetasan dan suhu yang tersendiri.

Projek ini direka khas menggantikan inkubator manual dengan menggantikan thermostat kepada sistem digital menggunakan microcontroller.

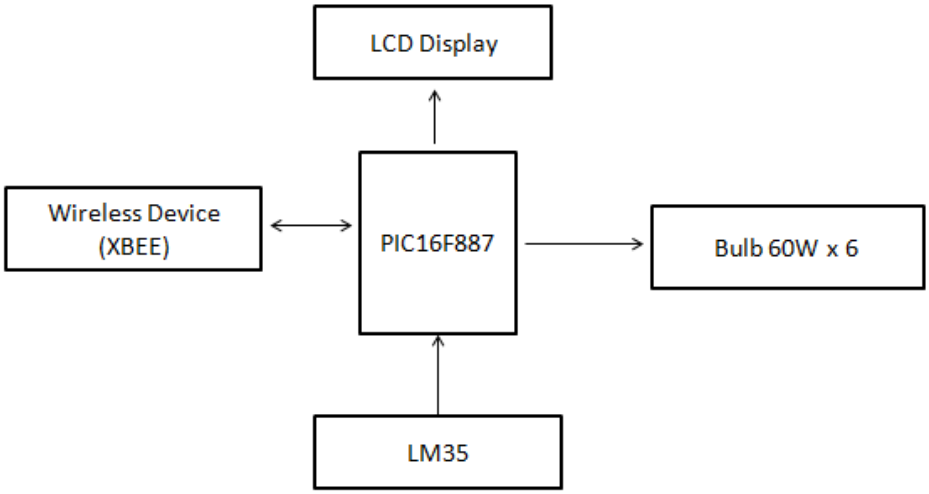
2.0 Latar belakang

Projek ini menggunakan *PIC16f887* dan sensor suhu *LM35* untuk mendapatkan bacaan suhu. Menggunakan teknik aturcara *digital PID* sabagai asas untuk kawalan suhu. *PIC16F887* akan mendapatkan bacaan suhu dari *LM35* seterusnya membandingkan dengan suhu yang ditetapkan dan seterusnya dengan teknik PID untuk mendapatkan suhu yang stabil. Alat pemanas disini digantikan dengan mentol 60W sebanyak enam biji. Pemanas digantikan dengan mentol kerana mentol lebih murah disamping mudah didapati di kedai-kedai. Penggunaan mentol dipilih adalah kerana mentol dapat dikawal setiap satunya menjadikan kawalan suhu lebih baik berbanding dengan penggunaan pemanas. Kipas juga dipasangkan untuk penyebaran suhu disamping mengekalkan kelembapan yang tinggi (>75%) daripada penyejatan air yang diletakkan dalam inkubator ini.

Projek ini juga dapat memberi kemudahan kepada pengguna dengan menawarkan kemudahan untuk membaca suhu dalan inkubator dari dalam rumah tanpa perlu ke tempat penternakan. Hal ini kerana projek ini dilengkapi dengan sistem tanpa wayar *(XBEE).* Satu remote akan diletakkan di kawasan yang sesuai dalam radius 300meter dari inkubator berada.

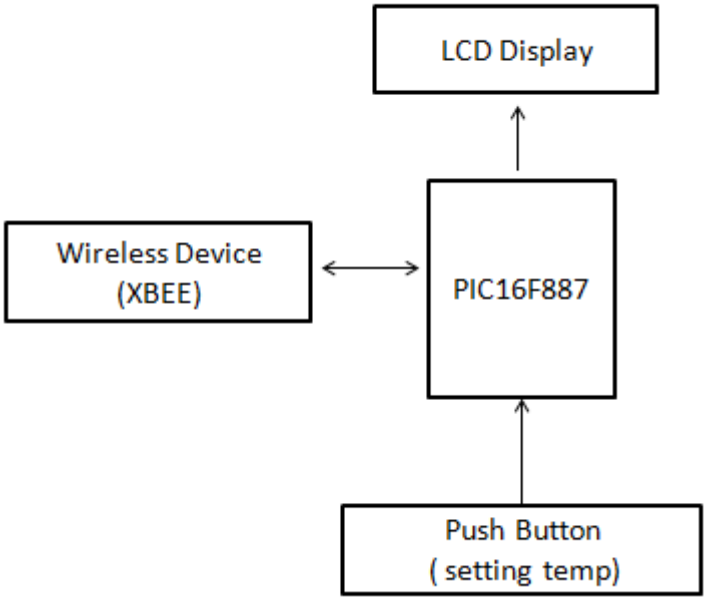
3.0 Metodologi Projek

Projek ini dapat dibahagikan kepada dua bahagian. Pertama bahagian inkubator dan kedua ialah bahagian alat kawalan dan bacaan suhu. Pada inkubator juga dilengkapi *LCD display* untuk memaparkan suhu inkubator disamping memaparkan penetapan suhu mengikut jenis telur.



Rajah 1 : Inkubator

Pada inkubator *PIC16F887* berperanan sebagai pengawal. Daripada suhu yang diperoleh *LM35*, *PIC16F887* akan membandingkan dengan suhu yang ditetapkan dan seterusnya mengawal nyalaan lampu sama ada *ON* atau *OFF*. Seterusnya bacaan suhu ini akan dihantar kepada alat kawalan melalui medium *Xbee*.



Rajah 2 : Alat kawalan Inkubator

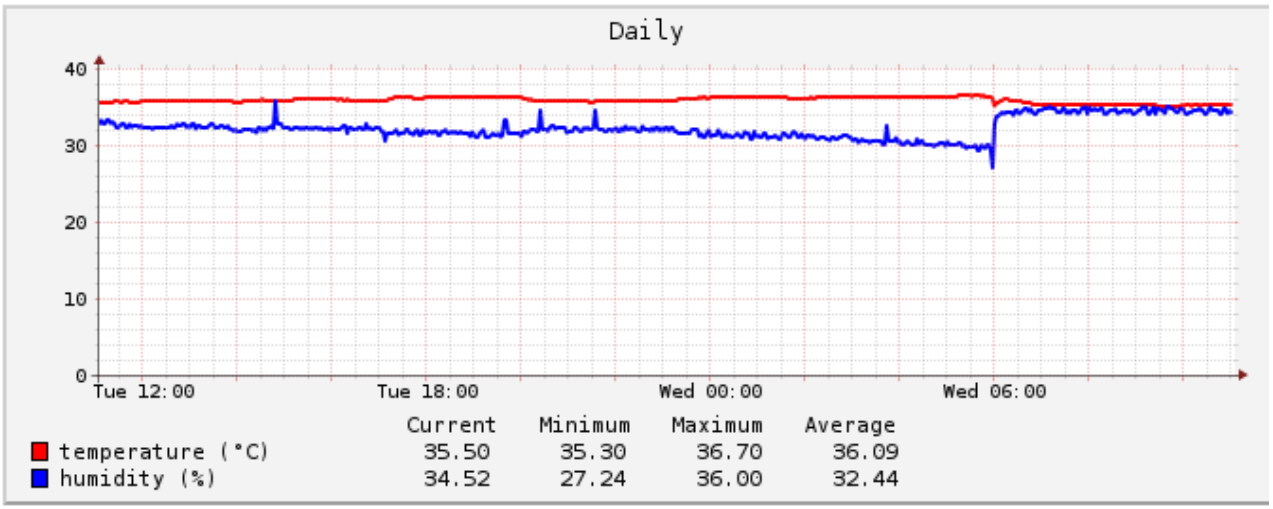
Alat kawalan pula berfungsi untuk mengambil bacaan suhu dari inkubator dan paparkan bacaan suhu tersebut pada LCD display. Alat kawalan juga berfungsi untuk menetapkan suhu dan seterusnya menghantar tetapan suhu kepada inkubator.

Species	Incubation Period (days)	Incubation Temperature (°F)
Chicken	21 (bantams: 20)	99.5
Ducks (not muscovy)	28	99.5
Muscovy Duck	35	99.5
Geese	28 to 33	99.5
Turkey	28	99.5
Quail: Coturnix (Japanese)	16 to 18	99.5
Quail - Bobwhite	23 to 24	99.5
Guinea Fowl	27 to 28	99.5
Lovebirds	23	99.5
Pheasants	24 to 26	99.5
Peacocks	28	99.5
Ostrich	42	97.0

Rajah 3 : Jadual penetapan antara jenis telur

4.0 Keputusan dan Perbincangan

Keupayaan inkubator di uji dengan mendapatkan bacaan suhu pada setiap hari untuk memastikan kestabilan bacaan suhu dan kelembapan.



Rajah 4 : suhu dan kelembapan

Berdasarkan Rajah 4 di dapati mampu untuk mengekalkan suhu sepertimana yang telah ditetapkan. Pada hari Rabu jam 6 am suhu didapati sedikit menurun kerana pintu inkubator telah dibuka untuk menambah air kerana kelembapan semakin rendah.

Kelembapan adalah satu faktor yang sukar dikawal. Peratusan kejayaan penetasan telur akan meningkat jika kelembapan tinggi. Oleh itu keadaan inkubator perlulah dipastikan sentiasa lembab dengan kelembapan melebihi 75%. Oleh itu cara untuk mengawal kelembapan adalah dengan memastikan bekas yang berisi air wujud dalam inkubator disamping kipas dihidupkan supaya air cepat tersejat.

5.0 Kesimpulan

Inkubator ini mampu digunakan kerana mampu memberikan suhu yang stabil disamping mengekalkan kelempaba. Akan tetapi kelemahan projek ini ialah pengguna perlu sentiasa membalikkan telur sendiri. Sewaktu membalikkan telur, pernggguna perlu membuka inkubator yang semestinya member impak kepada suhu dan kelembapan dalam inkubator ini. Oleh itu satu mekanisma lain perlu dikaji bagi mengatasi masalah ini.

6.0 Rujukan

[1] http://arduino.fisch.lu/index.php?menu=53&page=&portal=9 19 Aug 2015 1:14pm

[2] http://www.mypetchicken.com/hatching-eggs/chapter-5-choosing-an-incubator-incubation-tips.aspx 19 Aug 2015 1:14pm

[3] (2) Mkye Press, Programming & Customizing the PIC Microcontroller 3rd Edition (2008) Tab Electronics

E27: Switch Smart Phone

Noor Hairilfaiz Bin Mohammad[1], Mohd Edzrin Bin Abd Aziz[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Kulim

Abstrak

Suis untuk mengawal peralatan elektrik seperti lampu dan kipas adalah menjadi kewajipan yang perlu ada pada setiap rumah. Suis yang ada di rumah kadang kala mencacatkan hiasan yang ada disamping aturan suis yang tidak tersusun membuatkan pengguna sering alpa pasangan suis dan alat elektrik yang dikawalnya. Kedudukan suis yang tetap pada dinding menyebabkan pengguna sering bergerak untuk mengawal peralatan elektrik. Jika pengguna berada jauh dari rumah, suis tersebut sudah tidak mampu dikawal lagi.Perkembangan pesat teknologi telekomunikasi, teknologi tanpa wayar dan teknologi pembuatan telefon pintar mampu di aplikasi untuk kemudahan manusia. Rentetan itu terhasillah ilham untuk mengaplikasi teknologi tersebut dalam penciptaan projek yang diberi nama 'Switch Smart Phone'. Fokus utama penciptaan projek ini adalah untuk memberi kemudahan dan keselesaan kepada pengguna di rumah untuk mengawal suis elektrik disamping meningkatkan keselamatan rumah jika pengguna berada di luar.'Switch Smart Phone' adalah satu projek yang menjadikan telefon pintar sebagai alat kawalan untuk mengawal suis peralatan dirumah ketika berada di rumah mahupun jauh dari rumah. Ketika berada di rumah, pengawalan suis dilakukan melalui telefon pintar dengan menjadikan teknologi BlueTooth sebagai perantara. Manakala jika berada jauh dari rumah, pengawal suis akan dijadikan sebagai web server yang boleh diakses melalui telefon pintar dari mana-mana sahaja tempat yang mempunyai rangkaian internet.

Kata Kunci : *Telekomunikasi, Bluetooth, Web server, Ethernet, Telefon pintar*

1.0 Pengenalan

Pada masa kini kebanyakkan teknologi menjurus kepada memberi kemudahan kepada orang awam. Teknologi yang paling berkembang dengan pesat ialah teknologi berkaitan telefon bimbit. Pintar. Aplikasi yang dibina untuk telefon pintar tumbuh dengan pesat kerana keadaan masyarakat sekarang sibuk dan sentiasa bersama dengan telefon pintar mereka.

Telefon pintar yang sentiasa bersama-sama dengan pengguna mampu diaplikasikan sebagai alat kawalan untuk mengawal peralatan elektrik di rumah ketika pengguna berada di rumah mahupun berada di luar rumah.

Kawalan peralatan di rumah dengan menggunakan telefon pintar boleh memberi keselesaan kepada pengguna dari segi keselamatan ketika berada di luar rumah dan memudahkan pengguna ketika berada di rumah.

2.0 Latar Belakang

Projek ini dibangunkan dengan menggunakan *arduino UNO board*, *wifi shield* dan *Bluetooth module* untuk perkakasan. Manakala untuk perisian pula untuk mengawal *arduino UNO board* dibangunkan dengan *arduino IDE 1.64* menggunakan bahasa *Java* dan paparan web dibangunkan menggunakan *Bootstrap framework*. Untuk aplikasi telefon pintar pula dibangunkan dengan *Android Studio IDE* juga dengan menggunakan bahasa *Java*.

Arduino UNO board adalah satu litar microcontroller yang menggunakan cip *Atmega 328P* sebagai nadinya. Berbagai ciri istimewaada pada papan ini disamping harganya yang murah menjadikannya pilihan sesuai untuk digunakan dalam projek ini. *Wifi Shield* pula adalah satu peranti tambahan untuk disambungkan pada *arduino UNO board* supaya dapat menjadikan *arduino UNO board* ini sebagai *web server* dengan sambungan *WIFI*. *Bluetooth module* pula disambungkan pada *board* untuk berkomunikasi dengan telefon pintar melalui *Bluetooth*.

Technical specs

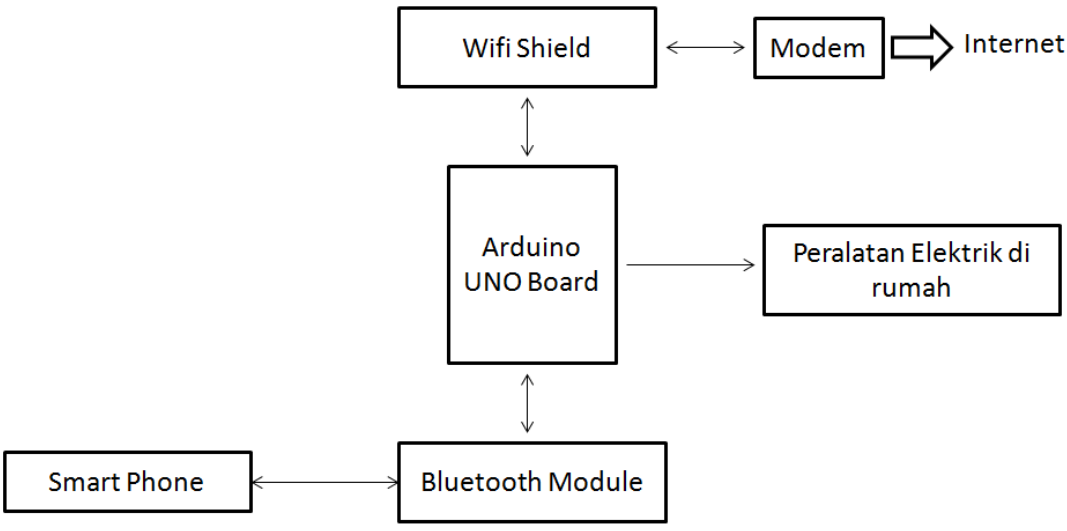
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Rajah 1 Spesifikasi microcontroller ATmega328p

Bootstrap framework adalah *framework* yang popular digunakan oleh pembina laman sesawang untuk membina *responsive website*. *Arduino IDE* adalah satu projek *open source* dibangunkan untuk mengaturcara *arduino board*. *Arduino IDE* mudah digunakan disamping library yang tersedia untuk digunakan. *Android Studio IDE* pula adalah aplikasi percuma yang dibangunkan oleh pihak *Google* untuk developer aplikasi *Android*.

3.0 Gambarajah Blok

Ada dua mod untuk operasi projek ini. Pertama ketika pengguna berada di rumah. Ketika ini di rumah pengguna menggunakan telefon pintar dan teknologi *Bluetooth* untuk beroperasi. Kedua ketika pengguna berada jauh dari rumah pengguna akan menggunakan telefon pintar untuk akses *arduino board* yang telah dijadikan sebagai web server. Rajah 2 menunjukkan bagaimana penyambungan setiap peranti dan komunikasi antara peranti.



Rajah 2 : Sambungan antara peranti

4.0 Keputusan dan perbincangan

Projek ini dilihat mampu member keselesaan kepada pengguna dan mempunyai pasaran yang tinggi kerana melibatkan kos yang rendah. Namun begitu, web server yang menawarkan pelbagai aplikasi tidak dapat dibina kerana ingatan arduino board yang rendah iaitu 253,952 bytes sahaja. Namun begitu ingatan tersebut mencukupi untuk kegunaas asas.

Projek yang berorientasikan pengguna awam dilihat mampu menarik minat pengguna. Tambahan pula berfokuskan kepada telefon bimbit yang sememangnya dimiliki oleh kebanyakkan rakyat di Malaysia.

Satu arduino board mempunyai 14 I/O pin. Setelah ditolak dengan sambungan peranti yang digunakan hanya 6 pin yang tinggal. Jadi projek ini mampu mengawal enam peranti elektrik di rumah. Walaupun jumlah itu tidak besar, tetapi memadai untuk mengawal alat yang kritikal seperti lampu, kipas.

Aplikasi untuk telefon pintar pula dibangunkan khas untuk telefon dengan *OS android* sahaja. Oleh itu penguna telefon pintar dengan *OS IOS* ataupun *windows* tidak dapat menggunakan telefon bimbit untuk mengawal telefon ketika berada di rumah dengan menggunakan Bluetooth tetapi masih lagi mempu untuk menggunakan *web server*.

5.0 Kesimpulan

Smart Switch Phone adalah satu projek yang ringkas yang menggabungkan teknologi web server, teknologi Bluetooth dan telefon pintar untuk kebaikan pengguna. Projek ini berfokuskan kepada pengguna dengan kos yang rendah untuk kemudahan pengguna. Projek ini sesuai untuk kegunaan domestik mahupun untuk kegunaan perniagaan.

Aplikasi projekadalah mudah dengan paparan muka yang menarik untuk *website* mahupun pada aplikasi *mobile* (*Bluetooth*).

6.0 Rujukan

[1] http://randomnerdtutorials.com/arduino-webserver-with-an-arduino-ethernet-shield/ 19 Aug 2015 1:14pm

[2] https://www.arduino.cc/en/Main/ArduinoBoardUno 19 Aug 2015 1:14pm

[3] Mkye Press, Programming & Customizing the PIC Microcontroller 3rd Edition (2008) Tab Electronics

E29: Analyzing The Major Influential Factors That Affect The Deterioration of AGV Battery Performance

Suffian Ayob[1], Ahmad Fauzi Shah [2]
Pusat Latihan Teknologi Tinggi (ADTEC) Kulim, Kedah
suffian@jtm.gov.my

Abstract

In today available technology, rechargeable battery is the selected power source, which allows for the autonomous behavior in duration of battery-life. There were numbers of research analysis been done in the area of mobile robot but most of them were concentrating on the navigation techniques of the vehicles. Although battery management is important for vehicle management, this problem is usually neglected in the research studies. The main idea behind this project is to develop a battery monitoring system that is capable of performing the 'real-time' monitoring on the mobile robot battery performance level. Hence, the outcome monitoring data will be utilized as one of the input to better manage the performance of mobile robot. This will done by performing an experimentally study and identifying the major factor that will affect the deterioration of mobile robot battery performance. Nickel-Metal Hydride (Ni-MH) battery is selected due tremendous advantages such as high-energy density, fast charging and discharging, and safety. The greatest hope for this research outcome is that it can be used as part of supplementary data to construct better establishment of Mobile robot Battery Monitoring and Battery Management activity.

Keywords: Battery Monitoring System, Battery Management System, Re-chargable Battery, Mobile Robot

1.0 Introduction

From the first introduction of Automated Guided Vehicle (AGV) in early 1950's by Barrett Electronics of Northbrook, Illinois, up to this day, there seems to be a tremendous efforts and research to upgrade the capability and flexibility of this vehicle system. Throughout this development stage, many definitions have been done to describe and define the AGV terms. Muller (1983) as cited in Vis (2004) identifies an automated guided vehicle (AGV) as a driverless transport system used for horizontal movement of materials [1].

Most of today AGV's using their on-board power supplies that on the other hand have the tendency to limit their operating time. This limitation will then eliminate the possibilities for long-term autonomy. In today available technology, rechargeable battery is the selected power source, which will allow for the autonomous behavior in duration of battery-life. Looking into this restriction, it shows that we need to find the most effective technique to manage AGV battery which in return will optimize the performance of the AGV.

2.0 Background

Nowadays, there were numbers of review papers on AGV systems but majority of them were concentrating on the navigation techniques of the vehicles. Although battery management is important for vehicle management, this problem is usually omitted in the research. Naturally, vehicles have to be charged after a certain operating period, but most research on AGVSs assumes that the battery problem has little effect on performance.

Vis (2004) agrees with McHaney (1995) in arguing that battery usage is frequently omitted in AGV research. In addition, this author also concluded that battery management is hardly addressed in AGV research. Both McHaney (1995) and Vis(2004) have mutual understanding that the performance of AGV systems with high utilization and hardly any off shift times, is influenced by incorporating battery management. This author also proposed that in future research for large AGV systems; it is of great importance to incorporate battery management decisions.

To simplify the understanding, Meissner and Richter (2003) defined the term ''Battery Monitoring'' as an activity that comprises taking and/or receiving data from and/or about the battery, processing of this information, including predictions of performance, and indicating raw data or processed information to a human being or a unit, i.e. only passive surveillance and evaluation[2].

2.1 Selection of the influential factor

Even though there is no exact experimental and research analysis that can be described as the foundation of this undertaken title, there were several information from the previous paper that could help in identifying the influential factor.

Wei et al (2011) have listed several techniques that have been proposed to solve energy-efficient path planning problem for mobile robot. Wei et al (2011) cited that Mei, Lu, Hu, and Lee (2004, 2005) analyzed power consumption of a robot at different speeds and proposed an effective energy-aware motion scheme.

This author further mentioned that Barili, Ceresa, and Parisi (1995) developed an energy-saving scheme by controlling the speed and avoiding unnecessary stops for mobile robots[3].

Based on this several energy-efficient saving technique proposal, the selected AGV's variable operating factors throughout this experiment are identified as per below;

i. AGV travelling distance
ii. AGV driving speed
iii. Weight of the carried load

2.2 Critical parameter for measurement

In order to proceed with the experiment analysis on the battery performance, we need to identify the critical battery data that need to be measure. Perez (1993) stated that battery voltage can be affected by three factors known as State of charge, current, and temperature[4].

Meissner and Richter (2003) mentioned that taking voltage (U), current (i) and temperature (T) of the battery is the most direct monitoring approach and requires no change to the battery[5]. State-of-Charge (SoC) is the percentage of the maximum possible charge that is present inside a rechargeable battery.

With reference to the theoretical knowledge and the proposal from previous research work, the conclusion is to measure voltage (U), current (i) and temperature (T) as the indicator of the battery performance level.

2.3 Experimental Equipment Set-Up

The experiments were conducted by using NI Robotics Starter Kit (DaNI) which have been powered by TETRIX 12 V Re-chargeable Ni-MH Battery Pack. DaNI was controlled via NI LabVIEW graphical programming and the LabVIEW Robotics module.

The overall system configuration is as per shown in Figure 1.

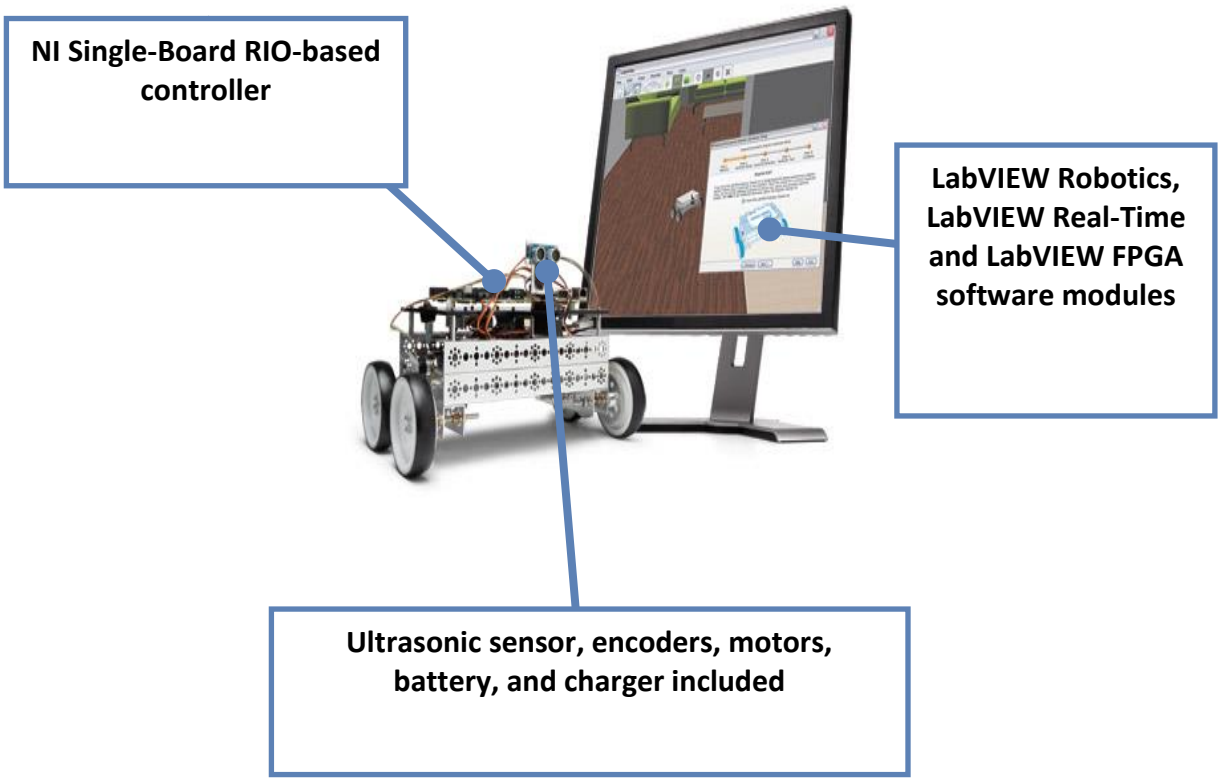


Figure 1: Overall system configuration

NI Robotics Starter Kit 2.0, known as DaNI robot is a mobile robot platform that features sensors, motors, and NI Single-Board RIO (NI sbRIO-9632) hardware for embedded control. DaNI is a two-wheel robot, powered with two 12VDC motors and equipped with ultrasonic distance sensor for distance measurements. The Pitsco 39057 TETRIX 12-Volt Rechargeable NiMH Battery Pack provides power to this mobile project.

LabVIEW Robotics 2011 is the main software platform utilized within this experiment and it provides all of the necessary software tools required for interfacing with several input and output devices (such as sensors and motors), controlling robot's motion, implementing navigation algorithms and advanced control. The integration of the LabVIEW Robotics and SbRIO-9632 platform (via Real-time and FPGA based hardware) makes it easy for developers to connect to any sensor signal, acquire data from sensors and control the mobile robot's movement.

Within this experiment, 3 main VI (with numbers of Sub-VI) have been created to control, navigate and read acquisition data from DaNI. Those 3 main VI is identified as:

i. BMS RT VI
ii. BMS Variable Distance VI
iii. BMS Variable Speed VI

3.0 Experimental Implementation Method

The experiment have been performed by manipulating 3 variables, identified as:

i. DaNI travelling distance parameter
ii. DaNI speed parameter
iii. Carriage Load

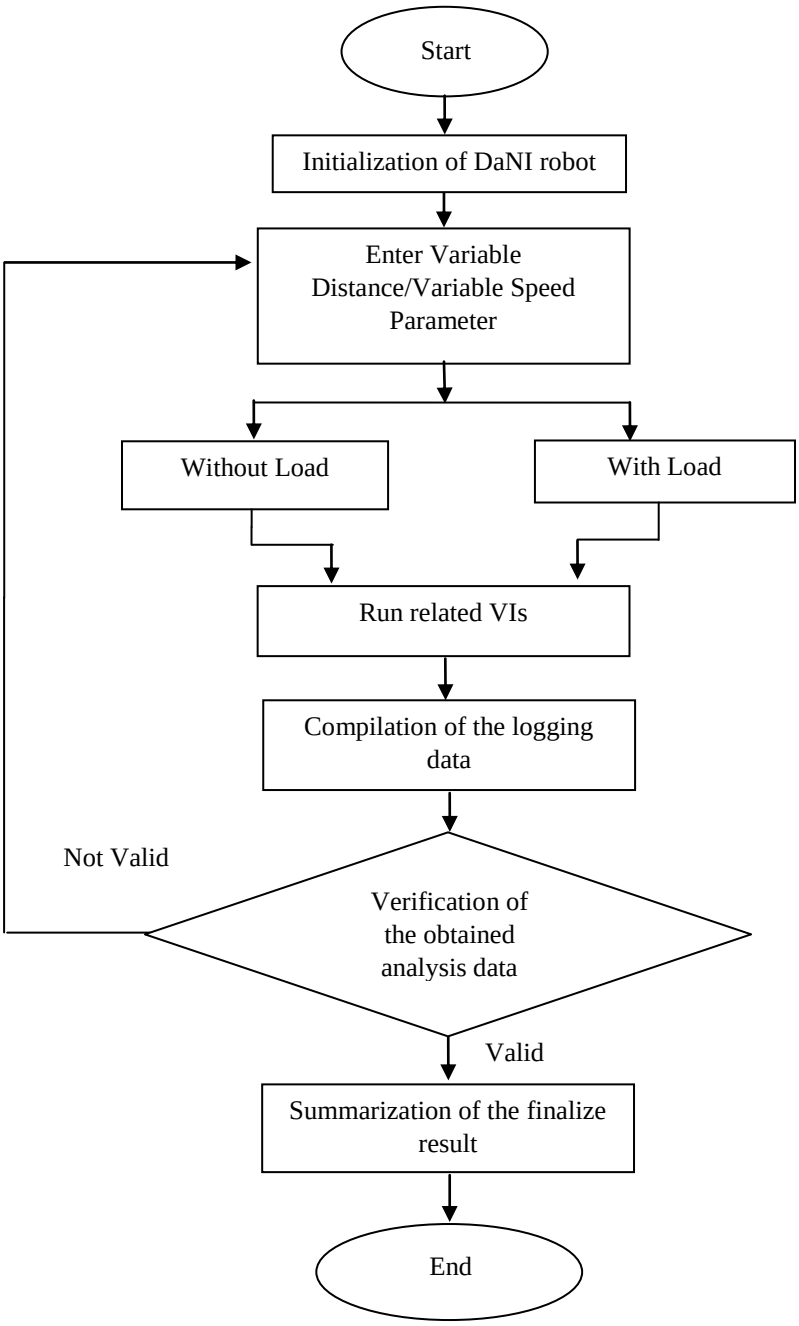


Figure 2: Experimental implementation process flow

4.0 Results And Discussion

The experiments have been divided into 4 main sections, whereby for every section some setting parameter will varies and some remains constant. The description of those 4 main sections is conceptualized as per shown in Table 1.

Table 1: Concept of experimental implementation parameter setting

Experiment No.	Descriptions
1	Regulate distance , constant speed, without carriage load
2	Regulate distance , constant speed, with additional carriage load
3	Regulate speed, constant distance, without carriage load
4	Regulate speed, constant distance, with additional carriage load

The establishment of Experiment No.1 is initializing by setting up the value of DaNI robot as per described in Table 2 respectively.

Table 2: Setting parameter for Experiment No.1

Testing No.	Travelling Distance	Travelling Speed	Carriage Load
1	20 Meter	0.25 m/s	None
2	70 Meter	0.25 m/s	None

Based on Experiment No.1 activities, the obtained graph based on the voltage variation category is as per shown in Figure 3.

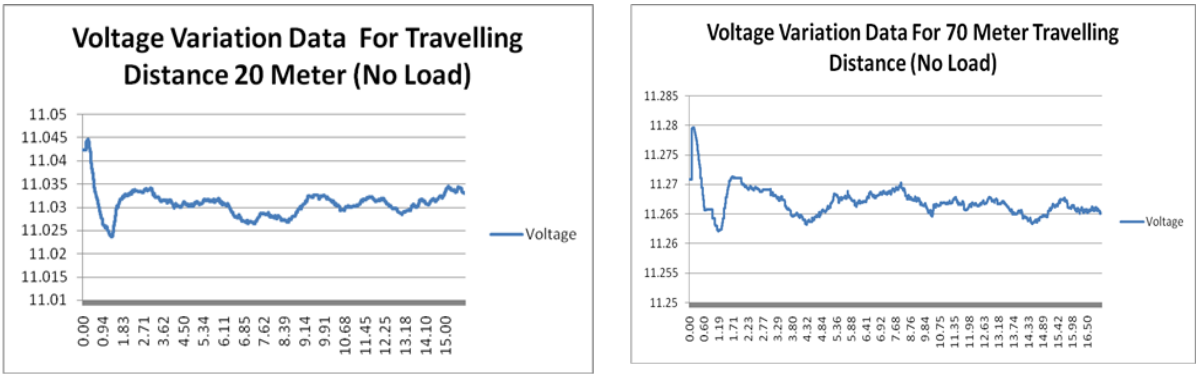


Figure 3: Voltage variation graph obtained from Experiment No.1

The overall obtained result from Experiment No.1 is summarized in Table 3.0 below:

Table 3: Experimental No.1 result

Distance	Running Time	Voltage Variation Percentage	Ave Current	Ave Power	Ave Temperature
20 Meter	80 sec	0.2324%	4.967	54.79316	32.3336
70 Meter	280 sec	0.3195%	5.076	57.18672	26.70281

Result from Experiment No.1 demonstrates that there is no significant difference in term of voltage variation (or voltage deterioration rate) between travelling distance of 20 Meter and 70 Meter. Theoretically, the further the travel the more the voltage drop but in this actual experiment the difference is only by 0.0871%. In the other side of the results, the travelling distance of 70 Meter seems to utilize slightly higher power consumption and current rate. The average temperature value seems somewhat odd because this experiment is not done in the continuous mode. The robot need to be return to the docking station due to re-charging requirement that might cause some inconsistency in the outcome result.

In Experiment No.2, DaNI robot is configured based on the setting parameters as per described in Table 4.

Table 4: Setting parameter for Experiment No.2 (with additional load)

Testing No.	Travelling Distance	Travelling Speed	Carriage Load
1	20 Meter	0.25 m/s	3 Kg
2	70 Meter	0.25 m/s	3 Kg

The obtained graph based on voltage variation category is as per shown in Figure 4.0.

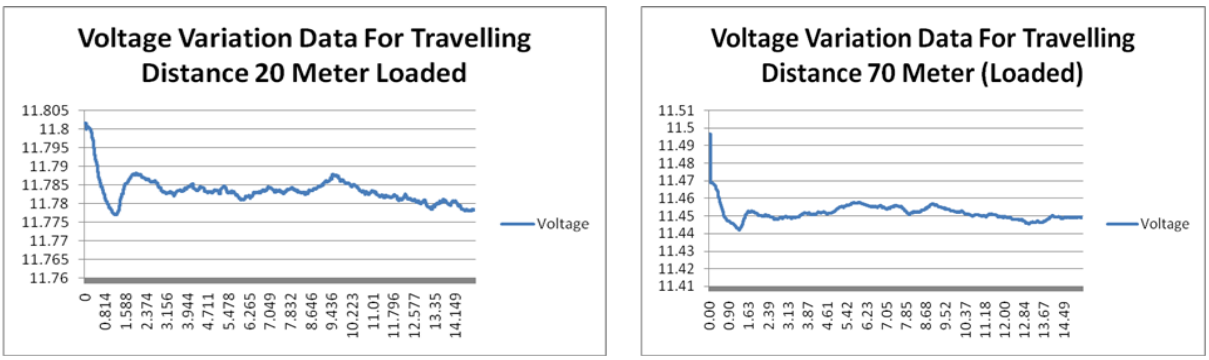


Figure 4: Voltage variation graph obtained from Experiment No.2

The overall obtained result from Experiment No.2 is summarized in Table 5.0 below:

Table 5: Experimental No.2 result

Distance	Running Time	Voltage Variation Percentage	Ave Current	Ave Power	Ave Temperature
20 Meter	80 sec	0.4450%	4.9334	58.1176	30.8664
70 Meter	280 sec	0.8281%	5.032	57.5114	36.9118

The Experiment 2 result demonstrates a slight significant value in term of voltage variation (or voltage deterioration rate) between travelling distance of 20 Meter and 70 Meter. The additional load on DaNI seems to double increase the voltage drop in both of the travelling distance (0.4450% and 0.8281% respectively).

The voltage drop difference between those 2 travelling distance parameter seems to be more obvious at the value of 0.3831%. Thus, it can be concluded that within this experiment, the additional load did brings some major effect on the voltage deterioration rate. Significantly, increasing travel distance with additional load will contribute to higher voltage drop.

In Experiment No.3, the objective is to regulate DaNI robot speed and setting-up the travelling distance constant at 50 meter. Details setting parameters configuration is as per described in Table 6.0.

Table 6: Setting parameter for Experiment No.3 (speed variance)

Testing No.	Travelling Speed	Travelling Distance	Carriage Load
1	0.2 m/s	50 Meter	None
2	0.5 m/s	50 Meter	None

The obtained graph based on voltage variation category is as per shown in Figure 5.0.

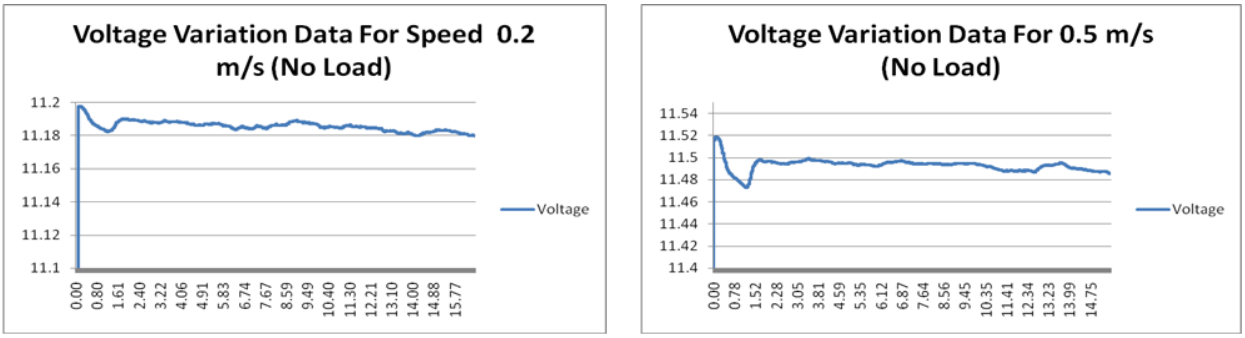


Figure 5: Voltage variation graph obtained from Experiment No.3

The overall obtained result from Experiment No.3 is summarized in Table 7.0 below:

Table 7: Experimental No.3 result

Speed	Running Time	Voltage Variation Percentage	Ave Current	Ave Power	Ave Temperature
0.2 m/s	250 sec	0.452%	4.943	55.28	32.2284
0.5 m/s	100 sec	0.529%	5.168	59.296	30.936

The Experiment 3 result shows a vital value in term of voltage variation (or voltage deterioration rate) related to DaNI speed. At the speed range of 0.2 m/s and travelling distance of 50 Meter, the obtained result is almost similar Experiment No.1.On the other hand, by increasing the speed to 0.5 m/s seems to enhance the voltage drop rate to the figure of 0.529%. The output result of the current and power consumption seems to increase linearly related to the increment of the speed. Hence, it can be concluded that the increment of the robot speed will linearly contribute to battery voltage drop.

As for Experiment No.4, an additional load has been attached to DaNI robot while we regulate the speed movement. The setting parameters configuration is as per described in Table 8.0 below.

Table 8: Setting parameter for Experiment 4 (speed variance)

Testing No.	Travelling Speed	Travelling Distance	Carriage Load
1	0.2 m/s	50 Meter	3 Kg
2	0.5 m/s	50 Meter	3 Kg

The output graph based on Experiment No.4 is as per displayed in Figure 6.0 below.

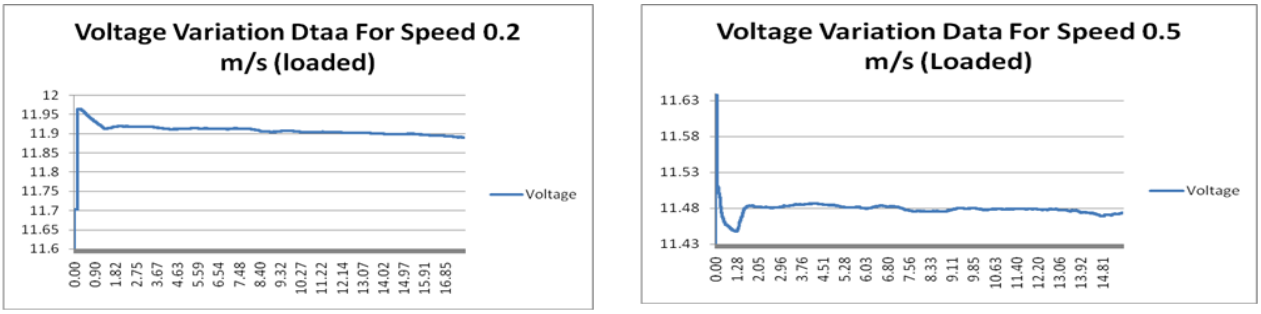


Figure 6: Voltage variation graph obtained from Experiment No.4

The overall obtained result from Experiment No.4 is summarized in Table 9.0 below:

Table 9: Experiment No.4 result

Speed	Running Time	Voltage Variation Percentage	Ave Current	Ave Power	Ave Temperature
0.2 m/s	250 sec	0.564%	4.8682	57.8963	33.8416
0.5 m/s	100 sec	1.7019%	5.3365	61.15	32.709

The Experiment No.4 result shows a clear evident on how the combination of high speed and additional load will provide the most significant effect to the deterioration of DaNI battery voltage. The voltage variation rate at the value of 1.7019% should be considered as the highest value obtained comparing to the others set parameter. The same condition can be concluded on the output result of the average of current and power consumption.

The rate seems to increase tremendously related to the increment of the speed. Therefore, it can be concluded that the increment of the robot speed with the help of additional load will significantly contribute to the deterioration DaNI battery performance.

5.0 Conclusion

Based on the result of the 4 main experiments sections, the comparison table on the value of voltage variation percentage has been collectively included in Table 10.0.

Table 10: Voltage variation comparison table between each experiment

Experiment	Distance	Speed	Load/No load	Voltage Variation Percentage
1	20 Meter	0.25 m/s	No Load	0.2324%
	70 Meter	0.25 m/s	No Load	0.3195%
2	20 Meter	0.25 m/s	Load	0.4450%
	70 Meter	**0.25 m/s**	**Load**	**0.8281%**
3	50 Meter	0.2 m/s	No Load	0.452%
	50 Meter	0.5 m/s	No Load	0.529%
4	50 Meter	0.2 m/s	Load	0.564%
	50 Meter	**0.5 m/s**	**Load**	**1.7019%**

The conclusion that can be drawn-out based on Table 10.0, is that all of these 3 parameters: travelling distance, speed and load do contribute to the deterioration of DaNI battery performance. Every selected parameter has its own signature attribute effect that is reflected in terms of battery voltage variation percentage. The result clearly demonstrates that there were 2 combination conditions that cause the highest deterioration effect to the battery voltage, identified as:

i. (70 Meter Travelling Distance) + (3 Kg Load) = 0.8281% deterioration
ii. (0.5 m/s Speed) + (3 Kg Load) = 1.7019% deterioration

However, between these 2 significant results, it can be summarized that speed with additional load are the major factor that gives the most significant deterioration effect to AGV or DaNI battery performance.

6.0 References

[1] Vis,I.F.A., 2004, Survey of research in the design and control of automated guided vehicle systems. European Journal Of Operation Research,170(2006),pp.677-709.

[2] Meissner,E., and Richter,G., 2004, The challenge to the automotive battery industry: the battery has to become an increasingly integrated component within the vehicle electric power system . Journal of Power Sources, 144 (2005) , p.p.438–460.

[3] Wei,H., Wang,B., Wang.Y.,Shao, Z., and Chan,K.C.C , 2011, Staying-alive path planning with energy optimization for mobile robots. Expert Systems with Applications ,39 (2012) ,pp.3559–3571.

[4] Perez, R., 1993, Lead-Acid Battery State of Charge vs. Voltage. Home Power , #36 (August / September 1993), pp. 66 -69.

[5] Meissner,E., and Richter,G., 2004, The challenge to the automotive battery industry: the battery has to become an increasingly integrated component within the vehicle electric power system . Journal of Power Sources, 144 (2005) , p.p.438–460.

E30: Sistem Pemantauan Banjir

Mohd Norhisham Bin Maznan [1]
Pusat Latihan Teknologi Tinggi (ADTEC) Kulim, Kedah
NorsyahidatulFarah binti nanyan [2], Mohmad hisam bin Mohd Adam[3]
Electronic Department, Pusat Latihan Teknologi Tinggi (ADTEC) Kulim, Kedah

norhisham@jtm.gov.my

Abstract

Sistem Pemantauan Banjir merupakan sebuah projek yang digunakan untuk mengesan paras air sungai ketika bencana banjir. Sensor pengesan paras air akan diletakkan di dalam sungai untuk memantau kadar limpahan paras air sungai. Maklumat yang diperolehi akan dihantar dan dipantau oleh pihak berwajib. Sensor ini bertindak sebagai input kepada mikropengawal PIC 16F877A untuk diproses dan seterusnya data akan dihantar secara tanpa wayar menggunakan Xbee-Pro Module. Data ini dihantar secara sesiri menggunakan wayar usb ke komputer untuk dipantau secara masa nyata menggunakan perisian LAB VIEW. Selain itu, sistem ini dilengkapi dengan GSM modem yang akan menghantar Short Message Service (SMS) kepada pihak berkuasa sekiranya paras air menghampiri paras bahaya. Lampu amaran turut akan menyala agar pegawai pemantau dan penduduk berhampiran bersedia untuk proses penempatan banjir.

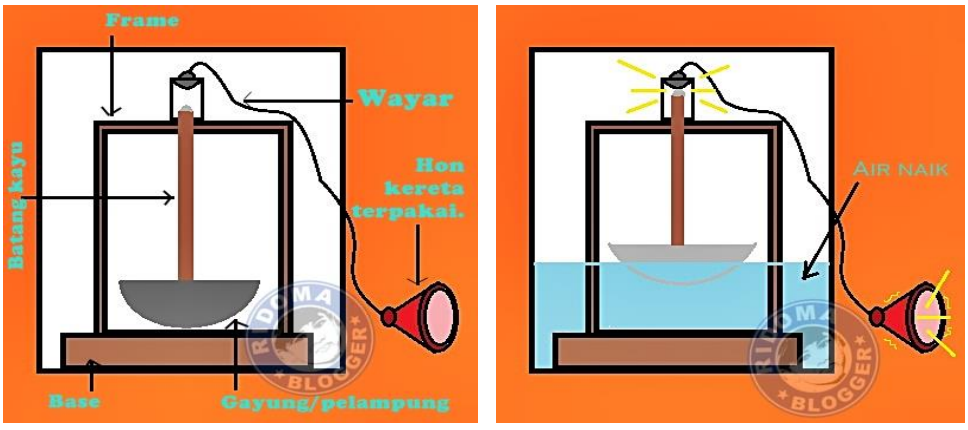
Keywords: *sistem pemantauan banjir, mikropengawal, labview, dan GSM modem.*

1.0 Pendahuluan

Banjir merupakan fenomena bencana yang tidak asing lagi bagi Malaysia. Bencana banjir di negara ini boleh dikategorikan kepada dua bahagia iaitu bermusim dan banjir kilat. Banjir bermusim disebabkan oleh perubahan angin monsun yang sering berlaku pada bulan Disember setiap tahun. Tahun 2014 merupakan bencana banjir terburuk yang melanda negeri-negeri disebelah pantai timur iaitu Kelantan, Terengganu, dan Pahang. Manakala banjir kilat bersifat singkat dan diakibatkan oleh hujan lebat dan halangan dalam sungai atau saluran peparitan.

Antara kesan daripada banjir adalah kehilangan nyawa, kerosakan harta benda, mengganggu kegiatan sosial dan ekonomi, terputus jaringan hubungan akibat kerosakan jalan dan sebagainya. Walau bagaimanapun, kesan ini dapat dikurangkan sekiranya penduduk mendapat maklumat awal mengenai bencana ini. Oleh yang demikian, satu sistem untuk memantauan paras kenaikan air sungai yang dilengkapi dengan sistem amaran banjir diperlukan.

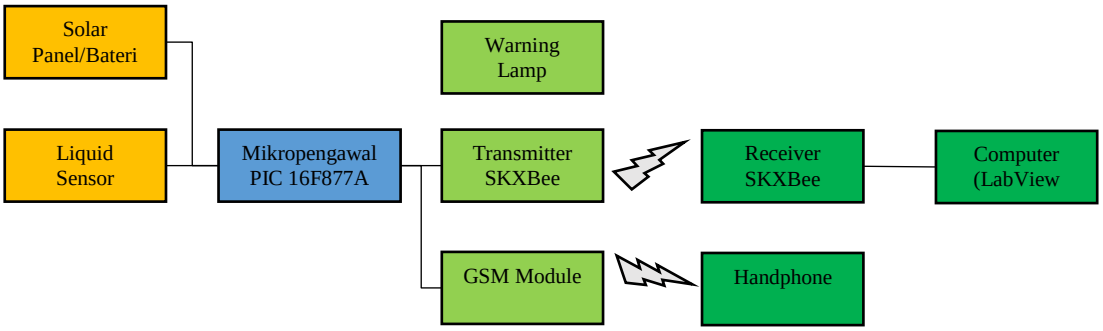
Rajah 1 menunjukkan salah satu kaedah pengesan banjir. Apabila paras air meningkat, konduktor yang diletakkan dibatang kayu akan menyentuh konduktor disebelah atas dan melengkapkan litar. Seterusnya hon akan berbunyi sebagai amaran kepada penduduk sekitar. Walau bagaimanapun, sistem ini hanya dapat memberikan amaran kepada penduduk yang berhampiran sahaja.



Rajah 1: Alat Pengesan Banjir

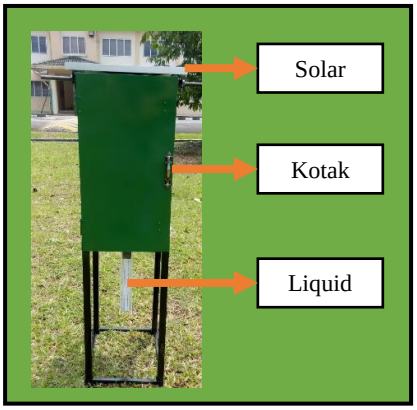
2.0 Latar Belakang Projek

Sistem Pemantauan Banjir merupakan sebuah projek yang digunakan untuk mengesan paras air sungai ketika bencana banjir. Sistem ini menggunakan *Liquid Level Sensor* sebagai input dan panel solar serta bateri sebagai bekalan kuasa. Sensor ini diletakkan di dalam sungai untuk memantau paras air sungai. Selain itu, mikropengawal PIC 16F877A digunakan untuk mengaktifkan keluaran iaitu lampu amaran, *GSM module*, dan *XBeePro module*. Rajah 2 menunjukkan gambarajah blok bagi sistem ini.

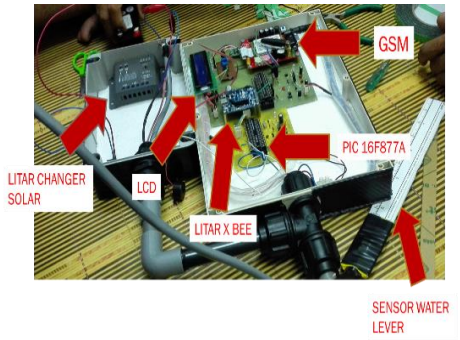


Rajah 2: Gambarajah blok projek

Liquid Level Sensor ini bertindak sebagai input kepada mikropengawal. Seterusnya, data akan dihantar secara tanpa wayar menggunakan Xbee-Pro Module. Data ini diterima secara sesiri menggunakan wayar usb ke komputer untuk dipantau secara masa nyata menggunakan perisian *Lab View*. Selain itu, sistem ini turut dilengkapi dengan *GSM modem* yang berkemampuan untuk menghantar *Short Message Service (SMS)* kepada pihak berkuasa sekiranya paras air menghampiri paras bahaya. Apabila paras air mencapai paras bahaya, lampu amaran akan menyala agar pegawai pemantau dan penduduk berhampiran bersedia untuk berpindah ke kawasan penempatan banjir.



Rajah 3: Pandangan hadapan projek

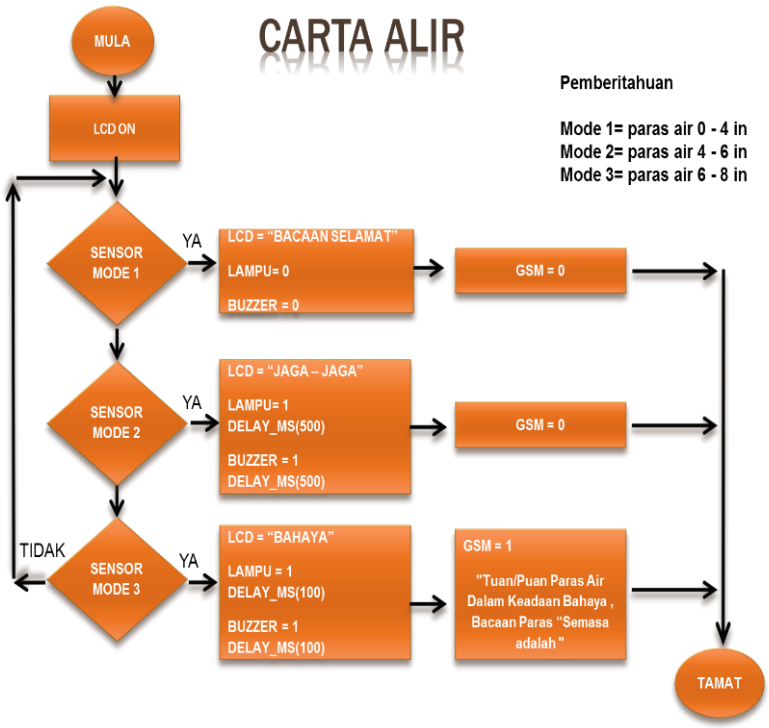


Rajah 4: Bahagian dalam kotak litar

Rajah 3 dan Rajah 4 menunjukkan pandangan hadapan projek dan bahagian dalam kotak litar. Bahagian mekanikal projek ini terdiri daripada panel solar, kotak litar dan *Liquid Level Sensor*. Kotak litar yang digunakan merupakan kalis air untuk melindungi litar daripada rosak.

3.0 Metadologi

Terdapat tiga mod bacaan paras air iaitu mod selamat, berjaga-jaga, dan bahaya. Setiap aras kenaikan air, bacaan bagi paras air akan dipaparkan pada skrin LCD. Selain itu, untuk mod berjaga-jaga, lampu dan buzzer akan dihidupkan untuk memberi amaran kepada pegawai pemantau dan penduduk persekitaran. Pada mod bahaya, GSM module akan diaktifkan dan mesej akan dihantar kepada pihak berwajib.



Rajah 5: Carta alir bagi pengaturcaraan

4.0 Keputusan Dan Perbincangan

Sistem pemantauan banjir ini dikonfigurasi kepada dua bahagian. Bahagian pertama adalah bahagian perkakasan manakala bahagian kedua merupakan bahagian perisian.

4.1 Bahagian Perkakasan

Di dalam bahagian perkakasan ini projek ini boleh dibahagikan kepada dua bahagian. Bahagian pertama adalah rekabentuk mekanikal dan bahagian kedua adalah rekabentuk litar elektronik. Kebanyakan bahagian mekanikal sistem ini, mengguna aluminum terpakai. Bahagian atas sistem pemantau banjir diletakkan dengan panel solar untuk membekalkan voltan kepada sistem elektronik sistem pemantau banjir. Terdapat lima jenis litar yang dibangunkan di dalam sistem pemantau banjir ini. Antara litar yang dibangunkan adalah litar bekalan kuasa, litar asas pengawal mikro, litar Xbee dan litar GSM. Dalam litar pengesan paras air, data yang diperoleh akan dikongsi oleh dua sistem iaitu: 1) sistem info maklumat oleh gsm dan 2) sistem pengawalan kenaikan paras air masa nyata yang dikawal oleh komputer menggunakan perisian *Labview*.

Berdasarkan teori, IR01A menggunakan sensor khas untuk memodulasi isyarat IR yang dipancarkan daripada dua IR pemancar dan mengesan isyarat termodulat IR dipantulkan semula daripada objek yang berhampiran. Sensor ini mempunyai IR terbina dalam cakera. Pemacu LED untuk memodulasi isyarat IR pada 38KHz sepadan dengan pengesan terbina dalam. Termodulat IR isyarat imunasi sensor dari gangguan yang disebabkan oleh cahaya biasa cahaya mentol atau cahaya matahari. Modul ini akan memaparkan TINGGI jika objek tidak dikesan dan RENDAH jika objek dikesan.

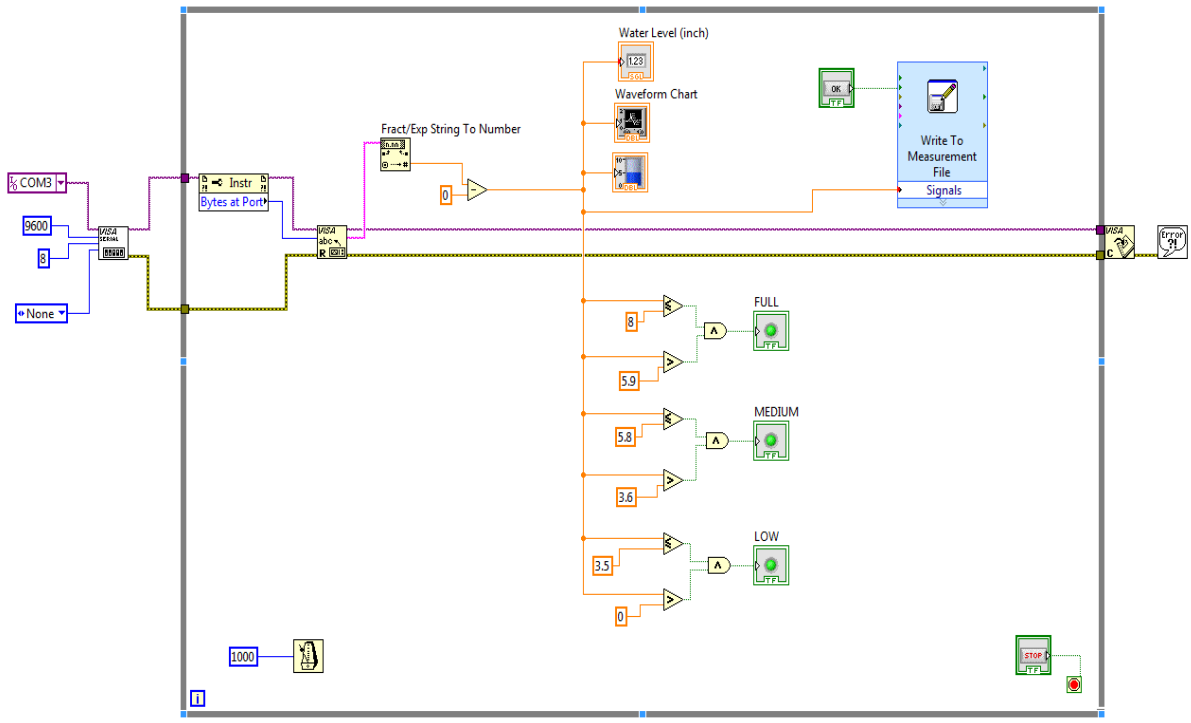
Jadual 1 menunjukkan kadar pengiraan mencari persamaan bacaan *Liquid Level Sensor.*

Jadual 1: Bacaan Liquid Level Sensor.

Paras	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	Max
Bacaan LCD	840	838	838	831	817	802	767	749	728	707	666	647	617	590	550	532	466	455

4.2 Bahagian Perisian

Di dalam bahagian ini, perisian yang digunakan untuk membuat pemantauan banjir adalah menggunakan perisian *Labcenter Labview 8.1*. Perisian ini dibangunkan aturcaranya bagi membolehkan bacaan yang diambil dari pengesan paras air diambil secara masa nyata terus ke komputer dan memaparkan grafik yang besesuaian dengan paras air yang dibaca. Rajah 10 merupakan aturcara yang dibangunkan bagi membolehkan data secara masa nyata diambil.



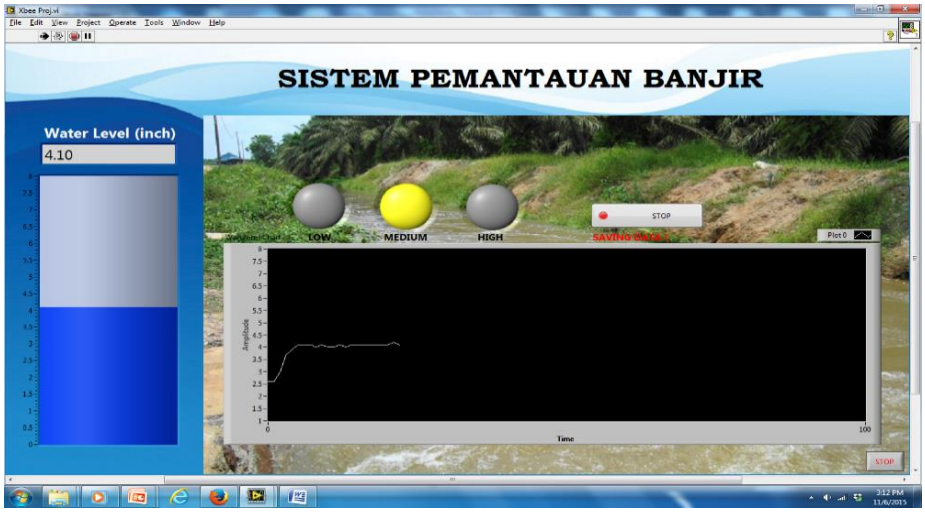
Rajah 10: Blok Litar Dalaman Sistem Pemantauan Banjir

Antaramuka membuat pemantauan sistem banjir ini turut dibangunkan yang terdiri daripada graf *water level*, graf amplitud melawan masa, tiga penunjuk led *(low, medium , high)* dan ditambah dengan satu butang bagi membolehkan pengguna merekod data dan satu butang lain untuk menghentikan proses merekod data.

Apabila pengesan paras air mengesan mod 1, antara muka seperti gambar Rajah 12 akan dipaparkan. Dalam keadaaan ini, paras air sungai berada dalam keadaan selamat.

Rajah 12: Antaramuka sistem pemantau banjir- Tahap Selamat

Apabila pengesan paras air mengesan mod 2, antara muka akan memaparkan seperti gambarajah 13. Keadaan ini merupakan paras air sungai dalam keadaan berjaga-jaga. Dalam keadaan ini, *buzzer* akan berbunyi dan lampu keselamatan yang disertakan dengan sistem pemantau banjir akan menyala dalam kadar 500ms.

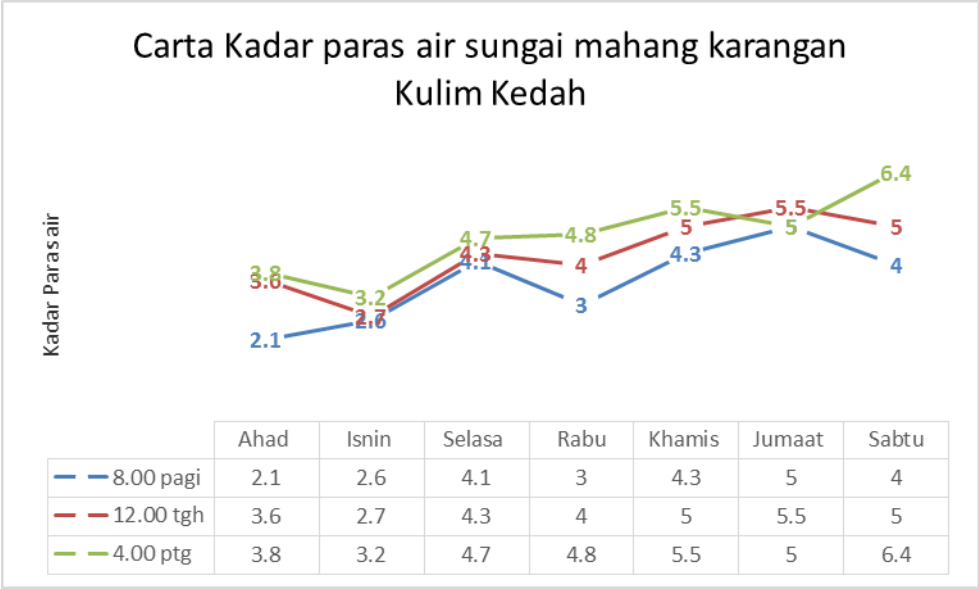


Rajah 13: Antaramuka sistem pemantau banjir- Tahap Berjaga-jaga

Apabila pengesan paras air mengesan mod ke 3, antara muka seperti Rajah 14 akan dipaparkan. Keadaan ini menujukan kadar kenaikan air banjir sudah mencapai tahap merbahaya dan maklumat ini akan dihantar dalam bentuk *SMS* ke pihak berkuasa dan serta pihak berkepentingan seperti Ketua Kampung bagi kawasan yang terlibat. Dalam keadaan ini *buzzer* akan berbunyi lagi lebih kuat dan lampu keselamatan yang disertakan dengan sistem pemantau banjir akan berkelip pada kadar 100ms.

Rajah 14: Antaramuka sistem pemantau banjir- Tahap Bahaya

Berikut merupakan data yang di ambil dari Sg.Mahang sepanjang tujuh Hari menggunakan sistem pemantauan banjir ini dengan kadar anggaran jarak yang diambil dari sungai ke stesen pemantauan 200 meter.



	Ahad	Isnin	Selasa	Rabu	Khamis	Jumaat	Sabtu
8.00 pagi	2.1	2.6	4.1	3	4.3	5	4
12.00 tgh	3.6	2.7	4.3	4	5	5.5	5
4.00 ptg	3.8	3.2	4.7	4.8	5.5	5	6.4

Rajah 15: Carta Kadar Pemantauan Paras air Sg.Mahang

Rajah 15 menujukan hasil pengujian sistem pemantau banjir yang digunakan untuk mengambil data dari Sungai Mahang, Karangan, Kulim, Kedah selama tujuh hari. Selaan bacaan diambil pada pukul 8 pagi ,12 tengah hari dan 4 petang. Daripada pengujian ini didapati bahawa sistem pemantau banjir ini dapat mengambil data dari sungai dan dihantar ke sistem komputer pemantau banjir dalam ukuran 100 -200 meter. Kadar kenaikan air bergantung kepada jadual yang telah disediakan. Masa yang diambil telah disetkan dalam sistem pemantauan banjir menggunakan perisian *labview*.

Merujuk kepada jadual di atas, sistem berjaya mengenalpasti paras air sungai mahang telah melepasi tahap bahaya pada hari Sabtu. Hal ini disebabkan oleh hujan yang turun tidak berhenti di Mahang dan sekitar kawasan Kerian pada hari tersebut. Sistem pemantau banjir kami telah mendapati kadar paras air telah berada pada keadaan bahaya iaitu pada paras air 6.4 meter pada pukul 4 petang dan satu sms telah di hantar kepada ketua kampung Mahang.

5.0 Kesimpulan

Secara kesimpulannya, rekabentuk sistem ini boleh mengambil data dari limpahan air banjir dengan menggunakan pengesan paras air untuk diterima oleh sistem GSM untuk dihantar ke telefon yang didaftarkan sementara yang sama data yang sama dapat dipantau secara masa nyata oleh pihak pemantau menggunakan perisian *labview*.

6.0 Cadangan Penambahbaikan

Untuk penambahbaikan lagi sistem pada **"Sistem Pemantauan Banjir"** ini, antara cadangan untuk diaplikasikan pada masa hadapan ialah dengan:

- Menambah lampu amaran 100 meter dari tempat banjir.
- Mengunakan amaran bunyi yang lebih kuat.
- Membuat mekanikal yang lebih kukuh.

7.0 Rujukan

[1] Durfee W. 2011. Arduino MicrocontrollerGuide. Minnesota: University ofMinnesota. http://www.me.umn.edu/courses/me2011/arduin o/arduinoGuide.pdf. [3 Maret 2014]. Guochao W, Changzan G, Jennifer R, Takao I, Changzhi L. 2013. Highly Accurate

[2] Noncontact Water Level Monitoring using Continous-Wave Doppler Radar. *IEEE*. doi: 10.1109/WiSNet.2013.6488620

[3] Li, G., *et al.* 2010. Remote Monitoring System of Greenhouse Environment based on LabVIEW. In Computer Design and Applications (ICCDA) International Conference on. 2010.

[4] Gani, A. and M. J. E. Salami. 2002. A LabVIEW based Data Acquisition System for Vibration Monitoring and Analysis. In Research and Development. SCOReD 2002. Student Conference on. 2002.

E31: Mesin Pengitar Semula Layan Diri

Harniza Harman, Mohd Sani Saian, Dipl.-Ing. Ubaidullah Mohammad, Mac O'Brynn Jol,
Mohd Izwan Farhan Muhamad Fitri
Makmal Sistem Automasi, Pusat Latihan Teknologi Tinggi (ADTEC) Shah Alam, Selangor

ubaidullah@jtm.gov.my

Abstrak

Pencemaran dan kehausan sumber alam menjadi topik perbualan utama dewasa ini. Tanpa tindakan, bumi mungkin tidak dapat diwarisi kepada generasi akan datang. Dalam mengejar status negara maju, aspek alam sekitar perlu di beri perhatian. Salah satu caranya adalah dengan mengitar semula. Mengitar semula adalah aktiviti yang mudah. Jika disediakan kemudahan, ramai orang akan mengitar semula. Oleh itu, projek ini RECYCLING VENDING MACHINE telah dibangunkan.

Mesin layan diri ini berfungsi untuk mengumpul tin minuman kosong untuk dikitar semula dan memberi ganjaran terus kepada pengguna dalam bentuk token. Mesin ini akan diletakkan di tempat awam yang strategik bagi memudahkan pengguna. Pengguna akan memperolehi bayaran bagi setiap tin disamping dapat memelihara alam sekitar. Ia juga dapat memudahkan pihak pengitar semula untuk mendapatkan tin minuman. Mesin automatik ini dikawal oleh Programmable Logic Controller (PLC) yang tahan lasak. Ia menggunakan kuasa motor untuk memampatkan tin dan mempunyai mekanisma untuk mengeluarkan syiling sebagai bayaran. Pengguna memasukkan tin satu persatu ke dalam mesin. Tin itu akan di mampatkan dan Ganjaran akan diberikan.Mesin ini adalah sesuatu yang baru di Malaysia. Ia telah diuji secara dalaman dan ia berfungsi dengan baik serta mendapat respon yang positif.

***Kata Kunci** : Tin Minuman, Kitar Semula, Mesin layan Diri, Bayaran Terus*

1.0 PENGENALAN

Pemanasan global, perubahan cuaca, pencemaran alam, gangguan ekosistem, kepupusan flora dan fauna dan kehausan sumber alam merupakan antara topik perbualan utama penduduk bumi akhir-akhir ini. Banyak masalah akan dan telah timbul akibat pencemaran alam atau pembangunan secara tidak terkawal sebagai contoh banjir kilat, hakisan dan runtuhan, bencana alam, cuaca ekstrim dan sebagainya. Tanpa tindakan segera masyarakat dunia hari ini, bumi akan menuju kehancuran dan bumi mungkin tak dapat di warisi kepada generasi akan datang. Lantaran itu, dalam mengejar status negara maju, aspek alam sekitar dan ekosistem perlu di beri perhatian. Pembangunan perlu mengambil kira aspek-aspek alam sekitar dan tidak hanya berorientasikan keuntungan semata-mata. Banyak program atau perkara yang boleh kita lakukan baik di peringkat global, nasional, masyarakat setempat atau secara individu sebagai contoh membungan sampah di tempat sepatutnya, guna semula, dan mengurangkan penggunaan seperti tenaga dan plastik. Salah satu cara berkesan adalah dengan mengitar semula.

Mengitar semula merupakan aktiviti mengguna semula produk yang telah digunakan. Ini termasuklah menggunakan semula suatu produk tanpa di proses semula seperti mengguna semula beg plastik di pasaraya atau memproses semula sesuatu produk yang telah digunakan untuk menjadikannya bahan mentah kembali seperti mengitar semula kaca, kertas dan tin agar dapat dijadikan bahan mentah untuk produk yang sama atau produk baru. Mengitar semula mampu mengurangkan pencemaran dan juga mengurangkan kebergantungan kepada sumber alam bumi yang semakin kehausan.

Mengitar semula adalah aktiviti yang mudah jika diberi peluang dan disediakan kemudahan. Banyak kempen telah diadakan bagi mempromosi dan mendidik masyarakat untuk mengitar semula. Pun begitu, infrastruktur yang tidak lengkap atau kemudahan kitar semula yang tidak menyeluruh, menyebabkan ramai orang tidak berminat untuk mengitar semula kerana ia menyusahkan dan tidak memberi pulangan yang setimpal. Daripada kajian yang dijalankan, ramai orang berminat untuk mengitar semula jika terdapat kemudahan yang sesuai.

Oleh itu, bagi merungkai masalah yang dihadapi, sebuah projek prototaip *RECYCLE VENDING MACHINE* telah dibangunkan. Fokus utama projek ini adalah untuk melihat samada sebuah mesin layan diri automatik yang bertujuan untuk mengutip tin, mengemikkannya dan memberi ganjaran kepada penggunanya mendapat sambutan atau tidak. Konsep ini masih baru di Malaysia dan jika ia berjaya, terdapat rancangan untuk meluaskannya kepada botol plastik, kaca dan kertas. Kesedaran mengenai kitar semula di Malaysia tidaklah berada pada tahap yang rendah, pun begitu disebabkan kekurangan kemudahan dan fasiliti menyebabkan rakyat Malaysia tidak mahu mengitar semula. Oleh itu, dengan adanya mesin ini, kita dapat membungan sampah, memberi sumbangan tidak langsung kepada alam sekitar dengan mengitar semula dan seterusnya mendapat ganjaran terus daripada tindakan kecil kita. Konsep ini diharap dapat memotivasikan masyarakat untuk lebih proaktif dalam mengitar semula.

Sepertimana yang diterangkan di atas, mesin layan diri ini berfungsi untuk mengumpul tin minuman kosong untuk dikitar semula dan memberi ganjaran terus kepada pengguna. Ganjaran adalah dalam betuk duit, token atau kupon yang boleh digunakan. Dalam projek ini, ganjaran yang diberikan adalah dalam bentuk duit syiling bernilai 5 sen. Mesin ini akan diletakkan di tempat-tempat awam yang strategik bagi memudahkan pengguna untuk mengitar semula. Ia juga boleh menjadi tarikan kepada orang ramai sebagai contoh, jika sebuah pasaraya menggunakan mesin ini di premisnya dan memberi kupon kepada pengguna. Maka pasaraya tersebut dapat menjual hasil kutipan barang kitar semula disamping pengguna akan menggunakan kupon yang didapat untuk membeli belah di pasaraya tersebut. Pengguna akan memperolehi bayaran terus bagi setiap tin disamping dapat memelihara alam sekitar. Bagi pihak lain, ia memberi peluang perniagaan sama seperti pengusaha mesin layan diri minuman pada hari ini. Ia juga dapat memudahkan pihak pengusahan barang kitar semula atau barang lusuh untuk mendapatkan tin minuman yang telah dikemikkan. Dari perspektif lain pula, selain dapat membersihkan kawasan sekitar, di mana pengguna akan menyimpan tin yang telah diminum untuk dikitar semula dan tidak membuangnya merata-rata, ia juga merupakan sumber pendapatan kepada golongan yang kurang bernasib baik seperti gelandangan dimana mereka boleh mengitar semula dan medapat pulangan dengan lebih mudah.

Mesin ini adalah mesin layan diri automatik yang dikawal Programmable Logic Controller (PLC) yang lebih tahan lasak dan dinamik. Ia menggunakan kuasa motor untuk memampatkan tin dan mempunyai mekanisma untuk mengeluarakan syiling sebagai bayaran. Pengguna akan memasukkan tin satu persatu ke dalam mesin. Setelah itu, tin itu akan di mampatkan oleh mekanisma pemampat menggunakan motor. Ganjaran akan diberikan sebaik sahaja tin telah dimampatkan. Tin yang telah dimampatkan akan jatuh ke dalam tong yang disediakan di dalam mesin. Apabila sensor bukan logam mengesan objek, mesin akan gagal berfungsi sehingga objek tersebut dialihkan daripada mesin.

2.0 PENERANGAN PROJEK

2.1 Pernyataan Masalah

Projek ini dibangunkan bagi mengatasi masalah kekurangan kemudahan untuk mengitar semula. Berikut merupakan pernyataan masalahnya.

i. Kekurangan kemudahan dan fasiliti kitar semula.
ii. Tiada motivasi untuk mengitar semula atau membuang sampah dengan betul.
iii. Kesukaran untuk mengitar semula dan mendapat pulangan yang setimpal lebih-lebih lagi bagi golongan yang kurang bernasib baik seperti gelandangan.
iv. Sukar untuk pengusaha barang lusuh untuk medapat bekalan barang kitar semula secara konsisten.

2.2 Objektif Projek

Objektif utama projek ini adalah untuk mengkaji penggunaan mesin layan diri automatik sebagai satu wadah untuk pengguna mengitar semula dan mendapat pulangan terus. Berikut merupakan objektif pembangunan mesin pengitar semula.

i. Untuk membina mesin layan diri automatik
ii. Membina mesin yang boleh memampatkan tin
iii. Membina mesin yang boleh mengeluarkan bayaran dalam bentuk duit syiling atau token
iv. Membina ruang simpanan tin yang telah dikemik yang mudah dikeluarkan.

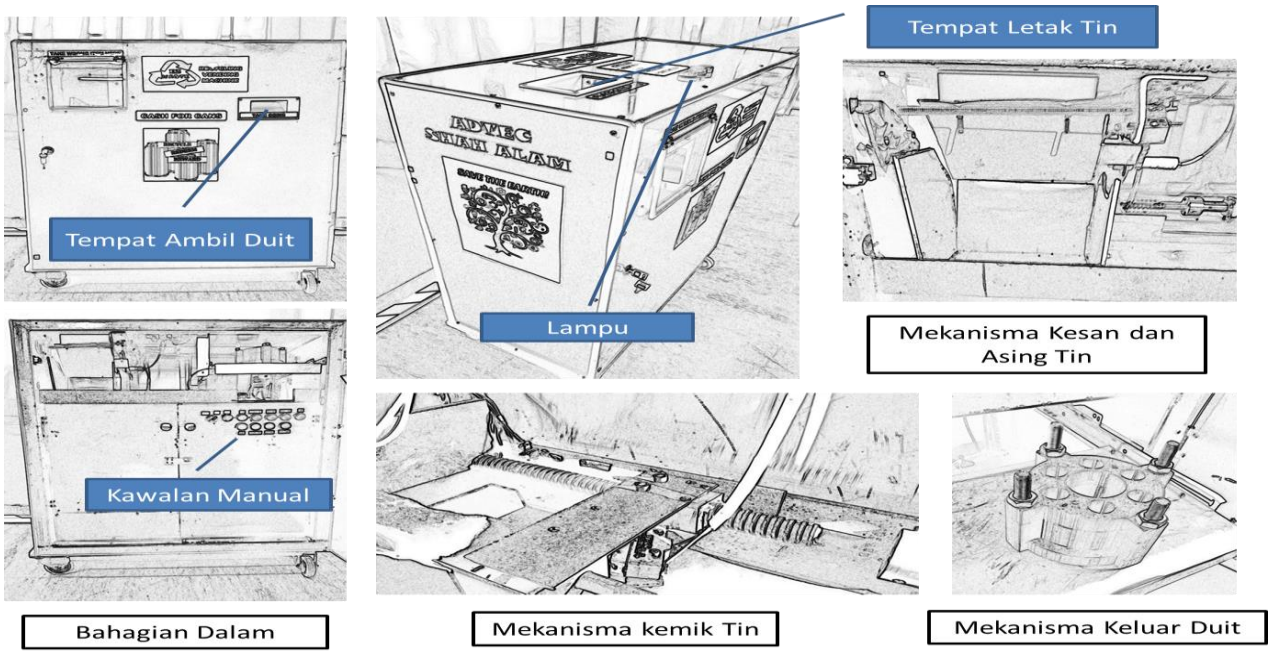
2.3 Spesifikasi

Berikut merupakan spesifikasi asas mesin kitar semula yang telah dibangunkan.

- Sistem kawalan : Programmable logic Controller (PLC).
- Bahasa pengaturcaraan : Sequnetial Functional Chart (SFC).
- Bekalan kuasa : 240 V AC.
- Sensor : Sensor kapasitiv dan optikal.
- Dimesi : 38 cm X 78 cm X 90 cm.
- Berat : 60 Kg.
- Pemampat tin : B*all screw mechanism* dengan motor DC.
- Pengeluar duit : 3D printer dengan motor DC.

2.4 Cara ia berfungsi

3.0 Rekabentuk Mesin



3.1 Ciri-ciri dan Keistimewaan Produk

Berikut merupakan ciri-ciri dan keistimewaan produk.

i. Keselamatan : Direkabentuk agar mempunyai ciri-ciri keselamatan seperti mempunyai butang kecemasan.
ii. Kerangka : Mempunyai kerangka yang kuat dan tahan lasak dari besi.
iii. Ergonomik : Direkabentuk dengan mengambil kira aspek pengguna, mesra pengguna, dan tidak membahayakan pengguna.
iv. Produktif : Satu kitaran proses mengambil masa lebih kurang 18 saat.
v. Mudah digunakan : Mesra pengguna dan konsep penggunaan yang ringkas iaitu hanya letak tin dan dapatkan ganjaran.
vi. Jimat ruang : Mampu mengemikkan tin minuman untuk menjimatkan ruang
vii. Mudah alih : Mempunyai roda supaya mudah di alihkan.

3.2 Faedah Dan Aplikasi Produk

Terdapat pelbagai faedah yang boleh diperolehi, hasil daripada projek ini baik kepada pengguna mahupun penyedia kemudahan ini. Berikut adalah antara faedahnya.

i. Mampu memupuk kesedaran terhadap masalah alam sekitar dan sebahagian daripada kempen selamatkan bumi melalui kitar semula.
ii. Memotivasikan pengguna untuk mengitar kerana mudah dan memberi ganjaran.
iii. Membantu untuk memastikan kawasan sekitar sentiasa bersih di mana masyarakat tidak membuang sampah merata-rata kerana tahu akan mendapat ganjaran jika menggunakan mesin kitar semula disamping membantu menyelamatkan bumi.
iv. Boleh diletakkan di tempat-tempat awam yang mudah dicapai oleh semua lapisan masyarakat sama seperti tong sampah.
v. Memberikan atau mendapat ganjaran terus dalam bentuk duit, kupon atau token
vi. Memudahkan masyarakat untuk mengitar semula dimana jua lebih-lebih lagi bagi masyarakat yang kurang bernasib baik seperti gelandangan yang mampu mengitar semula tanpa rasa segan dan silu atau bersusah payah mencari kedai kitar semula selain mendapat keuntungan yang lebih daripada mengitar semula melalui orang tengah.
vii. Boleh diletakkan bersama atau sebelah menyebelah dengan mesin layan diri minuman.
viii. Mampu mengemik tin untuk memberi penjimatan ruang dan memudahkan proses kitar semula.
ix. Menjadi satu peluang perniagaan baru sama seperti mesin layan diri lain.
x. Boleh digunakan untuk majlis-majlis tertentu, pameran, untuk kempen-kempen kitar semula atau dimana-mana tempat yang menjual tin minuman sebagai salah satu pengurusan sampah.
xi. Efisien, menjimatkan masa, dan penyelenggaraan yang mudah.

3.3 Potensi komersial dan keboleh pasaran.

Produk ini merupakan produk baru yang masih belum dikomersilkan dan di Malaysia. Oleh itu, peluang dan ruang untuk konsep ini berkembang maju masih terbuka luas. Ia mampu menarik pelanggan, memberi pulangan kepada pengguna dan pengusahan dan disamping itu, dapat menyumbang kepada alam sekitar.

i. Masih baru di Malaysia dan belum dikomersilkan di Malaysia.
ii. Memberi peluang dan kemudahan untuk mengitar semula.
iii. Alam sekitar merupakan isu yang besar pada hari ini.
iv. Ganjaran terus untuk tin kosong mampu menarik ramai pengguna.
v. Boleh diletakkan di tempat awam.
vi. Mampu mengurangkan pembuangan sampah merata-rata dan secara tidak langsung mengurangkan keperluan mengupah pekerja pembersihan.
vii. Durable, mesra pengguna, sistem yang ringkas dan penyelenggaraan yang mudah.

3.4 Kos

Angaran kos bagi projek ini adalah sekitar RM 2500. Oleh kerana ia hanyalah sebuah prototaip dan bukan dikeluarkan secara komersil, maka kosnya agak tinggi. Adalah di harapkan, bagi tujuan komersil, kosnya dapat dikurangkan kepada RM 1500 – 1800. Ini supaya operatornya mendapat pulangan modal dengan lebih cepat dan mendapat hasil yang lebih lumayan.

4.0 Analisa Dan Perbincangan

Secara keseluruhannya, mesin ini berfungsi dengan baik. Daripada kajian yang telah dijalankan, kebanyakkan respondan menyatakan bahawa mereka ingin mengitar semula tetapi tidak ada kemudahan yang secukupnya. Sebanyak 96% respondan menyokong kempen kitar semula. 72 % respondan belum mengitar semula atas faktor-faktor seperti tiada kemudahan.

Kesemua respondan memberi maklumbalas bahawa dengan adanya mesin ini, mereka lebih bersemangat untuk mengitar semula dan berharap agar mesin ini dapat diperluaskan ke semua tempat. Ia senang digunakan dan konsep membuang sampah, mendapat duit dan menyelamatkan bumi sangat-sangat disukai oleh respondan.

Kebanyakkan respondan mengharapkan agar mesin ini dapat menerima bukan sahaja tin tetapi juga kertas, botol kaca dan juga botol plastik. Ini memberi ruang kepada mereka untuk mengitar semula dengan lebih mudah.

5.0 Cadangan Penambahbaikan

Pada dasarnya, tujuan utama projek ini adalah untuk melihat maklumbalas terhadap konsep mesin kitar semula layan diri. Fokus seterusnya adalah membangunkan sebuah mesin layan diri yang lebih komersial pada kos yang lebih efektif. Antara penambahbaikan yang dicadangkan adalah seperti berikut.

i. Memperkenalkan mesin yang boleh menerima bukan sahaja tin malah kertas, botol kaca dan botol plastik
ii. Menambah alat pengimbas kod bar untuk mengenalpasti bahan yang dimasukkan dalam mesin bagi mengelakkan vandalisma.
iii. Memperkenalkan ganjaran yang pelbagai iaitu tidak terhad kepada duit sahaja seperti token, kupon, atau dan sebagainya.
iv. Membina mesin yang lebih kos efektif, efisien atau lebih komersil bagi memberi pulangan semula modal yang lebih cepat dan lumayan kepada operatornya.

6.0 Kesimpulan

Bumi bukanlah untuk kita warisi tetapi adalah sesuatu yang kita pinjam dari generasi akan datang atau anak cucu kita. Jika kita merosakkannya, maka yang tinggal hanyalah bumi yang tandus dan binasa. Pelbagai kempen telah di jalankan oleh pelbagai pihak dalam usaha untuk mengatasi pencemaran dan kehausan sumber alam di bumi ini.

Oleh itu, diharapkan mesin ini sedikit sebanyak mampu untuk memainkan peranan sebagai pemangkin sikap mengitar semula dikalangan kita semua. Dengan konsep yang mudah, iaitu pengguna membuang tin dan mendapat ganjaran terus daripada perbuatannya itu, ia secara tidak langsung memotivasikan masyarakat untuk mengitar semula. Ini kerana penjagaan alam sekitar adalah perkara yang paling penting untuk memastikan kualiti kehidupan yang lebih baik dan ia adalah tanggungjawab bersama. Dengan itu diharapkan projek ini dapat mengubah cara pemikiran seterusnya menyelamatkan bumi ini.

7.0 RUJUKAN

[1] Reverse vending, http://www.reversevending.co.uk , [Retrieved on 22 Julai 2015].

[2] Wikipedia:**"**Reverse vending machine**,"** https://en.wikipedia.org/wiki/Reverse_vending_machine , [Retrieved on 22 Julai 2015].

[3] Wikipedia:**"Recycling,"** https://en.wikipedia.org/wiki/Recycling , [Retrieved on 22 Julai 2015].

[4] Tomra:**"About Reverse Vending,"** https://www.tomra.com/en/solutions-and-products/collection-solutions/reverse-vending/about-reverse-vending/ , [Retrieved on 22 Julai 2015].

[5] Emma Hutchings: **"**Reverse Vending Machines Take Recyclable Goods As Payment**,"** http://www.psfk.com/2014/07/reverse-vending-machine-rewards-recyclers.html , [Retrieved on 22 Julai 2015].

[6] Julian Bajkowski:**" Sydney's new reverse vending machines swallow cans, spit out food vouchers,"** http://www.governmentnews.com.au/2014/06/sydneys-new-reverse-vending-machines-swallow-cans-spit-food-vouchers/ , [Retrieved on 22 Julai 2015].

[7] **Su Yuting**:**" Beijing trials bottle-recycling vending machines,"** http://english.cntv.cn/2014/09/21/VIDE1411276563132182.shtml , [Retrieved on 22 Julai 2015].

E32: Analysis on Handover Parameters in Femtocell LTE Based Network

Rhoma Erma bin Zaini[1] Izwah Ismail[2], Asmah Mustapha[3],
[1]*Institut Latihan Perindustrian (ILP), Ipoh, Perak*
[2,3]*Politeknik Ungku Omar (PUO)*

rhomaerma.jtm@1govuc.gov.my

Abstract

The emerging technology of wireless mobile network and devices, increase the bandwidth usage and demand for more network capacity. Femtocell is a low power access point (FAP) that is used to extend and offload the capacity from the macrocell and give excellent experience for indoor subscribers. The handover between femtocells are quite complicated since there are hundreds of possible target FAPs when the Femtocell User Equipment (FUE) moves out from the coverage of its serving FAP and in the same time need to sustain the quality of service (QoS). This study introduced a new mechanism for femtocell-to-femtocell handover which, considers several factors such as received signal level and downlink transmission power gain. Open and close femtocell's access mode are considered in this study. The simulation results compared wih the existing scheme show that probability femtocell not included in the list for proposed scheme is lower than existing scheme. Besides that, number of femtocell in the neighbor cell list for a proposed scheme approaching the number of the serving femtocells as well as avoiding unnecessary handovers and handover failure.

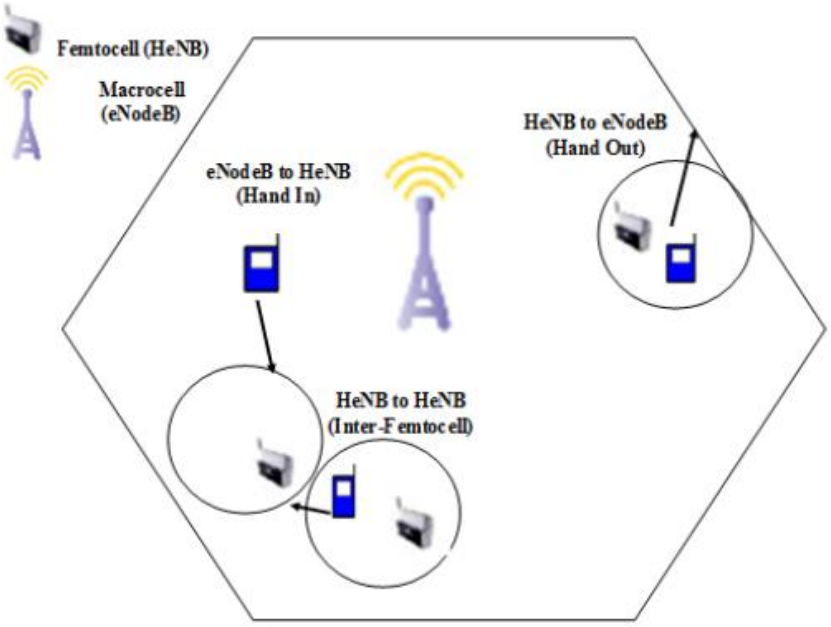
Keywords:*handover, femtocell, indoor coverage, LTE, QoS.*

1.0 Introduction

The emerging technologies in current network architecture attract the user and indirectly increased the user data rates and increased cell-edge bit-rate as well as reduced delays for seamless mobility of indoor subscribers with the deployment of Femtocell. This coincided with the 3GPP standard[1] of Home eNodeB for LTE femtocell which is aiming to be one of the best approaches to reduce the Operating Expenditures (OPEX) for operators as well as to diversify the load from the LTE macrocell networks. As an introduction, Femtocells are low-power access points, providing wireless voice and broadband services to customers primarily in the building such as home or office. 3GPP has been carried out the research on Home eNodeB, while the HomeeNodeB applications may also introduce some challenges to the network.

It must be stressed that with the deployment of the Femtocell , the handover between femtocell and macrocell in the LTE based network is become more important to ensure the seamless connection. Thousands of femtocell within a macrocell area will create a large neighbor cell list and interference problem. So the modifications of handover procedures for existing networks are needed.However, our focus in this paper is to provide a handover scheme with the optimization of handover procedure and algorithm to improve the performance of both the femtocell and macrocell networks. The scenarios created when User Equipments (UEs) with various velocities moving through the femtocell usually unnecessary handovers will occur especially for high speed users. These cause the reduction of the system capacity. Conventional handover methods cannot promise a good enough handover performance for multi-service under different mobility in macrocell and femtocell.In fact, unnecessary handovers have mixed environment lead to heavy load and degrade the communications of the overall broadband wireless system as well as the reduction of user's QoS level. Conventional handover decision algorithms for users in mobile vehicles cannot meet current need, which means the unnecessary handovers and quality of service (QoS) problems will get even worse for users' different mobility and status of real-time service.[2]

However, there are still some issues in order to integrate Femtocells/Macrocell, since the existing cellular networks architecture is very different from Femtocells architecture.This paper focused on the handover issue in three ways of scenarios Femtocells handover procedure, i.e., Macrocellto Femtocells handover (Hand In), Femtocells to Macrocell handover (Hand Out) and Inter-Femtocells handover procedure based on 3GPP LTE specification as shown in Figure1.



2.0 Background

Previous studies in [4] and [5] have primarily concentrated on the handover procedure for femtocell architecture and system throughput. Due to the different architecture of two tier network (macrocell and femtocell), the conventional handover mechanism need to be modified for selecting an appropriate target indoor cell from many candidate of Femtocell Access Points (FAPs).

Author in [6] indicated that there are some different characteristics in mobility between macro and femtocell network. First, the femtocell radius is much smaller than the macro cell radius, consequently the user equipment (UE) attempting handover (HO) between the macrocell and the femtocell will experience more severe signal-to-ratio (SINR) degradation than the UE interference noise moving between macro cells at the same speed. Second, the indedicate channel environment which the macro and femtocells use different frequency bands, outbound HO is more important than inbound HO. For inbound mobility, the UE connecting to the macro cell can move inside the femtocell without the occurrence of radio link failure (RLF) since the macro and femtocells use different frequency bands. However, the failure during outbound HO will lead to the disconnection of UE from the femtocell, which causes serious degradation of user's experience. Therefore, it is more important to support the successful outbound mobility than inbound HO. To achieve this purpose, this study interested in optimizing handover parameters in the femtocell network.

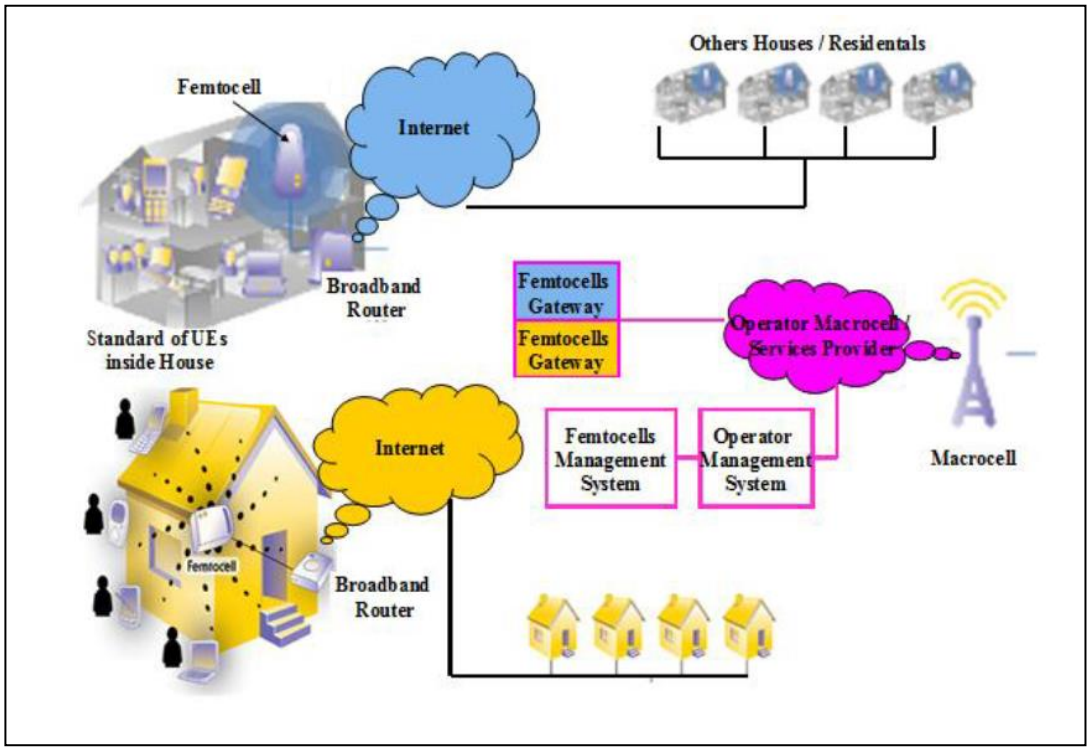


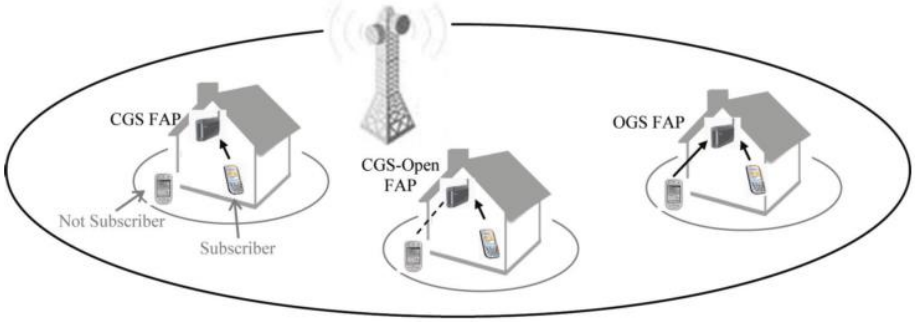
Figure 3 Typical deployment of femtocell [3]

As highlighted by the author in [7], details of the handover procedure: information gathering, decision strategies and the base station exchange process. All these three phases face difficulties in multi-tier networks. High dense femtocell deployment makes handover related information gathering very hard, but efficient handover decision mechanisms are vital to reduce the number of unnecessary handovers and avoid the ping-pong effect as analyzed by the author in [8].

During the handover evaluation period, there is a possibility for a service interruption time caused by reading system information of target Femtocell Access Point (FAPs). Author[9] carried out experimental studies by comparing three measurement approaches intensively and provide helpful tips for reducing service interruption time. From the results, the autonomous measurement approach provides the best performance in a dense femtocell deployment through simulation and it is a very effective way for user equipment to make the best use of the timing of target FAP to reduce frame loss and the measurement overhead as well as reducing the average idle time are significantly.

Another important part to be considered is the access control method as it is a key approach to mitigate two-tier interference and handover attempts in the femtocell system. The selection of an access control mechanism of femtocells has dramatic effects on the performance of the overall network. Study by author [10] stated that the subscriber is known as femtocell registered users while the non-subscriber is a un-registered femtocell user. The access method is divided into three groups.

The Close Subscriber Group(CSG) defines the group of femtocell registered users while the non-subscribers are considered an Open Subscriber Group (OSG). The closed or open access of a CSG describes three categories of femtocell as represented in Figure 4. For instance, the three types of access method are the open femtocell, CSG-open femtocell,and CSG-closed femtocell.



The handover mechanism is indispensable to wireless mobile communication networks where "handover" refers to aprocedure by which user equipment (UE) services can be handed over from an original eNB (also named the source eNB)to another eNB (also named the target eNB). Generally, the first-turned-on UE will scan all the carrier frequencies in the assigned spectrum. Then, the UE finds a suitable eNB (orHeNB) to camp on. After camping on it, the UE periodicallylistens to the neighboring list message which is broadcast by the eNB (HeNB). The neighbor list consists of the neighboring cell information (e.g., frequencies and scrambling codes).

The UE periodically measures the signal strengths of the neighboring cells on the basis of the cell information to evaluate all eNBs in the neighboring eNB list. If the measurement results accord with the reporting criteria, the UE sends them to the eNB. When handover is needed, the eNB chooses a target eNB for the UE according to the measuring reports. During the measurement procedure, no data transmission is allowed between the UE and the eNB because the UE has to switch to other radio frequencies to search for the eNBs in the vicinity. Femtocell handover or femtocell handoff techniques need to ensure that seamless coverage is perceived by the user when moving onto or off a femtocell. Femtocell handover is more challenging than normal macrocell cellular handover because the backhaul network is different and there is also little possibility of direct communication between the femtocell and the macrocell. There are 3 types of Handover in two tier network as listed below:

2.1 Macrocell to femtocell handover

A conscious decision was made to exclude handover from the macro cellular system to the femtocell devices (sometimes called macro to femtocell hand-in). This decision was driven by two factors:

- There are a number of technical challenges in supporting hand-in with unmodified mobile devices and core network components.
- The system operator requirements clearly indicate that supporting handout is much more important to end users. Nonetheless, there is still a strong desire to develop open, interoperable ways to support hand-in in an efficient and reliable manner, and the second phase of standards in 3GPP is anticipated to support such a capability as highlighted in [1]

2.2 Femtocell to Macrocell Handover

The outbound handover for Home eNodeB is not so complex like inbound handover for Home eNodeB. Author in [2] stated whenever a user move out from femtocell network, eNodeB's signal strength may be stronger than Home eNodeB networks in the neighbor cell list. Consequently, the selection of interference complex target cell is easier. No calculation and authorization check in needed for the "handout" like the inbound handover. Outbound femtocell handover is similar with the standard macrocell to macrocell handover except that the direct interface between the base stations does not exist.

Signaling must take place over the backhaul link to the core network for both the macrocell and the femtocell, although the femtocell routing will include the femtocell gateway. This form of femtocell handover occurs when a cell-phone or user equipment needs to transfer from a macrocell on the standard external network to a femtocell.

This form of handover is one of the most common forms, but it is also quite challenging because the macrocell and the femtocell will have different backhaul routes, and efficient communication is required between the two as well as transfer of the backhaul route.

To effect an inbound femtocell handover the same basic principles are implemented as for a macro to macro handover. However signaling for the handover needs to be undertaken via the backhaul route (S1 interface for LTE femtocells).When the User Equipment is in operational it will detect local cells, including femtocells (HNBs - UMTS or HeNBs - LTE). It will therefore be ready to undertake a handover when the conditions are correct. The femtocells will have a unique physical cell identifier, ID and they will be known to the macrocell. In this way it is possible to effect a handover more efficiently.

2.3 Femtocell to Femtocell Handover

Femto-to-femto hand over is further divided into handovers within the same femto gateway and handovers between different gateways. Author in [11]studied the situations where handover will occur between one femtocell and another close by. This will be commonplace in offices that may have a number of femtocells to give continuous coverage within a building. For the femtocell to femtocell handover, the signaling is handled entirely within the femtocell gateway - HeNB-GW via the S1 interface for LTE. Femtocell handover is a key element of femtocell technology. For femtocell technology to be adopted, the femtocell handover must be able to be undertaken effectively. While there are significant challenges to implementing it in a way that operates efficiently, because of the different backhaul routes for the signaling, these issues have been addressed.

2.4 Simulation Scenario

Author extended this work by doing the simulation using Matlab. According to author in[12], due to the small scale of femtocell's coverage, users with a high velocity will cross the femtocell in a short time, considering the users' QoS, the high speed user may be not necessary to execute handover especially for the non-real-time service. The special velocity environment changes described here include the following scenes:

- Low mobile state: from 0 to 15 km/h, slow walk, stationary.
- Medium mobile state: from 15 to 30 km/h, when ride a bike.
- High mobile state: above 30 km/h, drive a car.

QoS (quality of service) also play an important role in HeNB related handover. Unsuitable handover algorithm may unnecessary cause QoS degradation for these users by handover. For non-real-time applications, delay and packet loss can be tolerated to some extent; however, the long interruption of handover is horrible for delay and packet loss sensitive real-time applications such as IPTV, VoIP, and online games. Sometimes the low speed user wants to move to Home eNodeB as quickly as possible and stay there as long as possible.

2.5 Simulation Parameters

Detailed simulation parameters configurations are in Table 1 and 2. According to an investigation by Author in[13], this study used system parameters as recommended. With assumption of 20 macro cells and femtocells are collocated 2/3 of macro cell radius. Every femtocell is located around 20cm to simulate the femto-to-femto HO.

With the consideration of RSSI, the velocity of the UE, the SINR, the capacity bandwidth that one Femtocells can accept, the user type and the duration UE maintains the signal level above the threshold level. The threshold is the minimum level required for the handover from Macrocell to Femtocells. Various value of handover threshold (HTh) from 1dBto12dB with a fixed time to trigger (TTT) value of 160ms for all UE speeds is applied in this scenario. In the simulation, we assumed 64 numbers of UEs distributed uniformly with random velocity.

Table 1 : System Simulation Parameter

UE speed	0-30 km/h
Handover threshold	1 … 12
Add time to trigger	40ms, 100ms, 160ms
Drop time to trigger	240ms, 640ms, 1280ms
Cell radius	1000m
Node B spacing	1500m
Traffic type	Conversational ; bit rate 12.2 kbps
Path loss model	Vehicular ; Okumura-Hata
Path loss (macro)	$PL_{mu} = 15.3+37.6\log_{10}(d[m]) + S^{out}$
Path loss (Femto)	$PL_{fu} = 38.5 +20 \log(d[m]) + 0.7d_{2D,}$indoor $+18.3n^{((n+2)/(n+1)-0.46)}$ (Femtocell)
System Bandwidth	5 MHz
No of Subcarriers	512
Subcarriers Bandwidth	375 kHz
Base Station Frequency	2000 MHz
Cell radius (M/F)	280/30 m

The default parameter that have been used by the LTE network service provider list as in the **Table 2**:

Table 2: Parameter setting at LTE network provider

Parameter setting	
Addition Window	4 dB
Addition Time	100 ms
Addition Reporting Interval	0.5 s
Drop Window	6 dB
Drop Time	640 ms
Replacement Window	2 dB
Replacement Time	320 ms
Replacement Reporting Interval	0.5 ms
Maximum Active Set Number	3

This simulation start by monitoring the 64 UEs moving from Macrocell to the Femtocells/Macrocell area. If the velocity of UE moving were below than 30km/h, they are allowed to go to the next procedure. Ten Base Stations (BS), Macrocell/Femtocells with the highest available RSSI are determined. The BS which can support the bandwidth as well as having the highest SINR will be chosen. If the BS chosen is Femtocells, and the UEs are Registered, handover will immediately occur. The threshold time interval (T) for handover is set to 0 when the Registered users move from Macrocell to the Femtocells.

2.6 Performance Evaluation

Author found that femto-femto handover gain can be noted at the level almost 4.5 dB. The gain is calculated between transmitted power for adding and dropping 0 dB and 1 dB, and power transmitted for 6 dB and 9 dB adding and dropping thresholds. For the fixed time to trigger value 160ms, it can be seen that handover gain is significant and reaches almost 6 dB.

The highest transmitted power is at the level of 31 dBm and the lowest one is over 23 dBm which is in good agreement with the results of the present study.

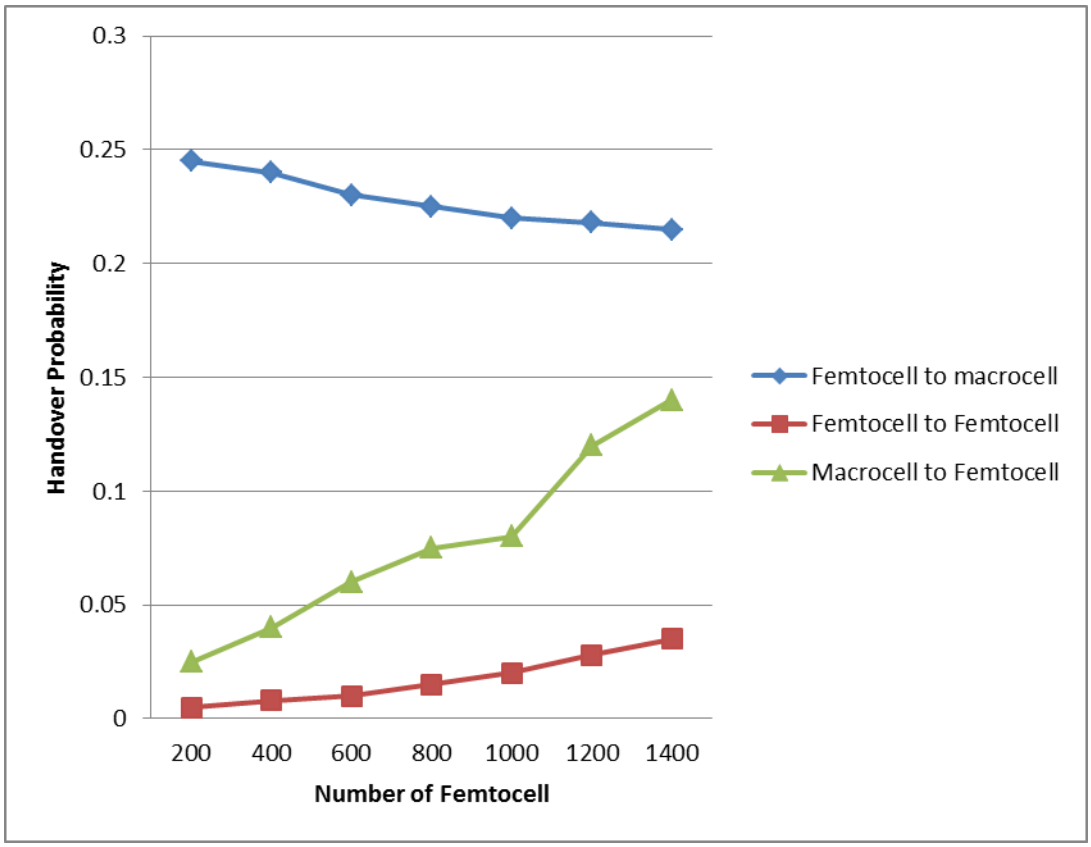


Fig. 5 : Handover Probability

The minimization of the probability of unnecessary handovers with respect to the femtocell coverage area is shown in Fig. 6. An unnecessary handover occur when a UE first moves from the Macrocell to the Femtocells and within 50seconds for Registered UE, it bounce back to the Macrocell again or within 10 seconds for Un-Registered UE. Result clearly prove the probability of unnecessary handovers for Un-Registered users without propose scheme is about 50 ~ 60% and it is reduced to around 40%~ 50% at maximum femtocell coverage area.

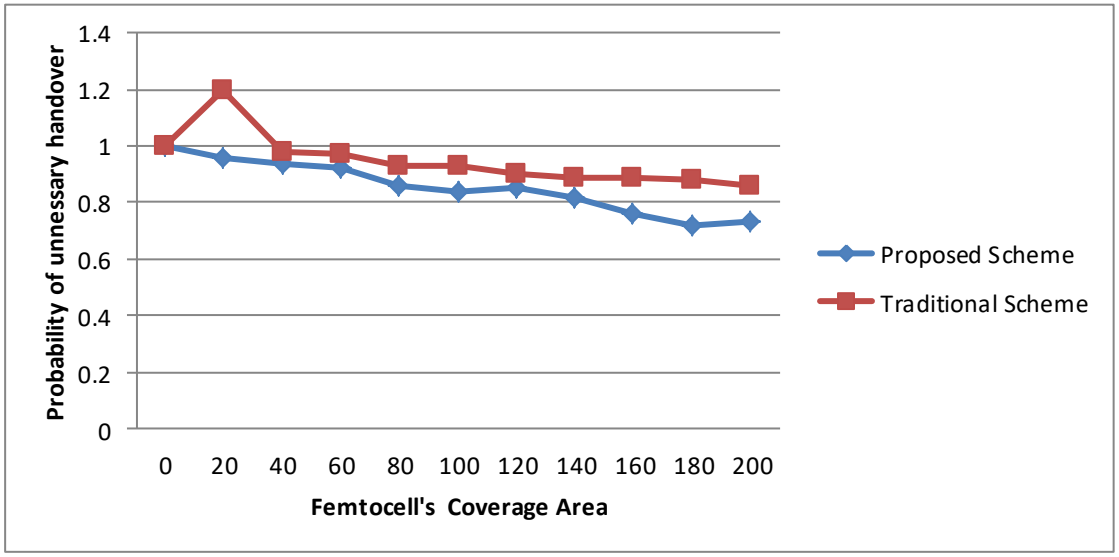


Fig. 6 : Unnecessary Handover Probability

Table 3: Proposed femto-femto HO parameter for LTE network service provider

Parameter setting before changes		Proposed new parameter setting	
Addition Window	4 dB	Addition Window	6 dB
Addition Time	100 ms	Addition Time	160 ms
Addition Reporting Interval	0.5 s	Addition Reporting Interval	0.5 s
Drop Window	6 dB	Drop Window	6 dB
Drop Time	640 ms	Drop Time	1280 ms
Replacement Window	2 dB	Replacement Window	2 dB
Replacement Time	320 ms	Replacement Time	320 ms
Replacement Reporting Interval	0.5 ms	Replacement Reporting Interval	0.5 ms
CPICH Ec/No filter coefficient	600	CPICH Ec/No filter coefficient	600
Active Set weighting coefficient	0	Active Set weighting coefficient	0
Maximum Active Set Number	3	Maximum Active Set Number	3

Short time to trigger values resulted also in the high amount of drop calls, which were affecting smooth transmission. The drop calls can be also avoided by use of larger time to trigger values. Moreover, the time to trigger values up to 640 ms is very short and there was no significant femto-femto HO gain, if these values were used. The conclusions of femto-femto HO optimum parameters for the radio network planning are clear. The femto-femto HO thresholds providing the large femto-femto HO area should be used as well as longer time to trigger values.

With these conditions, in this project, the new femto-femto HO parameter setting is proposed to the network provider. The new SHO parameter setting for 3G network as shown in the **Table 3**.

Thus the finding of the present study suggest that the differentiated treatment of the threshold stay time interval between the Registered and the Un-Registered UE reduces the amount of unnecessary handovers and provides better service quality and flexibility compared to the traditional handover parameter.

3.0 Conclusion

In radio network planning it is important to estimate correctly the capacity and plan the coverage for given area. This paper presented the effect of handover on improvement of the femto-femto handover parameter. In order to improve the transmission power in downlink direction in LTE based network as well as the capacity of the network. Important conclusions drawn from this work include optimum parameters, responsible for functionality of the network, are needed to satisfy above criteria.

Overall, this study has contribute to our knowledge about handover gain which was varying from 3 dB to 5.5 dB, depending on the femto-femto handover window sizes changed by handover adding and dropping thresholds and their adding and dropping time to trigger values. These simulations also indicate that femto-femto handover provides downlink transmission power gain, which can be seen as improvement of the femtocell LTE based network performance.

In particular, further research should be conducted on the performance comparison of handover procedure by three types of access mode: Open Access Mode, Closed Access Mode and Hybrid Access Mode by considering the load balancing and access control management.

4.0 Acknowledgment

The authors would like to thanks the Department of Electrical Engineering, Institut Latihan Perindustrian Ipoh and Department of Electrical Engineering, Politeknik Ungku Omar for their support and assistance given to the authors in carrying out this research study.

5.0 References

[1] D. N. Knisely, T. Yoshizawa, and F. Frank, "Standardization of Femtocells in 3GPP," *IEEE Commun. Mag.*, vol. 47, no. September, pp. 68–75, 2009.

[2] H. Zhang, X. Wen, B. Wang, W. Zheng, and Y. Sun, "A Novel Handover Mechanism Between Femtocell and Macrocell for LTE Based Networks," in *2010 Second International Conference on Communication Software and Networks*, 2010, pp. 228–231.

[3] A. L. Yusof, S. S. Salihin, N. Ya'acob, and M. T. Ali, "Performance Analysis of Handover Strategy in Femtocell Network," *J. Commun.*, vol. 8, no. 11, pp. 724–729, 2013.

[4] M. Chowdhury and W. Ryu, "Handover between macrocell and femtocell for UMTS based networks," in *11th International Conference on Advanced Communication Technology,*, 2009, pp. 237–241.

[5] H. Chueh, "A beacon-based Handover Scanning Mechanism with QoS Support in WiMAX FemtoCell Architecture," no. Iccse, pp. 1069–1074, 2011.

[6] H.-D. Bae, B. Ryu, and N.-H. Park, "Analysis of handover failures in LTE femtocell systems," in *2011 Australasian Telecommunication Networks and Applications Conference (ATNAC)*, 2011, pp. 1–5.

[7] G. Gódor, Z. Jakó, Á. Knapp, and S. Imre, "A Survey of Handover Management in LTE-based Multi-tier Femtocell Networks: Requirements, Challenges and Solutions," *Comput. Networks*, Nov. 2014.

[8] H. Bae and N. Park, "Impact of Reading System Information in Inbound Handover to L TE Femtocell," in *2010 16th Asia-Pacific Conference on Communications (APCC)*, 2010, pp. 476–480.

[9] C. Chang, Y. Lin, R. Jan, and C. Chen, "Efficient Measurement Procedure for Handover in LTE Femtocell Networks *," 2012, pp. 119–123.

[10] R. Mokhtar, R. Saeed, and B. Chaudari, "Introduction to Femtocell," in in *Femtocell Communications and Technologies: Business Opportunities and Deployment Challenges*, 2012, pp. 1–14.

[11] P. Brown, "Worldwide Standardizations of Femtocell," in in *Femtocell Communications and Technologies: Business Opportunities and Deployment Challenges*, 2012, pp. 15–33.

[12] H. Zhang, B. Wang, W. Zheng, and Y. Sun, "A Novel Handover Mechanism between Femtocell and Macrocell for LTE based Networks," in *2010 Second International Conference on Communication Software and Networks*, 2010, pp. 2–5.

[13] J. M. Ruiz Avilés, M. Toril, and S. Luna-Ramírez, "A femtocell location strategy for improving adaptive traffic sharing in heterogeneous LTE networks," *EURASIP J. Wirel. Commun. Netw.*, vol. 2015, no. 1, p. 38, Feb. 2015.

E33: Performance Study of Wireless Body Area Network (WBAN) in Medical Environment

Sarudin Rohseli, Muhamad Nadzri Bin Abdul Ghani , Mohamad Azahari Bin Mohamed Khair Johari
Pusat Latihan Teknologi Tinggi (ADTEC) Taiping, Perak

sarudin@adtectaiping.gov.my

Abstrak

Projek yang akan dijalankan adalah untuk membuat kajian tentang ketebalan silikon dengan penggunaan suhu, masa dan gas terhadap wafer <100> jenis P dan N. Projek yang telah dipilih ini adalah sebagai rujukan penambahbaikan untuk proses penghasilan lapisan dioksida ke atas wafer <100> jenis P dan N dengan proses pengoksidaan kering(dry oxidation) dan pengoksidaan basah(wet oxidation). Projek ini adalah bagi memudahkan pelajar untuk melakukan apa-apa proses pengoksidaan dengan menggunakan kajian yang telah kami lakukan. Segala proses pembakaran adalah suhu 800°c dan 1000°c untuk setiap proses pengoksidaan kering (dry oxidation) dan pengoksidaan basah(wet oxidation). Gas yang digunakan adalah gas oksigen dan gas nitrogen. Gas oksigen digunakan semasa bermulanya proses pengoksidaan untuk menghasilkan lapisan oksida di atas wafer. Gas nitrogen pula digunakan sebelum bermulanya masa dan berkhirnya masa bagi proses tersebut dimana ia digunakan sewaktu suhu meningkat dan menurun. Kadar aliran gas yang diguunakan adalah bermula dari 0.5, 1.0, 1.5, 2.0 dan 2.5 l/min. Masa yang digunakan ialah selama 30 minit, 60 minit, 90 minit dan 120 minit. Wafer yang digunakan adalah jenis <100> P dan N bersaiz 4". Ia juga sebagai langkah penjimatan suhu, masa dan gas.

Katakunci: *proses pengoksidaan*

1.0 Pengenalan

Lapisan silikon dioksida, SiO_2 memainkan peranan yang penting dalam operasi dan proses fabrikasi sesuatu peranti semikonduktor. Silikon dioksida merupakan bahan penebat yang digunakan sebagai pemisah atau pengasing di antara komponen-komponen di dalam litar terkamir, pemisah antara dua lapisan logam penyambungan, dan sebagai pempasif atau pelindung simpangan p-n dan pada tahap akhir pemprosesan peranti semikonduktor. Selain daripada itu, SiO_2 juga digunakan sebagai bahan dielektrik dan sebagai get transistor MOS. Dalam proses fabrikasi, lapisan SiO_2 digunakan sebagai topeng terhadap atom-atom dopan semasa proses resapan dilakukan untuk membolehkan hanya kawasan tertentu sahaja terdedah kepada sumber dopan. Si yang terdedah kepada udara sekitaran pada suhu bilik akan bertindak dengan oksigen dan membentuk lapisan nipis SiO_2. Lapisan oksida ini disebut sebagai oksida asli yang ketebalannya lebih kurang 30-50Å jika terdedah kepada lebih dari 10 jam. Oleh sebab lapisan silikon dioksida terdiri daripada oksigen dan silikon yang biasanya dibentuk di atas lapisan wafer silikon, maka permukaan silikon akan digunakan untuk membentuk SiO_2.

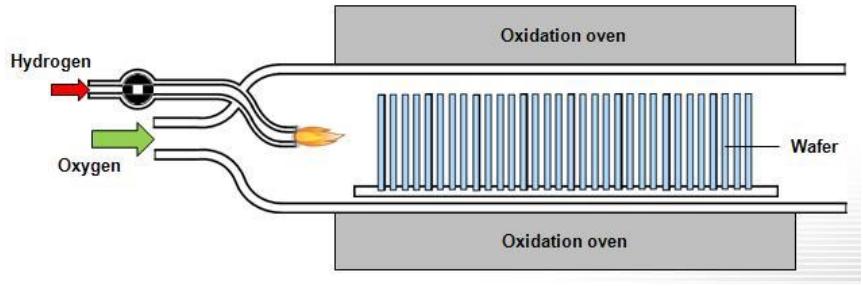
2.0 Latar Belakang

Terdapat beberapa amalan yang digunakan untuk memasuk dan mengeluarkan bot wafer daripada zon rata tiub pengoksidaan. cara yang biasanya digunakan ialah dengan memasukkan bot yang mengandungi wafer di dalam sekitar gas lengai seperti argon atau nitrogen. Dalam sekitaran gas lengai pada suhu tinggi (1000ºc), wafer akan mecapai suhu pengoksidaan tanpa berlaku pengoksidaan. Pada keadaan ini juga sebarang bendasing pada permukaan akan meruap meninggalkan permukaan silikon yang bersih. Pada suhu tinggi, kecerunan suhu pada wafer meleding, dan boleh mengalih kehabluran. keadaan ini adalah lebih nyata bagi saiz wafer yang besar. Oleh itu, untuk mengelakkan ini berlaku, wafer dimasukkan dan dikeluarkan daripada kawasan panas dengan perlahan.

Kadar pertumbuhan sebenar Sio2 pada Si dengan proses pengoksidaan kerig dan kadar pertumuhan lapisan oksida dengan proses pengoksidaan basah. Oleh sebab bilangan atom silikon pada permukaan berbeza mengikut orientasi, maka kadar pengosidaan juga bergantung pada orientasi hablur. keadaan ini kerana tindak balas atom silikon yang berbeza semasa pengoksidaan. kadar pengoksidaan bertambah dalam nisbah 1:2:3 bagi orientasi (100), (110), dan (111).

3.0 Proses Pengoksidaan Terma

Terdapat beberapa amalan yang digunakan untuk memasuk dan mengeluarkan bot wafer daripada zon rata tiub pengoksidaan. cara yang biasanya digunakan ialah dengan memasukkan bot yang mengandungi wafer di dalam sekitar gas lengai seperti argon atau nitrogen. Dalam sekitaran gas lengai pada suhu tinggi (1000ºc), wafer akan mecapai suhu pengoksidaan tanpa berlaku pengoksidaan. Pada keadaan ini juga sebarang bendasing pada permukaan akan meruap meninggalkan permukaan silikon yang bersih. Pada suhu tinggi, kecerunan suhu pada wafer meleding, dan boleh mengalih kehabluran. keadaan ini adalah lebih nyata bagi saiz wafer yang besar. Oleh itu, untuk mengelakkan ini berlaku, wafer dimasukkan dan dikeluarkan daripada kawasan panas dengan perlahan. Kadar pertumbuhan sebenar SiO_2 pada Si dengan proses pengoksidaan kering $Si+O_2 \rightarrow SiO_2$ dan kadar pertumuhan lapisan oksida dengan proses pengoksidaan basah $Si+O_2+2H_2 \rightarrow SiO_2+2H_2$.



Gambarajah 1: Pengoksidaan Kering

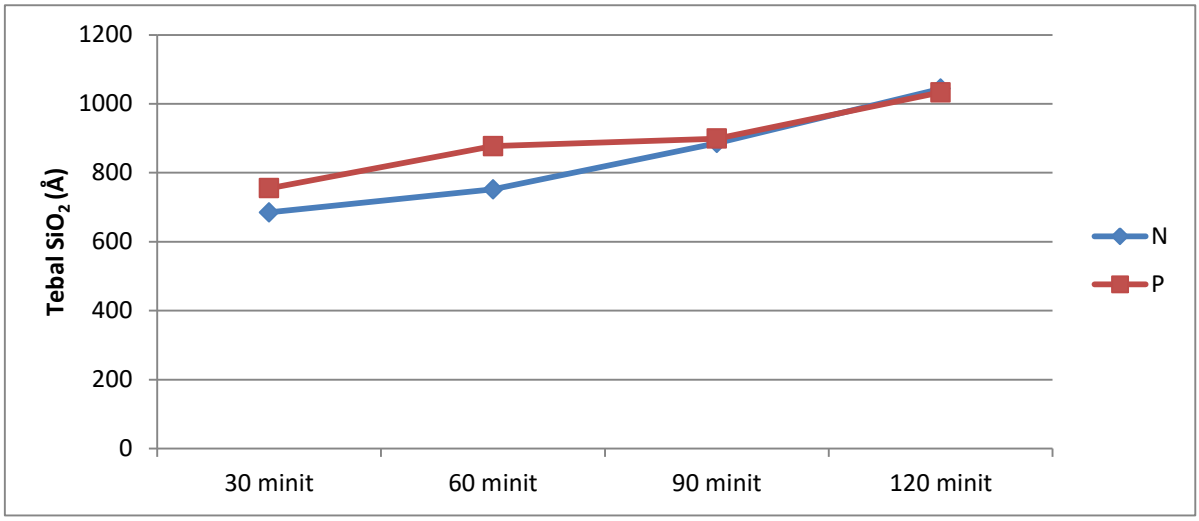
Gambarajah 2: Pengoksidaan Basah

4.0 Kaedah Proses

Kaedah yang digunakan dalam proses pengoksidaan adalah mengikut urutan dan langkah-langkah yang telah disediakan. Kaedah projek yang terlibat adalah:

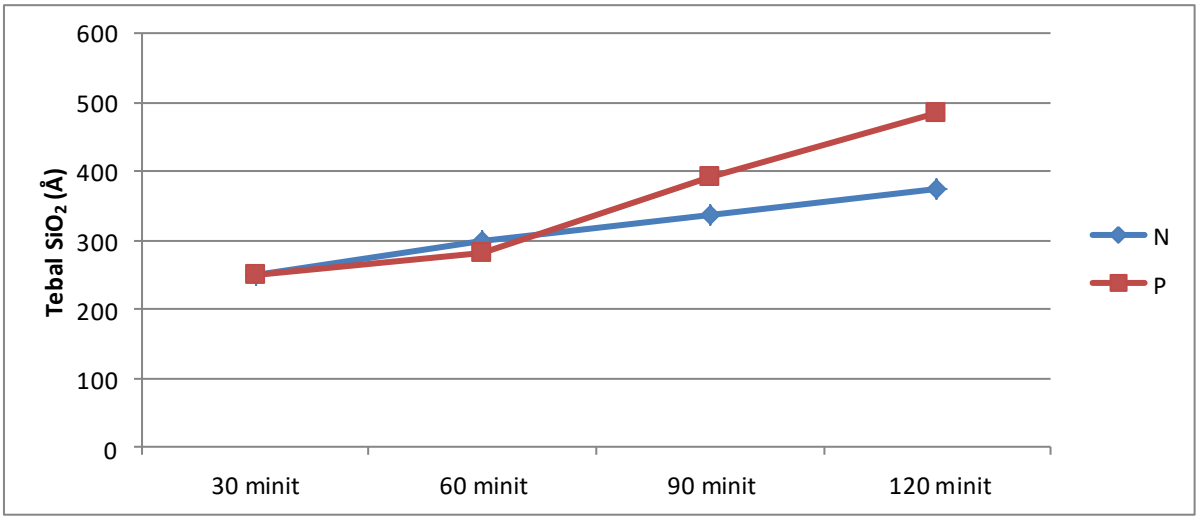
i. Wafer saiz 4" dengan struktur <100> jenis P dan N sebagai bahan uji kepada perbezaan masa, suhu dan gas.
ii. Masa yang diambil bagi melakukan proses pengoksidaan ini adalah selama 30 minit, 60 minit, 90 minit dan 120 minit.
iii. Takat suhu yang digunakan bagi melakukan proses pengoksidaan ini adalah 800°c dan 1000°c.
iv. Gas yang digunakan bagi melakukan proses pengoksidaan ini adalah gas oksigen sebagai pemangkin pembakaran.
v. Peralatan yang digunakan adalah *High Temperature Furnace* di dalam cleanroom di ADTEC Taiping.
vi. Proses ini dilakukan dengan menggunakan kaedah pengoksidaan kering (dry oxidation) $Si+O_2 \rightarrow SiO_2$ dan Pengoksidaan basah (wet oxidation) $Si+O_2+2H_2 \rightarrow SiO_2+2H_2$.
vii. *Wet Bench Module* adalah sebagai proses di mana wafer dicuci menggunakan BOE (Bufferd Oxide Etch) dan wafer tersebut dibilas dengan air Deionized (DI) Water kemudian dikeringkan menggunakan spinner di dalam *wet bench*

5.0 Keputusan dan Perbincangan



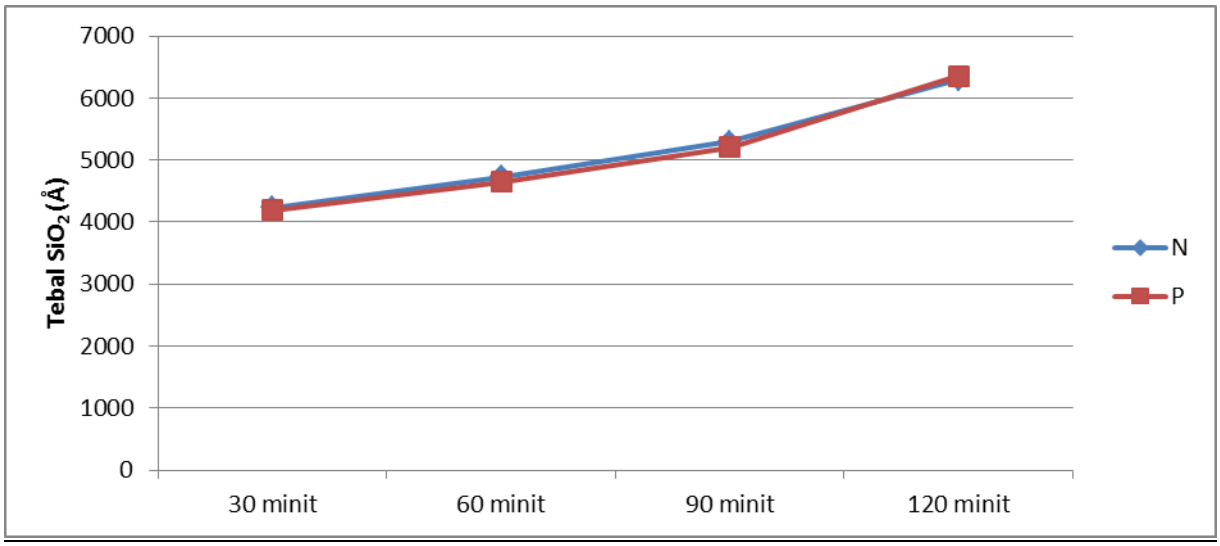
Gambarajah 3: Tebal SiO_2 Lawan Masa Bagi Suhu = 1000 °C, O_2 = 2.5

5.1 Pengoksidaan Kering



Gambarajah 4 : Tebal SiO_2 Lawan Masa Bagi Suhu = 800 °C, O_2 = 2.5

5.2 Pengoksidaan Basah



Gambarajah 5: Tebal SiO_2 Lawan Masa Bagi Suhu = 1000 °C, O_2 = 2.5

6.0 Perbincangan

Hasil kajian ini mendapati makin tinggi suhu, maka silikon dioksida yang terhasil adalah semakin tebal kerana suhu memainkan peranan yang penting dalam pengoksidaan basah dan kering. Turut diperhatikan, semakin lama masa yang diambil dalam proses pengoksidaan, maka ketebalan silikon dioksida menjadi semakin tebal. Hal ini kerana masa yang lama diambil untuk melengkapkan proses pengoksidaan dan menghasilakan keputusan yang semakin menebal.

Selain daripada itu, faktor jumlah oksigen yang dibekalkan juga mempengaruhi hasil yang diperolehi. Sekiranya lebih banyak gas oksigen digunakan, maka ketebalan silikon oksida akan menjadi semakin tebal. Pengoksidaan kering juga mempunyai perbezaan yang ketara dengan pengoksidaan basah. Hal ini kerana pengoksidaan kering menghasilkan SiO_2 yang nipis, manakala pengoksidaan basah menghasilkan SiO_2 yang tebal 10 kali ganda daripada pengoksidaan kering.

Pemilihan jenis wafer juga memberikan keputusan yang berbeza. Wafer jenis P menghasilkan ketebalan yang lebih tinggi berbanding wafer jenis N.

7.0 Kesimpulan

Kesimpulannya, didapati terdapat 5 faktor penting yang mempengaruhi proses pengoksidaan dan ketebalan silicon oksida iaitu kuantiti gas, suhu, tempoh masa, kaedah yang digunakan, jenis bahan yang digunakan. Secara khususnya, kesan terhadap factor-faktor tersebut adalah seperti berikut:

1. Makin tinggi suhu maka silikon dioksida yang terhasil makin tebal.
2. Masa yang diambil lama, maka ketebalan silikon dioksida makin tebal.
3. Lebih banyak gas oksigen, lebih tebal silikon dioksida.
4. Proses pengoksidaan kering hasilkan SiO_2 yang nipis dalam 500 Å.
5. Proses pengoksida basah hasil SiO_2 yang tebal 500 Å.
6. Wafer jenis P lebih tebal > wafer jenis N.

8.0 RUJUKAN

[1] Michael Quirk and Julian Serda, Semiconductor Manufacturing Technology, Prentice Hall, 2001, Upper Saddle River.

[2] S. M. Sze, Semiconductor Device: Physic and Technology 2nd Edition, 2002, John Wiley & Sons, United State of America.

[3] Hong Xiao, Introduction to Semiconductor Manufacturing Technology, 2000, Prentice Hall, United State of America.

[4] Yves J. Chabal, Fundamental Aspects of Silicon Oxidation, 2001, Springer.

[5] Burhanuddin Yeop Majlis. 2000. Teknologi Fabrikasi Litar Bersepadu, UKM.

E35: Fabrication and Characterization of Metal Thin Film Produced By PVD Process

Nurul Hana Abu Hassan
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

nurulhana.jtm@1govuc.gov.my

Abstract

Physical Vapor Deposition is a process by which a thin film of material is deposited on the substrate. In this research, metal thin film was deposited by Aluminum Evaporator and Platinum Sputter Coater. In PVD by sputtering, the material to be deposited as a film is converted into vapor by bombarding the source material with high-energy particles or ions. In PVD by evaporation, the conversion into vapor phase is achieved by applying heat to the source material, causing it to undergo evaporation. PVD by evaporation has been used primarily in the deposition of aluminum (Al) [1]. A several time deposition will be used during deposition process. The changes of the thickness of the metal thin film were investigated respect to the deposition time and a size of trench. However, equivalent resistivity was dependent on the presence and thickness of the metal thin film.

Keywords: *PVD, sputtering, metal thin film,*

1.0 Introduction

Physical vapor deposition (PVD) is another old process adapted to semiconductor needs. It is a process first formulated in 1852 by Sir William Robert Grove [2] and developed as a thin film deposition technique in the 1920s by Langmuir. Physical Vapor Deposition (PVD) is a process that can deposit any material on any substrate. To date, there is no work have been done to study the metal thin film properties using the Aluminum Evaporator and Platinum Sputter Coater existing in our university. Generally, a size of patterned or trench width will influence the deposition of metal thin films. Thin film thickness and its morphology are important to study because it will influence the application of thin film. Pattern design also is very important so that trench which is producing can give good effect towards morphology after deposition process.

2.0 Methodology

This chapter will further explain on the method and procedures that related with this project.

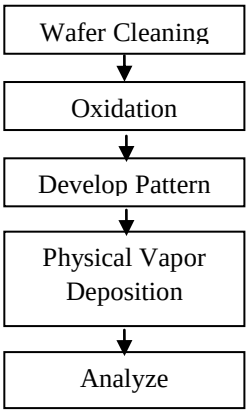


Figure 1: Block Diagram of the Project

2.1 Wafer Cleaning

The predominant wafer surface cleaning process is with wet chemistry. Wet cleaning of wafers is thriving and is being improved to attain more effective surface cleaning. The silicon wafer was immersed in Buffered Oxide Etch (BOE). Then, agitate the wafer and rinse with Deionized (DI) water. Then spin dry the silicon wafer and inspect the wafer.

2.2 Oxidation

The formation of silicon dioxide (SiO_2) on a silicon substrate is known as oxidation. Generally this is accomplished by thermal oxidation, wherein the wafer is exposed to an oxidizing environment at elevated temperature. Thus, an oxidation system has to have a heat source to elevate the temperature of the oxidizing environment and a system for delivering the oxidizing gases to the wafers. The oxide of silicon, or silicon dioxide (SiO_2), is one of the most important ingredients in semiconductor manufacturing, having played a crucial role in the development of semiconductor planar processing. The formation of SiO_2 on a silicon surface is most often accomplished through a process called thermal oxidation. Thermal oxidation, as its name implies, is a technique that uses extremely high temperatures (usually between 700˚C to1300˚C) to promote the growth rate of oxide layers.[3]

Wet oxidation is used for oxidation process in this research. The temperature of Oxidation Furnace Module was set 1100 °C and oxidation time set at 2 hours. The reactions wet oxidation is governed by the following equations: [3]

$$Si\ (solid) + 2H_2O\ (vapor) \dashrightarrow SiO_2\ (Solid) + 2H_2\ (vapor) \quad (1)$$

A. Develop Pattern

Develop process are photolithography process and etching process.

1) First pattern

Fig. 2 shows the first pattern that was used to develop a trench with specific sizes.

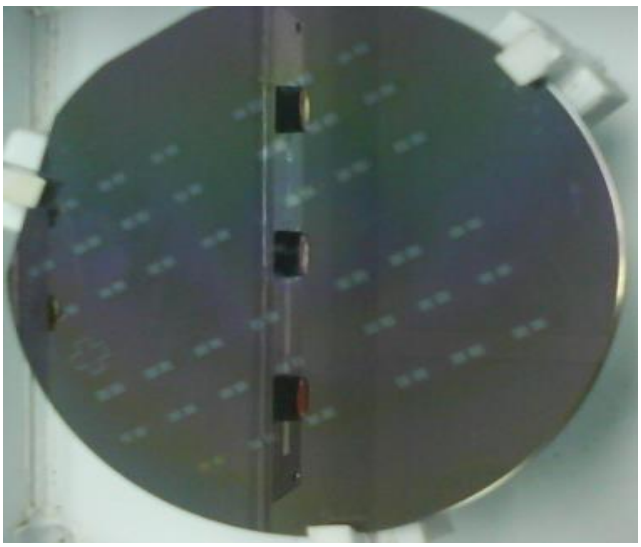


Figure 2: The First Pattern

After develop the first pattern, problem occurs when observe the cross section by using SEM image. Fig. 3 shows a shadow was existed when view the cross section from the front side.

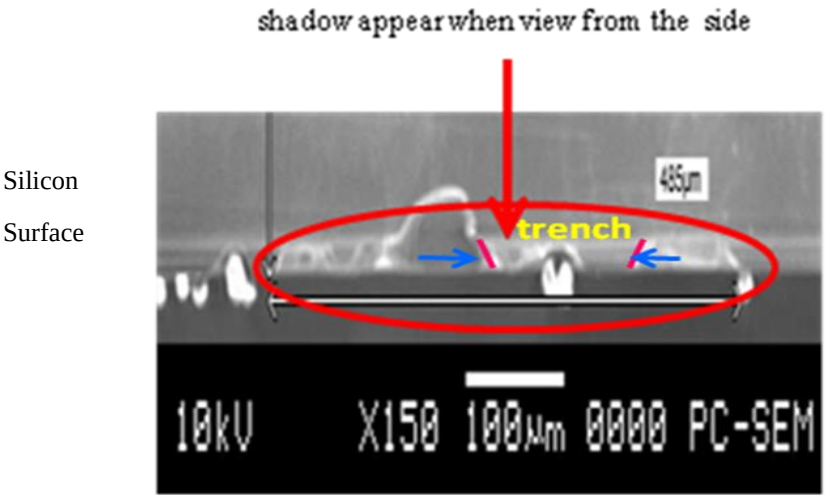


Figure 3: The cross section of first pattern

2) Second Pattern

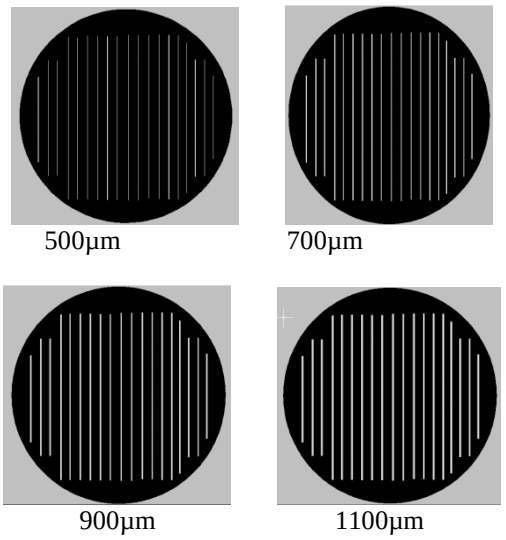


Figure 4: The set of third pattern

There are four patterns (300 µm, 500 µm, 700 µm, 900 µm and 1100 µm) developed. The pattern of 300 µm size of trench was not used in this research because the size of pattern is too small and cannot develop on silicon dioxide (SiO_2) wafer.

B. Physical Vapor Deposition

In VLSI fabrication, the most widely-used method of accomplishing PVD of thin films is by sputtering. However, there is a second method of PVD, it is PVD by evaporation and also used in semiconductor fabrication

In PVD by sputtering, the material to be deposited as a film is converted into vapor by bombarding the source material with high-energy particles or ions. In PVD by evaporation, the conversion into vapor phase is achieved by applying heat to the source material, causing it to undergo evaporation. This is done in a high-vacuum environment, so that the vaporized atoms or molecules will be transported to the substrate with minimal collision interference from other gas atoms or molecules. In this study, we use Aluminum Evaporator as a PVD by evaporation and Platinum Sputter Coater as a PVD by sputtering. Since the Aluminum Evaporator system was broken during the experiment, we deposit the Platinum thin film on patterned substrate by using Platinum Sputter Coater.

1) Platinum Sputter Coater

Platinum were deposited by Platinum Sputter Coater. Platinum deposition process will operate when we set deposition time. Sputtering has become one of the most widely used techniques for depositing various metallic films on wafers, including aluminum, aluminum alloys, platinum, gold, TiW, and tungsten. Sputtering as a deposition technique may be described as a sequence of these steps:

a) ions are generated and directed at a target material;
b) the ions sputter atoms from the target;
c) the sputtered atoms get transported to the substrate through a region of reduced pressure;
d) the sputtered atoms condense on the substrate, forming a thin film.

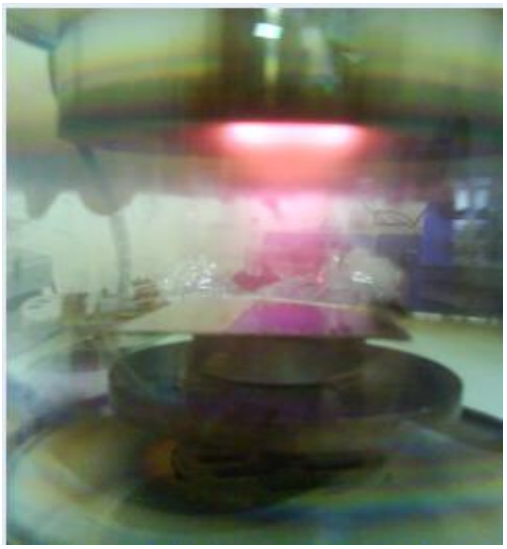


Figure 5: Operation of Platinum Sputter Coater

2) Aluminum Evaporator

Aluminum was deposited by Aluminum Evaporator. [4] The simplest is to employ resistive heating, wherein a wire of low vapor pressure metal such as tungsten is used to support strips of the material to be evaporated. The wire is then resistively heated, so that the metal to be deposited melts first and evaporates

3.0 RESULT AND ANALYSIS

This chapter will discuss about result had been obtain and make an analysis base on the result.

3.1 Thickness of Platinum Thin Film

Platinum was deposited on the silicon dioxide (SiO_2) wafer using different sputtering times (from 50 sec to 200 sec). In this research, we used XP-1 Surface Profiler to measure the thickness. The value of all the thickness convert from Angstrom unit to µm.

Fig. 6 shows four different of thickness after deposition process of the Platinum thin films on the silicon dioxide (SiO_2) wafer. The average of thickness is below than 30 µm, respectively, which is the increase of the amount of deposited platinum from 3 µm to 22 µm. In this study, deposition time 50 sec, which has a 22 µm, which is the highest thickness. From these results, we can deduce that platinum deposits well on silicon dioxide (SiO_2) wafer without pattern on it.

Fig. 7 shows the thickness of the Platinum thin films in a width range of 500 µm. The average of thickness is below than 30 µm, respectively, which is the increase of the amount of deposited platinum from 10.4 µm to 27.7 µm. From these results, we can deduce that platinum deposits well on the trench. Among the Platinum thin films, the 200 sec of deposition time show the highest observed thickness at 27.7 µm. The thickness decreased with decreasing deposition time. The graph of 100 sec and 150 sec of deposition time are close to each other and the results of thickness for 100 sec and 150 sec are also close to each other. They show the rapid change between the plots of 150 sec and 200s. The result is repeatable but unexplained.

Fig. 8 shows four different of thickness after deposition process of the Platinum thin films in a width range of 700 µm. The average of thickness is below than 30 µm, respectively, which is the increase of the amount of deposited platinum from 9.03 µm to 23.1 µm. In this study, deposition time 50 sec, which has a 9.03 µm, which is the lowest thickness. From these results, we can deduce that platinum deposits well on the trench.

Fig. 9 shows the thickness of the Platinum thin films in a width range of 900 µm. The average of thickness is below than 30 µm, respectively, which is the increase of the amount of deposited platinum from 22.7 µm to 28.5 µm. Among the Platinum thin films, the 200 sec of deposition time show the highest observed thickness at 28.5 µm. The thickness decreased with decreasing deposition time.

Fig. 10 shows four different of thickness after deposition process of the Platinum thin films in a width range of 1100 µm. The average of thickness is below than 30 µm, respectively, which is the increase of the amount of deposited platinum from 13.7 µm to 27.4 µm. In this study, deposition time 50 sec, which has a 13.7 µm, which is the lowest thickness. From these results, we can deduce that platinum deposits well on the trench.

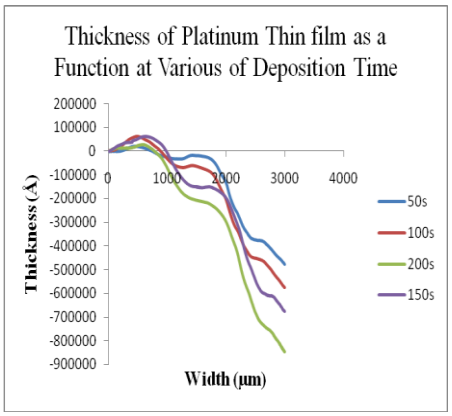


Figure 6: Thickness of Platinum Thin Film for no pattern on the silicon dioxide wafer

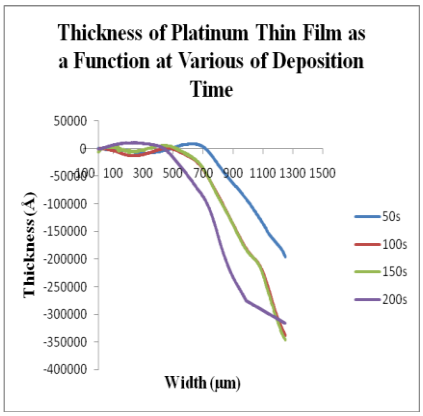


Figure 7: Thickness of Platinum Thin Film for size of trench, 500 µm

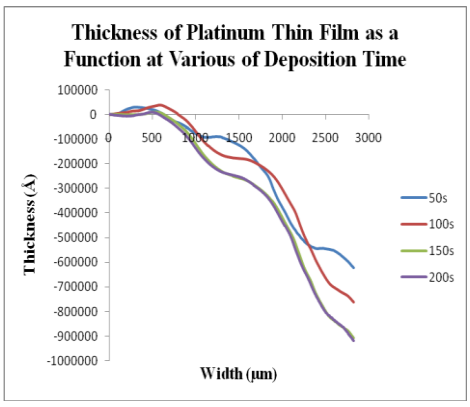


Figure 8: Thickness of Platinum Thin Film for size of trench, 700 µm

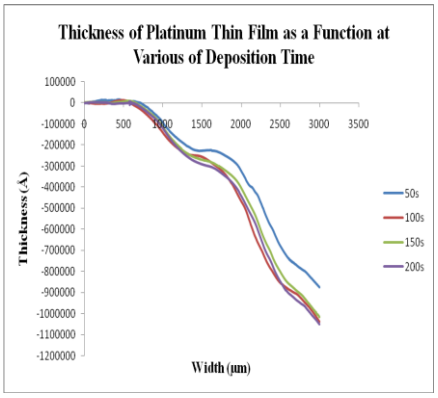


Figure 9: Thickness of Platinum Thin Film for size of trench, 900 µm

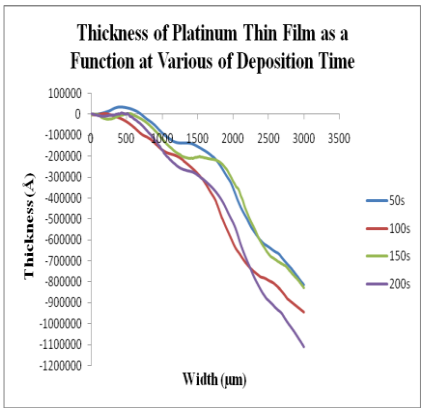


Figure 10: Thickness of Platinum Thin Film for size of trench, 1100

3.2 Resistivity of Platinum thin film

We used 4-Point Probe to measure the I-V characteristic of each pattern. Then, we determine the bulk resistivity from the graph of I-V characteristic. The formula for bulk resistivity is:

$$\rho = \frac{V}{I} \times 4.523 \times thickness$$

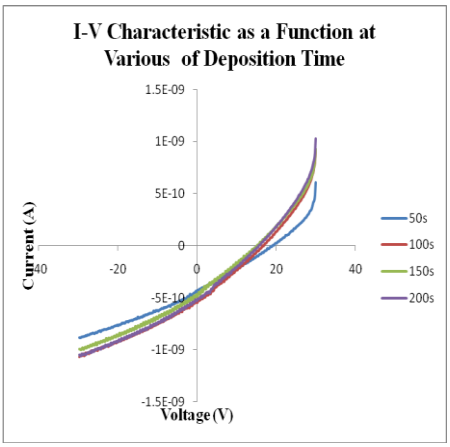


Figure 11: I-V characteristic for Platinum Thin Film for no pattern on the silicon dioxide wafer

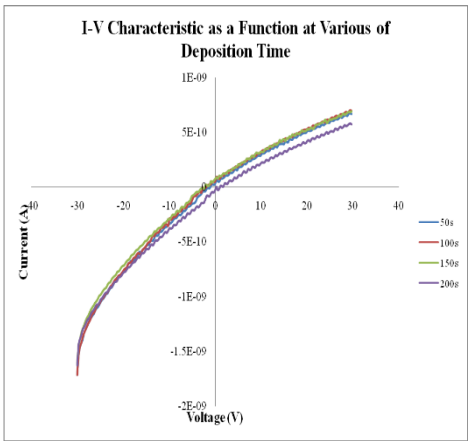


Figure 12: I-V characteristic for Platinum Thin Film for size of trench, 500 µm

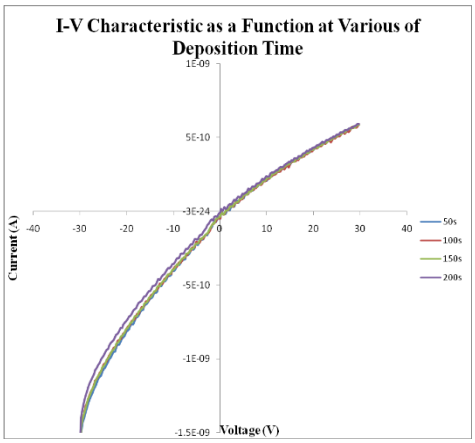


Figure 13: I-V characteristic for Platinum Thin Film for size of trench, 700 µm

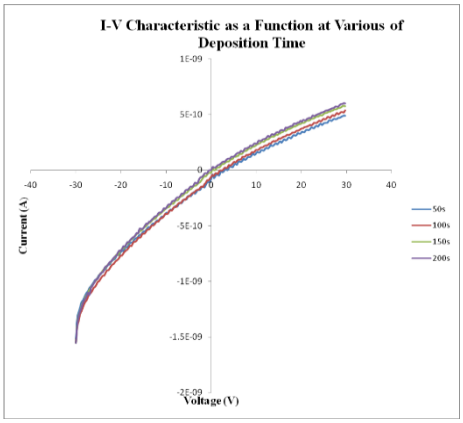


Figure 14: I-V characteristic for Platinum Thin Film for size of trench, 900 µm

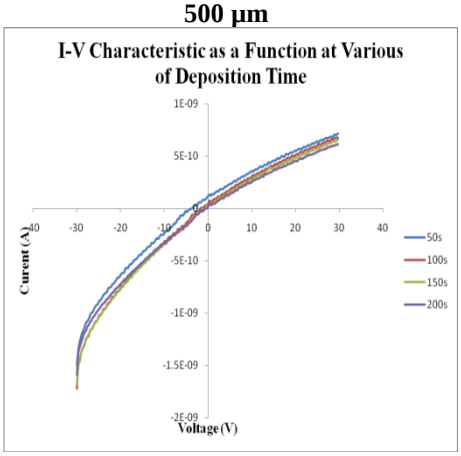


Figure 15: I-V characteristic for Platinum Thin Film for size of trench, 1100 µm

Fig. 11 shows four different of I-V characteristic at several of deposition time in a width range of no pattern on silicon dioxide wafer after deposition process of platinum thin film. The resistance at 50 sec of deposition time shows the highest value of resistance at 3.129 x 10^{10} Ω. In this study, deposition time 200 sec, which has a 2.19 x 10^{10} Ω, is the lowest value of resistance. From this study, we can deduce that when the value of resistance is decreased, deposition time is increased.

Fig. 12 shows four different of I-V characteristic at several of deposition time in a width range of no pattern on silicon dioxide wafer after deposition process of platinum thin film. The resistance at 50 sec of deposition time shows the highest value of resistance at 3.96 x 10^{10} Ω. In this study, deposition time 150 sec, which has a 3.64 x 10^{10} Ω, is the lowest value of resistance. From this study, we can deduce that when the value of resistance is decreased, deposition time is increased.

Fig. 13 shows four different of I-V characteristic at several of deposition time in a width range of no pattern on silicon dioxide wafer after deposition process of platinum thin film. The resistance at 50 sec of deposition time shows the highest value of resistance at 3.45 x 10^{10} Ω. In this study, deposition time 200 sec, which has a 3.12 x 10^{10} Ω, is the lowest value of resistance. From this study, we can deduce that when the value of resistance is decreased, deposition time is increased.

Fig. 14 shows four different of I-V characteristic at several of deposition time in a width range of no pattern on silicon dioxide wafer after deposition process of platinum thin film. The resistance at 50 sec of deposition time shows the highest value of resistance at 3.68 x 10^{10} Ω. In this study, deposition time 150 sec, which has a 2.30 x 10^{10} Ω, is the lowest value of resistance. From this study, we can deduce that when the value of resistance is decreased, deposition time is increased.

Fig. 15 shows four different of I-V characteristic at several of deposition time in a width range of no pattern on silicon dioxide wafer after deposition process of platinum thin film. The resistance at 150 sec of deposition time shows the highest value of resistance at 2.38 x 10^{10} Ω. In this study, deposition time 100 sec, which has a 2.00 x 10^{10} Ω, is the lowest value of resistance. From this study, we can deduce that when the value of resistance is decreased, deposition time is increased

Table 1 shows comparison of the thickness of Platinum thin film at no pattern on the silicon dioxide wafer, resistance and bulk resistivity, and deposition time. The highest of the bulk resistivity is 21.79 x 10^5 at 200 sec of deposition time. When the resistivity is decreased, the conductivity is increased.

Table 1: Comparison of the thickness of Platinum thin film, resistance and bulk resistivity at no pattern on the silicon dioxide wafer respect to deposition time.

Deposition Time	50s	100s	150s	200s
Thickness (μm)	3	7	15	22
Resistance (Ω)	3.129 x 10^{10}	2.2 x 10^{10}	2.25 x 10^{10}	2.19 x 10^{10}
Bulk Resistivity (Ωm)	4.25 x 10^5	6.96 x 10^5	15.27 x 10^5	21.79 x 10^5

Table 2 shows comparison of the thickness of Platinum thin film, resistance, bulk resistivity and deposition time at 500μm size of trench. The highest of the bulk resistivity is 47.48 x 10^5 Ωm at 200 sec of deposition time. When the resistivity is increased the bulk resistivity is decreased. We can deduce that when the resistivity is decreased, the conductivity is increased.

Table 2: Comparison of the thickness of Platinum thin film, resistance and bulk resistivity at 500µm size of trench, respect to deposition time.

Deposition Time	50s	100s	150s	200s
Thickness (µm)	10.4	20.2	20.2	27.7
Resistance (Ω)	3.96×10^{10}	3.96×10^{10}	3.64×10^{10}	3.79×10^{10}
Bulk Resistivity (Ωm)	18.62×10^{5}	36.18×10^{5}	33.25×10^{5}	47.48×10^{5}

Table 3 shows comparison of the thickness of Platinum thin film, resistance, bulk resistivity and deposition time at 700µm size of trench. The highest of the bulk resistivity is 22.67×10^{5} Ωm at 150 sec of deposition time. When the resistivity is increased the bulk resistivity is decreased. We can deduce that when the resistivity is decreased, the conductivity is increased.

Table 3: Comparison of the thickness of Platinum thin film, resistance and bulk resistivity at 700µm size of trench, respect to deposition time

Deposition Time	50s	100s	150s	200s
Thickness (µm)	9.03	17.5	23.1	23.1
Resistance (Ω)	3.45×10^{10}	$2.62x\ 10^{10}$	2.17×10^{10}	2.12×10^{10}
Bulk Resistivity (Ωm)	$14.09x\ 10^{5}$	20.73×10^{5}	22.67×10^{5}	$22.15x\ 10^{5}$

Table 4 shows comparison of the thickness of Platinum thin film, resistance, bulk resistivity and deposition time at 900µm size of trench. The highest of the bulk resistivity is 37.89×10^{5} Ωm at 200 sec of deposition time. When the resistivity is increased the bulk resistivity is decreased. We can deduce that when the resistivity is decreased, the conductivity is increased.

Table 4: Comparison of the thickness of Platinum thin film, resistance and bulk resistivity at 900µm size of trench, respect to deposition time.

Deposition Time	50s	100s	150s	200s
Thickness (µm)	22.7	26.2	28	28.5
Resistance (Ω)	3.68×10^{10}	2.31×10^{10}	2.30×10^{10}	$2.94x\ 10^{10}$
Bulk Resistivity (Ωm)	37.78×10^{5}	27.37×10^{5}	29.13×10^{5}	37.89×10^{5}

Table 5 shows comparison of the thickness of Platinum thin film, resistance, bulk resistivity and deposition time at 1100µm size of trench. The highest of the bulk resistivity is 26.64×10^{5} Ωm at 200 sec of deposition time. When the resistivity is increased the bulk resistivity is decreased. We can deduce that when the resistivity is decreased, the conductivity is increased.

Table 5: Comparison of the thickness of Platinum thin film, resistance and bulk resistivity at 1100µm size of trench, respect to deposition time.

Deposition Time	50s	100s	150s	200s
Thickness (µm)	13.7	17.9	20.6	27.4
Resistance (Ω)	2.14×10^{10}	2.00×10^{10}	2.38×10^{10}	2.15×10^{10}
Bulk Resistivity (Ωm)	13.3×10^{5}	16.19×10^{5}	22.17×10^{5}	26.64×10^{5}

Table 1- Table 5 shows the influence of a several of deposition time during platinum thin film deposition process produced by Platinum Sputter Coater. At the beginning of the deposition platinum is present on the trench with a denser platinum surface.[6] Increasing the deposition time from 50s to 200s, for the average, the resistivity of all size of trench increases. For no pattern on the silicon dioxide wafer, the bulk resistivity increase from 4.25 $x10^6$ Ωm to 21.79 $x10^6$ Ωm. For the size of trench 500 µm, the bulk resistivity increase from 18.62 $x10^6$ Ωm to 47.48 $x10^6$ Ωm. For the size of trench 700 µm, the bulk resistivity increase from 14.09 $x10^6$ Ωm to 22.67 $x10^6$ Ωm. For the size of trench 900 µm, the bulk resistivity increase from 27.37 $x10^6$ Ωm to 37.89 $x10^6$ Ωm. For the size of trench 1100 µm, the bulk resistivity increase from 13.3 $x10^6$ Ωm to 26.64 $x10^6$ Ωm. The equivalent bulk resistivity of Platinum thin film increased with increasing the thickness of Platinum thin film. [7]

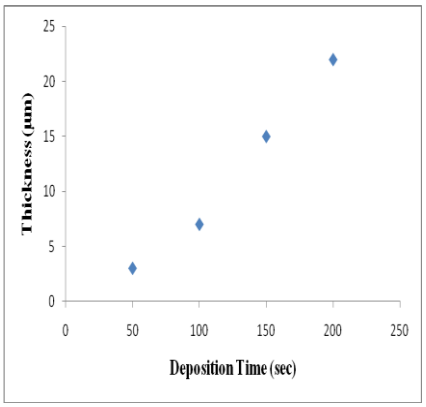


Figure 16: Graph of thickness respect to the deposition time at no pattern on silicon dioxide wafer

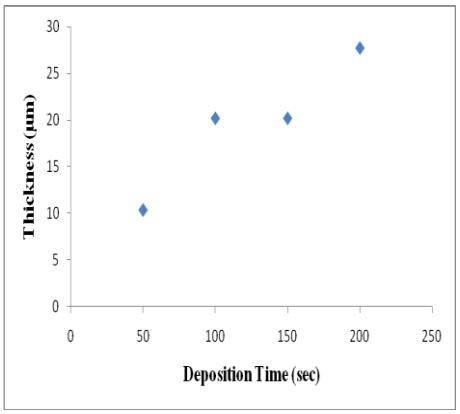


Figure 17: Graph of thickness respect to the deposition time at 500µm size of trench

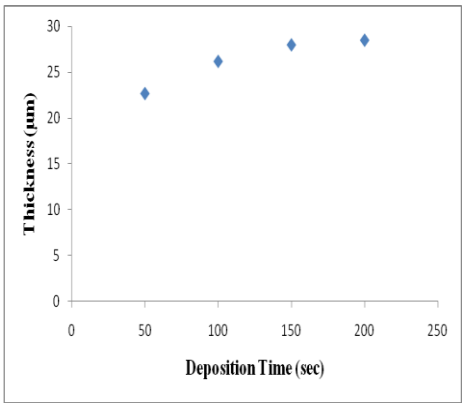


Figure 18: Graph of thickness respect to the deposition time at 700µm size of trench

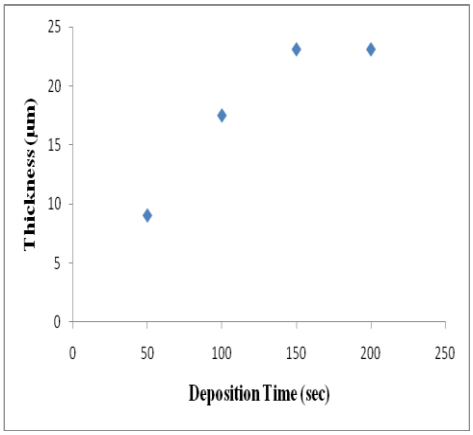


Figure 19: Graph of thickness respect to the deposition time at 900µm size of trench

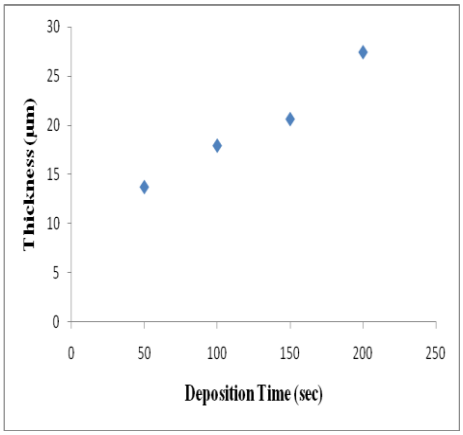


Figure 20: Graph of thickness respect to the deposition time at 1100µm size of trench

Fig. 16 – Fig. 20 shows the influence of thickness respect to deposition time during platinum thin film deposition process produced by Platinum Sputter Coater. We can deduce that when the deposition time is increased, the thickness of platinum thin film also increased.

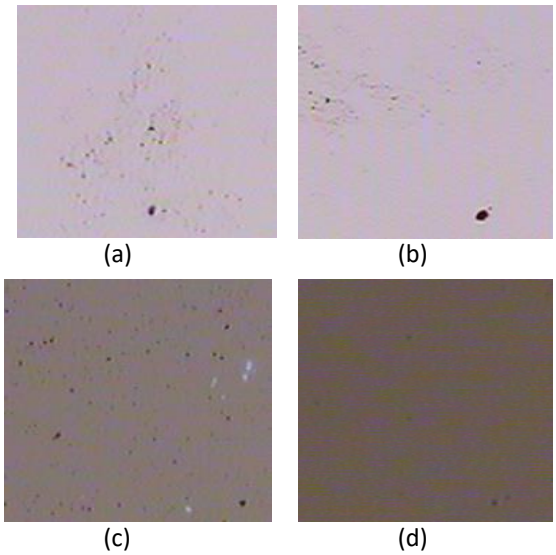


Figure 21: Revolution Microscope images of Platinum thin film during deposition time (a) 50 sec (b) 100 sec (c) 150 sec (d) 200 sec on the silicon dioxide wafer

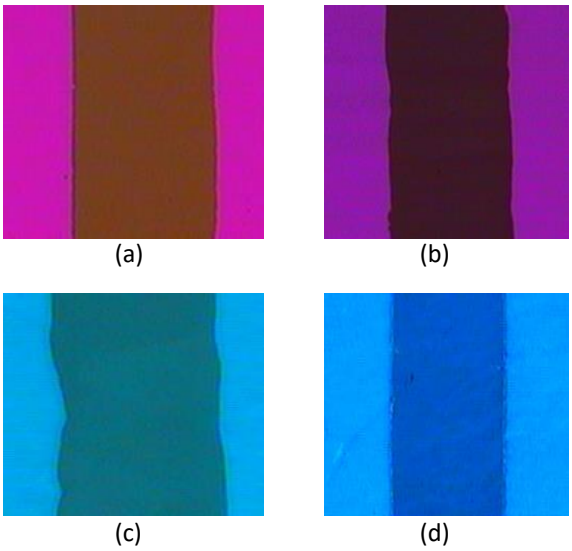


Figure 22: Revolution Microscope images of Platinum thin film during deposition time (a) 50 sec (b) 100 sec (c) 150 sec (d) 200 sec at 500 µm size of trench

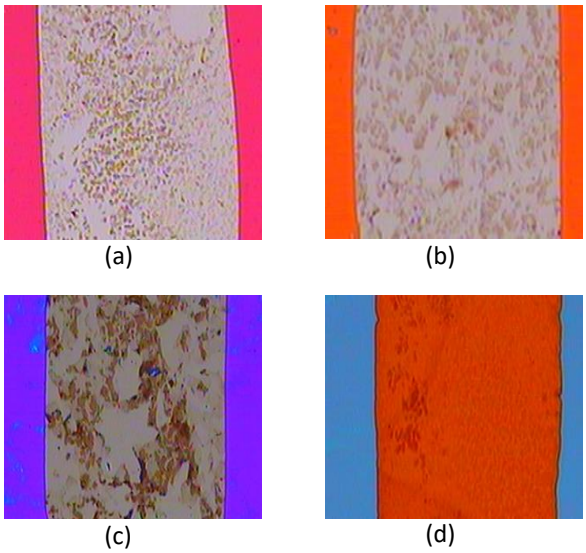


Figure 23: Revolution Microscope images of Platinum thin film during deposition time (a) 50 sec (b) 100 sec (c) 150 sec (d) 200 sec at 700 µm size of trench

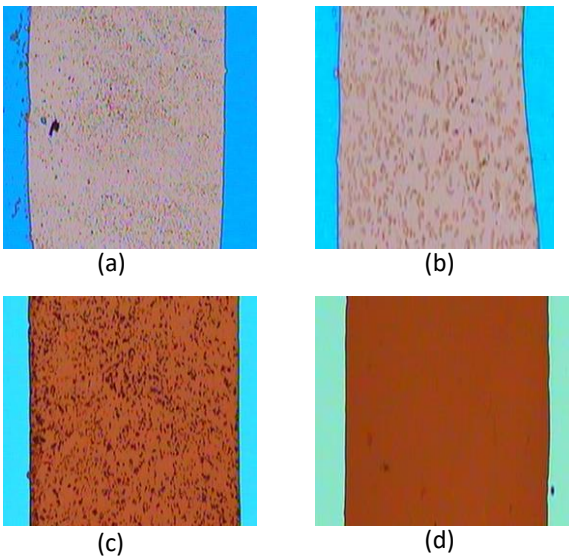


Figure 24: Revolution Microscope images of Platinum thin film during deposition time (a) 50 sec (b) 100 sec (c) 150 sec (d) 200 sec at 900 µm size of trench

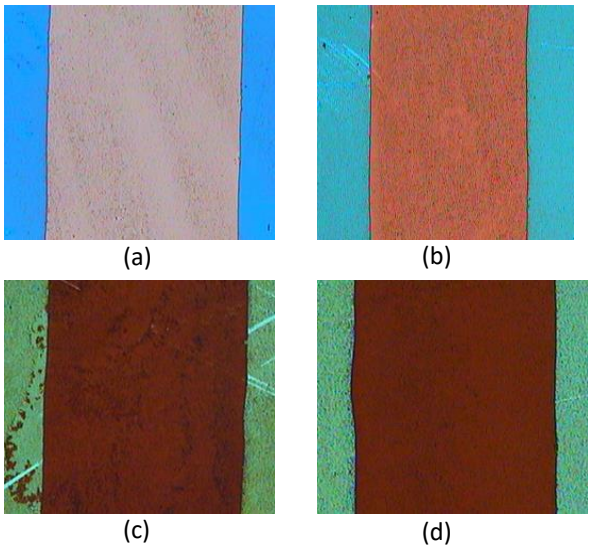


Figure 25: Revolution Microscope images of Platinum thin film during deposition time (a) 50 sec (b) 100 sec (c) 150 sec (d) 200 sec at 1100 µm size of trench

4.0 Conclusion

As a conclusion, the deposition time will influence a thickness of metal thin film. The resistivity of Platinum thin film is increased when the thickness is increased. The pattern that used for this research must appropriate for the size of trench that we need. Further investigation on the denser of deposition profile is needed by using Aluminum Evaporator or Platinum Sputter Coater inside the trenches.

References

[1] K. Bachmann, (1995). "The Materials Science of Microelectronics", New York, VCH Publisher, p. 484.

[2] A. J. Aronson, (1987). "Fundamentals of Sputtering," p.27.

[3] Peter Van Zant (2004), "Microchip Fabrication 5th Edition", McGraw Hill.

[3] Michael Quirk, Julai Serda (2001). "Semiconductor Manufacturing Technology" New Jersey, Prentice-Hall.

[4] Burhanuddin Yeop Majlis (2000). "Teknologi Fabrikasi Litar Bersepadu", Bangi, Universiti Kebangsaan Malaysia.

[6] Herve´ Rabata,b, Caroline Andreazzac, Pascal Braulta,*, Amae¨l Caillarda,d, Franc¸ois Be´guinc, Christine Charlesd, Rod Boswelld, "Carbon/platinum nanotextured films produced by plasma sputtering.", CARBON 47 (2009) 209–214, The Australian National University.

[7] J.I. Choi, J.Y. Lee, J.H. Park, J.H. Chae, H.J. Park, Daeil Kim, "Fabrication and characterization of Pt intermediate transparent and conducting ITO/Pt/ITO multilayer films", Journal of Physics and Chemistry of Solids 70 (2009) 272–275, School of Materials Science and Engineering, University of Ulsan, Republic of Korea.

KATEGORI TEKNOLOGI KEJURUTERAAN MEKANIKAL

M1: Effect of Welding Heat Input on The Microstructure and Mechanical Properties at Coarse Grain Heat Affected Zone (CGHAZ) of ABS Grade A Steel

Wan Shaiful Hasrizam Wan Muda[1, a], Saifulnizan Jamian[2, b] and Sarizam Mamat[3], Shamsudin bin Hamzah, Waji bin Risman [c]

[1]*Institut Latihan Perindustrian Kuantan,Pahang,* [2]*Universiti Teknologi Tun Hussein Onn Malaysia, Batu Pahat, Johor,* [3]*Universiti Malaysia Kelantan, Jeli, Kelantan*

[a]*wansaypul@yahoo.com,* [b]*saifulnz@uthm.edu.my,* [c]*sarizam@umk.edu.my*

Abstract

The fabrication and construction of structures used in the offshore and marine industries are made according to the international code and standard requirements to ensure the quality and to extend the life span. Proper material selection needs to be carried out to achieve proper function and to reduce the cost. The ABS Grade A steel is one of the huge materials used in the marine industries. The study has been carried out to scrutinize the effect of welding heat input to the distribution of microstructure formation and its mechanical properties at CGHAZ of the ABS Grade A steel. Three heat input combinations designated as low heat (0.99 kJ/mm), medium heat (1.22 kJ/mm) and high heat (2.25 kJ/mm) have been used to the weld specimen by using flux cored arc welding (FCAW) process. The microstructure formation at CGHAZ consists of grain boundary ferrite (GBF), Widmanstatten ferrite (WF) and pearlite (P). Significant grain coarsening was observed at the coarse grain heat affected zone (CGHAZ) of all the joints and it was found that the extent of grain coarsening at CGHAZ increased with the increase in the heat input. The results of the mechanical investigation indicate that the joints made using low heat input exhibit higher hardness and impact toughness value than those welded with medium and high heat input. It can be concluded that the higher the heat input, the higher the grain size of microstructure but will lead to lower hardness and impact toughness value.

Keywords: *Heat input, microstructure, hardness, toughness, CGHAZ*

1.0 Introduction

In practice, the most essential properties of the steels used in marine and offshore structures are good toughness characterized by charpy V-notch impact test, and tensile strength of the weld joints made by welding procedures. Nowadays, because of high heat inputs during the joining process, the CGHAZ adjacent to the fusion line of this steel grade represents a region of pronounced low toughness. This is often revealed by fracture toughness tests, which are being increasingly used in marine structural applications.

Heat input is known to be one of the factors that influences the formation of microstructure at HAZ. The formation of microstructure especially martensite, bainite and martensite-austenite (MA) constituent potent to affect the toughness of HAZ, thus lead to HAZ cracking just after the welding work. In order to control this problem, it is crucial to understand how the heat input affects a microstructure and relate it to mechanical properties of the material. To date, there are many researches have been done to study the effects of heat input and relate it to formation of microstructure and its mechanical properties. However, there are still less studies done to the weldments itself since the previous studies are merely based on simulated HAZ.

Thus, this study aims to characterize and appraise the behavior of microstructure transformation at CGHAZ and its correlation to the heat input. The use of Flux Core Welding Process (FCAW) during sample preparation reflects to the current practice by industry to weld the steel structure. In addition, the elucidation of the transformation behavior can be obtained through the optical microstructure technique and its properties through the mechanical testing. The outcome of this study may provide a good information in determining the welding parameter during welding procedure specification (WPS) preparation. The gained knowledge could embark a further research in investigating the optimum heat input range to be set during welding work, thus improve the quality of the weldments.

2.0 Literature Review

The microstructure in the HAZ is largely dependent upon the heat input and its location or distance from the fusion boundary. As the distance from the fusion boundary increases, the peak temperature that the base metal microstructure is exposed to, decreases. A high heat input increases the time that the base metal microstructure is exposed to the peak temperature. The peak temperature in the HAZ does not reach the melting point of the carbon steel [1].

Generally, the HAZ is the base metal underlying the weld which has been heated to temperatures above the iron – iron carbide (Fe – FeC_3) metastable phase diagram A1 line (723 ^oC) temperature and below the solidus temperature, typically 1495 ^oC as shown in Fig. 1. Weld area can be defined as the area that includes weld metal and heat affected zone (HAZ). The HAZ in metal can be divided into four main areas; coarse grained supercritical HAZ (CGHAZ), fine grained supercritical HAZ (FGHAZ), intercritical HAZ (ICHAZ) and subcritical HAZ (SCHAZ). Among these, CGHAZ is the most affected area during welding process due to rapid cooling which caused hardening which in turn possible to be the main factor of cleavage cracking [1].

The effects of coarse initial grain size on the microstructure, hardness and toughness of the weld metal and HAZ of a low carbon steel were investigated by Eroglu [2]. From the results of the toughness tests, it was seen that the weld metal of coarse initial grain sized specimens and original specimens exhibited nearly the same toughness values with the same heat input, whereas different HAZ toughness values were obtained with the same heat input. Maximum toughness of HAZ of the coarse initial grain sized specimen was achieved with a high input, while maximum toughness of original specimen was obtained with a medium heat input. As a result, considering the heat input, it was observed that the coarse initial grain size had a great influence on the microstructure, hardness and toughness of HAZ of low carbon steel. The microstructure in weld metal changed from martensite and bainite to grain boundary ferrite, Widmanstaten ferrite, acicular ferrite and pearlite, and the microstructure in GCHAZ changed from martensite, bainite, pearlite and polygonal ferrite to pearlite and polygonal ferrite. The amount of pearlite in GCHAZ increased at the expense of martensite and bainite.

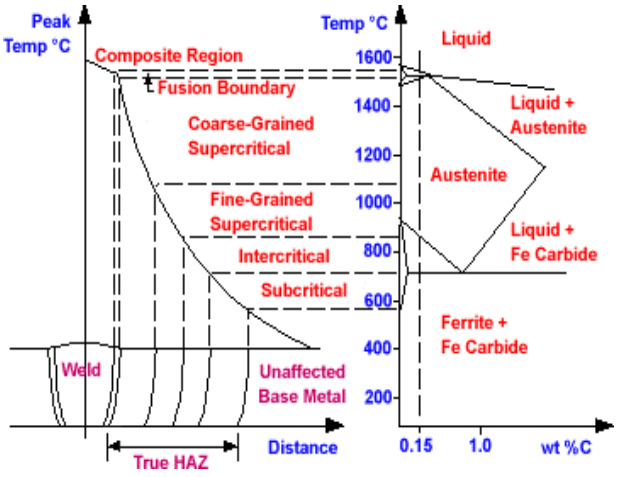


Figure 1:Relation between heat affected zone and corresponding temperature [1]

Meanwhile, Gharibshahiyan [3] investigate the effect of microstructure on hardness and toughness of low carbon welded steel using inert gas welding. Results showed that by raising the voltage form 20 V to 30 V the grain size number decreased from 12.4 to 9.8. It was also observed that high heat input and rapid cooling rates, in the weld metals produced fine grained polygonal ferrites at ambient temperature. High heat input led to grain coarsening which was more pronounced in the HAZ, as well as reducing the impact energy and toughness. Elevation of heat input reduced the hardness in the HAZ, for instance, raising the heat input from 5 to 8 kJ/cm decreased the hardness from 160 to 148 HBN. This is considered to attribute a reduction in the density of dislocations and microstructural coarsening.

3.0 Methodology

ABS Grade A steel in the form of a 6 mm thick plate was chosen for the study. The welding specimens were prepared in the dimensions of 200 mm x 125 mm. This steel plate is almost exclusively used in the marine industry for the hull structure. This grade is certified by ABS – American Bureau of Shipping. The steel plate was manufactured by Nippon Steel & Sumitomo Metal Corporation. The chemical composition and mechanical properties of the steel is presented in Table 1.

Table 1: Chemical composition and mechanical properties of ABS Grade A steel plate

Chemical Composition, [%]									Tensile Strength Rm [N/mm^2]	Elongation, A_c [%]
C	Si	Mn	P	S	Cu	Ni	Cr	Mo		
0.17	0.14	0.49	0.018	0.005	0.02	0.02	0.03	0.01	448	28

The technique of FCAW was employed to produce all experimental weld metals analyzed in this work. Welding was carried out with three different heat inputs (0.99 kJ/mm, 1.22 kJ/mm and 2.25 kJ/mm). The heat input values were adopted from the welding procedure specification (WPS) of Sime Darby Engineering Sdn. Bhd.. All welding was carried out in a single pass.

Following the welding, samples were obtained from welded specimens for microstructural examination in HAZ and in weld metal. The samples were ground, polished and etched with nital 2%. Microstructure investigations were done by using Meiji MT 8100 optical microscope (OM). Meanwhile, JEOL JSM-6380LA scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM / EDX) was used to analyze quantitative elemental information at the microstructure. The image of microstructures was analyzed using ImageJ software in order to get the grain size and grain area.

Microhardness indentations in the welding zone and HAZ were made with a 1 kg load. The test was carried out in accordance to ASTM E384. The toughness values of the CGHAZ were determined by charpy V-notch testing (5 x 10 x 55 mm) at room temperature according to ASTM E23.

4.0 Results and Discussion

Weld Specimen and Profile**.** The location of the different zones in the weld profile is clearly shown in Figure 2. The weld cap, weld penetration and HAZ area, all of which can be seen in macro photographs below. The influence of heat input is noticeable from the pictures, as the weld cap and HAZ zone are wider with higher heat inputs. It should bear in mind that, the complete joint penetration cannot be obtained because the experiment was carried out in single pass welding. The suitable weld pass for 6 mm thick plate is two in order to get the complete joint penetration (CJP) of the weld. However, due to multiple heat treatments would occur to the area, single pass welding was used during sample preparation.

Dimension of weldment and HAZ are shown in Figure 3. At low heat input, the average weld width is 8 mm. Meanwhile the average depth of penetration and HAZ width is 4 mm. When the heat input increases to 1.22 kJ/mm and 2.25 kJ/mm, the average welds width, depth of penetration and HAZ showed the increment. As indicated by these values, it was found that as heat input increases, the fusion areas of the joints also increase proportionately. The same trend was followed in the HAZ area associated with each of these joints. Yan [4] has reported similar trends while studying TIG welded 304 stainless steel and SMAW welded duplex stainless steel, respectively, in which fusion zone and HAZ area increased with increasing of heat input value.

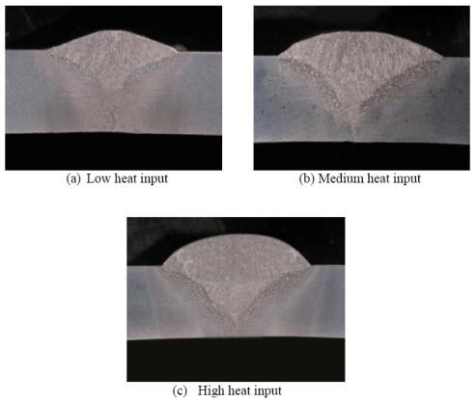


Figure 2: Macrograph of weld specimen at different heat input

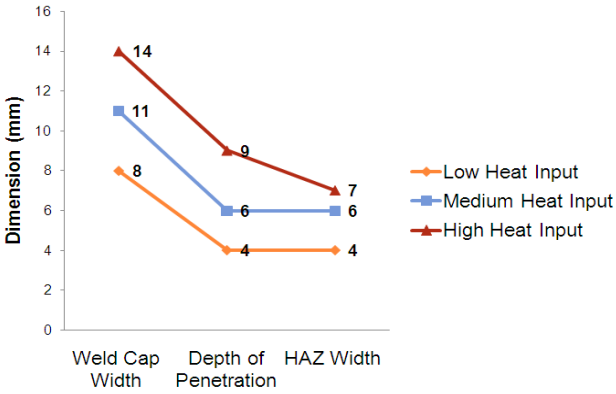


Figure 3: Dimension of weldment and HAZ at different heat input

Weld Microstructure of ABS Grade A Using FCAW**.** Micrograph of all of the weld specimens was taken. The micrograph in Fig. 4 shows the different zones which include the weld metal, fusion line and HAZ (CGHAZ and FGHAZ) for different heat input. As the heat input increases, the HAZ areas of the joints also increased proportionally. The heat input moves the place of HAZ further from the fusion line. The average of grain size also increases with the increasing heat input value. The highest concentration of pearlite was observed in the CGHAZ. The FGHAZ is the zone after CGHAZ, in which the microstructure is smaller than the latter.

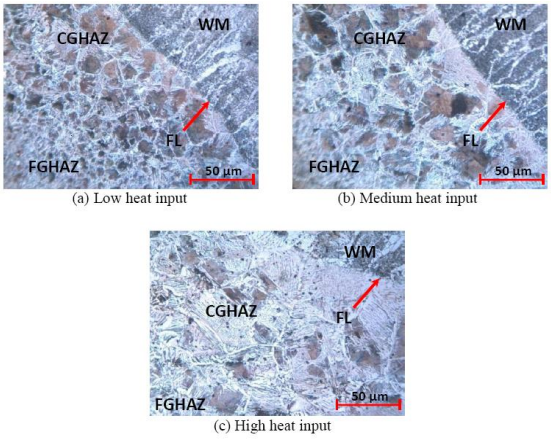


Figure 4: Microstructure of ABS grade A at different heat input

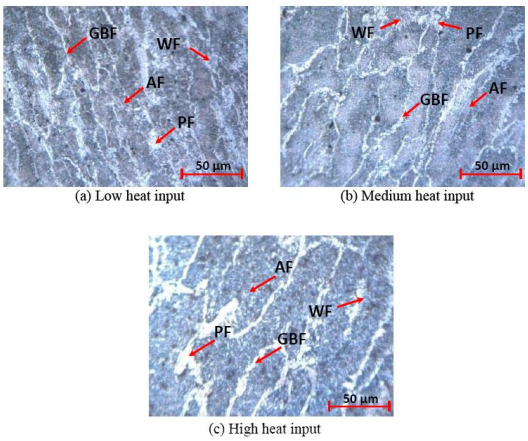


Figure 5: Weld microstructure at different heat input

Figure 5 shows the weld microstructure of ABS Grade A steel with low heat input, medium heat input and high heat input. The weld structure of ABS Grade A steel plate was a ferrite-pearlite microstructure. Initial columnar grains formed by epitaxial growth were detected by the presence of grains of polygonal ferrite (PF) and Widmanstatten ferrite (WF) along the former grain boundaries. However, the main constituent is an acicular ferrite (AF), forming a "wicker basket" structure [5]. The first phase forming on grain boundary ferrite (GBF) during cooling below the A3 temperature is referred to as polygonal ferrite (PF). Eroglu [2] also found similar weld metal microstructures on his study of effect of coarse initial grain size on microstructure and mechanical properties of a low carbon steel.

At relatively low undercooling temperatures, Widmanstatten ferrite formation occurs. The ferrite plates grow rapidly with a high aspect ratio, resulting in parallel arrays. Widmanstatten ferrite plates grow directly from a grain boundary ferrite (GBF) or from polygonal ferrite at the grain boundaries. Acicular ferrite is recognized as an intragranular nucleated morphology of ferrite in which there are multiple impingements between grains. The acicular ferrite nucleates on inclusions inside the grain boundary ferrite (GBF) during the $\gamma \rightarrow \alpha$ transformation. Provided there is a high density of inclusions, a fine interlocking structure is produced [5].

Effect of Heat Input on CGHAZ Microstructure. The microstructures at CGHAZ were illustrated clearly in the Figure 6. It can be seen that the CGHAZ microstructures contain some colonies of pearlite which was represented by brown region. Meanwhile the ferrite was represented by white region.

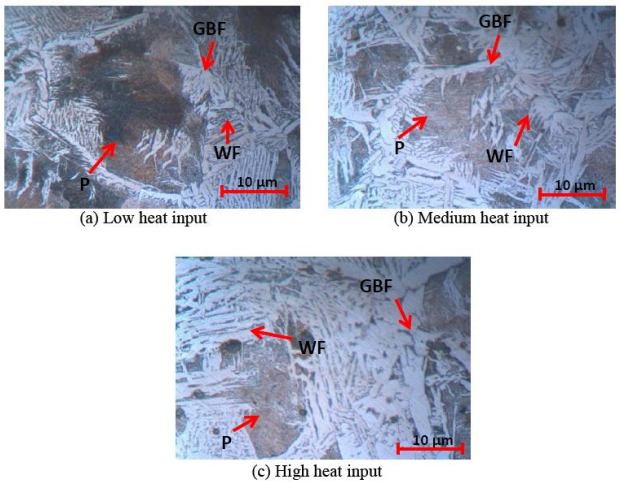


Figure 6:CGHAZ microstructure at different heat input

The microstructures at CGHAZ of all specimens consists of grain boundary ferrite (GBF), Widmanstatten ferrite (WF) and pearlite (P). The results of this microstructures are in good agreement with the study conducted by Eroglu [2].

Martensite does not seem to present in all specimens. The phenomenon happened might be due to the selection of heat inputs used (0.99 kJ/mm , 1.22 kJ/mm and 2.25 kJ/mm) are still considered as high heat input. It was already known that the higher heat input resulting in slower heating and cooling. Relatively higher heat input resulting in longer cooling time causes the diffusion of carbon between the carbon-rich austenite and the carbon-poor austenite [2].

It can be observed that ferrite and pearlite tend to refine when compared the microstructure of CGHAZ at low, medium and high heat input. It also can be noted that the amount of pearlite region was decreased with increasing the value of heat input. The rate of pearlite formation can be varied under certain circumstances. An important factor is the amount of carbon diffusing in the metal and its effect of pearlite layers formation. Diffusion is directly proportional to the temperature according to Eq. 1.

$$D = D_o \exp\left(-\frac{Q}{RT}\right) \quad (1)$$

where D is the diffusion coefficient, D_o is the self diffusion, Q is the activation energy, R is the Boltzmann's constant and T is the absolute temperature. During cooling, austenite to pearlite transformation proceeds at a fast rate due to its nucleation and growth [3].

If a specimen undergoes a low heat input, there would be a suitable condition for nucleation in the, edges, and grain boundaries. Consequently, carbon can dissipate extensively resulting in the formation of pearlites. However, supercooling from a high temperature, may contribute to reduced nucleation and hence the formation of ferrites. At high supercooling conditions, there would be a greater tendency for the formation of ferrites from the grain boundaries, possibly in the form of widmanstatten [3].

The average grain size of CGHAZ increased with an increase of the heat input. At low heat input, the average grain size is 28.31 µm. This indicated that when the heat input was relatively low, although recrystallization occurred in the HAZ, the coarsening of grains in the HAZ was not obvious. Meanwhile, when the heat input increased to the medium (1.22 kJ/mm) and maximum value (2.25 kJ/mm), the grains in the HAZ grew up to an average grain size of 43.31 µm and 68.90 µm respectively. The grain area also showed the similar trend. Low heat input has the smallest area (1016.83 μm^2) compared to the medium heat input (2091.21 μm^2) and high heat input (4947.56 μm^2). It can be seen clearly in the Figure 7.

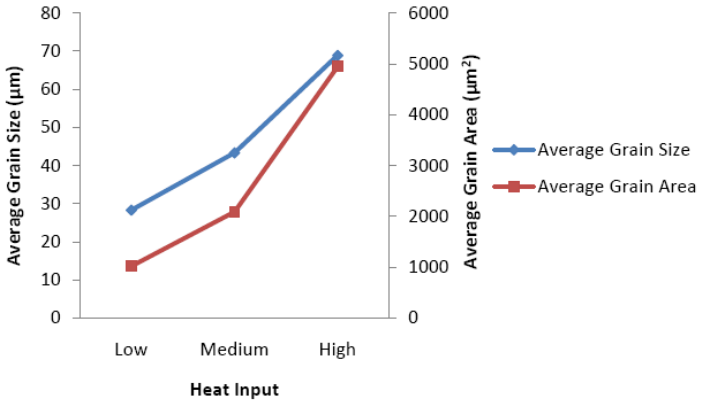


Figure 7:Average grain size and average grain area of CGHAZ at different heat input

According to Gharibshahiyan [3] grain coarsening in the HAZ can be explained by the operating thermal cycle and diffusion. The grains close to the fusion line are exposed to higher temperatures, therefore grain growth occurs. Clearly large ferrite grains resulted in large austenite grains.

Another important factor that contributes to grain coarsening is grain boundary mobility and fusion. Grain boundary movement depends on diffusion and atomic migration on both sides of the grain boundary. Diffusion itself is a function of retention time at high temperature and leads to the migration of atoms and displacement of grain boundaries. The relation between atomic displacement and time is given by the Eq. 2:

$$r = 2.4\sqrt{Dt} \qquad (2)$$

where r is the radial distance from the origin, D is the diffusion coefficient, which is related to the temperature and t is the elapsed time.

It can be seen that the atomic displacement is directly proportional to the square root of time. Low welding speed and high heat input led to larger grain size.

Effect of Heat Input on CGHAZ Hardness**.** In this study, microhardness test was conducted on the base metal, weld metal and HAZ areas at 1 mm intervals. It can be observed that the lower the heat input, the higher the microhardness of the HAZ and weld metal. As an example elevation of heat input from 0.99 kJ/mm to 1.22 kJ/mm reduced the range of hardness from 152 – 197 HVN to 157 – 169 HVN. Meanwhile, range of hardness of 204 – 226 HVN, 207 – 216 HVN and 197 – 199 HVN were measured in the corresponding welded material. The microhardness profile at different zones in the weld metal at low heat input, medium heat input and high heat input can be seen clearly in the Figure 8, 9 and 10 respectively.

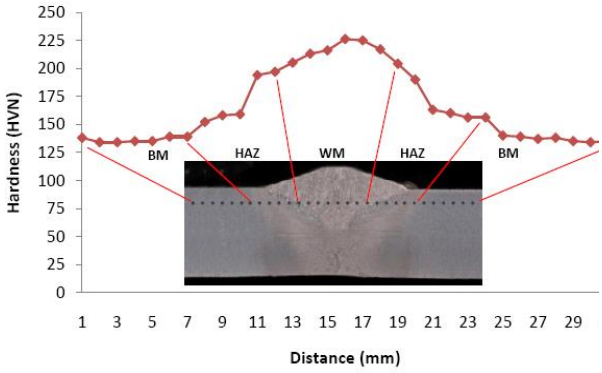


Figure 8: Microhardness profile at low heat input

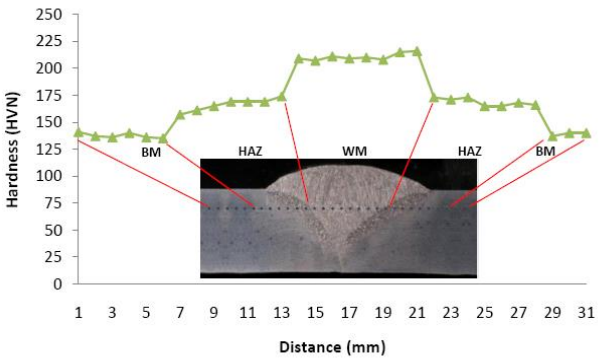


Figure 9: Microhardness profile at medium heat input

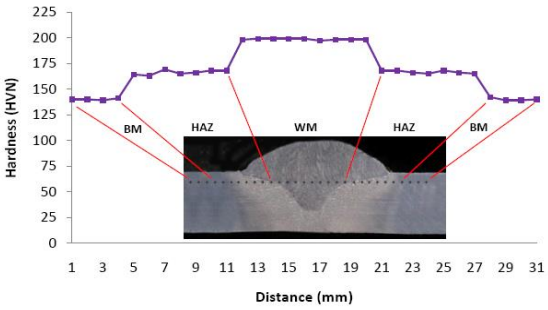


Figure 10: Mirohardness profile at high heat input

As the indentor moves from the left of base metal towards the fusion boundary and weld metal, microhardness increases from 134 to 226 HVN for low heat input, 135 to 216 HVN for medium heat input and 139 to 199 HVN for high heat input. It was found that microhardness on the weld metal is the highest compared with HAZ and base metal. One of the factors contributing to lower hardness in the HAZ zone is that of the high heat input and hence retention of heat in this region. Gharibshahiyan [3] explained the above mentioned phenomenon in his study on low carbon welded steel using inert gas welding. Generally, grain nucleation and growth of austenite can lead to reduced dislocations and work hardening compared to its elementary condition. Annealing of the HAZ can have pronounced effect on phase and morphology. The net effect reduces dislocations and hardness. In spite of the presence of high temperature in the welded metal, the cooling rate is also high which presents the nucleation of very fine grains. Besides, fine grain structures exhibit low intergranular spacing. The stress, for dislocations to cross grains can be calculated using the Eq. 3:

$$\tau_o = Gb/L \qquad (3)$$

where *G* is the shear Young modulus, *b* is the dislocation Burger's vector and *L* is length of separated distance.

High hardness in the welded zone may be attributed to the fine grain size, needle shaped ferrite or the existence of widmanstatten inside ferrite grains. Hardness and are inversely proportional as given by Eq. 4:

$$H = Ho + K/\sqrt{d} \qquad (4)$$

Where *H* is hardness, *K* is a proportionality constant and *d* is grain size. Thus, the lower hardness in the HAZ may be related to grain growth and the existence of the ferrite phase in this region, which has been reported by Gharibshahiyan [3].

At low heat input, the maximum hardness value of HAZ area was 197 HVN on the left and 190 HVN on the right weld metal. The location was closed to the fusion boundary and it was determined as CGHAZ. The similar location was found for the medium heat input and high heat input. The maximum hardness values at HAZ were 174 HVN on the left and 173 HVN on the right for medium heat input. Meanwhile, for high heat input the maximum hardness values were 168 HVN for both side. The results show that any increase in the heat input has an inverse effect of the hardness of at CGHAZ. The microhardness comparison at different heat input can be clearly shown in the Figure 11.

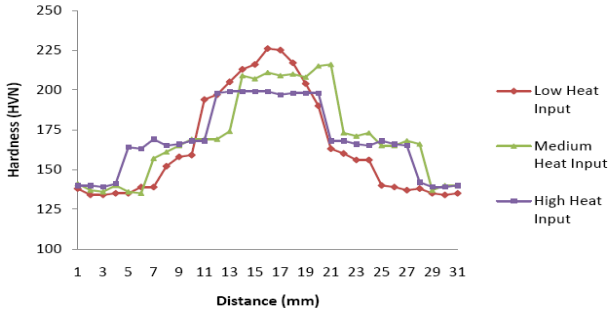


Figure 11: Microhardness profile at different heat input

Effect of Heat Input on CGHAZ Toughness. According to Wang [6] lower toughness values occur because of a wide HAZ. The lowest toughness values were in CGHAZ and if the HAZ is wide, all zones will be wider and then the charpy V-notch test place is more in CGHAZ and fusion line. In this study, the same results have been observed. The impact toughness values of the CGHAZ tested at room temperature are presented in Figure 12.

It can be observed that the impact toughness values are proportionally decreased when heat input increase. The maximum of impact toughness value of 66 J was achieved after welding with low heat input (0.99 kJ/mm). At medium heat input and high heat input, the average impact toughness values are 35 J and 30 J respectively. The average impact toughness value at base metal is 103 J. Absorption of impact energy can be controlled by chemical composition, microstructure and the heating cycle. Excess grain growth can lead to reduced strength and increase crack initiation and growth. Furthermore, it can adversely affect the fracture toughness, which may arise due to heating and cooling cycles [3].

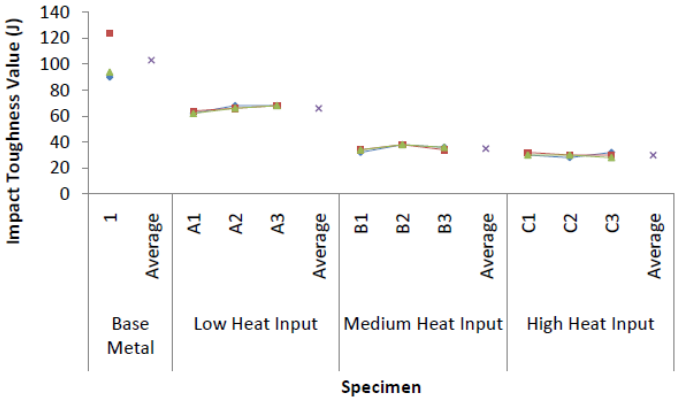
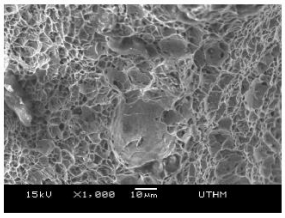
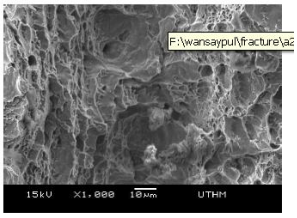


Figure 12: Charpy V-notch test result of all samples at different heat input

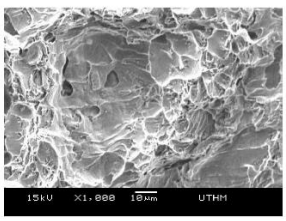
The fracture surfaces were also evaluated by SEM, and the results are shown in Figure 13. As seen in the figure, dimples of varying size and shape were observed in all the fractured surfaces which indicate that a major fracturing mechanism was ductile. It was observed that the fractured surface of the specimen at low heat input contains a large population of small and shallow dimples which is indicative of its relatively ductile fracture. As heat input increases, coarse and elongated dimples were observed. When welding with medium heat input, entirely ductile fracture together with a local cleavage type fracture appeared. The fracture surfaces showed a combination of transgranular fracture and microvoid coalescence (MVC). The fracture surface broken with high heat input exhibited a brittle fracture behavior. Due to high heat input, transgranular fracture by quasi-cleavage and relatively flat surface was observed.



(a) Low heat input



(b) Medium heat input



(b) High heat input

Figure 13: Fracture surface of specimens at different heat input

At low cooling rates, growth of austenite grains proceeds, which ultimately lead to the formation of coarse pearlite and planar ferrite. The existence of acicular ferrite is desired, because it improves the toughness of the weld metal. Behole [7] observed that the toughness of welded metal increases with increasing volume fraction of acicular ferrite. The interlocking nature of acicular ferrite, together with its fine grain size; provide the maximum resistance to crack propagation and cleavage fracture.

Ferrite grains get larger than the austenite grains under high heat input conditions. The net effect of such structure is grain boundary growth. Since the yield strength of ferrite grain is lower than that of pearlite, crack initiation and growth is more likely to occur in the ferrite grains. On the other hand, dislocations can move easier in structures containing large grains resulting in reduced ductility.

Correlation between Microstructure and Mechanical Properties at CGHAZ. The correlation between microstructure and mechanical properties at CGHAZ can be illustrated in the Figure 14. As seen in the figure, by raising the heat input, the average grain size was increased from 28.31 µm to 68.90 µm at CGHAZ. Meanwhile, hardness and impact toughness value proportionally decreased when increasing the heat input. The elevation of heat input led to grain coarsening which was more pronounced in the CGHAZ, as well as reducing the hardness and impact toughness value. When the heat input increased, the hardness and impact toughness value was decreased from 197 HVN to 168 HVN and 66 J to 30 J respectively. This is considered to be attributed to a reduction in the density of dislocations and microstructural coarsening.

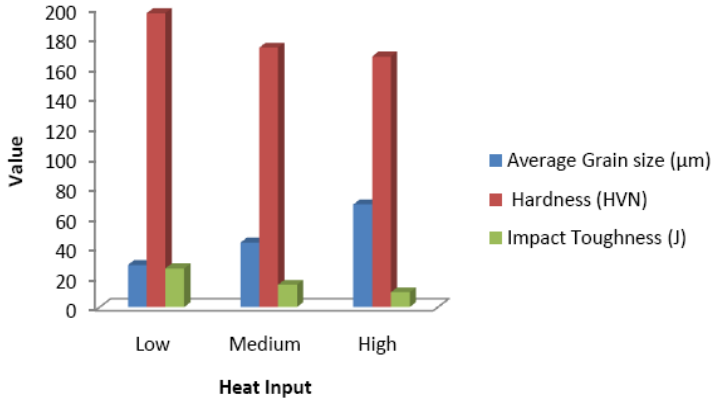


Figure 14: Correlation between microstructures and mechanical properties

5.0 Conclusion

In this study, the observation was concentrated to the microstructure and mechanical properties (hardness and toughness) at CGHAZ. The use of the actual FCAW welding process instead of using simulated HAZ gives the actual distributions of microstructure formation and mechanical properties at CGHAZ. As a conclusion of this study, the objectives which were to scrutinize the effect of welding heat input to the distribution of microstructure formation and its mechanical properties at CGHAZ of the ABS Grade A steel were achieved. The correlation of heat input and mechanical properties and its relationship with HAZ cracking also being elucidated.

The main conclusions of the effects of welding heat input on microstructure and mechanical properties at CGHAZ of ABS Grade A steel are as follow:

i. The higher the heat input, the coarser the microstructure. Grain coarsening occurs due to operating thermal cycle and diffusion. The grains close to the fusion line are exposed to higher temperatures, therefore grain growth occurs.
ii. The higher the heat input, the lower the hardness value at CGHAZ. Retention of heat in the CGHAZ zone contributes to lower the hardness value.
iii. The higher the heat input, the lower the impact toughness value. Excess grain growth led to reduced strength and increased crack initiation and growth. It adversely affected the fracture toughness, which may arise due to heating and cooling cycles.
iv. The higher the grain size, the lower the hardness and impact toughness value. High heat input led to grain coarsening which was more pronounced in the CGHAZ. Hardness and impact toughness value decreased when heat input increased.

6.0 References

[1] Mamat, S. *Variant Analysis of Bainite Phase Transformation in Heat Affected Zone(HAZ) Of Cr-Mo Steel*. Master's Thesis. Osaka University, Japan; 2012.

[2] Eroglu, M., Aksoy, M. & Orhan, N. Effect of coarse initial grain size on microstructure and mechanical properties of weld metal and HAZ of a low carbon steel. *Materials Science and Engineering A.* 1999. A269: 59–66.

[3] Gharibshahiyan, E., Raouf, A.H., Parvin, N. & Rahimian, M. The effect of microstructure on hardness and toughness of low carbon welded steel using inert gas welding.*Materials and Design.* 2011. 32: 2042 – 2048.

[4] Yan, J., Gao, M.& Zeng, X. Study on microstructure and mechanical properties of 304 stainless steel joints by TIG, laser and laser-TIG hybrid welding. *Opt Lasers Eng*. 2010. 48: 512 – 7.

[5] Pirinen, M.*The effects of welding heat input n the usability of high strength steels in welded structures.* Ph.D. Thesis.Lappeenranta University of Technology, Finland; 2013.

[6] Wang, J., Li, Y. & Liu, P. Effect of welding heat input on toughness and structure of HAZ of a new super-HSS. *Material Science*. 2003. Vol 26, No3: 301 – 305.

[7] Behole, S.D., Nemade, J.B., Collins, Z. & Liu, C. Effect nickel and molybdenum additions on weld metal toughness in a submerge arc welded HSLA linepipe steel. *J Matter Process Technol*. 2006. 173: 92 – 100.

[8] American Bureau of Shipping. *Rule Requirements for Materials and Welding.* Houston, Part 2. 2014.

[9] American Society for Testing and Materials. *Standard Test Methods for Determining Average Grain Size.* West Conshohocken, ASTM E112. 2013.

[10] American Society for Testing and Materials. *Standard Test Methods for Knoop and Vickers Hardness of Materials.* West Conshohocken, ASTM E384. 2011.

M2: Modelling of Pad Support For Foot Osteoarthritis

M. Eley Rosli, Amir Giman, Shahrul Fahmi Effandi Shoabani, and W. Azizurrahman W. Hassan
Advanced Technology Training Centre of Batu Pahat, Johor

mdeley.jtm@1govuc.gov.my, amir.giman.jtm@1govuc.gov.my, sfahmi.jtm@1govuc.gov.my, wan_azizurrahman@1govuc.gov.my

Abstract

Osteoarthritis is a disease that affects joints or ankles of human body that will cause the patients of this disease feels pain, swelling and stiffness in the joint. Human who was affected by the foot osteoarthritis (OA) disease always have problem in doing daily activities due to the pain at their foot. OA patients will always feel pain and stiffness in the inflammation joint. They also feel swelling in or near that joint. These symptoms will always make them difficult in walking and bending their affected joints or ankles when doing daily activities. In relieve the pain that having by the patient, a research of developing the pad support had been done. Development of pad support for osteoarthritis patient which is focused on big toe osteoarthritis become a subject of study and ABAQUS 6.13 software is selected as preferred software to design the geometry of pad support and analysed it using finite element analysis. The CAD model of the pad support then imposed to pressure load to study the effect of this pressure load upon proposed geometries and materials. Three types of geometry models and three types of materials used have been studied for this project. Then the results of the analysis had been discussed by observing to three parameters which is stress, pressure and reaction force. Lastly, the development of big toe osteoarthritis pad support had been studied.

Keywords: *Pad support, foot osteoarthritis, ABAQUS, stress, reaction force*

1.0 Introduction

Arthritis is a disease that affects joints or ankles of human body. This disease commonly involves ankles that support body weight like hip, spine, knee and foot. There are more than hundred types of arthritis in the world and the most common form of arthritis that affected million on Americans is osteoarthritis (OA). Usually an OA appear at the foot which are in the big toe, middle foot and ankle. The characteristic of OA can be determined by damage of connective tissue at the end of the bones in the joints known as cartilage. This cartilage is use to protect and cushions the bones during movement in daily activities. With repeated stress of the joint may cause the cartilage tissue wear and tear that lead to OA disease [1].

This OA disease can be treat either non-surgical method or surgical method. The non-surgical method become the main choice by the patients to relieve the pain, reduce disability and provide support to help their live as active a life as possible [2]. If the non-surgical treatments fail to reduce the pain, surgical method may be recommended. This is because the non-surgical method is cost effective than surgical method. Human who was affected by the foot OA disease always have problem in doing daily activities due to the pain at their foot. OA patients will always feel pain and stiffness in the inflammation joint. They also feel swelling in or near that joint. These symptoms will always make them difficult in walking and bending their affected joints or ankles when doing daily activities [1]. These kinds of foot OA disease can be prevented from be worsen by using the pad support during walking or do any activities that use the foot.

2.0 Literature Review

2.1 Osteoarthritis

Osteoathritis (OA) is a form of joint disorder that involves inflammation of one or more joint. OA has long been considered a “wear and tear” disease leading to loss of cartilage. OA used to be considered the sole consequence of any process leading to increased pressure on one particular joint (e.g., overload on weight-bearing joints, anatomical joint incongruency) or fragility of cartilage matrix (genetic alterations of matrix components) [4].

OA also known as degenerative arthritis and degenerative joint disease is a group of mechanical abnormalities that involves degradation of the joints [5]. OA is a condition characterized by breakdown and eventual loss of cartilage which is connective tissue at the end of the bone of the joints in one or more joint as shown in Figure A.1. OA appears at various joints throughout the body including hands, feet, spine, hips and knees. In the foot, the disease most frequently occurs in the big toe or hallux.

The cartilage between the bones at the joint is used to protect and cushions the connecting bone during the movements of the joints or ankles. When this connective tissue tears or wears, the bone at the joints will be touching each other without any protection [5]. This will develop the symptoms that can restrict the ability of OA patients to easily perform daily activities. The signs and symptoms of human who affected by this disease are :

- Pain at the joint - a sharp ache or a burning sensation in the associated muscles and tendons.
- Stiffness in the joint - feel numb around the ankle when long times stand.
- Swelling in and around the joint when doing any movement of the joints or ankles.
- Difficulty in walking and bending the joint - cause by friction between two bones without lubricant.

2.2 Big Toe Osteoarthritis

Big toe is the biggest toe among the toes in human foot. In medical term, the big toe is called hallux. There are three types of big toe OA which are hallux limitus, hallux rigidus and hallux valgus. Normally, the human hallux joint can be move upward at about 90° which is fully upward bending and it will bending about 45° while walking. The hallux limitus shows a reducing of the big toe joint movement that indicate the early of big toe OA. Meanwhile, the hallux rigidus is second stage of big toe OA where the big toe joint will not move normally [6]. The comparison between the motion of hallux limitus and rigidus to the normal motion of big toe is shown in Figure A.2.

The big toe OA always affect the joint at the big toe and it may push the big toe toward the other toes. This condition will make the damage big toe overlapping the nearest toe and it will feel pain while walking or long time standing. It also can lead to a bunion which is also known as hallux valgus. Hallux valgus usually affects the human with age older than 40 years old [7]. The patients who having bunion will face the problem in choose a suitable shoes to comfort their foot. It is because the bunion will enlarge the joint at the base and the side of the big toe. When wearing some close shoes, the patient feel pain and difficult to walk due to the pressure that the joints. The imbalance in the forces inside the close shoes that exerted across the joint while will lead to worsen bunion.

2.3 Osteoarthritis Treatment

Treatment is a therapy method that is use by the medical group to remedy the health problem. OA diseases should be having their own treatment to relieve the pain that had been feel by the OA patients. Whether it is a surgical treatment or non-surgical treatment, the goal of treatment is to reduce joint pain and inflammation while improving and maintaining joint function. As we know, the OA disease is a degenerative arthritis which is develop with aging process. We cannot prevent the foot from affected by the OA disease but we can prevent it from become worse [11].

Surgery is generally reserved for those patients with OA that is particularly severe and unresponsive to the conservative treatments. In severe cases, damaged cartilage is removed surgically and the joint is fixed in a permanent position with the pins. Surgical options will depend on the severity of the OA disease condition. The only goal of surgery is to decrease pain and improve function of the foot if there are no more respond from the non-surgical treatment [8].

Non-surgical treatment of OA is the most recommended treatment to begin treating the OA to help relieve the symptoms [12]. There are two types of non-surgical treatment which are OA treatment without medication and OA treatment with medication. A physical therapy and exercise can improve flexibility and strengthen the muscles surrounding the joints. Beside that physical treatment such as braces, strapping or insoles can be helpful in reduce pain joint. Braces and strapping can help in limiting the movements in painful joints. The orthoses or orthotic devices are a custom device that provides support to keep the joints aligned and functioning correctly [11]. Pad support which is one of orthotic devices that is used to relieve the joint pain and prevent it from become worse. In this research will be design the pad support for treating the big toe osteoarthritis disease.

3.0 Methodology

Methodology is a step to determine the directions and guidelines to perform the project. The project started from an introduction to the project (project objective, project scope and problem statement); literature review of the osteoarthritis diseases (general osteoarthritis, foot osteoarthritis and current design of pad support) and design the pad support using the ABAQUS software. This project will be continued with simulate the pad support using the ABAQUS software (determine the 3 types of material selection and peak pressure value at big toe); get the simulation data; analyze the simulation data and end with discussion.

3.1 Pad Support Design

This section, we will be discussing on developing or designing the orthotic device which is pad support to help patient in relieve their pain due to big toe OA disease. In designing the pad support, we should know the dimension of the pad support that will comfort the patient. Therefore, a survey had been done to 20 healthy subjects who are 12 person male and 8 person female with range of age around 18 to 23 years old. Their foot size is in range of 5 inches to 8 inches. According to the survey that had been done, it can be concluded that the dimension of normal human foot as shown in Table 3.1.

Table 3.1: Dimension of normal human foot (Mean of 20 person subject).

Parts	Dimension	Variation
A - Gab between big toe and its nearest toe	12 mm	± 2 mm
B - Length of big toe	40.5 mm	± 5 mm
C - Height of big toe	15 mm	± 2 mm

By referring to the result of normal human foot dimension survey, a pad support was designed using ABAQUS 3D Solid Modelling. It was designed to give comfort to the big toe osteoarthritis patient while walking. This pad support will be support big toe and prevent it from overlapping to its nearest toe. It also can help the patient relieve their pain and prevent the disease from become more worsen or severe. It was designed in a simple geometry to be fit in between of big toe and its nearest toe as shown in Figure A.3. While Figure A.4 shows the feature of designed pad support with the dimension in Table 3.1 where the area between the big toe and its nearest toe is 12 mm (A) x 15 mm (C) x 20 mm (B).

3.2 ABAQUS Simulation

ABAQUS/CAE is a complete ABAQUS environment that provides a simple, consistent interface for creating, submitting, monitoring, and evaluating results [10]. It is divided into modules, where each module defines a logical aspect of the modeling process; for example, defining the geometry, defining material properties, and generating a mesh. The procedure of each simulation is in accordance to the steps in Figure A.5.

The pad support which had been design will be simulated by firstly defining its material. The used material must be elastic and soft to give more comfort to big toe OA patient while walking. The materials that we choose to be analysed for the pad support is Polypropylene Copolymer (rigid material), Natural Rubber (medium soft material) and Open Cell Polyurethane Foam (soft material). Table 3.2 shows the material properties of these materials.

Table 3.2: Material properties of pad support.

Material	Modulus Young	Poison Ratio
Polypropylene Copolymer	1049.3 MPa	0.3
Natural Rubber	4 MPa	0.5
Open Cell Polyurethane Foam	0.3 MPa	0.3

The pressure load to be applied to the pad support is determine through the plantar pressure distribution that was measured using the Pedar-x System (Novel, GmbH, Munich, Germany). There are 20 person of healthy female were taken as subject in mean of age is 20.7 years old, 1.6 meter height and 53.35 kg of weight. The subjects were ask to run on a same slope of 0% with different speed of 1.5 m/s, 2.0 m/s and 2.5 m/s. The plantar foot was divided into 8 section as shown in Figure A.6 (M01 - Heel; M02 - Lateral midfoot, M03 - Medial midfoot, M04 - Medial forefoot, M05 - Central forefoot, M06 - Lateral forefoot, M07 - Hallux and M08 - Toes) [9]. The result of finding is shown in Table 3.3.

Table 3.3: The peak pressure (kPa) at same slop 0% with different speed (m/s) (data are means) [9].

Mask	Speed 1.5	Speed 2.0	Speed 2.5	F Value
M01	143.6	170.7	191.3	4.54*
M02	154.1	172.9	178.2	7.23*
M03	130.3	149.5	162.3	19.17*
M04	339.8	360.7	377.8	2.42*
M05	223.8	244.5	266.5	10.74*
M06	172.7	189.0	203.9	11.76*
M07	309.3	323.6	333.1	0.94*
M08	126.3	139.0	147.8	5.13*

M01 - Heel; M02 - Lateral midfoot, M03 - Medial midfoot, M04 - Medial forefoot, M05 - Central forefoot, M06 - Lateral forefoot, M07 - Hallux and M08 - Toes. *p<0.05

The big toe is located at section M07 in human plantar foot in Figure A.6. So that, the pressure load to be applied to the pad support is refer to the value of peak pressure in section M07 [15]. The speed of human walking is 1.0 m/s to 1.5 m/s and the speed of slow running is 2.0 m/s. In our case, the value of pressure load can be determine by taking the value from Table 3.3 in row M07 and speed 1.5 m/s column which is 309.3 kPa. The pressure load was applied to the side of big toe cause of pressure produce by the big toe in push its nearest toe as shown in Figure A.7. There are two side were decided to be applied as boundary condition to the pad support which is the other toe side and bottom side (Refer to Figure A.8). These two sides of the pad support will be remained as fixed. The bottom of the pad support will be connected to the insole. From that, the reaction forces on those particular sides can be analysed [9].

One of the most important steps in doing the simulation on the product design is creating the mesh. Before start building the mesh for a particular problem, the types of element that will be used is need to be considered. Another thing need to be considered when designing a mesh is the type of results that we want from the simulation. Four quadratic elements per 90° is the minimum number that should be considered for this pad support. However this mesh should be adequate to predict the overall level of deformation pad support under the applied load which is what we were asked to determine.

At this point, the only task remaining to complete the model before get the results is defining the job. The job can be submitted from within ABAQUS/CAE (Figure A.9) and the simulation will be running until it completed. The simulation may take some certain time depend on how complicated the model that we designed to completed. The complicated model may take more time than the simple one. The job solution progress can be monitored interactively in the window as shown in Figure A.10. After completed the job, the result can be visualized in Visualization Module.

4.0 Results and Discussions

In this research, the pad support that had been designed will be analyzed to know its performance. By using the same software as designing, it will be analyzed through the Finite Element Analysis (FEA) method. The FEA will help in find out how the applied stresses will affect the material and design of the product. Results of the analysis will inform us about the reaction of the stress upon the pad support to the osteoarthritis patient. From this reaction, we can know whether the pad support can prevent the big toe from overlapping the other toe or not. Besides that, we also can know how comfort this pad support to suite with osteoarthritis patient foot.

4.1 Pad Support Geometry Selection

According to Figure A.11, there are three different types of geometrical pad support model that had been created which are Model 1, Model 2 and Model 3. These three models were developed in three different features to suite with the osteoarthritis patient foot. Reaction stress, pressure and reaction force are the parameters that we are looking for in this analysis.

Model 1 had been analyzed to get the reaction of the pad support upon the stress, pressure and force. The results of the analysis upon these three parameters are shows in Figure A.12, Figure A.13 and Figure A.14. The results of reaction stress for Model 1 shows the minimum reaction stress, 6.592E-06 MPa is occur at node 3375 which is at the top of pad support. The minimum pressure also occurs at the top of pad support in value of minus 2.041E-01 MPa. From the analysis, the maximum reaction stress, 5.283E-01 MPa is occur at node 66 which is at the other toe side of pad support. Besides that, the maximum pressure and reaction force also occur at the other toe side which is 2.726E-01 MPa and 1.542E-01 N.

The analysis result of Model 2 was represented by Figure A.15, Figure A.16 and Figure A.17. The results of reaction stress for Model 2 shows the minimum reaction stress, 5.673E-05 MPa and the minimum pressure, minus 7.721E-02 MPa is occur at node 33069 and node 733 which is located at the top of pad support. While the maximum reaction stress, 3.108E-01 MPa is occur at node 66 which is at the other toe side of pad support. Besides that, the maximum pressure and reaction force also occur at the other toe side which is 2.238E-01 MPa at node 2232 and 8.512E-02 N at node 76291.

For the Model 3 of the OA pad support, the result of the analysis was showed in Figure A.18 for the stress analysis; Figure A.19 for the pressure analysis; and Figure A.20 for the reaction force analysis. Figure A.18 shows the minimum and maximum reaction stress for the pad support is 2.039E-04 MPa and 2.853E-01 MPa which is occur at big toe side. About 3.557E-01 MPa of pressure occur at the end big toe side which is the maximum value. While the minimum pressure, -1.324E-01 MPa was occurring at front of big toe side. as shown in Figure 4.13, the maximum reaction force was occur at other toe side of the pad support which is 1.183E-01 N.

Table 4.1: Results of the reaction stress, pressure and reaction force analysis upon to type of pad support design.

Parameter	Types of Pad Support Design		
	Model 1	**Model 2**	**Model 3**
Maximum Reaction Stress	0.583 MPa	0.3108 MPa	0.2853 MPa
Maximum Pressure	0.2726 MPa	0.2238 MPa	0.3557 MPa
Maximum Reaction Force	0.1542 N	0.08512 N	0.1183 N

From the results given (refer Table 4.1), a bar chart had been develop to make a comparison between the maximum and the minimum value of the reaction stress, pressure and reaction force to the types of pad support model as shown in Figure A.21. Model 3 shows the lowest maximum reaction stress than other two models. While the maximum pressure is highest one but it is occur at the end of big toe side rather than other two models which occur at the whole side of the big toe.

This shows that, Model 3 can give lower pressure to the front and cushion at the end of patient big toe. It may relieve the pain causes by big toe OA diseases. The reaction force may make the other toe of the patient feel pain. It shows that the Model 2 gives the lowest reaction force and the differentiation of the reaction force between Model 2 and Model 3 is about 28%. From comparison chart, we concluded that the geometry of the Model 3 is better than other two models.

4.2 Comparison of Materials Determination

In this chapter, the analysis was continued with different materials upon one geometry model which is Model 3 of the osteoarthritis pad support. This analysis was done to know which is material is better to develop the pad support for the osteoarthritis patient foot. There are two types of material analysis had been done to ensure a better material for the pad support which is homogeneous material analysis and heterogeneous material analysis. Homogeneous material analysis was done on three types of material which is Polypropylene Copolymer, Natural Rubber and Open Cell Polyurethane Foam. While the heterogeneous material analysis was done by combination of two type of materials which is Open Cell Polyurethane Foam with Polypropylene Copolymer. The material properties of these three different materials are shown in Table 4.2.

Table 4.2: Material properties of the osteoarthritis pad support.

	Modulus Young (MPa)	Poison Ratio
Polypropylene Copolymer	1049.3	0.3
Natural Rubber	4	0.5
Open Cell Polyurethane Foam	0.3	0.3

The homogeneous material analysis mean that the analysis was done by defined a single material for develop the pad support. One of the materials that is used in homogeneous material analysis is Polypropylene Copolymer. In the analysis of this rigid material, the maximum reaction stress was occur at the other toe side of the pad support in 2.942E-01 MPa as shown in Figure A.22. According to Figure A.23, the maximum reaction force, 1.181E-01 N also occur at a same side as maximum reaction stress while the maximum pressure was occur at the opposite side which is big toe side. About 3.557E-01 MPa of pressure was focused at big toe end as shown in Figure A.24.

For the next homogeneous material analysis, the Natural Rubber was used as pad support material. This material had been analyzed to get the reaction of the pad support upon the stress, pressure and force. The results of the analysis upon these three parameters are shown in Figure A.25, Figure A.26 and Figure A.27. The results of stress shows the minimum reaction stress, 5.825E-04 MPa is occurred at node 47484 which is at the top of pad support. While, the maximum reaction stress, 2.744E-01 MPa was occurred at node 34648 which is at the big toe side of pad support. Besides that, the maximum pressure and reaction force was occurred at the opposite of the big toe side which is the other toe side at 5.463E+02 MPa and 2.265E+01 N.

For the third analysis of pad support material, the Open Cell Polyurethane Foam material had been used. With a single material that was assigned to the pad support in homogeneous material analysis, three types of visualization results were produced as shown in Figure A.28, Figure A.29 and Figure A.30. Maximum reaction stress and maximum pressure was occurred at the big toe side of the pad support which is 2.853E-01 MPa and 3.557E-01 MPa. While, it is about 1.181E-01 N of reaction force was occurred at the other toe side of the pad support.

For the heterogeneous material analysis, the combination of Open Cell Polyurethane Foam and Polypropylene Copolymer was used in one geometry model. The geometry model of pad support was separated into two partitions other toe side and big toe side. Open Cell Polyurethane Foam material was assigned at big toe side and Polypropylene Copolymer was assigned at other toe side. From the analysis, the maximum reaction stress, 4.452E-01 MPa was occurred at the connection of other toe side and big toe side as shown in Figure A.31. While, the maximum pressure and reaction force were occurred at other toe side of the pad support in 4.483E-01 MPa and 1.910E-01 N as referring to Figure A.32 and Figure A.33.

All the results of the pad support material analysis was transferred into Table 4.3 above and one comparison chart had been developed as in Figure A.34. It shows that the lowest maximum pressure was come from Natural Rubber (NR) but it has a highest maximum pressure and reaction force. This material is not suitable to OA patient due to the reaction force is too high. It may not relieve the pain and make the patient foot more worse.

The Open Cell Polyurethane Foam (OCPF) wrote the second lowest reaction stress compared to the Polypropylene Copolymer (PC) and combination of OCPF and PC. The maximum reaction force and pressure for OCPF material is same as PC material which is 3.557E-01 MPa and 1.183E-01 N. It also shows that the combination of OCPF and PC material give a higher value of reaction force and pressure than OCPF material and PC material. The maximum pressure was focused at the end of the big toe side. This shows that, OCPF and PC material can give lower pressure to the front and cushion at the end of patient big toe. It may relieve the pain causes by big toe osteoarthritis diseases.

Table 4.3: Results of the reaction stress, pressure and reaction force analysis upon to type of pad support material.

Parameter	Types of Pad Support Material			
	Polypropylene Copolymer	Natural Rubber	Open Cell Polyurethane Foam	Heterogeneous Material
Maximum Reaction Stress	0.2942 MPa	0.2744 MPa	0.2853 MPa	0.4452 MPa
Maximum Pressure	0.3557 MPa	546.3 MPa	0.3557 MPa	0.4483 MPa
Maximum Reaction Force	0.1181 N	22.65 N	0.1183 N	0.197 N

From the analysis that had been done, OCPF and PC material are suitable to use as pad support material. But we concluded that the OCPF material is better than PC material because its properties are soft and poron. The OCPF material will make the patient feel more comfortable rather than PC material which their property is rigid. Beside that, this OCPF material can absorb sweat that produced by the foot while walking and the patient will not feel slippery between toe and the pad support.

5.0 Conclusion

Modelling the geometry of the pad support was conducted using ABAQUS 6.13 software and three models had been designed which are Model 1, Model 2 and Model 3. There are three parameter that were observed in this finite element analysis which is stress, pressure and reaction force. The analyses were done upon the three geometry model and three different materials. For the geometry model analysis, Model 3 of the pad support was chosen due to its geometry that can give the patient feel more comfort while wearing it and can relieve the foot OA pain. The result of the stress analysis also shows that the life span of this model is longer than other models.

Second was carried out carried out to see the reaction of those three parameters upon three different materials that were used in developing the pad support for foot OA patient. This analysis was done in two categories which is homogeneous and heterogeneous material analysis. The materials that were used in this analysis is Polypropylene Copolymer, Natural Rubber and Open Cell Polyurethane Foam (OCPF). The results of analysis show that the use of homogeneous material is better than heterogeneous material upon to the pad support. The OCPF material gives the lowest reaction stress and force results which is good to develop a comfortable pad support.

Besides that, analysis also done to the OA pad support in different geometry analysis and global seed size. By using non-linear geometry analysis, we can get better results rather than use linear geometry analysis. Global seed size also gives a main role in getting more accurate results. Small size of seed will represent fine coarse meshes to the product analysis. It means that using the non-linear geometry and small seed size of the pad support can get more accurate results. But it needs a high performance of computer to run the analysis and it also may take a long time to finish it.

From the overall results, we can conclude that the foot OA pad support should be develop as Model 3 geometry using the OCPF material. This pad support can relieve pain of the big toe OA patients and make them comfort while walking. It also can prevent the disease become more worse. Further more, this research can be continued by improve the geometry and material used of pad support. We suggest that the geometry of the pad support can be improve by develop an internal rigid structure in the pad support and it will be covered by soft material with a suitable geometry that suite to patient's foot. Then the analysis should be done by observing reaction of the stress, strain, pressure and force upon the pad support.

6.0 References

[1] Consumer Education Committee (2012). *Osteoarthritis of Foot and Ankle*. American College of Foot and Ankle Surgeon.

[2] NHS Choices (2014). *Osteoarthritis*. Retrieved on March 20, 2014, from http://www.nhs.uk

[3] Pietrangelo, A. (2014). *Osteoarthritis of the Big Toe: Symptoms, Causes and Treatments*. Retrieved on March 13, 2014, from http://www.healthline.com.

[4] Berenbaum, F. (2013). Osteoarthritis as an inflammatory disease (osteoarthritis is not osteoarthrosis!). *Osteoarthritis and Cartilage*, *21*, pp. 16-21.

[5] Consumer Education Committee (2012). *Osteoarthritis of Foot and Ankle*. American College of Foot and Ankle Surgeon.

[6] NHS Trust (2013). *Osteoarthritis of big toe joint*. Retrieved on March 20, 2014, from http://www.leedcommunityhealthcare.nhs.uk/msk.

[7] Abhishek, A., Roddy, E., Zhang, W., Doherty, M. (2010). Are hallux valgus and big toe pain associated with impaired quality of life? A Cross-sectional Study. *Osteoarthritis and Cartilage*, *18*, pp. 923-926.

[8] Shiel Jr., W.C. (2014). *Osteoarthritis*. Retrieved on March 13, 2014, from www.onhealth.com.

[9] Ho, I.J., Hou, Y.Y., Yang, C.H., Wu, W.L., Chen, S.K., Guo, L.Y. (2010). Comparison of Plantar Pressure Distribution Between Different Speed and Incline During treadmill Jogging. *Journal of Sport and Science Medicine*, *9*, pp. 154-160.

[10] ABAQUS 6.13 (2014). *Abaqus/ CAE User Guide*. ABAQUS 6.13 Documentation.

[11] Arthritis Care (2012). *Osteoarthritis of the Foot*. Retrieved on March 13, 2014, from http://www.arthritiscare.org.uk.

[12] Kalunian, K.C. (2014). *Patient Information: Osteoarthritis Treatment (Beyond the Basics)*. Retrieved on March 13, 2014, from www.uptodate.com.

[13] WebMD (2013). *Joint Often Affected by Osteoarthritis*. Retrieved on March 20, 2014, from http://www.webmd.com

[14] OurHealthNetwork.com (2006). *Hallux Rigidus and Hallux Limitus*. Retrieved on March 20, 2014, from http://www.ourhealthnetwork.com

LIST OF FIGURES

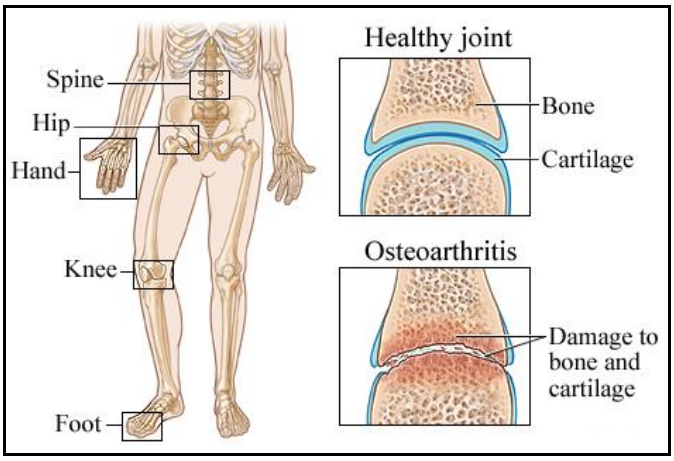


Figure A.1: Comparative between healthy joint and osteoarthritis joint [13].

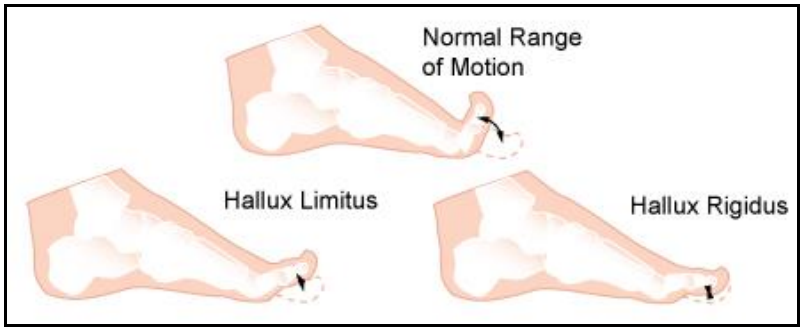


Figure A.2: The comparison between the motion of hallux limitus and rigidus to the normal motion of big toe [14].

Figure A.3: The pad support for big toe osteoarthritis.

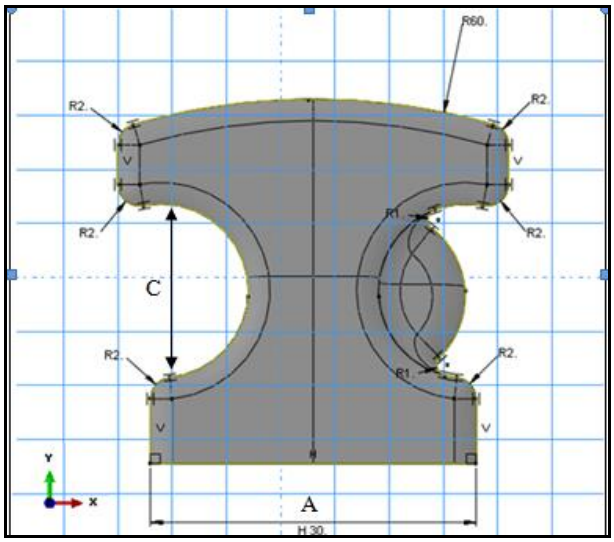


Figure A.4: Dimension of big toe osteoarthritis pad support in ABAQUS.

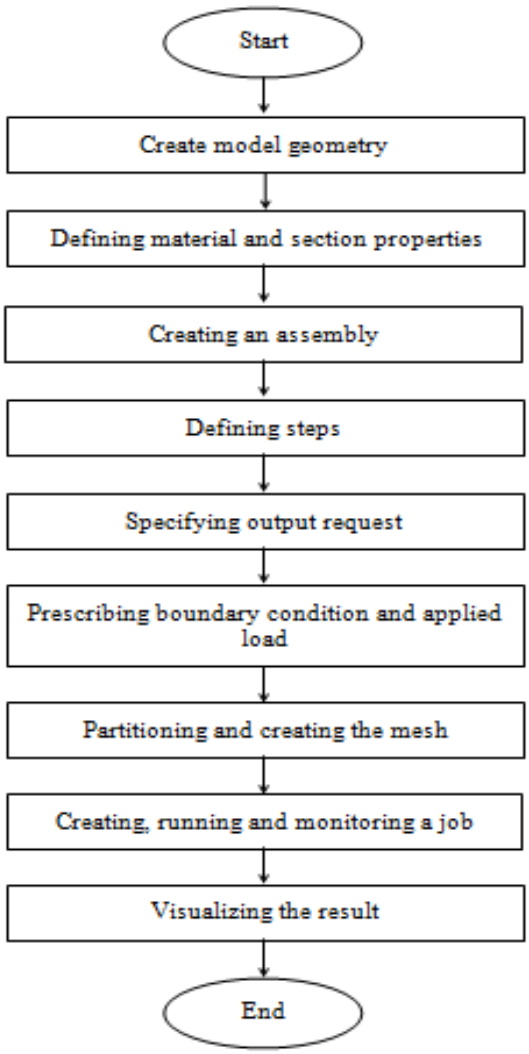


Figure A.5: Flowchart of the structural analysis by ABAQUS [10].

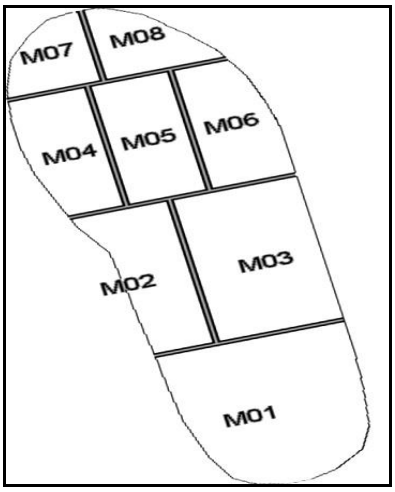


Figure A.6 - 8 section of human plantar foot [9].

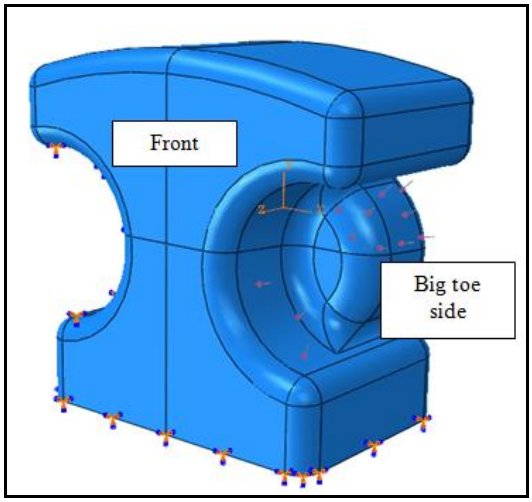


Figure A.7: Pressure load applied at big toe side.

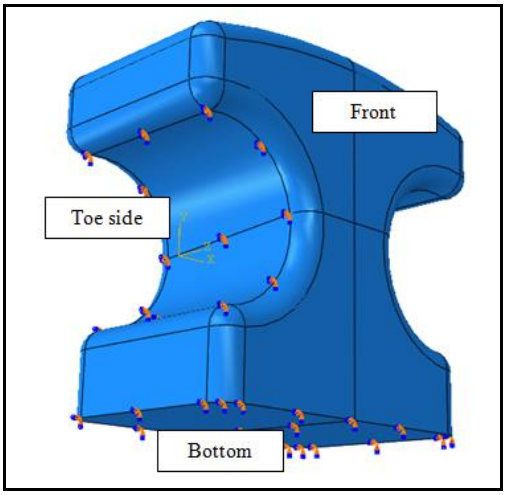


Figure A.8: Boundary condition at other toe and bottom side.

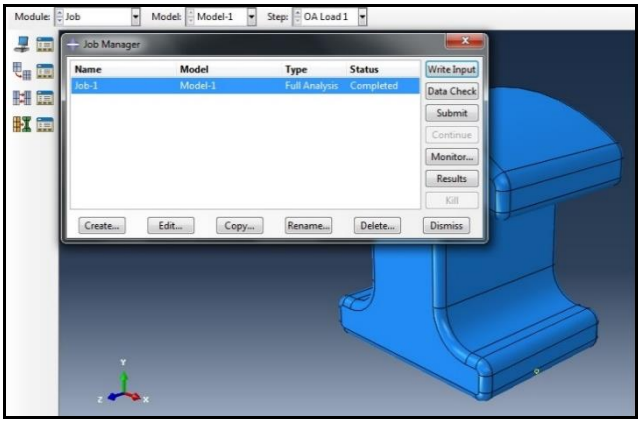


Figure A.9: Creating the job for the pad support.

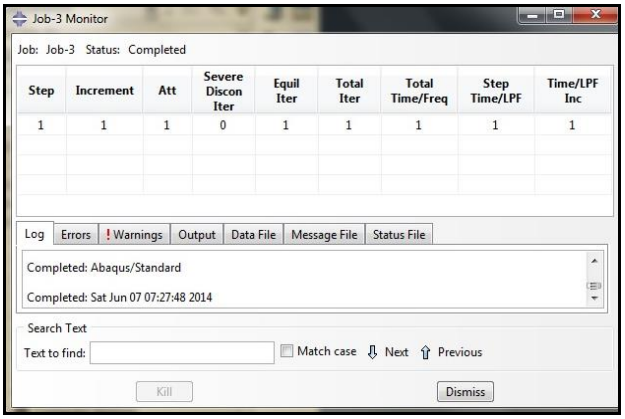


Figure A.10: The window of the monitoring the job analysis.

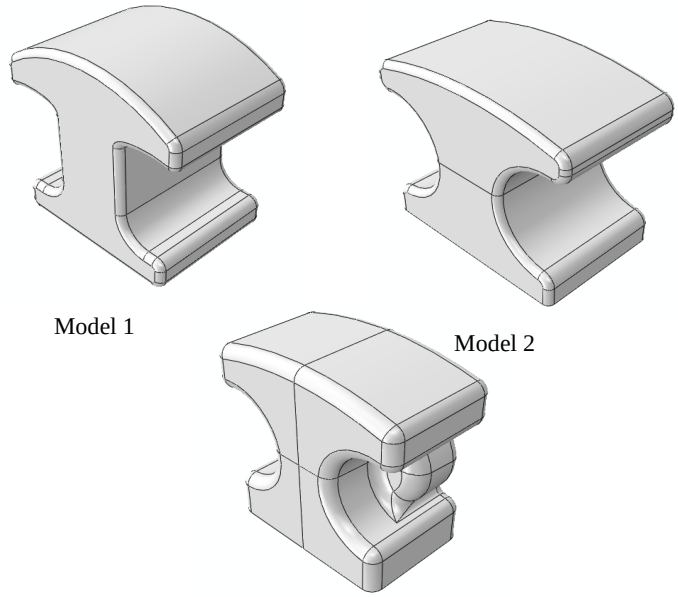


Figure A.11: Geometrical model of osteoarthritis pad support.

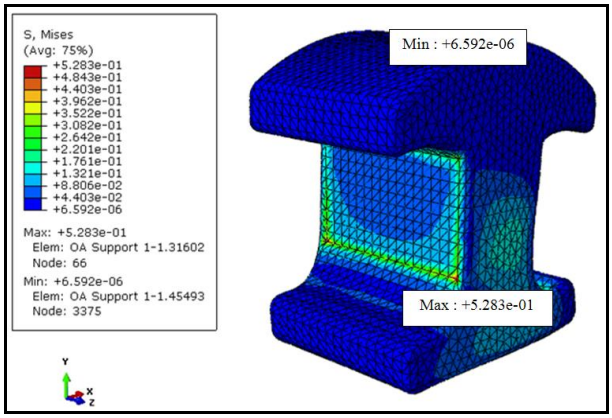


Figure A.12: Result of reaction stress for Model 1.

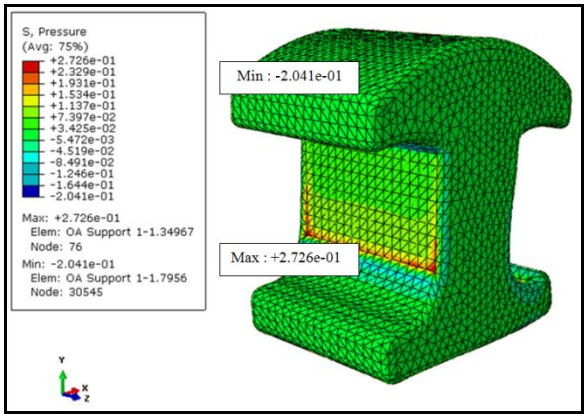


Figure A.13: Result of pressure for Model 1.

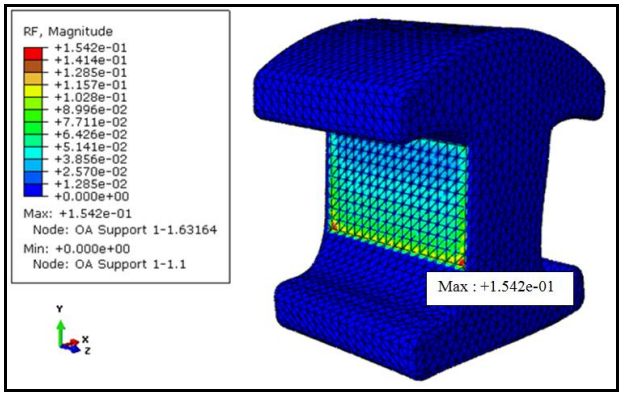


Figure A.14: Result of reaction force for Model 1.

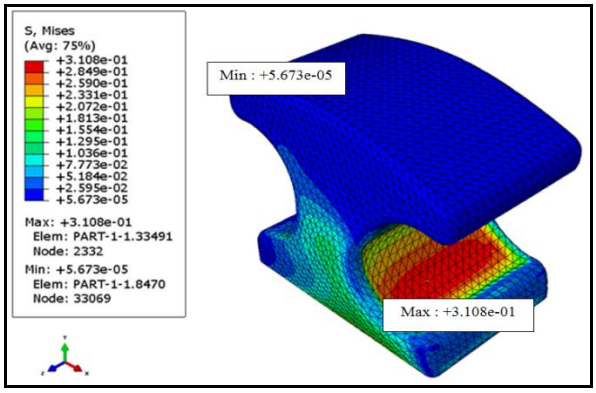


Figure A.15: Result of reaction stress for Model 2.

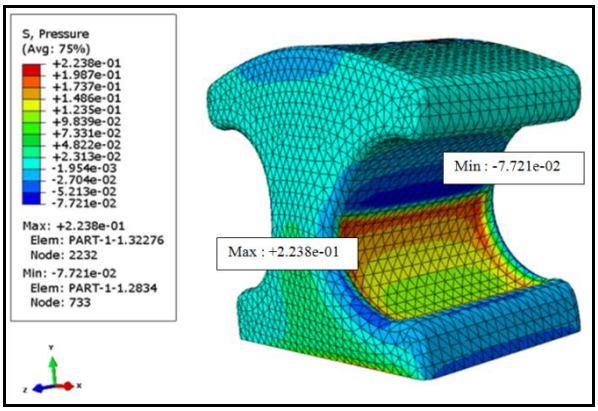


Figure A.16: Result of pressure for Model 2.

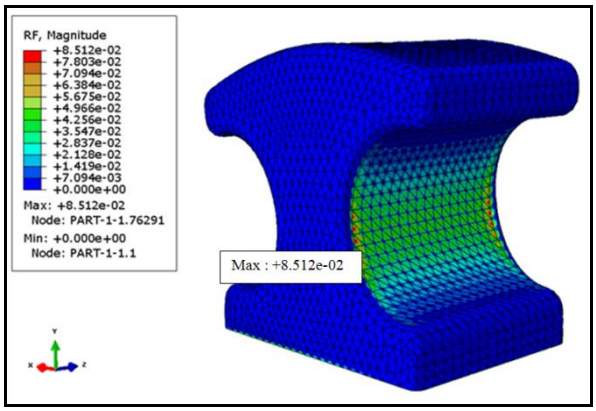


Figure A.17: Result of reaction force for Model 2.

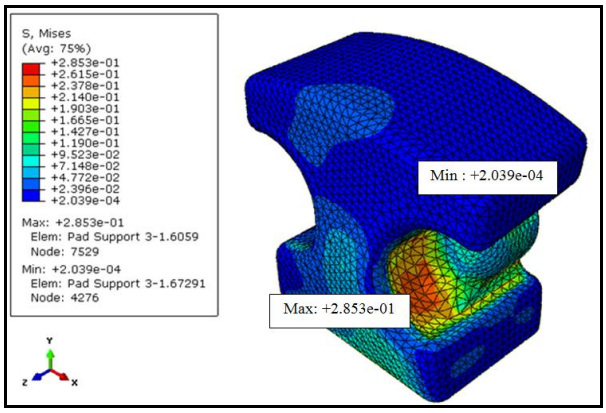


Figure A.18: Result of reaction stress for Model 3.

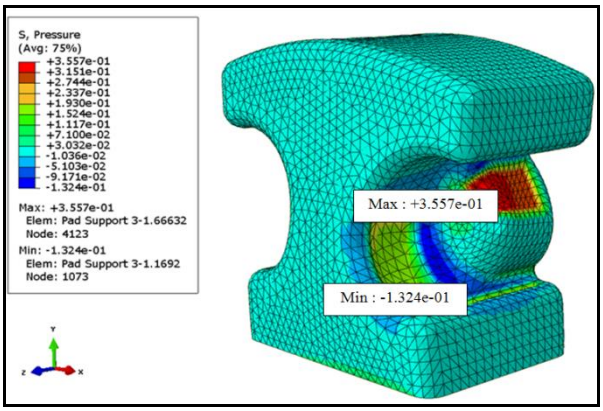


Figure A.19: Result of pressure for Model 3.

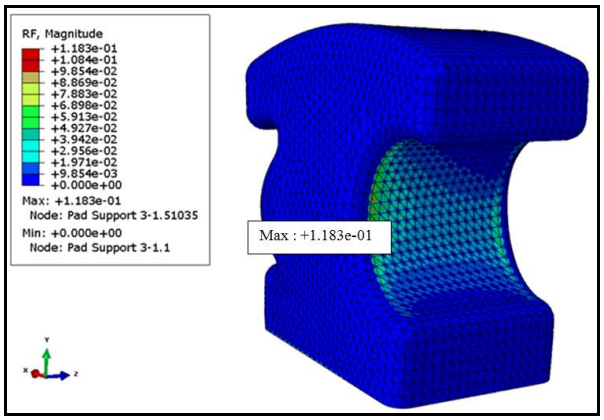


Figure A.20: Result of reaction force for Model 3.

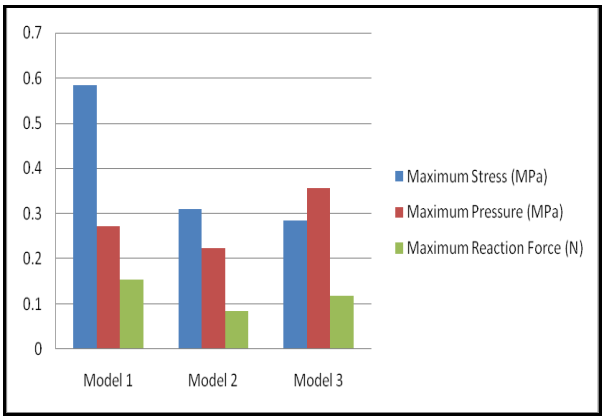


Figure A.21: Comparison chart between reaction stress, pressure and reaction force to types of pad support model.

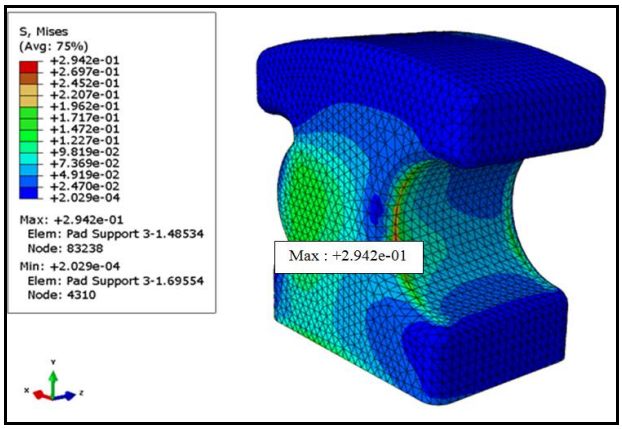


Figure A.22: Maximum reaction stress of Polypropylene Copolymer material.

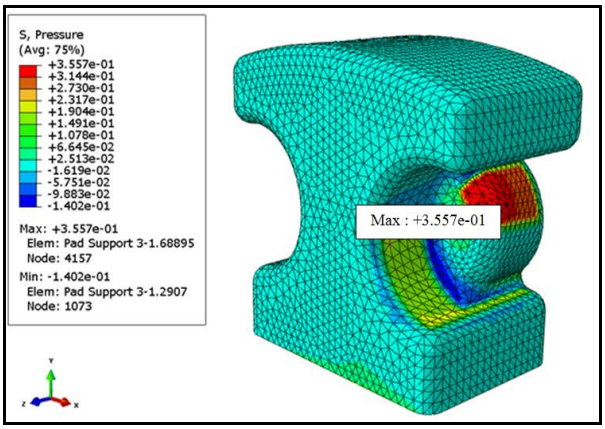


Figure A.23: Maximum pressure of Polypropylene Copolymer material.

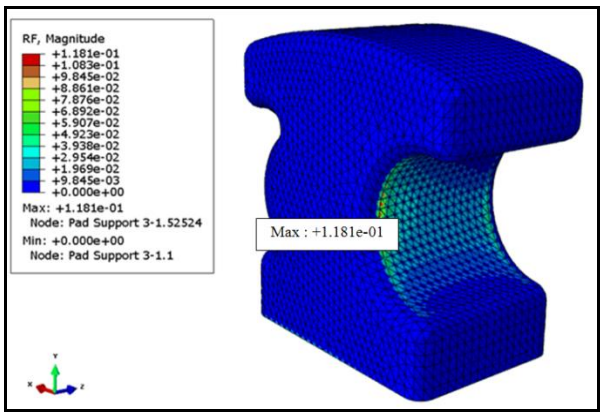


Figure A.24: Maximum reaction force of Polypropylene Copolymer material.

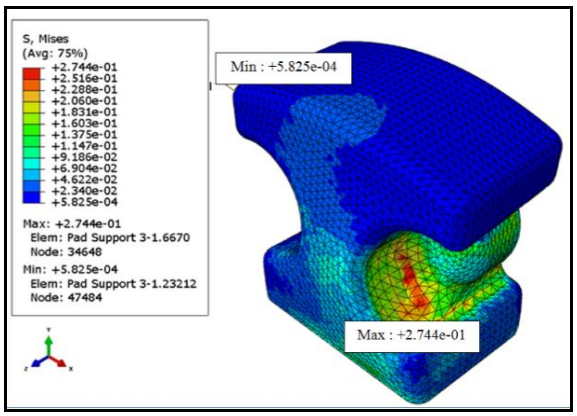


Figure A.25: Maximum reaction stress of Natural Rubber material.

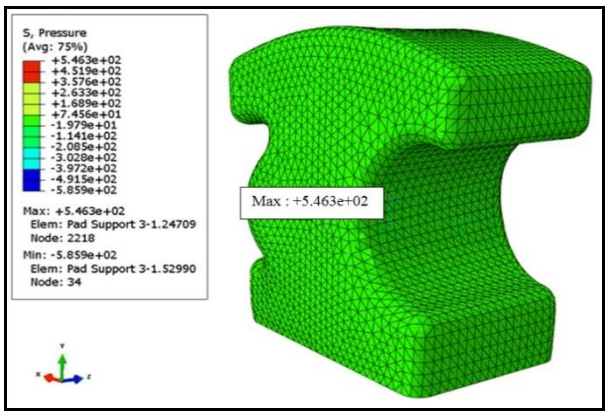


Figure A.26: Maximum pressure of Natural Rubber material.

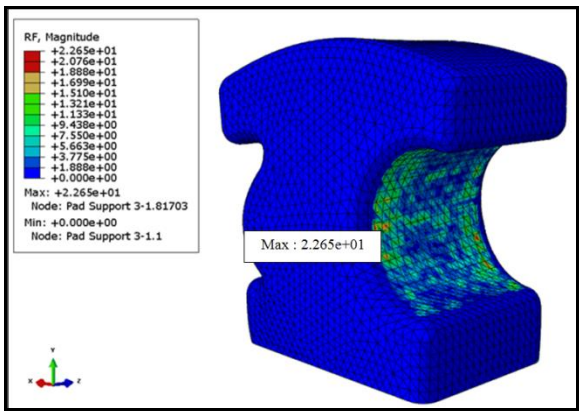


Figure A.27: Maximum reaction force of Natural Rubber material.

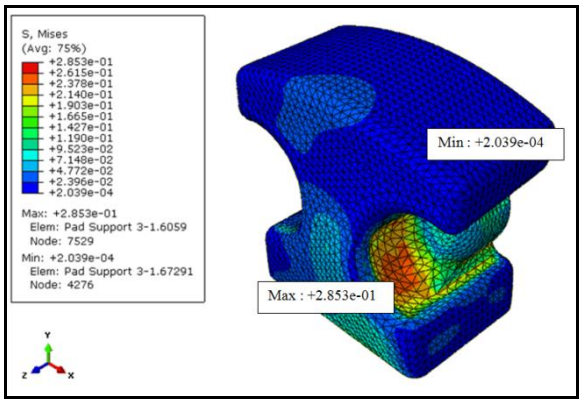


Figure A.28: Maximum reaction stress of Open Cell Polyurethane Foam material.

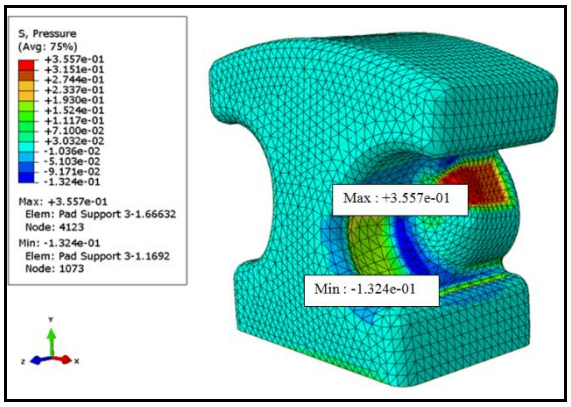


Figure A.29: Maximum pressure of Open Cell Polyurethane Foam material.

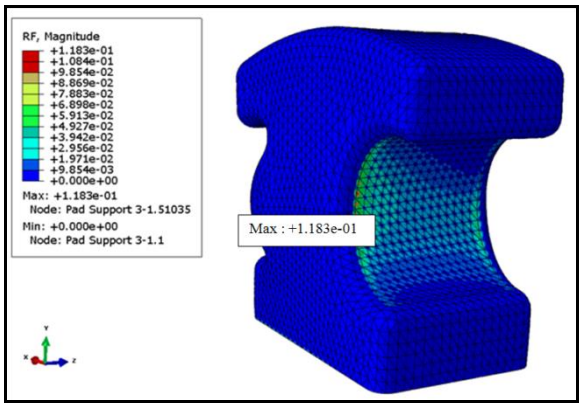


Figure A.30: Maximum reaction force of Open Cell Polyurethane Foam material.

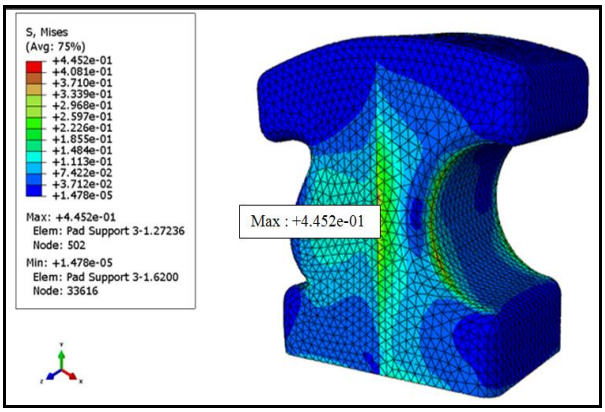


Figure A.31: Maximum reaction stress of heterogeneous material.

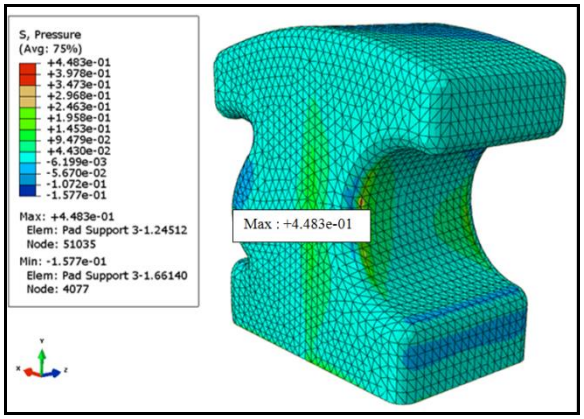


Figure A.32: Maximum pressure of heterogeneous material.

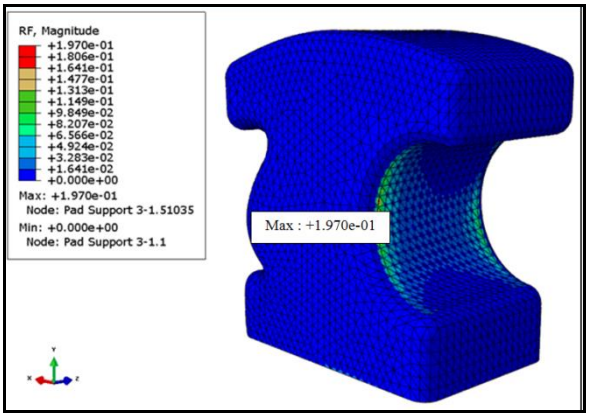


Figure A.33: Maximum reaction force of heterogeneous material.

M3: Reverse Engineering of Micro Light Aircraft Systems and Design

Wan Azizurrahman Wan Hassan, Mahadi Saat, Mohd Eley Rosli, Norazma Saari
Jabatan Mekanikal Pengeluaran, Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat, Johor

wan_azizurrahman@jtm.gov.my, mahadi.saat@jtm.gov.my,
mdeley.jtm@1govuc.gov.my, azma.saari@jtm.gov.my

Abstract

Microlight industry has become popular nowadays and has its own fan in Malaysia. In western side of the world, the microlight boom which started in late 1970s and 1980s was driven by a number of factors that permitted practical flying machines to be produced at lower cost than ever before. Here in Malaysia, most of the aircraft were imported from European and US as the manufacturer are from there. To reduce the cost of manufacturing an aircraft, this paper focus more on studying the construction of an aircraft by using proposed reverse engineering process. A microlight aircraft model Quicksilver GT500 has become a subject of study and Autodesk Inventor software is selected as preferred software to remodel the aircraft structure. Remodelling process of the aircraft started with taking actual measurement on the site aircraft guided with manual book of aircraft assembly and maintenance as reference. The CAD model of the aircraft then imposed stress load analysis to study the effect of proposed material to the structure reliability. Maximum take-off weight of aircraft of 1000lbs (454 kg) was used as maximum load on the aircraft while in cruise mode. Three types of aluminium alloy of Al2024, Al6061, and Al7075 have been studied on their influences to the wing structure design. The influence of Center of Gravity to the aircraft balancing is discussed. Wing structural design of joints between tubes is also discussed. Manufacturing process and techniques of the aircraft parts and components are identified. Lastly, the aircraft control system has been studied.

***Keywords** : Microlight, aircraft, reverse engineering, design*

1.0 Introduction

Reverse Engineering (RE) refers to the process of creating engineering design data from existing parts. It recreates or clones an existing part by acquiring the surface data of an existing part using a scanning or measurement device. It is useful in recreating the CAD model of an existing part when the engineering design is lost or when the model has gone through many design changes [1]. Many tools and methods had been introduced by researchers and engineers in order to propose the most economical ways of using reverse engineering techniques to the industry [2]. In related mechanical areas like automotive and machineries, the used of reverse engineering method gaining popular since it ability to minimizing manufacturing cost and produce the results at shortest period of time compared to conventional R&D method. RE application in aircraft industries are very similar to automotive industry. The techniques and methods are same as both of them apply general engineering knowledge during the whole development of the product [3].

Currently in Malaysia, aircraft industry is developing quite slowly due to the high cost of producing aircraft and also limited acquisition of manufacturing technology. These constraints cause a lack of interest from investors to invest in the aeronautics industry. However, in other countries especially Europe, there are a lot of investor and small scale manufacturers who actively involved in producing microlight aircraft to fulfill the demands. To produce an aircraft, a lot of money needs to be invested and very time consuming. Besides, lack of knowledge and limited facilities are the main factors of inability to produce an aircraft in Malaysia.

Reverse engineering (RE) is the best way to be applied by designers in order to produce their product at short time and at relatively lower cost. By applying RE into aircraft design, the designers are able to concentrate on small modification and upgrading the current product instead of spending a lot of time to build a new one. In most cases, the manufacturers are just selling their products, but not the entire information regarding the product. Therefore, RE technique is appropriate to identify the material specifications, manufacturing and assembly process, and also the alternative design for the product.

1.1. Significant of Research

This project has been carried out to prove the ability of reverse engineering techniques in reproducing the microlight aircraft with the help of available CAD software in the market. Besides, this project also hopefully will help to boost the manufacturing industry of microlight aircraft in Malaysia by producing it at lower cost.

2.0 Literature Review

Reverse Engineering (RE) refers to the process of creating engineering design data from existing parts. It recreates or clones an existing part by acquiring the surface data of an existing part using a scanning or measurement device. According to [4], RE is useful in recreating the CAD model of an existing part when the engineering design is lost or when the model has gone through many design changes.

2.1 Micro Light Aircraft

According to [5], microlight aircraft are defined as an aeroplane having no more than two seats, minimum flying speed in the landing configuration at maximum take-off mass (VSO) not exceeding 35 knots CAS (calibrated air speed) and a maximum take-off mass of no more than:

- 300 kg for a landplane, single seater, or
- 450 kg for a landplane, two-seater, or
- 330 kg for an amphibian or floatplane, single seater, or
- 495 kg for an amphibian or floatplane, two seater.

2.2 Quicksilver GT 500 Microlight Aircraft

The Quicksilver GT500 is in a family of strut-braced, with high wing, pusher configuration, tricycle gear aircraft built by Quicksilver Manufacturing of Temecula, California. The aircraft is available as a kit for amateur construction or as a completed ready-to-fly. The GT500 was developed specifically for the Sportplane class of the primary aircraft category (Part 21.24 of the Federal Aviation Regulations), and on 26 July 1994 became the first aircraft certified in that category. The aircraft's nomenclature is unclear as the manufacturer variously refers to it as the GT500, GT 500 and the GT-500. The FAA certification officially calls it the GT500 [6].

2.3 Structural Analysis

According to [7], the loading of an aircraft in flight may be placed into two general categories:

i. The forces and moments present while the aircraft is in steady flight. These often being referred to as the trim condition. In the case of conventional aircraft having a vertical plane of symmetry, the loading in the trim condition is limited to that plane that is, to longitudinal forces and moments.
ii. The forces and moments consequent upon the departure of the aircraft from the trim conditions as a result of control inputs or atmospheric disturbances. This may be referred to as transient loading.

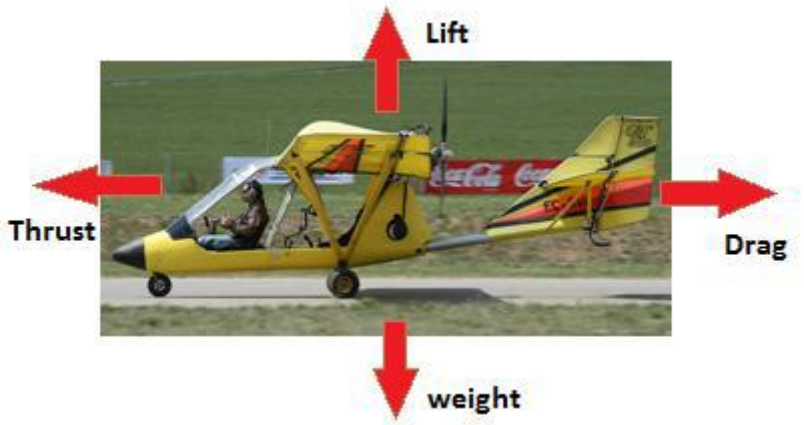


Figure 2.1: Types of load acting on aircraft.

3.0 Methodology

There are five procedural steps that need to be followed (refer to figure 3.1). The first step is studying the physical object of this project. Second, using selective device, the physical data of the object will be gain. After that, all the data will be transfer to the CAD software for image modelling. Engineering analysis will be conducted using CAE software to determine the physical properties of the product. After complete doing the analysis, the propose material can be determined.

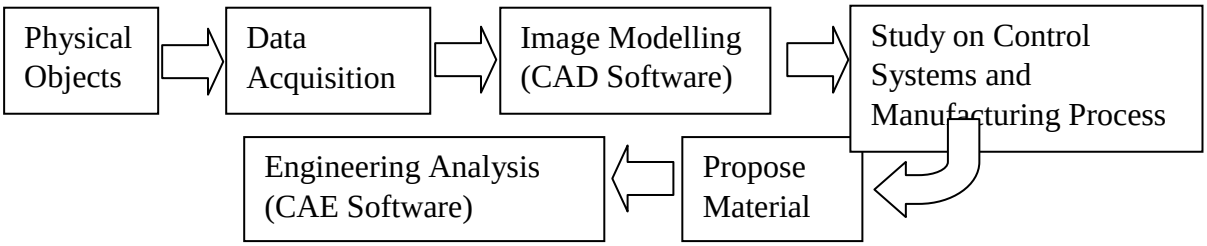


Figure 3.1: Reverse Engineering procedure for the project.

3.1 Image Modeling

To transfer the measurement data into 3D images, CAD/CAE software has been used. The Autodesk Inventor 2012 software had been chosen for its capabilities. The advantages of using this CAD/CAE software in designing products are:

- Ability to integrate the data between CAD file to the CAE type file for analysis purpose.
- No need to use different software for design purpose since it can perform both 3D design and engineering analysis. Thus, save the money and time consume.
- The Autodesk Inventor 2012 software is user friendly and suitable for engineering designer. This software use worldwide in manufacturing industries either small or heavy industries. Therefore, the reliability of this product is proven.

3.2 CAE Analysis

There are four stages in engineering analysis as follow:

- Stage 1: Identification of the physical problem – specification of the problem.
- Stage 2: Idealization of actual physical situations for subsequent mathematical analysis.
- Stage 3: Mathematical modeling and analysis.
- Stage 4: Interpretation of results.

4.0 RESULTS AND DISCUSSION

Figure 4.1 (a) to (c) are the schematic view of the aircraft basic strucure design using CAD Inventor Autodesk 2012 software. Right wing purposely had no ribs on the drawing as the structures are similar with the left wing.

The Quicksilver GT500 aircraft frames are generally constructed by tubular aircraft grade aluminum. Two main items of the structure are the forward fuselage and tail boom tube. The flight controls, nose wheel, and seats are attached to the forward fuselage.

The mounting structure for the root tube is attached to the aft center section of the forward fuselage tube and to the front section of the tail boom tube. The main landing gear carry-thru structure is joining both of the main tube at the center of aircraft. Empennage which is located at the tail of the aircraft is attached to the aft section of the tail boom tube.

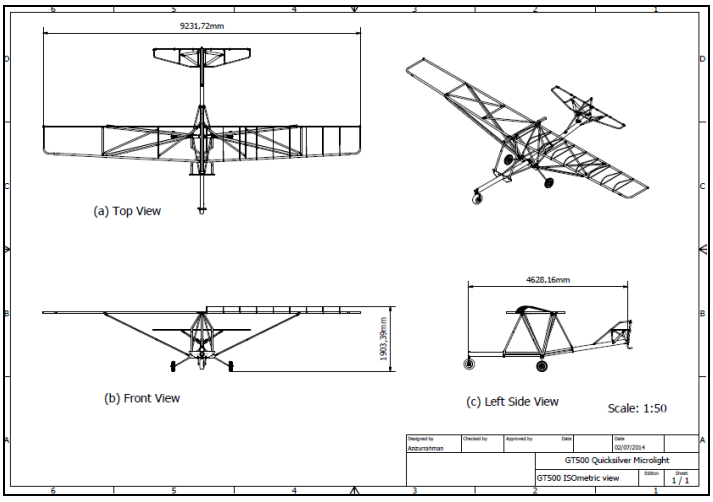


Figure 4.1: (a) Top view of CAD design for Quicksilver GT500 microlight aircraft structure. (b) Front view of CAD design for Quicksilver GT500 microlight aircraft structure. (c) Side view of CAD design for Quicksilver GT500 microlight aircraft structure.

4.1 Stress Load Analysis

To obtain the total lift force on the aircraft, Schrenk's method is used to find the spanwise lift distribution. In general it has two lift components which are trapezoidal (Lt) and elliptic distribution (Le). By using the Schrenk's propose formula, shown below in Figure 4.2 and Table 4.1 are the calculated results of lift force distribution.

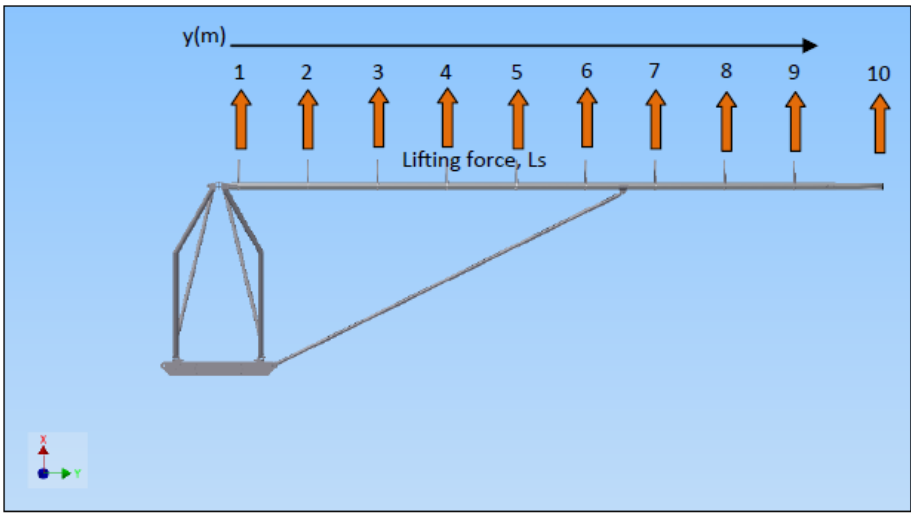


Figure 4.2: Total lift force, Ls distribution on the aircraft wing structure.

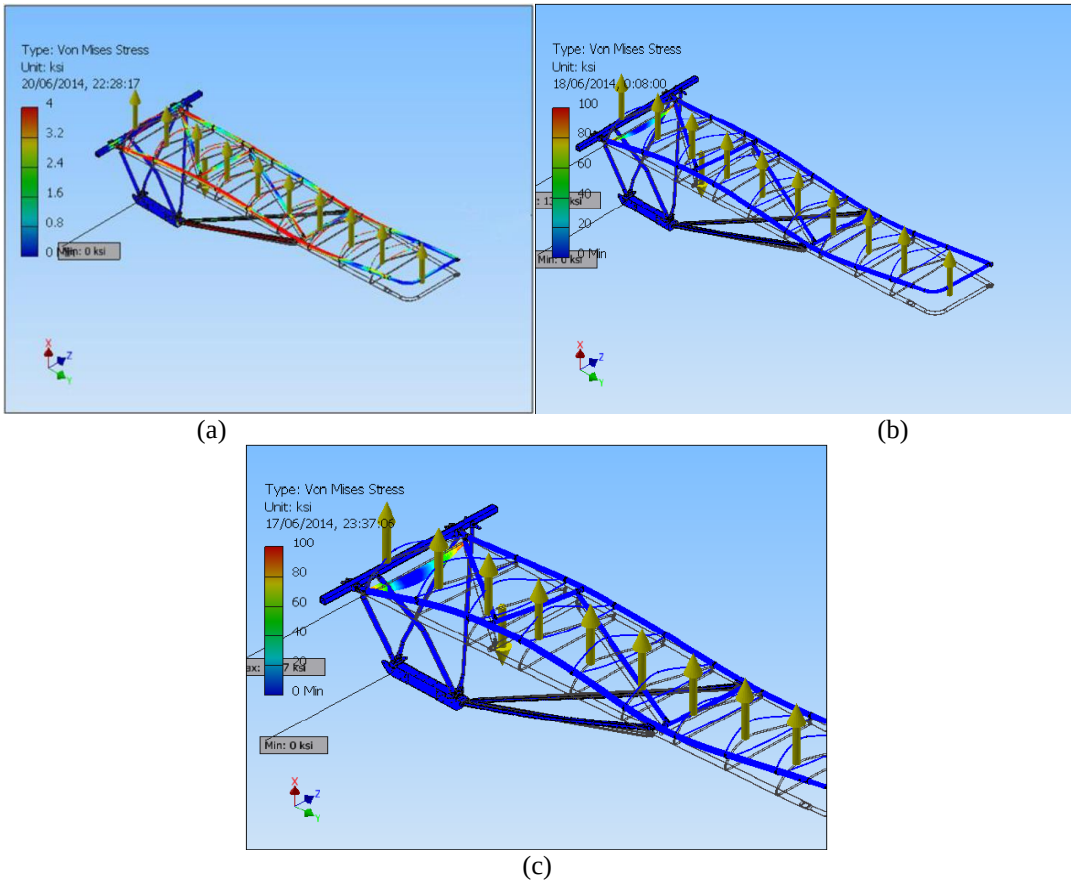
Based on generated data in table 4.1, the graph of wing spanwise lift distribution was generated. The graph is as Figure 4.3. The graph show the lift force distribution of trapezoidal and elliptical lift force acting on the one sided wingspan of GT500. From the graph and table, the trapezoidal lift distribution, Lt is in linear and negative slope along the spanwise cause by the distance of the loads from the origin which is at the root chord. The ratio of the chord gives effect to the trapezoidal lift distribution. Elliptical loads distribution produce exactly elliptical shape distribution. The highest lift force acts at the root of the wing and gradually decreases along the spanwise to the wingtip. The total lift distribution is calculated by averaging the trapezoidal and elliptical lift distribution. It has an elliptical shape distribution where the lift at the tip is assumed to be zero.

Table 4.1: Calculated lift distribution value of aircraft wing structure.

	Y(m)	Lt (N/m)	Le (N/m)	Ls (N/m)
1	0	553.14	1239.60	896.37
2	0.4826	539.15	1232.67	885.91
3	0.9652	525.15	1211.66	868.41
4	1.4478	511.16	1175.81	843.48
5	1.9304	497.16	1123.69	810.43
6	2.413	483.17	1052.89	768.03
7	2.8956	469.17	959.30	714.24
8	3.3782	455.18	835.28	645.23
9	3.8608	441.18	663.98	552.58
10	4.572	420.56	0.00	210.28

4.2 CAD/CAE Analysis

The complete assemble main structure of wing can be seen in Figure 4.1. This model was put to test using FEM in Autodesk Inventor 2012. The FEM analysis was meant to determine the stress and strain also the Von Misses stress value for the wing structure. In order to run stress load analysis on the model, 10 points of lifting force had been identified (upward arrow) on the structure. The locations of elliptical lifting forces were put at 0.25 of the chord value of each rib as explained in chapter 3. Downward arrow represents the total weight of the aircraft fuel tank which is 51 lbs. The test were run by using three different type of aluminum which are Al7075, Al 6061, and Al 2024 and the result can be seen in figure 4.2 (a) Al 2024; (b) Al6061; and (c) Al7075.



(a) (b)

(c)

Figure 4.2: Stress analysis results for three different materials using on aircraft wing structure. (a) Al2024, (b) Al6061, (c) Al7075

5.0 Conclusion

This study is only focus on a microlight aircraft for its design processes and manufacturing methods. The action force on aircraft and the reaction force from aircraft must be determined before progressing to the next stage. The frame structure of the aircraft has successfully being modeled using Autodesk Inventor version 2012. Little inaccuracy exist in the CAD modeling compare to actual object, but that does not affect the analysis results of stress load on the structure. In the stress load analysis, the main focus is on the wings' structure and fuselage deformation upon loading. The optimization of the structure had been done by varying the types of material of the main structure and from the results; aluminum alloy 6061 is the most suitable material.

6.0 References

[1] Barbero, B.R. (2009). *The recovery of design intent in reverse engineering problems. Computers & Industrial Engineering 56*, pp. 1265–1275

[2] Park, H.S. & Dang, X.P. (2010). *Structural optimization based on CADCAE integration and metamodeling techniques.* Computer-Aided Design 42, pp. 889-902

[3] Wanttaja, R.J. (2006). *Kit Airplane Construction*. 3rd Edition. McGraw Hill Company.

[4] Peng, Q.J. & Loftus M. (1998). *A new approach to reverse engineering based on vision information*. International Journal of Machine Tools & Manufacture 38, pp. 881–899

[5] Gratton G.B. (1999). *The weightshift-controlled microlight aeroplane*. British Microlight Aircraft Association, The Bullring, Deddington, Banbury, Oxfordshire OX15 0TT, UK.

[6] Cliche, A. (2001). *Ultralight Aircraft Shopper's Guide*. 8th Edition. Cybair Limited Publishing. pp B-95.

[7] Niu, CY Micheal. (1999). *Airframe Structural Design*. 2nd Edition. Hong Kong Conmilit Press Ltd.

M4: Stress Intensity Factors of Edge Cracks in Dissimilar Joint Plates

Nik Ainun Nik Ismail[1], Norazma Binti Saari[2]
Pusat Latihan Teknologi Tinggi (ADTEC), Batu Pahat, Johor[1]

ainun.jtm@1govuc.gov.my

Abstract

Nowadays, there are many applications in which need the combination of different materials. The development of this is caused by the mechanical wear problem, high temperature situation or other conditions in which different properties are required from different parts of the same applications. This problem brings about the need for joining dissimilar materials. However, the combination process between two dissimilar materials can caused mechanical mismatch and may lead to catastrophic failure or crack. Hence this study will focused on the stress intensity factor on edge crack between dissimilar joint plates. Three important parameters were used such as relative crack depth, a/L, relative offset distance, b/L and elastic mismatch, E_1/E_2 or α. It was found that such parameters significantly affected the characteristic of SIFs and it was depend on the location of cracks.

***Keywords** : Stress Intensity Factor, Edge Crack, Dissimilar Material*

1.0 Introduction

Stress intensity factors (SIFs) are important parameter in investigating the failure reliability of modern engineering structures. In order to minimize the structural weight or for other special purpose, the structures are jointed using dissimilar material properties [1]. As a result, such components experience mechanical mismatch leading to premature failure [2]. There are several methods for evaluating SIFs for the crack components and the most popular method is boundary element method (BEM) [3, 4]. Traditional method to estimate SIF is displacement extrapolation method [5, 6]. However, this method cannot be used especially for dissimilar joint materials. J-integral approach is alternatively used to calculate the SIFs where it is a contour integral around the crack tip. The J-integral values around the crack tip are converted into SIFs through the use of interaction integral method.

The solution of SIFs for plain strain bi-material plates are available in [1-4] using for example BEM [3] and FEM [4]. However, most of these report the SIFs of central cracks and none of literature found reported on the solution of SIFs especially for eccentric or offset cracks. Therefore, this paper presents the solution of SIFs for eccentric or offset cracks embedded in bi-materials plate. The model first validated with the existing model to determine the accuracy of this model. In order to understand the role of mechanical mismatches, the offset cracks are placed in different material stiffness. There are several important parameters are examined which are affected the SIFs for example relative crack depth, *a/L*, relative offset distance, *b/L* and mechanical mismatch, α. The behavior of SIFs related with such parameters are analyzed and discussed.

2.0 Methodology

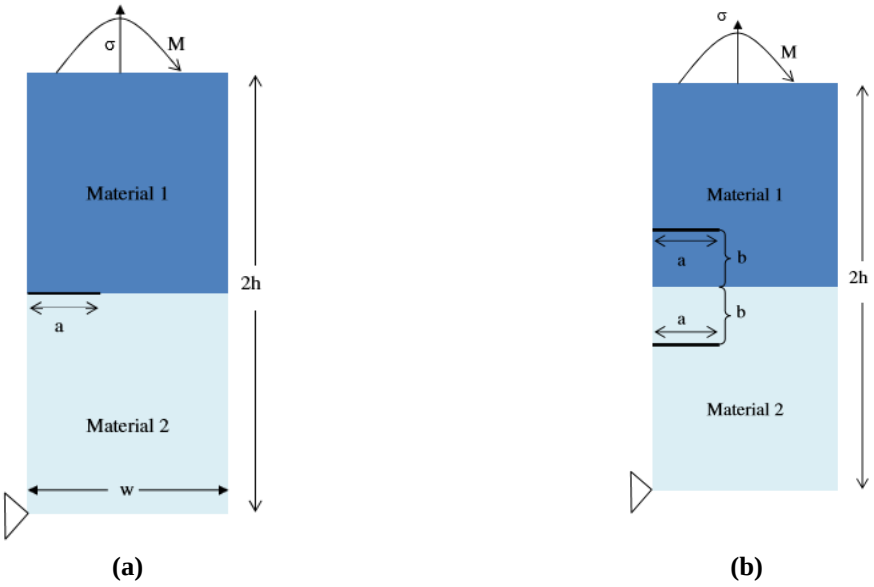
It is assumed that two plates of different materials are perfectly bonded as shown in Figure 1. Two types of cracks are considered; central and offset cracks. The central crack shown in Figure 1(a) is used for validation purpose and offset crack shown in Figure 1(b) is the main works to be solved in this paper.

The numerical model is developed using ANSYS finite element program. Two conditions of cracks are studied where the cracks are placed in the upper portion and the other cracks are positioned in the lower portion. The ratio of mechanical mismatch is defined as $\alpha = E_1/E_2$. Table 1 shown all the variables used in this experiment

Table 1: Offset edge crack simulation data

Condition	Value
$\alpha=(E_1/E_2)$	0.25, 0.33, 0.5, 1, 2, 3, 4, 5, 10
$\beta=(\sigma_p/\sigma_m)$	0.5, 1.0, 1.5
a/w	0.1, 0.2, 0.3, 0.4, 0.5, 0.6
b/h	0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5
w	25
h	37.5

A special attention is paid to the crack tip by employing 2D higher order 8-node singular element and the rest of model areas are mesh with irregular similar element. Upper and lower lines of the model with multi-point rigid element to ensure the mode I tension loading can be applied remotely. In this work, *J*-integral is used to characterize the crack driving force at the crack tip through the use of domain integral method. Then, SIFs are extracted from the calculated *J*-integral using interaction integral formulation.



(a) **(b)**

Figure 1: Single edge crack in bi-materials plate, (A) Central and (B) Offset cracks.

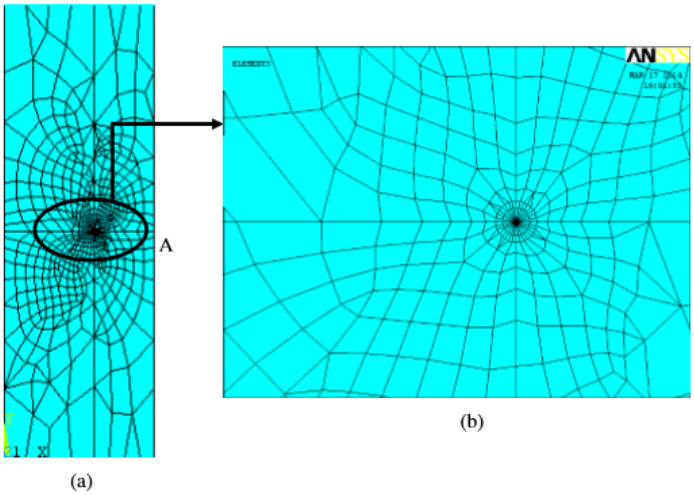


Figure 2: Finite element model of single edge crack, (a) a full model, (b) enlarge area *A*

There are two modes of SIFs are formed even mode I tension loading is applied due to the mechanical mismatches and crack eccentricities. The SIFs for modes I and II can be normalized and represented as follows:

$$F_I = \frac{K_I}{\sigma_a \sqrt{\pi a}} \quad (1)$$

$$F_{II} = \frac{K_{II}}{\sigma_a \sqrt{\pi a}} \quad (2)$$

Where, K and F are the stress intensity factor and dimensionless SIF or geometrical correction factor, respectively and the subscripts I and II are the modes I and II loadings. The applied tension loading, σ_a and a is the crack length where subscript a represent axial tensile loading.

For ensuring the present model is accurate and reliable, it is important to validate the model with the existing models by Toshiro et al for different mechanical mismatches α = 2, 4 and 10 shown in Figure 3. It is revealed that the present model is well agreed with the existing models and it can be used for further analysis.

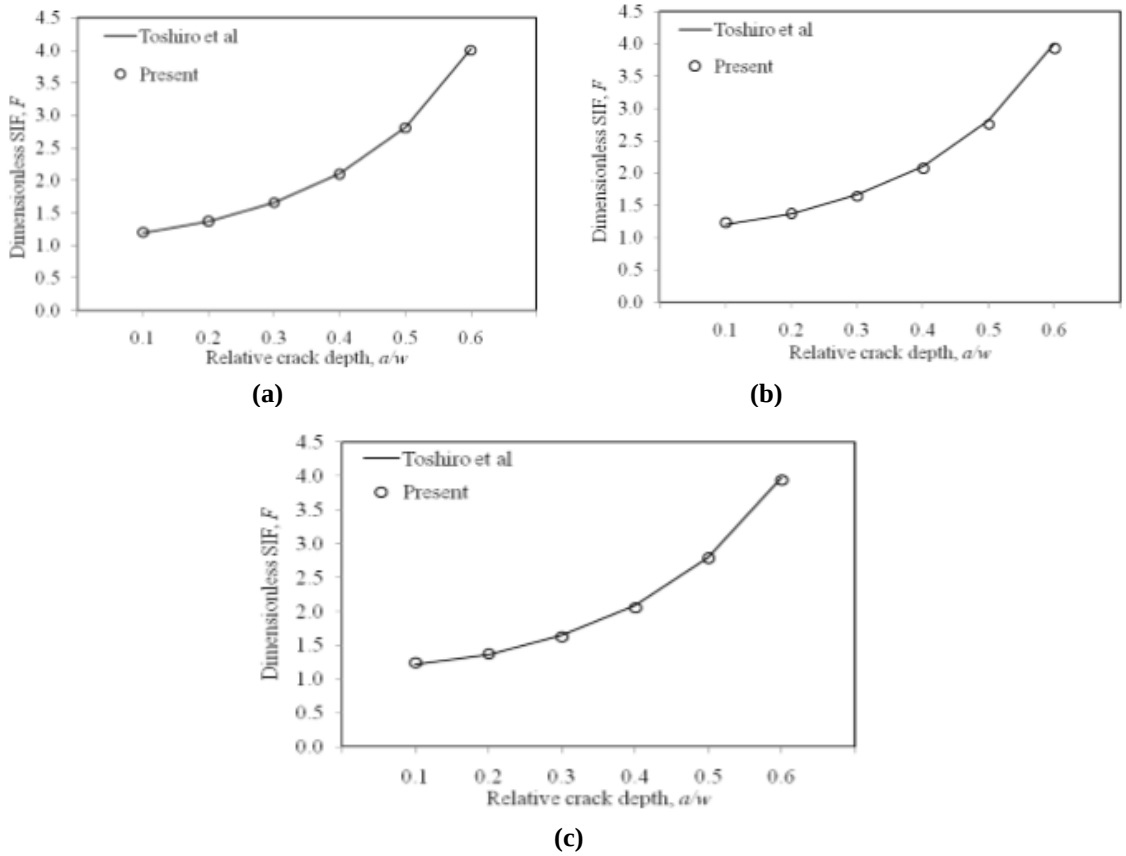


Figure 3: Numerical model validation for different mechanical mismatches, α, (a) 2 (b) 4 and (c) 10.

3.0 Result and Discussion

There are 3 type of simulation have been carry out for centre edge crack. For first simulation the material is subjected to only in plane tension with varying relative crack size a/w. Second simulation is conducted by varying relative crack size to the material which is subjected to bending moment. Last experiment is conducted by varying relative crack size to the material which is subjected to both of combination in plane tension and bending moment.

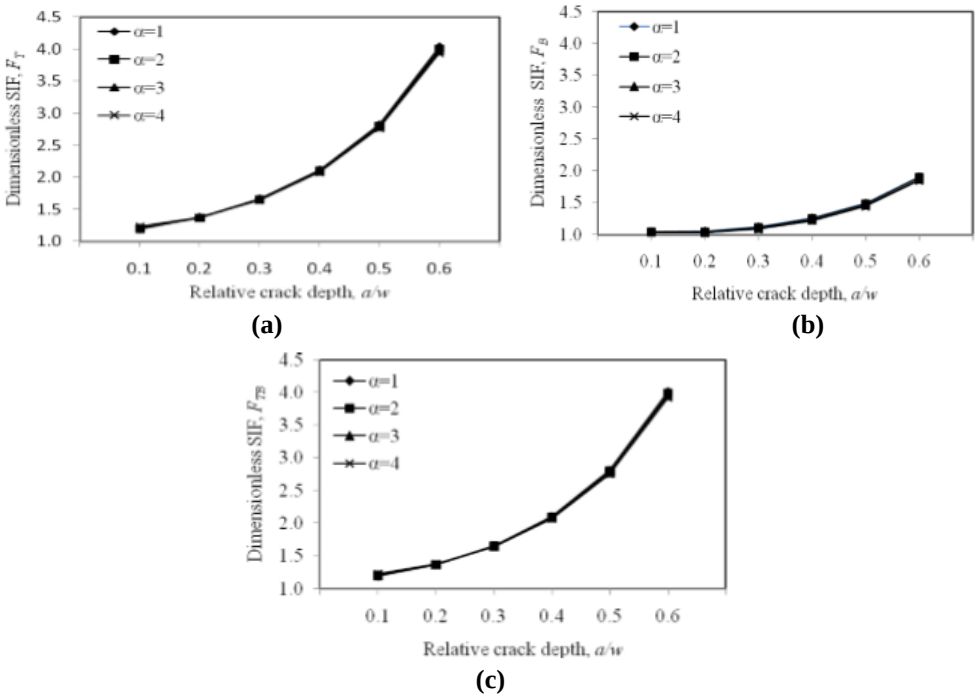


Figure 4: Plotted graph of centre edge crack simulation (a) Subjected to in plane tension, (b) Subjected to bending moment, (c) Subjected to both cases.

From plotted graph, it can be concluded that the increasing value of α is not given any major differences for the value of F. However, value of F will increase if the value of relative crack depth, a/w is increasing. For centre crack, it can concluded that when the F value is increasing, the SIF value K is also increasing.

For offset crack, there are 3 type of experiment have been carried out. First experiment is to find the effect of mechanical mismatch, α to the value of dimensionless SIF, second experiment is about the effect of ratio of stress, β to the value of dimensionless SIF and last experiment is about the effect of relative crack depth, a/w and relative offset distance, b/h to the value of SIF.

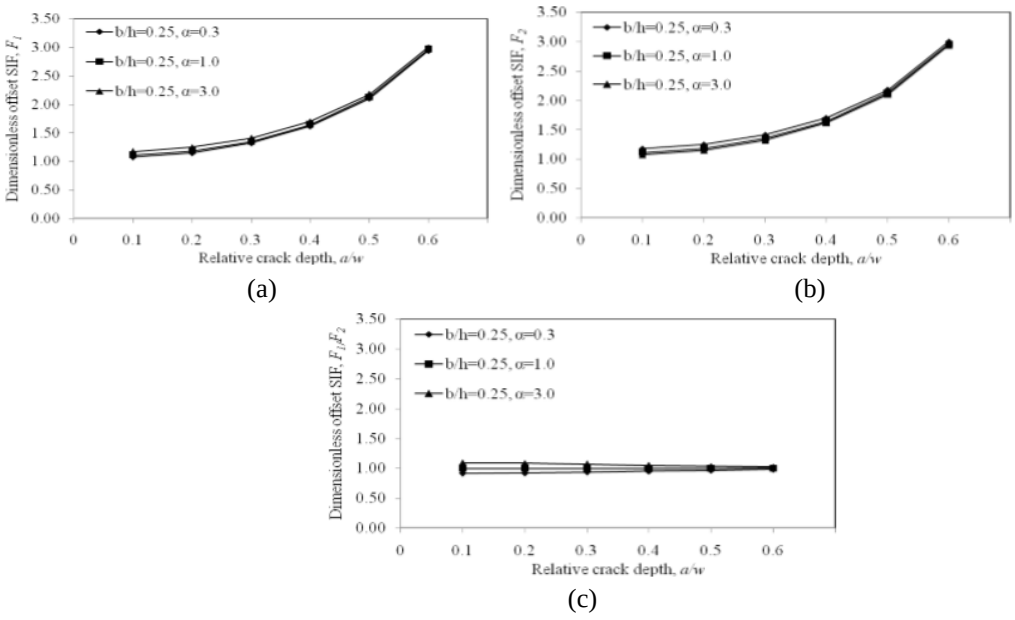


Figure 5: Dimensionless SIF, *F* versus relative crack depth, *a/w* for first analysis (a) Upper cracks, (b) Lower cracks and (c) SIF ratio between upper and lower cracks

From Figure 5, it is shown that the value of dimensionless offset SIF is different for each mechanical mismatch for upper crack, F_1 or lower crack, F_2. For cases of crack at material 1, the value of dimensionless SIF will increase with the increasing value of mechanical mismatch. However, for cases of crack at material 2, the value of dimensionless SIF will decrease with the increasing value of mechanical mismatch. It can concluded that the SIF ratio of F_1/F_2 is lower than 1 if the mechanical mismatch is below than 1 and is higher than 1 if mechanical mismatch is bigger than 1. However SIF ratio tend to converge to single value with the increasing value of crack depth.

Second analysis is about the relationship between ratio of stress, β to the value of dimensionless SIF. For this analysis, several values of mechanical mismatch, α, relative crack depth, a/w, and ratio of stress, β have been used as a comparison. An offset distance, b/h of 0.05 have been choose for this analysis. Figure 6 is the graph plotted for this analysis.

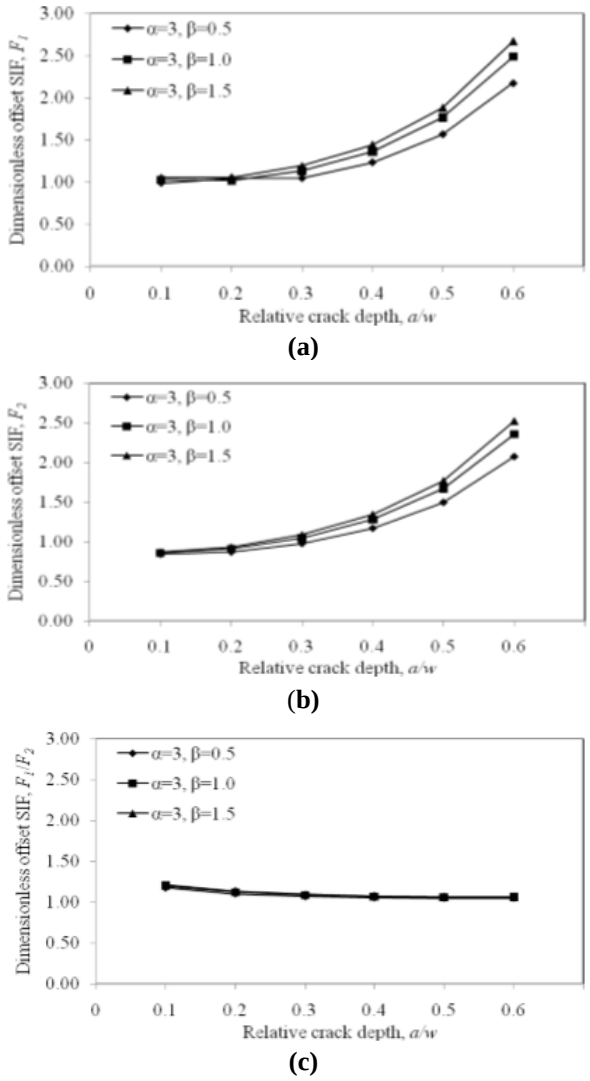


Figure 6: Dimensionless SIF, *F* versus relative crack depth, *a/w* for second analysis (a) Upper cracks, (b) Lower cracks (c) SIF ratio between upper and lower cracks

Figure 6 clearly shown that ratio of stress and moment is effectively affected the SIF value. The bigger the value of stress, the higher the value of SIF. It also concluded that relative crack depth will increase with the increase of ratio value. However, the value of SIF are higher for crack located at upper material compared to lower material. This is happened because of the stiffer plate is used for lower part of the experiment. Third analysis is focused on the effect of relative crack depth, *a/w* and relative offset distance, *b/h* to the value of dimensionless SIF, *F*.

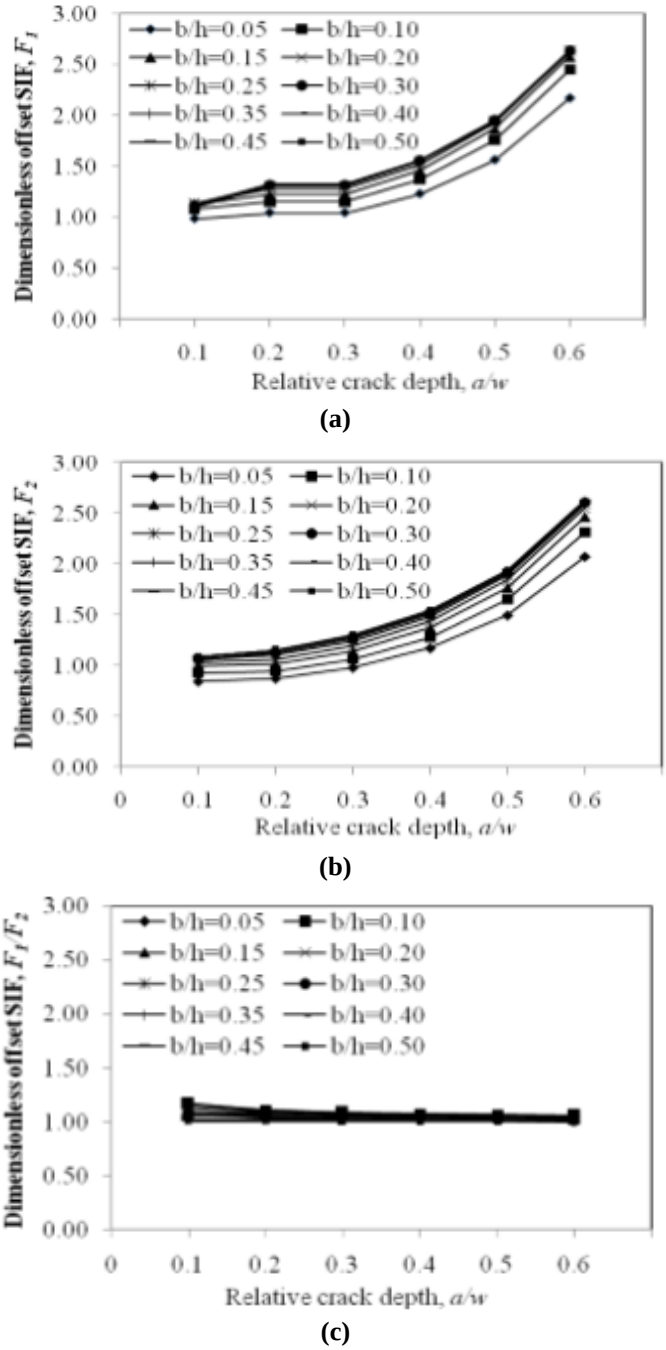


Figure 7: Dimensionless SIF, *F* versus relative crack depth, *a/w* for third analysis (a) Upper cracks, (b) Lower cracks (c) SIF ratio between upper and lower cracks.

From Figure 7, clearly shown that the value of dimensionless offset SIF for F_1 is higher than dimensionless offset SIF for F_2. Hence it is concluded that material 2 have higher resistance to withstand pressure and external moment compared to material 1.

4.0 Conclusion

This study was carried out to study the SIF of edge cracks in dissimilar joint plates. Mechanical mismatch, ratio of stress, relative crack depth and relative offset distance is a parameter related to SIF value that have been choose to be analyze. Each of these parameter have a set of range value to study the relation of these parameter to SIF value. The objective of study had been achieved and the SIF value from the finite element analysis had successfully observed and discussed.

From overall result discussed in Result and Discussion, it can conclude that mechanical mismatch, α, ratio of stress, β, relative crack depth, a/w and offset distance, b/h is a parameter that have been given an impact to the value of dimensionless SIF, F. Hence, it is advisable to the user or manufacturer to check this value in the future for further process involving the joining process of different materials in the future.

5.0 References

[1] V. X Tran and J. Pan, *Engineering Fracture Mechanics* **77**, 1417-1438 (2010).

[2] T. Ikeda, N. Miyazaki and T. Soda, *Engineering Fracture Mechanics* 59(6), 725-735 (1998).

[3] X. Lan, N. A Noda, Y. Zhang and K. Michinaka, *Acta Mechanica Solida Sinica* **25**(4), 404-416 (2012).

[4] T. Matsumto, M. Tanaka and R. Obara, *Engineering Fracture Mechanics* **66**, 683-703 (2000).

[5] A. E. Ismail, A. K. Ariffin, S. Abdullah and M. J. Ghazali, *Meccanica* **47**, 1141-1156 (2012).

[6] A. E. Ismail, A. K. Ariffin, S. Abdullah and M. J Ghazali, *Indian Journal of Engineering & Materials Science* **19**, 5-16 (2012).

[7] A. E Ismail, *IOP Conference Series: Material Science and Engineering* **50**, 012020.

M5: Merekabentuk dan Membangunkan Sebuah Mesin Tuangan Empar Mudah Alih

Nurul Aida Binti Ishak[1], Norlaily Binti Md Nor[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka

nurulaida.ishak@yahoo.com

Abstrak

Proses tuangan empar adalah suatu proses menuang logam ke dalam acuan yang berputar. Daya empar membantu meningkatkan daya tuangan membolehkan produk yang nipis, lebih kompleks dan mempunyai ketumpatan yang lebih tinggi dapat dihasilkan. Kebanyakan mesin yang berada di pasaran digunakan untuk pengeluaran tinggi dan tidak mudah alih. Tujuan projek ini dibangunkan ialah untuk merekabentuk dan membangunkan satu mesin tuangan empar mudah alih. Mesin ini boleh menampung beban maksimum sebanyak 10kg dan bergerak pada kelajuan yang tetap. Pelbagai analisis dilakukan sepanjang pembangunan mesin iaitu jenis motor, sistem transmisi, bearing, dan clamp. Bagi mengelakkan motor terbakar disebabkan oleh litar pintas, satu sistem direkabentuk supaya arus berlebihan yang mengalir kepada motor diputuskan dan tidak mengganggu suis utama. Sebuah mesin yang kecil dengan saiz 62.5cm x 40cm x 35cm dengan berat mesin kurang daripada 60kg dan boleh memegang saiz acuan maksimum 22cm direkabentuk dan dihasilkan dalam projek ini.

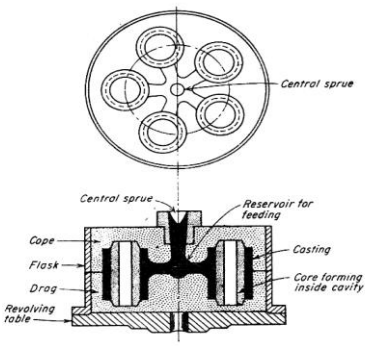
***Kata Kunci** : Mesin Tuangan Empar Mudah Alih, Produk yang Kompleks, Pemilihan Motor, Sistem Transmisi, Pengapit (Clamp), Analisis Bearing.*

1.0 Pengenalan

Proses tuangan telah dibangunkan sejak tahun 4000 sebelum masihi dan pada ketika itu proses ini hanya terhad kepada penghasilan senjata dan alat perhiasan. Tuangan ialah proses membentuk logam dengan menuang logam lebur ke dalam acuan dan membiarkan logam tersebut memejal di dalam acuan lalu mengambil bentuk kaviti acuan yang dikehendaki. Proses tuangan menggunakan tekanan untuk menuang logam lebur ke dalam acuan memberi lebih kelebihan berbanding tuangan yang hanya menggunakan tenaga graviti sahaja. Daya empar membantu menolak logam lebur untuk memenuhi kaviti. Proses ini sangat berguna apabila ingin menghasilkan produk yang kecil, nipis dan berkeratan rentas panjang di mana sangat sukar untuk diperoleh jika menggunakan tuangan logam yang menggunakan daya graviti sahaja. Bagi menghasilkan sebuah mesin tuangan empar mudah alih, kajian mendalam tentang proses tuangan empar dilakukan. Rekabentuk mesin ini dihadkan untuk memegang saiz acuan yang kecil dengan saiz maksimum bagi acuan ialah 22cm. Mesin tuangan empar ini direkabentuk supaya mudah alih dengan berat maksimum bagi mesin kurang daripada 60kg dan boleh memegang beban sehingga 20kg.

2.0 Kaedah Tuangan Empar

Proses tuangan empar jenis *Centrifuging / Spin Casting* tidak terhad kepada objek yang simetri seperti roda dan paip. Proses ini boleh menghasilkan produk dengan bentuk tidak seragam dan kompleks seperti *bearing caps, small bracket* dan alat kemas. Kaviti acuan berhubung dengan spru melalui *radial gates*. [1]



Rajah 1: Pandangan keratan rentas acuan bagi 5 tuangan [1].

2.1 Daya Empar [2]

Daya empar yang bertindak ke atas badan yang berputar ialah berkadaran dengan jejari pusingan dan kuasa dua halaju sudut.

$$F_c = mr\omega^2 = mv^2/r$$

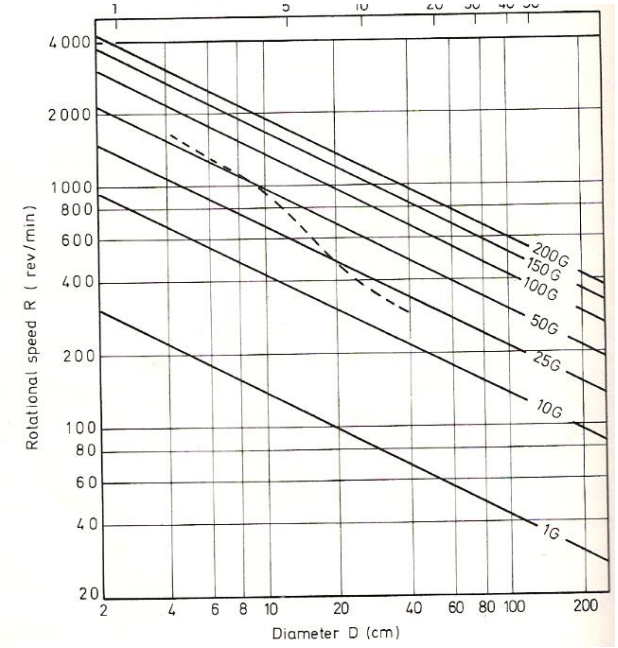
Di mana F_c = daya empar (N ; pdl)
m = jisim (kg ; lb)
r = jejari (m ; ft)
ω = halaju sudut (rad/s)

$$N = \left(\frac{G_{factor} xg}{0.001r}\right)^{1/2} = 29.9\left(\frac{G_{factor}}{r}\right)^{1/2}$$

$$= 42.3\left(\frac{G_{factor}}{d}\right)^{1/2}$$

Di mana D = diameter putaran (m)

Kaitan di antara kelajuan putaran, diameter dan daya empar diilustrasikan secara grafik dalam Rajah 2. Rajah ini digunakan untuk memilih kelajuan mengikut magnitud daya empar yang diperlukan.



Rajah 2: Kaitan di antara halaju putaran dan diameter untuk pelbagai magnitud daya empar.

Berdasarkan pemerhatian praktikal , Cumberland melaporkan lingkungan halaju yang diperlukan bagi mengelak pelemparan logam diwakili oleh garisan dot di dalam rajah. [3]

Bagi *centrifuging*, faktor-G yang digunakan ialah berdasarkan *semi-centrifugal* dan tuangan secara menegak. Maka, lingkungan faktor-G yang digunakan bagi *centrifuging* ialah di antara 15-33G.

Acuan Plaster of Paris, getah silicon, dan gypsum memejal dengan sedikit cepat berbanding acuan pasir. Maka, faktor-G yang lebih besar digunakan iaitu di antara 20-33G.

3.0 Analisis dan Rekabentuk Produk

3.1 Kelajuan Putaran

Saiz optimum bagi acuan ialah di antara 20-22cm dan dalam kajian ini, faktor-G 25 digunakan.

Kelajuan Maksimum, N_1 = $42.3\sqrt{\frac{20}{0.20}}$

= 472 rpm

Kelajuan Minimum, N_2 = $42.3\sqrt{\frac{33}{0.22}}$

= 451 rpm

3.2 Spesifikasi Motor

Motor dengan nilai tork yang lebih tinggi diperlukan bagi memastikan mesin tuangan empar mampu menampung beban sehingga 10kg pada kelajuan yang dikehendaki. Motor jenis aluminium juga dipilih kerana lebih ringan iaitu kurang 5-7 kg jika dibandingkan dengan motor dari jenis besi tuang. Spesifikasi motor ditunjukkan dalam Jadual 1.

Jadual 1: Spesifikasi motor yang digunakan

Kriteria	Jenis/ Nilai
Jenis Motor	**Single Phase DC Motor (BRANCO Motor BL 802-4)**
Kuasa	**745.7 Watt**
Kelajuan	**1410 rpm**
Voltan	**220 Volt**
Tork	**5.08 Nm**

3.3 *Belts*

Bagi sistem penghantaran, *V-belt* telah dipilih kerana berupaya untuk menyerap getaran dan bunyi bising, mudah dipasang dan mempunyai pegangan yang kuat pada takal.

H_{input} = 1 HP = 745.7Watt η_{input} = 1410 rpm

η_{output} = 470 rpm C_{min} = 270mm

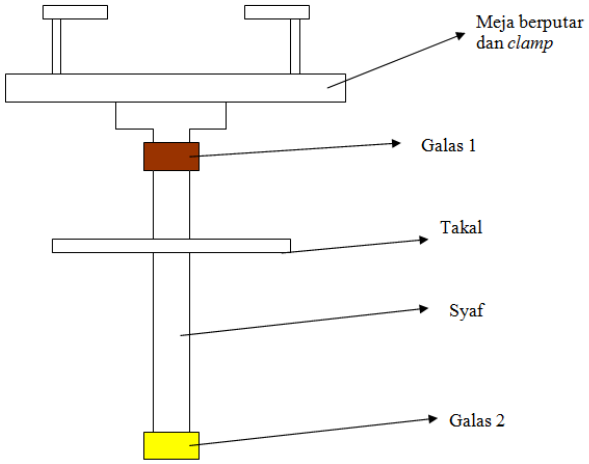
d = 2inch = 50.8mm D = 6inch = 152.4mm

Jadual 2: Jadual *V-belt* yang digunakan untuk mesin tuangan empar

Kriteria	*Belt Type B (B33)*
***Pitch length*, Lp**	**920 mm**
***Inside length*, Li**	**875mm**
Jarak antara tengah	**296.05 mm**
$H_{allowance}$	**0.4051kWatt**
Bilangan *belt*, N_b	**2 *belt***

3.4 Galas *(Bearing)*

Untuk analisa galas, *angular contact bearing* dipilih kerana ia mudah dilaraskan serta kosnya yang rendah. Rajah 3 menunjukkan kedudukan galas pada syaf.



Rajah 3 : Rajah kedudukan bearing pada syaf

Anggaran beban pada syaf utama:

i) Meja berputar + *Clamp* = 20kg
ii) Takal = 3.5kg
iii) Syaf utama = 3kg
iv) *Key ways* dan *belt* = 0.5kg

Menentukan *axial load*, F_a dan *radial load*, F_r

i) Galas 1,Fa = 20kg (9.81)
ii) Galas 2,Fa = (3kg + 3.5kg + 0.5kg) (9.81)

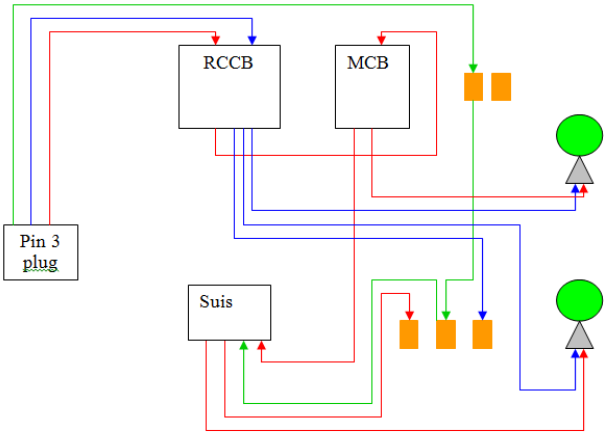
= 196.2 Newton = 68.67 Newton

Fr = anggap 3 (Fa) Fr = anggap 3 (Fa)
= 3 (196.2) = 3 (68.67)
= 588.6 Newton = 206.01 Newton

Daripada pengiraan, beban paksi di kedudukan galas 2 adalah kecil, jadi tiada pengiraan untuk galas tersebut. Saiz pada galas 2 akan menggunakan saiz yang sama seperti galas 1 kerana syaf mempunyai diameter yang sama. Oleh itu, mesin ini menggunakan *angular contact ball bearing* yang bersaiz 30mm.

3.5 Panel Kawalan

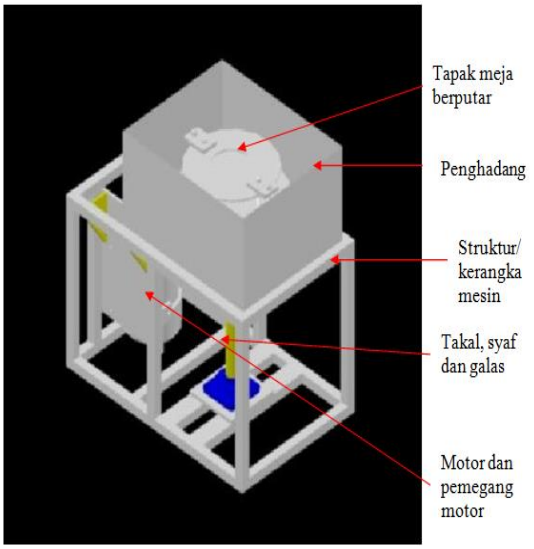
Panel kawal direka supaya terdapat suis untuk membuka dan menutup mesin. Sistem ini juga mempunyai suis utama supaya jika terdapat trip pada kuasa elektrik, hanya suis utama yang terlibat dan tidak akan melibatkan suis utama pada bengkel. Satu mentol akan bernyala jika terdapat kuada elektrik dan lagi satu mentol akan bernyala apabila suis pada mesin dihidupkan.



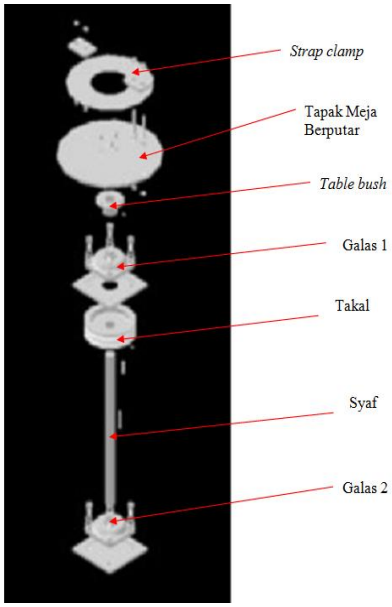
Rajah 4: Lukisan skematik panel kawalan

4.0 Keputusan

Mesin tuangan daya empar ini telah berjaya dihasilkan dan diuji. Acuan dan tuangan seberat 10kg telah diuji diletakkan di atas mesin yang berputar dan mesin dapat berputar pada kelajuan yang tetap. Berat mesin diukur dan didapati adalah kurang daripada 60kg iaitu 53.5kg. Rajah mesin tuangan empar dan komponen mesin merujuk kepada Rajah 4 dan 5.



Rajah 5a: Mesin tuangan empar



Rajah 5b : Komponen mesin pada syaf utama

5.0 Perbincangan

Ujian beban melawan kelajuan harus dilakukan untuk mengenalpasti beban maksimum yang boleh dibawa oleh mesin pada kelajuan pusingan yang tetap. Oleh kerana kelajuan putaran bagi tuangan empar ini bergantung kepada saiz produk, diameter dan ketinggian acuan, *inverter* perlu ditambah pada motor elektrik agar dapat mengawal kelajuan motor supaya dapat beroperasi pada kelajuan yang berlainan. Tapak plat hanya berukuran 29cm, maka penggunaan tapak plat yang lebih besar adalah lebih baik agar dapat memegang acuan yang lebih besar dan menghasilkan saiz produk yang lebih besar.

6.0 Kesimpulan

Mesin tuangan empar mudah alih seberat 53.5kg telah dapat dibangunkan dalam projek ini. Jika dibandingkan dengan mesin tuangan empar yang berada di pasaran, antaramesin yang kecil ialah keluaran syarikat Tulsa; Model VP500 yang mempunyai berat sebanyak 300kg.

Mesin ini dapat memegang beban yang tinggi iaitu sehingga 10kg. Struktur kerangka mesin, pemasangan motor, syaf, takal, dan galas disokong dengan kukuh. Ini dibuktikan oleh mesin berada dalam keadaan yang baik dan tidak bergetar dengan kuat apabila bergerak pada kelajuan yang tinggi.

7.0 Rujukan

[1] James S. Campbell (1961). *Principles of Manufacturing Materials and Processes.* New Delhi: TATA McGraw-Hill Publishing Company LTD.

[2] B.H. Amstead (1978). *Manufacturing Process*. 6th edition. Canada: John Wiley & Sons, Inc.

[3] Beeley, P.R. (1972). *Foundry Technology*. New York: John Wiley & Sons, Inc

[4] Serope Kalpakjian (1992). *Manufacturing Engineering and Technology.* edisi ke-3. Addison-Wesley Publishing Company.

M6: Pemecah Kulit Telur Rebus

Mohd Zailani bin Abd Ghani[1] , Dzul Azli bin Mohd Yunos[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka

zailani_456@yahoo.com

Abstrak

Mesin pemecah cengkerang telur rebus dicipta untuk membantu industri pemakanan mengurangkan masa dan menjimatkan penggunaan tenaga kerja. Mesin ini direkabentuk bagi memenuhi kehendak tersebut. Mesin ini boleh memecah kulit cengkerang telur rebus sebanyak enam biji secara serentak. Selepas proses pemecahan cengkerang, telur tersebut akan dikeluarkan secara automatik untuk proses peleraian cengkerang dari telur. Proses peleraian dilakukan dengan cara memasukkan telur tersebut di dalam bekas yang berisi air bersih. Masa yang diperlukan untuk mendapatkan telur bersih adalah antara dua hingga empat minit. Untuk mendapatkan telur bersih dari cengkerang secara insani mengambil masa dua hingga tiga minit untuk satu biji telur. Pada asasnya, mesin ini dibuat dari keluli lembut (mild steel). Mesin ini dilengkapi dengan enam biji cawan yang dibuat dari seramik. Untuk penghantaran kuasa bagi proses pegoncangan, satu motor dengan kelajuan yang boleh laras digunakan. Goncangan perlu dijana supaya cengkerang boleh berlaga dengan seramik untuk proses pemecahan. Motor disambung kepada flywheel untuk mengoncang perumah dimana cawan seramik ditempatkan. Akhir proses telur dikeluarkan dari cawan seramik dengan cara memusingkan perumah di mana cawan seramik dipasang. Timer digunakan untuk mengawal sela masa pemecahan dilakukan.

***Kata Kunci** : flywheel, timer, seramik, perumah, keluli lembut,*

1.0 Pengenalan

Malaysia merupakan negara yang tidak asing lagi dengan dunia pembangunan teknologi. Ini kerana ia dapat dibuktikan dengan peningkatan ekonomi yang sedia berkembang di seluruh negara. Ia boleh dilihat dari pelbagai segi terutamanya pembangunan tapak-tapak perindustrian dan pembinaan kilang berteknologi tinggi.

Oleh itu, ia perlu dibangunkan agar negara tidak ditelan arus permodenan zaman yang serba maju dan mencabar ini. Jesteru itu terdapat pelbagai idea atau inovasi yang tercipta bagi memudahkan pengguna, sekaligus menjadikan kehidupan pengguna yang lebih teratur dengan adanya pelbagai system dan teknologi yang baru pada masa kini.

Pusat Latihan Teknologi Tinggi (ADTEC) Melaka merupakan sebuah Institut Pengajian Tinggi di bawah Jabatan Tenaga Manusia Kementerian Sumber Manusia yang menyediakan latihan khususnya dalam bidang kejuruteraan.

2.0 Objektif Projek

i. Merekabentuk sebuah mesin 'Boiled *Egg Shell Breaker Machine'* sebagai tujuan memudahkan kerja-kerja mengupas kulit telur rebus.
ii. Membangunkan atau menghasilkan mesin *'Boiled Egg Shell Breaker Machine'* dengan tujuan menjimatkan masa.
iii. Mengujiguna *'Boiled Egg Shell Breaker Machine' s*upaya berfungsi dengan baik untuk mengupas kulit telur rebus.

3.0 Ciri-Ciri Projek

i. Boleh diangkat dan dipindahkan kemana-mana sahaja.
ii. Saiz yang sederhana dan mudahalih.
iii. Pengalihan telur secara manual pada mesin.

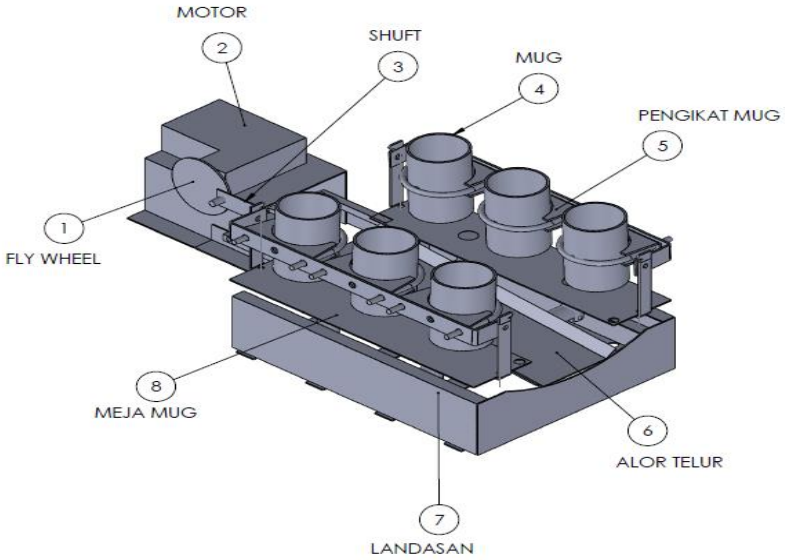
4.0 Speksifikasi Pojek

Gambarajah 1 : Boiled Egg Shell Breaker Machine

Jadual 1: Jadual spesifikasi projek

BIL	SPESIFIKASI	PENILAIAN
1	Bahan	Keluli lembut, seramik
2	Panjang	325 mm
3	Lebar	423 mm
4	Tinggi	240 mm
5	Berat	5 kg
6	Motor	240 vt
7	Bekas pemecah	8x6 (diameter mug x bilangan mug)
8	Punca kuasa	Bekalan kuasa 240 volt
9	Tempoh pemecahan	2 minit

5.0 Rekabentuk Model



Gambarajah 2: Lukisan Produk

6.0 Kaedah dan Aplikasi

6.1 Sop Pengunaan Egg Breaker Device

i. Memastikan mesin dalam keadaan baik dan kering.
ii. Pastikan suiz utama mesin dihidupkan
iii. Pastikan mug dalam keadaan bersih
iv. Masukkan sedikit minyak ke dalam mug
v. Masukkan telur rebus ke dalam mug
vi. On kan suiz mesin *Egg Breaker Device*
vii. Tunggu telur rebus siap dipecahkan
viii. Patuhi langkah-langkah keselamatan dengan betul
ix. Tutup suis utama mesin selepas digunakan.

7.0 Tafsiran Keupayaan Projek

Tafsiran keupayaan projek ialah tanggapan atau anggapan pontensi sesuatu kerja yang dihasilkan. Sesuatu projek yang baru dihasilkan adalah berpotensi besar untuk dipertingkatkan lagi kualiti dan fungsinya. Keupayaan projek adalah bergantung kepada perkembangan teknologi terkini dan kemampuan fungsinya pula adalah megikut kehendak dan kesesuaian semasa.

8.0 Pengujian Produk

Gambarajah 3: Keadaan telur yang siap dikupas; Percubaan pertama

Gambarajah 4: Keadaan telur yang siap dikupas; Percubaan kedua

9.0 Perbincangan

Setiap aktiviti yang dilakukan dalam menghasilkan projek perlu melakukan perbincangan. Perbincangan ini perlu dilakukan bagi mengatasi masalah yang di alami di dalam projek tersebut. Perbincangan boleh dibuat samaada dalam kumpulan, bersama pengajar atau bersama rakan lain.

Segala masalah yang berlaku perlu dicatatkan ,ini bagi memudahkan kerja. Setiap keputusan perbincangan adalah melalui apa yang dipraktikan dan diperlihatkan di dalam projek yang dilakukan.

Di awal perancangan lagi, projek *Egg Shell Breaker Machine* ini memerlukan kerjasama sepenuhnya dari ahli kumpulan. Ahli kumpulan perlu meneliti komponen dan peralatan yang akan digunakan bagi menyiapkan projek ini. Pelbagai cadangan telah diterima tetapi akhirnya setiap ahli kumpulan telah mencapai kata sepakat untuk memilih projek ini

10.0 Kesimpulan

Secara keseluruhannya, projek ini dapat diselesaikan dalam jangkamasa yang telah ditetapkan seperti yang dijadualkan. Daripada apa yang telah dijalankan didapati setiap proses yang terlibat seperti proses pengukuran, proses pemesinan, proses memasang komponen memerlukan ketelitian dan tumpuan yang amat tinggi.

Sebarang kesilapan atau kelalaian yang berlaku akan membuatkan projek ini tidak dapat berfungsi dengan baik dan lancar serta mencacatkan projek ini. Oleh itu, kami telah memastikan projek ini dilaksanakan dengan penuh ketelitian.

Dalam menghasilkan projek ini ia juga melibatkan proses pengiraan yang bertujuan untuk menentukan berat produk, ,pengunaan mesin lukisan produk, pemasangan dan lukisan terperinci. Melalui projek ini dapat dinyatakan bahawa dalam menjayakan sesuatu projek perlu :

i. Membuat lukisan yang diperlukan dan bersesuaian dengan pojek yang hendak dilakukan.
ii. Membuat kajian dan mencari rujukan bagi mengetahui sesuatu maklumat yang diperlukan itu.
iii. Memastikan setiap operasi pemesinan mengikut lukisan yang telah disediakan.

11.0 Rujukan

[1] http://thestonesoup.com/blog/2010/03/the-secret-to-easy-to-peel-boiled-eggs/

[2] http://www.lightneasy.org/buy-boiled-egg-peeling-machine

[3] http://www.thriftyfun.com/tf294583.tip.html

M7: Oil Filter Scrapper

Afdiman Bin Anuar[1]
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka[1]

afdiman@gmail.com

Abstrak

Pemilik bengkel kenderaan kecil dan sederhana (IKS) berkemungkinan berdepan dengan bebanan ratusan malah ribuan penapis minyak kenderaan terpakai. Pengusaha bengkel akan disabitkan kesalahan jika membuangnya sahaja ke dalam tong sampah komersial (Peraturan Kualiti Alam Sekeliling 2005). Secara amnya, penapis minyak terpakai dianggap sebagai barangan tidak bernilai untuk dikitar semula disebabkan oleh sisa minyak enjin di dalamnya. Pengusaha barang lusuh tidak menerima barangan ini untuk dikitar semula kecuali diasingkan sisa minyak enjin dan bahan logam penapis minyak tersebut. Oil Filter Scrapper dibina hasil dari rekabentuk akhir dari kajian rintis yang telah dilakukan. Tujuan projek ini adalah supaya dapat mengasingkan sisa minyak enjin dan bahan logam penapis minyak. Keberkesanan pemotongan oleh Oil Filter Scrapper telah diuji dengan beberapa sampel penapis minyak yang berlainan jenis dan saiz. Hasilnya menunjukkan pemotongan pada penapis minyak adalah sempurna, bersih dan kemas. Kesimpulannya, projek ini dibangunkan untuk membantu IKS ke arah penjimatan tenaga dan teknologi hijau.

***Kata kunci**: penapis minyak terpakai, Oil Filter Scrapper, industri kecil dan sederhana (IKS), kitar semula.*

1.0 Pengenalan

Industri automotif di Malaysia telah banyak berkembang sejak kereta nasional pertama Proton Saga dilancarkan pada tahun 1985. Antara penyumbang perkembangan tersebut ialah dari industri kecil dan sederhana (IKS) yang banyak membantu kepada ekonomi negara (Smidec, 2015). Pelbagai cabaran yang perlu dihadapi oleh pemilik bengkel IKS untuk kekal bersaing dalam industri automotif dengan dominasi pusat-pusat servis yang besar. Mereka perlu bijak dalam beroperasi seperti pengetahuan teknologi terkini, tahap kemahiran pekerja, soal selidik pasaran, aliran modal kewangan dan mengurangkan tahap sisa buangan. Pendekatan ini berlatarbelakangkan "*Waste Minimisation*"(Wikipedia).

Pemilik bengkel kenderaan kecil dan sederhana berkemungkinan berdepan dengan bebanan ratusan malah ribuan penapis minyak kenderaan terpakai. Pengusaha bengkel akan disabitkan kesalahan jika membuangnya sahaja ke dalam tong sampah komersial (Peraturan Kualiti Alam Sekeliling, 2005). Adakalanya bahan buangan boleh mendatangkan keuntungan (Liboiron, 2013). Secara amnya, penapis minyak terpakai dianggap sebagai barangan tidak bernilai untuk dikitar semula disebabkan oleh sisa minyak enjin di dalamnya. Pengusaha barang lusuh tidak menerima barangan ini untuk dikitar semula kecuali diasingkan sisa minyak enjin dan bahan logam penapis minyak tersebut. *Oil Filter Scrapper* direkabentuk dan dibina dengan tujuan dapat mengasingkan sisa minyak enjin dan bahan logam dari penapis minyak terpakai supaya menjadi barangan buangan yang bernilai untuk dikitar semula.

2.0 Metodologi Projek

2.1 Pelaksanaan projek

i. Perancangan - Melibatkan pembinaan awal Jadual Gantt. Memastikan semua maklumat dan keperluan seperti perkakasan, mesin dan permohonan bajet dilakukan dengan betul supaya spesifikasi projek ini terhasil dan mengikut jadual perlaksanaan.

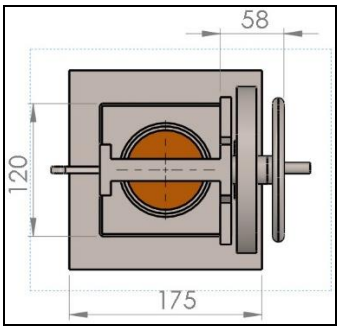
ii. Kajian Ilmiah - Pernyataan masalah projek dikaji dan dihuraikan. Rujukan seperti jurnal penyelidikan, terbitan artikel, buku dan lain-lain bahan dikumpulkan dari internet dan perpustakaan. Kajian rintis dilakukan melalui projek tahun akhir pelajar sebagai pra-ujian kepada konsep awal rekabentuk.

iii. Rekabentuk - Melalui data dari kajian rintis, rekabentuk projek dimurnikan sehingga menjadi rekabentuk akhir projek. Lakaran awal rupa bentuk projek diterjemahkan dalam perisian SOLID WORKS lengkap dengan dimensi ukuran dan simulasi jenis bahan logam yang digunakan untuk ditentukan berat akhir projek.

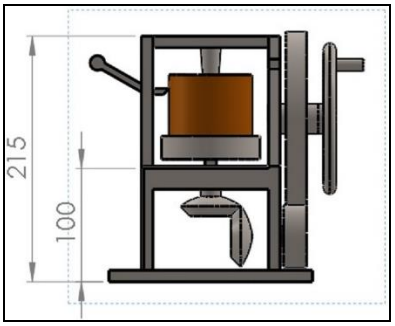
iv. Proses fabrikasi - Projek dibina mengikut rekabentuk akhir melalui proses pemesinan dan kimpalan.
v. Pengujian dan Penambahbaikan - Projek yang dibina telah diuji bagi memastikan kefungsiannya berjalan mengikut spesifikasi yang dirancang. Setiap permasalahan yang timbul dikaji dan ditambahbaik menuju kepada jalan penyelesaian.

3.0 Hasil Projek dan Analisis

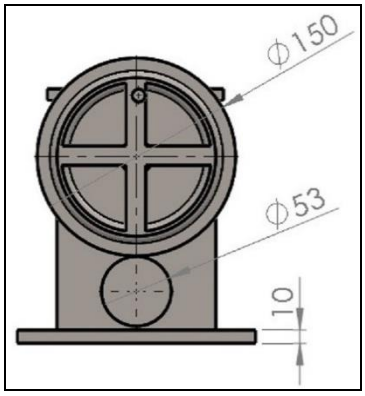
3.1 Rajah Projek



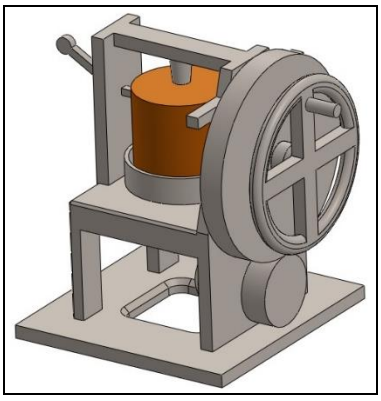
Rajah 1: Pandangan Atas



Rajah 2: Pandangan Depan



Rajah 3: Pandangan Sisi



Rajah 4: Pandangan Isometrik

3.2 Operasi Projek

3.2.1 Sebelum

i. Masukkan penapis minyak ke tapak pemegang bawah.
ii. Pastikan lubang penapis minyak menghala ke atas.
iii. Pastikan pemegang atas selaras dengan lubang oil filter.
iv. Tutup pemegang atas dan kunci.

3.2.2 Semasa

i. Pusingkan tombol mengikut arah jam dan kekalkan kelajuan pusingan.
ii. Tekan tuil mata pemotong ke bawah.
iii. Tekan perlahan-lahan sehingga penapis minyak dipotong sepenuhnya.

3.2.3 Selepas

i. Buka kunci dan pemegang atas.
ii. Tarik keluar penapis minyak yang telah dipotong.
iii. Berhati-hati supaya sisa minyak tidak tertumpah keluar.
iv. Asingkan lebihan sisa minyak dan bahan logam ke dalam bekas yang berlainan.

4.0 Perbincangan

4.1 Fungsi Projek

Oil Filter Scrapper berfungsi sebagai alatan untuk memotong penapis minyak terpakai. Tujuan utama projek ini adalah untuk mengasingkan sisa minyak enjin dan bahan logam dari penapis minyak. Keberkesanan pemotongan oleh *Oil Filter Scrapper* telah diuji dengan beberapa sampel penapis minyak yang berlainan jenis dan saiz. Hasilnya menunjukkan pemotongan pada penapis minyak adalah sempurna, bersih dan kemas.

4.2 Kebaikan dan Potensi Komersial

Alat ini berkemampuan untuk memotong penapis minyak terpakai dengan mudah, pantas dan selamat. Pengguna boleh memotong penapis minyak yang berlainan saiz, jenis dan model. Alatan ini dibina dengan rekabentuk sedemikian dengan mengambil faktor penjimatan tenaga dan teknologi hijau sebagai aspek utama. Selain itu, penghasilan alatan ini yang belum pernah ada di pasaran akan menjadikannya sangat berpotensi untuk dikomersialkan di pasaran tempatan atau global.

4.3 Ciri-ciri Unik dan Keistimewaan Projek

a) Penyelenggaraan yang ringkas.
b) Penjimatan tenaga dan teknologi hijau.
c) Mudah, bersih dan selamat dikendalikan.
d) Alat ganti mudah didapati dalam pasaran.
e) Binaan struktur projek unik, stabil dan tahan lasak.

5.0 Kesimpulan

Projek ini merupakan inovasi baru yang masih belum terdapat di pasaran. *Oil Filter Scrapper* direkabentuk untuk memotong penapis minyak terpakai supaya sisa minyak enjin dan bahan logam penapis minyak dapat diasingkan untuk tujuan kitar semula. Alatan yang sangat bermanfaat ini mudah dikendalikan, bersih dan selamat digunakan. Idea inovasi baru ini diharap mampu membantu pengusaha bengkel kereta kecil dan sederhana (IKS) mengurangkan sisa buangan melalui proses kitar semula.

6.0 Rujukan

[1] Liboiron, Max (2013). Waste as profit & alternative economies. www.discardstudies.com . Blog entry posted on 07/09/2013. Accessed on 11 August 2015.

[2] Peraturan Kualiti Alam Sekeliling (2005). Akta Kualiti Alam Sekeliling 1974 [Akta 127]. P.U. (A) 294/2005. Pindaan terkini P.U. (A) 157/2008.

[3] Smidec. www.smidec.gov.my . Accessed on 10 August 2015.

[4] Wikipedia. https://en.wikipedia.org/wiki/Waste_minimisation . Accessed on 10 August 2015.

M9: Performance Evaluation of R290 Propane Refrigerant at Existing R22 Air Conditioning System: Drop in Case Study

Azman Hussin[1], Sofiuddin Mohamad Isa[1], Ulul Azumi AH[1] & Ferdinand Ng[2]
Centre of Excellence for HVAC Technology, Institut Latihan Perindustrian,
Jalan Pokok Jenerih, 13200 Kepala Batas, Penang[1],
Ener-save Sdn Bhd, Taman Ungku Tun Aminah, 81300 Skudai Johor[2]

azmanhussien@yahoo.com

Abstract

In this study, performance of drop in (replacement) new hydrocarbon refrigerant for replacement of HCFC 22 (R22) used in existing air-conditioners unit was examined. The hydrocarbon refrigerant, R290 propane which is highly flammable under Class A3 was proposed to sup-plement HCFC 22. The system performances are evaluated by measuring the voltage, current, low and high side pressure and temperatures at standard ambient rating condition. The dry bulb temperature of indoor space was set to 24°C and outdoor measured data was 34°C, respectively. The R290 propane was a natural gases and green application which not harmful to the ozone layer and global warming potential. Due to it flammability, safety handling should be well introduced.

Keywords*: Hydrocarbon refrigerant, R290, R22, Performance, Flammability*

1.0 Introduction

There are currently about more than 100 million of hydrochloroflorocarbons (HCFCs) room air conditioners in operation worldwide. This including from residential, office, factory, mosque buildings and etc. Due to higher demand, more than 100 million units are added annually. Each unit contains on average 1.0 kg of refrigerant, mainly HCFC 22 or R22. Since the discovery of the depleting of ozone layer, primarily from the R22 refrigerant that being released during maintenance of air conditioning system, the Montreal Protocol committee has set the phase out the HCFC 22 in different countries and areas [1]. In accordance with Montreal Protocol, Malaysia as a developing country will freeze R22 refrigerant consumption at it level in 2013 and will ban the use of R22 from the year 2015 to 2030 base on percentages value. At present, alternative refrigerants that available for replacement for R22 in residential area can be categorized into two types. First, Hydrofluorocarbons (HFCs) represented by R410A. This refrigerant has a higher working pressure (1.6 times from R22) and consists of two different mixing refrigerant of R32 and R125. It is very difficult to carry out the maintenance for R410A air conditioning system due to it mixing composition. And also, R410A is contributed to global warming potential cause of florin atom.

Second, the use of natural refrigerants as alternatives such as hydrocarbons (HC). HC refrigerant presented by R290 (propane), has an excellent thermal performance and contributed to low greenhouse effect [2]. This refrigerant is a very significant in term of power consumption and less of volume refrigerant charge. The original R22 system can be directly change (drop in) with R290 refrigerant without any modifications or changing the components even though the safety performance is not acceptable. Therefore, the objective of the study was to evaluate the power consumption of both R22 and R290 in split air conditioner, the system performance and safety handling was also investigated.

2.0 Materials & Methods

The drop in case study of R290 refrigerant was been carried out in Canteen building between July and August 2015 at Johor Bahru. An existing R22 refrigerant from 2 units of split air conditioning (Ceiling Cassette) was used in the test. The design data for refrigerant charge is 2.30 kg per system. Each unit have a capacity of 5 horsepower. The power consumption and system performance of existing R22 air conditioner were measured in duration of 1 hour using power data logger (6s/sample data). Afterwards, R22 refrigerant was replaced by R290 propane and the air conditioner power consumption and performance was again measured. The dry bulb temperature of indoor space was set to 24°C and outdoor measured data was 34°C, respectively. The basic procedures and safety practices of drop in the R290 propane refrigerant in the air conditioner system is followed the GIZ Manual [3].

Table 1 describes the comparison of properties of R290 and R22 refrigerant.

Table 1: Properties of R290 and R22 refrigerant

Refrigerant	Chemical type	GWP	ODP	Atmospheric life	Boiling point (Btu/lb)	Oil
R22	HCFC (Hydrochlorofluorocarbon)	1800	0.05	12 years	101	Mineral
R290	HC (Hydrocarbon)	3	0	<1 year	186	Both

COP will be calculate using equation:

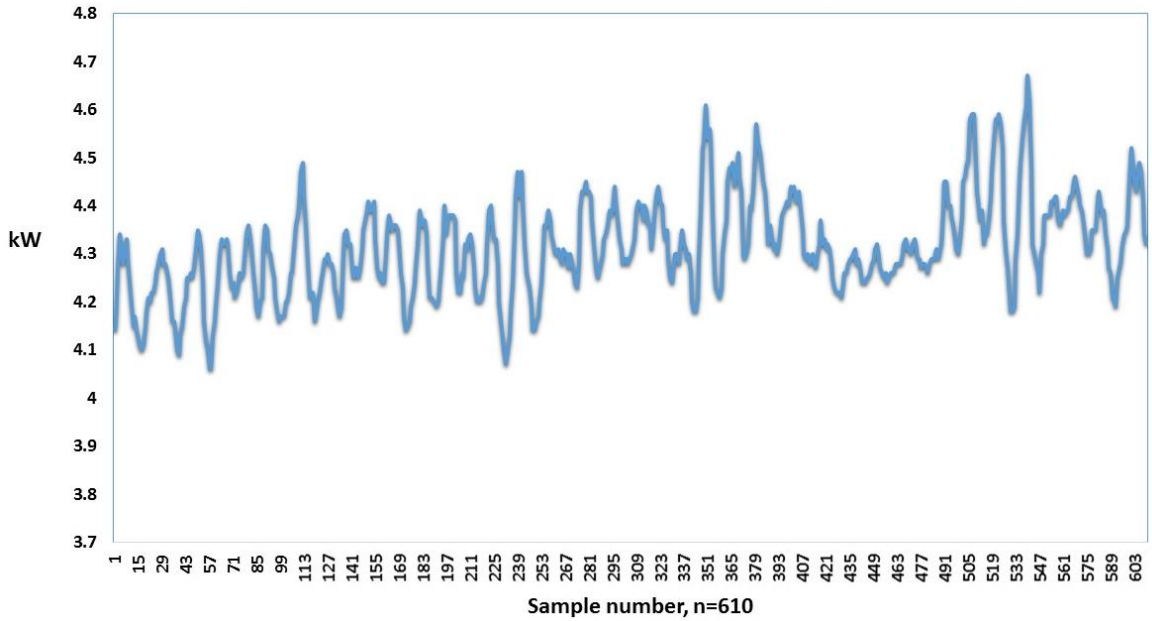
$$COP = \frac{\left(\frac{12}{\text{Specific power}}\right)}{3.412}$$

Where: Specific power, kW/ton

3.0 Results And Discussions

Figure 1 and Figure 2 showed the power consumption usage for data measured, n=2 for both R22 and R290 refrigerant. The average of R22 system operation was found to be slightly higher (4.17 kW) than R290 refrigerant (3.5 kW). It was clearly indicates that R290 systems operates more efficient when compared to R22 and the machine consumed less energy in duration of 1 hour.

Running data 3600 s.



Average power: 4.17 kW

Figure 1: Power consumption measured for R22 system

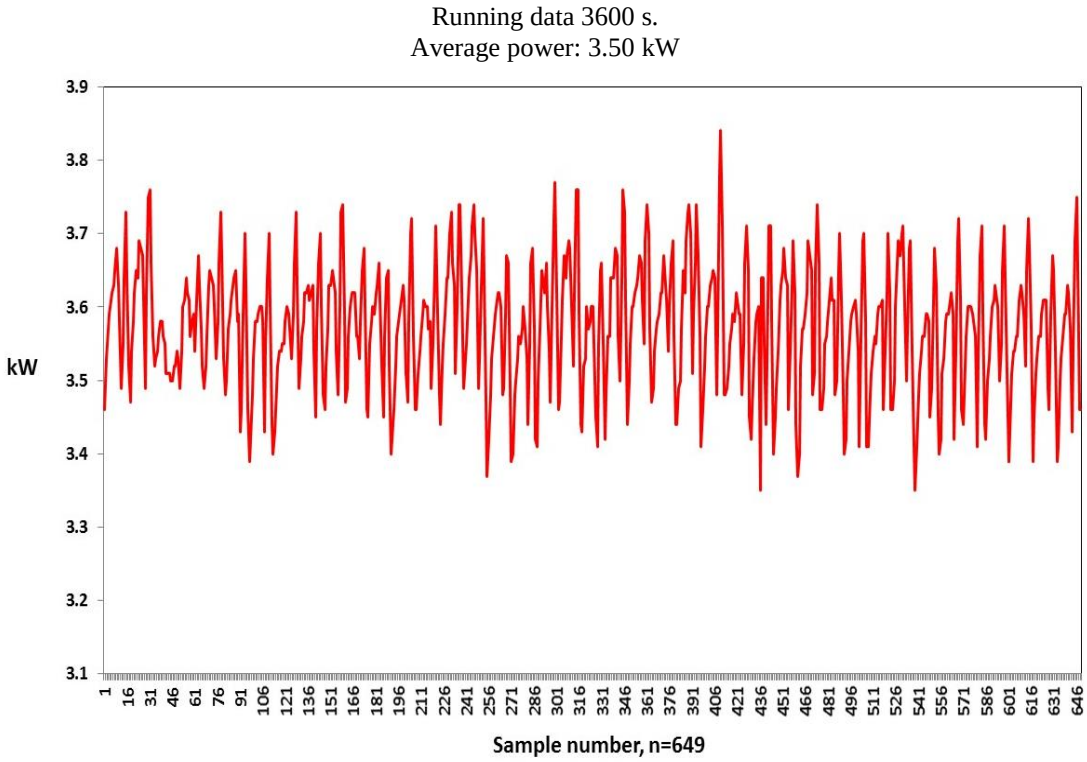


Figure 2: Power consumption measured for R290 system

Table 2 shows the comparison of data measured, n=2 for both R22 and R290 refrigerant. The refrigerant charged found to be less about 1.07 kg. This can save the volume of charge of R290 when compared to R22. Furthermore, the on coil and off coil air temperature were slightly increased for R290 system with 1.15 ^{o}C and 0.55 ^{o}C, respectively. The cooling coil temperature for R290 system also found slightly higher, 0.6 ^{o}C. The coefficient of performance (COP) indicated R290 system work very efficient, increasing about 0.9. Meanwhile, the power consumption saving when used the R290 refrigerant was 0.68 kW. This gives advantages to compressor that works less energy to compress the refrigerant. The similar report from Rahman et al [4] which indicated that R290 can easily be compressed compared to R22 refrigerant during operation.

Table 2: Comparison data measured (n=2) for both R22 and R290 refrigerant

Descriptions	R22	R290	Diff
Refrigerant Weight (kg)	2.49	1.43	-1.07
Air Intake Temp (On Coil), ^{o}C	22.65	23.80	1.15
Air Outlet Temp (Off-Coil), ^{o}C	12.95	13.50	0.55
Cooling Coil Differential Temp, ^{o}C	9.70	10.30	0.60
Estimated Cooling Capacity, Tons	3.98	4.23	0.25
Specific Power, kW/Tons	1.05	0.83	0.22
Coefficient of Performance, COP	3.35	4.25	0.90
Room Temperature (^{o}C)	24.00	24.00	-
Low Side Pressure (Psig)	60	59	-1
High Side Pressure (Psig)	227	180	-47
Average hourly Power Consumption (kW)	4.17	3.50	-0.68

The step of safety handling involved during practicing drop in R290 refrigerant at existing R22 system was listed below in Table 3.

Table 3: Working procedures and instruction for safe handling R290 refrigerant

Working procedures	Instructions
Step 1	Obtain current charge size R22. Unit suitable to be convert to R290 (Occupancies)
Step 2	Estimate equivalent HC charge-Use conversion graph R22 to R290
Step 3	Check the maximum charge limit
Step 4	Check all tools with working area safe
Step 5	Power supply and electrical source fully disconnected.
Step 6	Eliminate all mechanical joint from occupied spaces
Step 7	Confirm all potential source of ignition was fully eliminated
Step 8	Put temporary flammable zone at drop in working area
Step 9	Apply relevant system marking with warning sign
Step 10	Carryout leak test using HC leak detector

4.0 Conclusion

The performance of R290 refrigerant have better COP when compared to R22 refrigerant. The drop in of R290 refrigerant in existing R22 system reduce energy consumption (kW) up to 16.3 %. In addition to that, the amount of refrigerant required by R290 is relatively half (42.6%) of that required by R22 refrigerant. Thus, the compressor requires less energy to compress the refrigerant which in turn increases the life span of the compressor. The flammability of R290 need to be handle with extra care and suggested to develop a competent person with certified certificate in near future.

5.0 Acknowledgement

We are gratefully acknowledgement to Mr Ferdinand Ng from Ener-save Sdn Bhd and En Zamzuri Bin Hassan, Director of ILP Kepala Batas for continuous supports and permission during conducted the study.

6.0 References

[1] Lee YS, Su CC. (2004) Experimental studies of isobutane (R600a) as the refrigerant in domestic refrigeration system. Appl. Thermal. Eng.(22): 507–19.

[2] J. Ching-Song, T. Chen-Ching, W. Wei-Ru, 2009. Efficiency analysis of home refrigerators by replacing
hydrocarbon refrigerants, *Measurement*, (42): 697-701

[3] GIZ Manual (2011) Operation of split air conditioning systems with hydrocarbon refrigerant, Program Proklima Germany

[4] M. M. Rahman and H. Y. Rahman (2012) Hydrocarbon as refrigerant for domestic air conditioner: a comparative study between R22 and R290 *Elixir Thermal Engg. (53) 1976-1979*

M10: The Effect of Storage on Some Fresh-Cut Fruits in Controlled Cooling Temperature and Ice Cubes

Azman Hussin[1], Sofiuddin Mohamad Isa[2], Ulul Azumi Abdul Hamid[3], Abdul Rani Shariff[4], Noel Rossmi Abdul Jabbar[5], Mohamad Firdaus Mohmad[6] & Azrol Omar[7]
Centre of Excellence for HVAC Technology, Institut Latihan Perindustrian
Jalan Pokok Jenerih, 13200 Kepala Batas, Penang

azmanhussien@yahoo.com

Abstract

This paper present the effect of storage on some fresh-cut fruits that was stored in the cabinet filled with ice cubes. Meanwhile, a new invention prototype of cooling system was been developed to storage the fresh-cut fruits at control temperature in similar cabinet. Selected fresh-cut fruits such as watermelon and papaya were been tested and stored for up to 1 day. The post cutting life based on visual appearance was shorter than 1 days for all fresh-cut fruits that storage with ice cubes. On the other hand, fresh-cut fruits were still marketable after a day at control temperature of 10-15°C. Sensory result was carryout at day time starting from 8.00 am to 6.00 pm. Result from 10 trained panels shows that high water contents of fresh-cut fruits in control temperature of 10-15° were free from damages and can maintain the freshness throughout the day.

Keywords: *Fresh-cut fruits, Ices cube, Control temperature.*

1.0 Introduction

There has been increasing demand for fresh slice fruits mainly due to convenience as ready-to-eat products as well as health benefits associated with their consumption (Martin et al, 2002). A major benefit of from the higher intake of fruits may be the increased consumption of vitamins such as vitamin C, vitamin A and vitamin B6. Slice fruits are still under study because of the difficulties in preserving their fresh-like quality during prolong period (Soliva & Martin, 2003). Therefore, the processing and storage of the slice fruits was influence to be considered in order to maintain the freshness, colour, water loss and taste (Akaninwor, et al., 2005). Interest on the part of consumers and producers has encourage the researchers to find source for maintained the fresh-cut fruits after processing without physical damage and extended storage duration. In currently practices, the fresh slice fruits were stored in the cabinet which has been filled with ice cubes (Figure 1). But this method was seen to be more costly, high percentages of damage and cannot storage in a long period. The daily cost to maintain ice cubes in the storage container is up to RM150 per month. Therefore, the objective of the study is to examine if fresh-cut fruits maintain their quality when both are held for up to 8 hour storage at two different types of storage condition.

Figure 1: Existing fresh-cut fruit storage in the market

2.0 Material and Methods

2.1 New Storage apparatus:

The storage of fresh-cut fruit was design and develop as in Figure 2. The cabinet temperature was controlled in between 10 to 15 °C (Azman Hussin, 2010) by a controller Elliwel 976. The circulation of cool air in the cabinet is produces by 12V ventilation fan. The basic components of refrigeration system was been used and jointed in one single piping system. The power source is directly by 240V and can be switching with 12VDC battery in case no power supply is available.

2.2 Existing storage apparatus:

The existing storage fresh-cut fruit using ice cubes to maintain indoor cabinet temperature was also been used. The cabinet temperature was not controlled as well as no air circulation. The probe temperature connected to Fluke digital thermometer was been used to monitor the cabinet temperature.

2.3 Plant material:

Two local fruits such as Watermelon and Papaya were acquired on the sampling day. This two fruit was chosen due to higher water contents and easily to damage when not proper storage. All fruits used were obtained in November 2014. Fruits were storage at 10 to 15 °C in new storage apparatus after cutting as a fresh-cut fruit. Meanwhile, the normal storage apparatus (filled with ice cubes) was also been used for storage fresh-cut fruit. The storage condition was been observed and recorded in term of cabinet temperature, relative humidity and the outdoor ambient temperature.

2.4 Sensory:

The sensory method was apply to check the colour, percentage of water loss and the taste. Sensory result was carryout at day time starting from 8.00 am to 6.00 pm with a number of 10 trained panels.

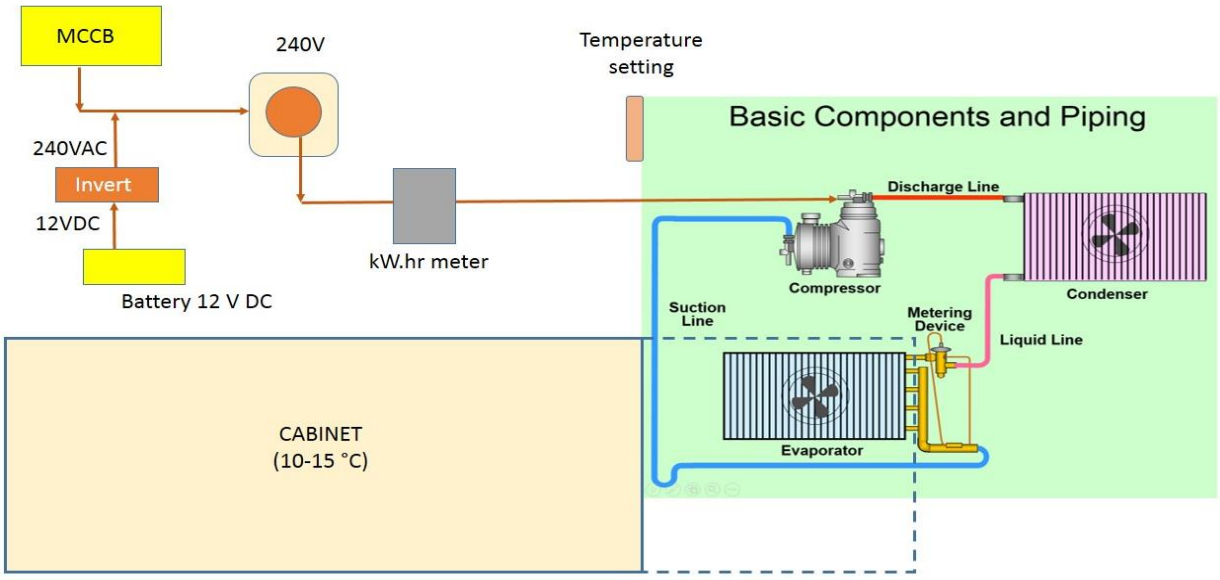


Figure 2: Block diagram of new fresh-cut fruit storage

3.0 Results and Discussions

The completed new storage apparatus for fresh-cut fruits was showed in Figure 3. This including the display cabinet, the evaporator, thermostat to control the cabinet temperature, the condenser, the compressor and the power supply system.

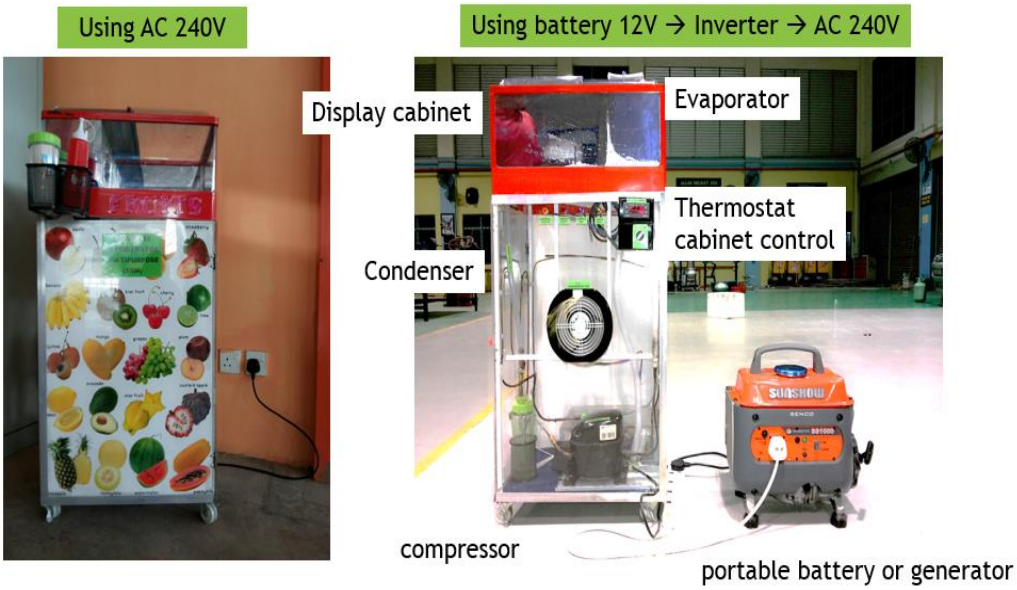


Figure 3: Photo of completed system of new storage apparatus for fresh-cut fruits

Figure 4 shows the cabinet temperature measured between new storage apparatus for fresh-cut fruits, existing filled with ices cube and outdoor temperature. It clearly indicated that the innovation apparatus work with control and constant temperature. The indoor cabinet was maintain it temperature within the setting limit (10 °C). At the other hand, the existing cabinet filled with ice cubes was slightly cool at beginning storage period but slightly increased the temperature, almost parallel with the outdoor temperature. This condition observed due to melting of ice cubes which cause the temperature rise.

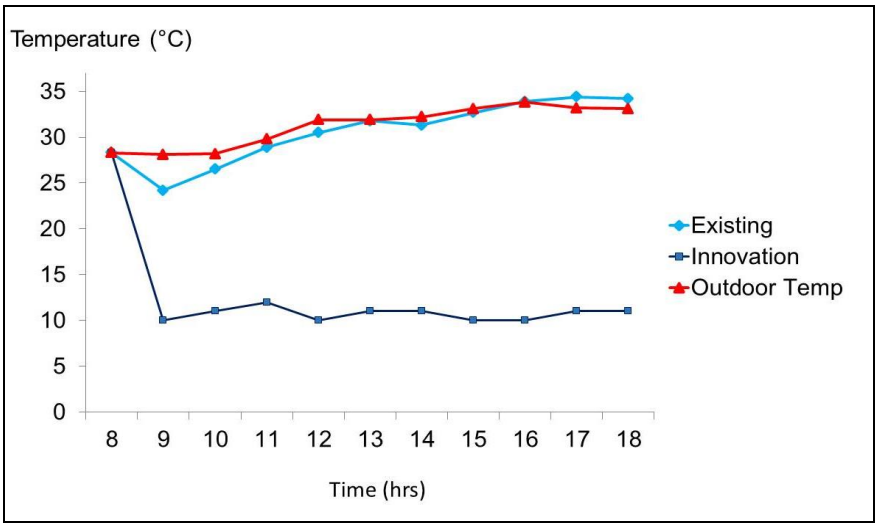


Figure 4: Cabinet temperature measured between new storage apparatus for fresh-cut fruits, existing filled with ices cube and outdoor temperature

Figure 5 shows the percentage of relative humidity measured between new storage apparatus for fresh-cut fruits and existing filled with ices cube. The apparatus removed about half of the moisture contents from the ambient storage when compared to existing cabinet.

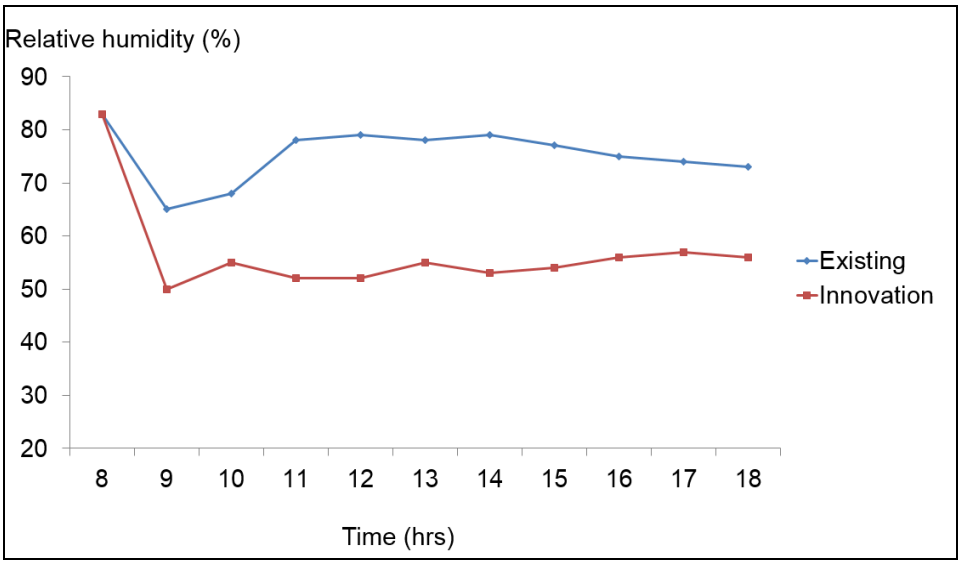


Figure 5: Cabinet relative humidity measured between new storage apparatus for fresh-cut fruits and existing filled with ices cube

Table 1 and Table 2 shows the sensory results between watermelon and papaya at 8 hours storage condition. The fresh-cut fruits was changes in colour, having a water losses and difference taste when compared with the new apparatus cabinet.

Table 1 : Sensory between watermelon and papaya in existing cabinet filled with ice cubes

Existing

Testing Time	Fresh slice Watermelon sensory results			Fresh slice Papaya sensory results		
	Color=red	% Water loss	Taste	Color=orange	% Water loss	Taste
Initial (8)	Red	0	Sweet	Orange	0	Sweet
9	Red	0	Sweet	Orange	0	Sweet
12	Red	6.7	Sweet	Orange	6.7	Sweet
15	Light dark red	6.7	Slightly sour	light dark orange	6.7	Slightly sour
18	Light dark red	6.7	Sour	light dark orange	6.7	Sour

Table 2: Sensory between watermelon and papaya in new storage apparatus

Innovation

Testing Time	Fresh slice Watermelon sensory results			Fresh slice Papaya sensory results		
	Color=red	% Water loss	Taste	Color=orange	% Water loss	Taste
Initial (8)	Red	0	Sweet	Orange	0	Sweet
9	Red	0	Sweet	Orange	0	Sweet
12	Red	0	Sweet	Orange	0	Sweet
15	Red	0	Sweet	Orange	0	Sweet
18	Red	0	Sweet	Orange	0	Sweet

4.0 Conclusion

It thus implies that storage of fresh-cut fruits can be made longer and maintain it quality in a control storage temperature (10 to 15 °C) than in ice cubes. Therefore, the saving cost is RM150 per month.

5.0 Acknowledgement

We are gratefully acknowledgement to En Zamzuri Bin Hassan, Director of ILP Kepala Batas for continuous supports and permission during conducted the study.

6.0 References

[1] Akaninwor, J.O & Sodje, (2005). The effect of storage on the nutrient composition of some Nigerian Foodstudds Banana and Plantain. J.Appl.Sciences.Environ.Mgt. Vol 9(3), pp 9-11.

[2] Azman Hussin, (2010). Peti ajainb di sudut dapur. Dewan Kosmik. Majalah Sains Dan Teknologi Dewan Bahasa Dan Pustaka Oktober pp 28-29, ISSN 0128-6579.

[3] Martin, A. Cherubini, A. Andres-Lacueva, C. Paniagua, M.Joseph, J. A. (2002). Effects of fruits and vegetables on levels of vitamins E and C in the brain and their association with cognitive performance. *J. Nutr. Health Aging 6*, pp: 392-404.

[4] Soliva-Fortuny, R. C.; Martı´n- Belloso, O. (2003). New advances in extending the shelf-life of fresh-cut fruits: a review. *Trends Food Sci. Technol*. *14*, pp: 341-353.

M11: Application of Solar Photovoltaic (PV) to Drive The Air Conditioning System at Residential House: A Preliminary Case Study

Azman H.[1], Sofiuddin M. I.[2], Noel Rossmi A.J[3], Koh S. K.[4], Zaid Kh S.[5], Farish. M[6]
Centre of Excellence for HVAC Technology[1], Institut Latihan Perindustrian
Jalan Pokok Jenerih, 13200 Kepala Batas, Penang[2], Koolman International (M) Sdn Bhd, Jalan Teluk Datuk
Taman Alam Megah, 40400 Shah Alam Selangor[3]

azmanhussien@yahoo.com, noel@gmail.com, farish@jtm.gov.my

Abstract

Synchronize of cooling loads with solar radiation intensity is an important advantage when introduce solar energy in cooling or air conditioning in residential buildings. Practical experience confirms that appropriate design of these systems can achieve good results to use solar energy in air conditioning projects if they compared with conventional systems. In this study, new application of a hybrid solar photovoltaic (PV) collector which produce electricity and drives the 1.5 horsepower room air conditioner is investigated. The air conditioner consists of compressor, fan and blower motor are driven by the collector in VDC current. To achieve this goal, practical performance test were been collected and compared.

Keywords*: Solar PV, Air conditioning, VDC current*

1.0 Introduction

Development of green technology worldwide has given opportunity to reduce the ozone-layer depleting substances (Aldy & Stavins, 2008). Besides, the problems occur associated with the burning of carbon-based energy sources are also eliminated (Berry & Jaccard, 2001). There is a potential green technologies application alternatively to the current technologies. The most potential alternatives are the solar photovoltaic (PV) technologies. This application can be a feeder to generate the power to drive the appliance product such as air conditioning system (Fong et al, 2010).

A hybrid solar PV air conditioning system is a solar PV system to generate energy that capture from sun and combined with power source feed from Tenaga Nasional Berhad (TNB. This energy is need to drive the air conditioning system. The hybrid system give advantages when the system operates which can switching the energy feed either from solar or from TNB supply. This system is estimated can reduced the energy consumption from TNB source which too costly for air conditioning applications. In hot and humid climates, the theoretical study found that the hybrid system is an excellent alternative to conventional systems. The objective of the present work is to investigate the performance characteristics of air conditioning system when used a hybrid solar PV integrated with 240V voltage at day time.

2.0 Materials and Methods

Figure 1 illustrates the model study to investigate the performance characteristics of air conditioning system that used the hybrid solar PV system and 240V supply TNB at day time. A 200 ft^2 container was used to run the system and analysis the performance. The solar PV hybrid air conditioning system and working principles also indicated in Figure 1. The basic refrigeration cycle contained the compressor, condenser, outdoor propeller fan and fan motor, evaporator, indoor fan and fan motor, with standard design of 1.5 horse power cooling capacity. Solar PV collector (1m x 0.6m x 2 units) was used to capture the energy from sun. The controller and converter were used to change the equipment power from alternating current (AC) to direct current (DC). In this study, the overall unit performance was evaluated at specific point such as;

Point 1 – Outdoor ambient temperature (OAT)
Point 2 – Return air temperature (RAT)
Point 3 – Off coil air temperature (OFAT)
Point 4 – Supply air temperature (SAT)

Psychometric chart no.1 (ASHRAE Chart no.1-sea level 101.3 kPa) was used to determine the properties of air and energy produced when the system operated. The solved the energy equation, basic equations from ASHRAE Handbook (1999) was used.

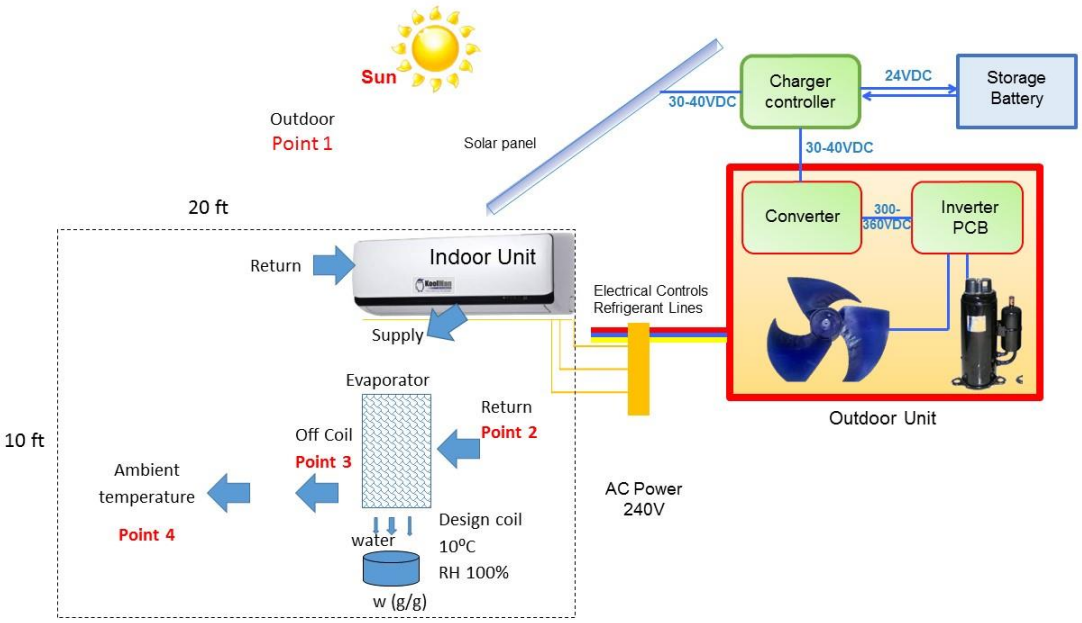


Figure 1: Model study and solar hybrid system working principles

3.0 Results and Discussions

Figure 2 showed the power consumption collected from the solar PV charger controller, n=4 days. The average power produced when the system operated was found around 650 W/days. This result effected due to climatic condition on the test day.

Figure 2: Power consumption calculated from solar PV charger controller

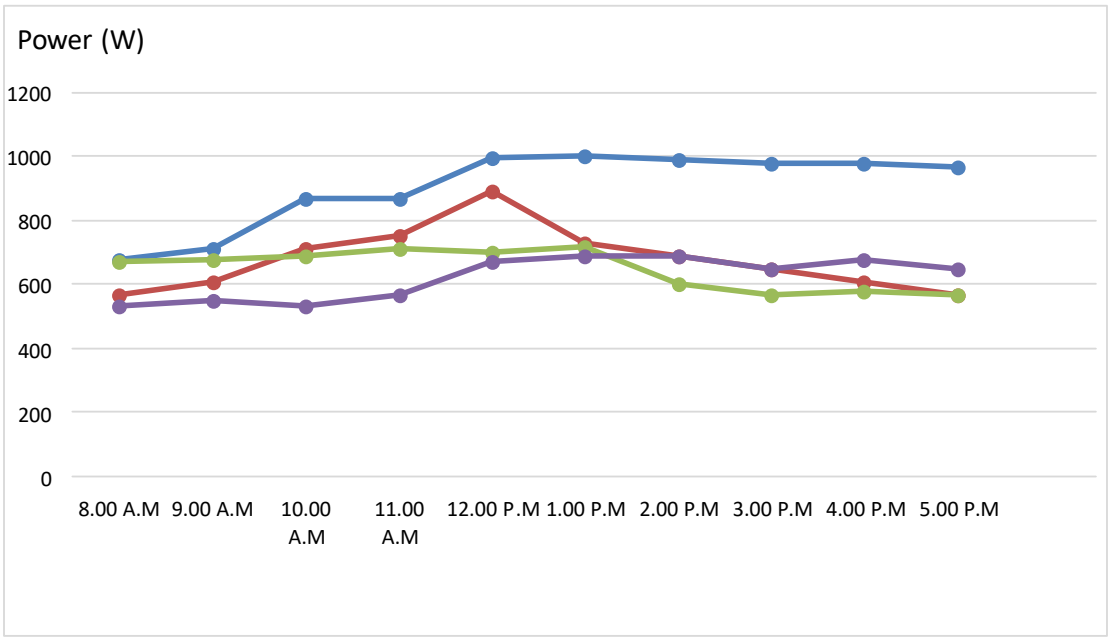


Table 1 shows the cooling energy (enthalpy) produced from the solar PV hybrid air conditioning system using ASHRAE psychometric chart no.1. The outdoor climatic gave impact to container at 110 kJ/kg. Meanwhile, the energy generated to achieve indoor ambient temperature (24 ºC) is 74 kJ/kg. Furthermore, the difference of energy from cooling process is 21 kJ/kg, from the return ambient air of the system (95 kJ/kg).

Table 1: Cooling energy (Enthalpy) produced from Solar PV hybrid

POINT	DRY BULB (ºC)	RH (%)	ENTHALPY (kJ/kg)
Point 1	34	66	110
Point 2	29	76	95
Point 3	15	90	56
Point 4	24	69	74

The outdoor ambient air temperature was recorded slightly high (34 ºC). This condition basically produced a warm and high radiant temperature condition inside the container. Return air temperature is 28 ºC and the off coil temperature is 14 ºC. The indoor ambient temperature is 24 ºC. The design specification of system is 3.285 kW (1.5 hp). The result shows that the power consumption generated for cooling process is 2.86 kW. Therefore, the solar PV hybrid air conditioning system saved 15 % of energy at 24 ºC indoor ambient temperature.

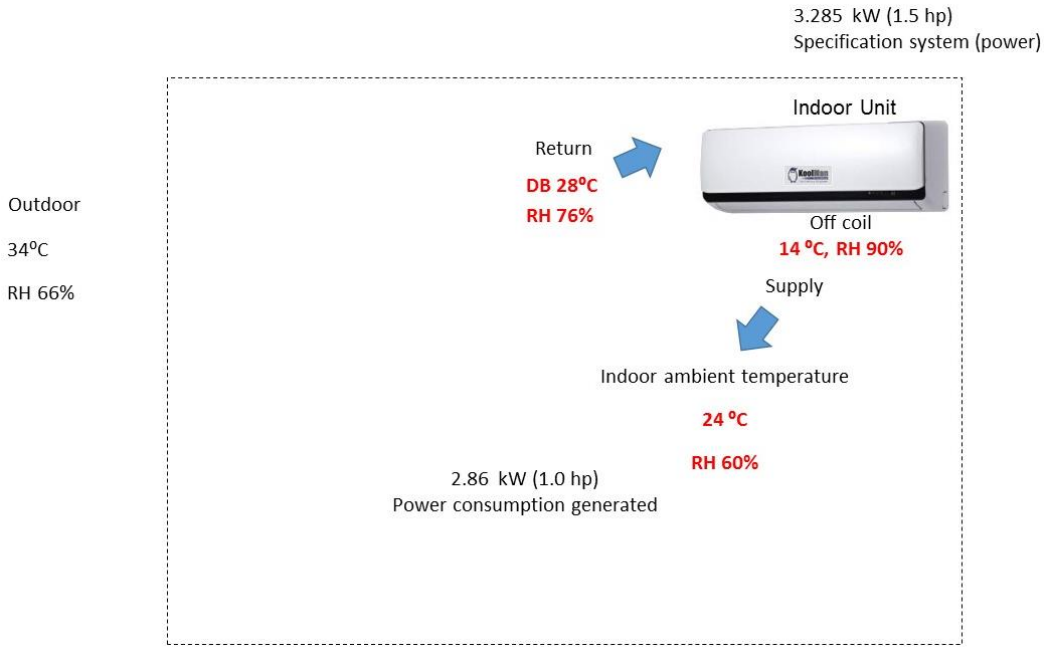


Figure 3: Overall performance result of model study

Figure 4 indicated the comparison of cost per month between normal air conditioning from AC 204V and solar PV hybrid system. The normal system estimated cost is RM52.25 and solar PV hybrid conditioning system is RM25.240. Thus, the saving cost per month is RM 27.00 when solar PV hybrid is used.

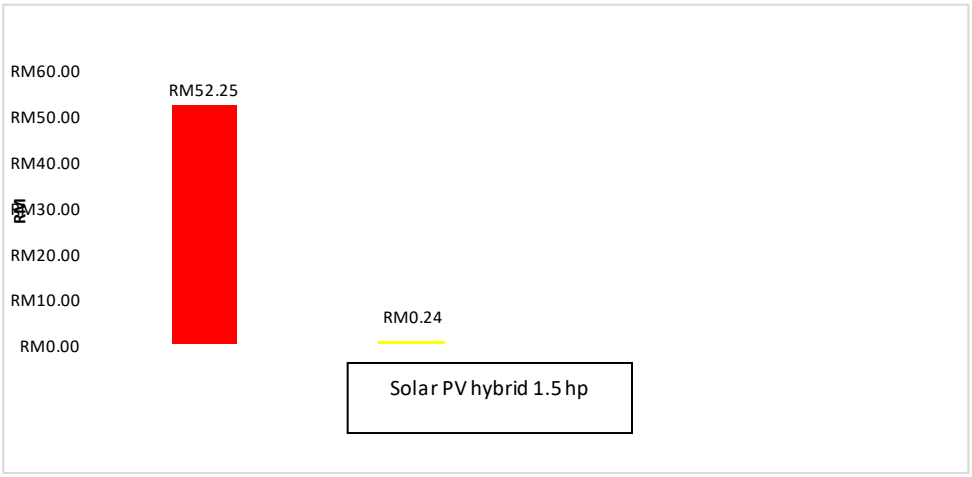


Figure 4: Comparison electrical cost per month

4.0 Conclusion

The combined solar PV hybrid with AC 240V was developed and initially tested. The system can be operated at daytime. The performance of the system was good and much better when compared to normal system. The system is preliminarily tested but will be subject for full investigation for commercialize near future. The energy saving of hybrid system is more than 50 % from the normal product.

5.0 Acknowledgement

We are gratefully acknowledgement to Mr Koh Siew Kiang, CEO from Koolman International (M) Sdn Bhd and En Zamzuri Bin Hassan, Director of ILP Kepala Batas for continuous supports and permission during conducted the study.

6.0 References

[1] Ashrae, (1999). Handbook of Fundamentals. *American Society of Heating, Refrigerating and Air-conditioning Engineers*, Atlanta, USA.

[2] Aldy, J.E., Stavins, R.N., (2008). Climate policy architectures for the post kyoto world. E*nvironment* 50 (3), 6–17.

[3] Berry, T., Jaccard, M., (2001). The renewable portfolio standard: design considerations and an implementation survey. *Energy Policy* 29 (4), 263–277.

[4] K.F Fong, T.T Chow, C.K Lee, Z Lin, L.S Chan (2010). Comparative study of different solar cooling systems for buildings in subtropical city, *Solar Energy* 84 (2) 227–244.

M12: Minimization of Spent Acid Waste from Galvanizing Plant in Malaysia

Nalienaa Muthu[1] and Faieza Abdul Aziz[2]
Institut Latihan Perindustrian (ILP) Pedas, Negeri Sembilan[1]
Department of Mechanical and Manufacturing Engineering, Faculty of Engineering
Universiti Putra Malaysia[2]

nalienaa@gmail.com[1] and dr.faieza.upm@gmail.com[2]

Abstract

Hydrochloric acid is used as pickling acid in galvanizing industry to remove rust from steel. Usage of this acid incurs high expenditure cost when it is disposed as scheduled waste. The importance of this study is to come up with a better way to minimize the cost being spent for hydrochloric acid disposal by optimizing and extending the life span of the hydrochloric acid. The methodology used in this project is by conducting experiment of regeneration of Hydrochloric acid using Kleingarn acid management system, collecting experiment data and calculating the short and long term cost reduction that can be achieved. The results obtained through experimentation shows that acid purchase time has been successfully extended; which in return helps to reduce the fresh hydrochloric acid purchase frequency. Implementation of Kleingarn acid management system helped the acid dumping frequency to be extended. This is a positive result because extension of the acid disposal time also means that lesser spent acid waste are being produced and lesser hazardous waste will be disposed in the future.

Keywords: *Galvanizing, hydrochloric acid, Kleingarn acid management system*

1.0 Introduction

Corrosion is a natural process of degradation caused by chemical reaction between steel which comes in contact with the environment or abrasive effects between steel and other material. Rusting is the most common and economically destructive form of corrosion. Potential damage that can be caused by corrosion is degradation of structures, machines, and containers. There are many approaches to protect steel from corrosion which can indirectly avoid damages caused by corrosion (Sastri, 2007).

Hot dip galvanizing process prevents corrosion of steel by providing a tough, durable barrier coating of metallic zinc which completely seals the steel from corrosive environment (Chandler, 1985). One of the main steps involved in galvanizing process would be removal of rust from the steel using pickling acid. In this project, the pickling acid used is hydrochloric acid because it is more economical and less hazardous. The fresh hydrochloric acid which is bought at certain price need to be disposed as scheduled waste which cost even more than the purchasing price of fresh hydrochloric acid.

The importance of this study is to come up with a better way to minimize the cost being spent for hydrochloric acid disposal. This project uses application of the Kleingarn acid management system to minimize wastage of hydrochloric acid in galvanizing process through optimization of hydrochloric acid. Hydrochloric acid is optimized by recovering the acid value and extending the life span of the hydrochloric acid. Extension of the acids life span helps in reducing the frequency of acid disposal, which in return helps in reducing the cost being spent for hydrochloric acid disposal. Once the strength of hydrochloric acid has been reduced, the hydrochloric acid cannot be reused, it needs to be disposed as schedule waste whereby the disposal cost happens to be more than the initial acid purchase price (McClay, 2007). There are many methods in disposing spent acid wastes, such as containing it in drums and selling it to vendors and disposing the spent acid waste in dedicated waste disposal landfill (Patnaik, 2007).

The main problem that the project concentrates on is minimization of spent acid waste in galvanizing industry. Galvanizing companies are facing the high expenditure cost spent in disposing the hydrochloric acid as scheduled waste. Once the strength of hydrochloric acid has been reduced, the hydrochloric acid cannot be reused and it becomes spent acid. This spent acid needs to be disposed as schedule waste whereby the disposal cost happens to be more than the initial acid purchase price. McClay, (2007); Fresner, (2006) and Steward, (1995) were facing the same problems that the company in galvanizing industry is facing which is the high expenditure cost spent in disposing the hydrochloric acid as scheduled waste.

This study is being conducted to propose an improved waste management system for hydrochloric acid and it can also act as a cost reduction project. The main objectives of this project are to identify feasible method for disposing hydrochloric acid as scheduled waste in a galvanizing company and to implement the Kleingarn acid management system method and test the effectiveness in reducing the waste.

2.0 Hot Dip Galvanizing

The main purpose of galvanizing is to provide a protective coating to steel so that corrosion does not take place. Rusting is the most common and economically destructive form of corrosion (The Effects and Economic Impact of Corrosion, 2000). The process of galvanizing steel with zinc layer helps to form a barrier between steel and other corrosive elements, preventing it from corrosion which can cause dangerous damage. The galvanized steel coating of zinc also has excellent abrasion resistance (Hall, 1963). Hot-dip galvanizing is a form of galvanization. It is the process of coating iron, steel or aluminum with a thin zinc layer, by passing the metal through a molten bath of zinc at a temperature of around 450 °C (Hall, 1963). When exposed to the atmosphere, the pure zinc (Zn) reacts with oxygen (O_2) to form zinc oxide (ZnO), which further reacts with carbon dioxide (CO_2) to form zinc carbonate ($ZnCO_3$) (Volovitch, 2011).

Hot dip Galvanizing process can only be carried out in a galvanizing company and a galvanized material is only available in one color (Graham, 1970). The physical appearance of galvanized steel may vary from one galvanizing company to another due to the difference in additives used in their zinc kettle. However, the physical appearance does not change the initial functionality of galvanized zinc coating, which is to prevent steel from corrosion.

2.1 Pickling Using Hydrochloric Acid

According to Tang (2012), every hot dip galvanizing process involves the steps of preparation and arrangement of untreated steel products, degreasing the steel, cleansing the steel, pickling, washing and cleansing the acid from steel, Pre-Fluxi chemical dipping, Molten Zinc dipping and at last there is the inspection step. Among these steps, the pickling process plays an important role in pre-treatment of the steel surface prior to chemical dipping and molten zinc dipping. Tang (2012) also mentioned that the pickling process is a chemical procedure where the steel is dipped into a tank that contains one of these four acids, namely the sulfuric, nitric, hydrochloric or phosphoric acid solution. Although all of these strong acids can be used as pickling acid, hydrochloric acid is the much preferred acid for pickling process.

During the pickling process, any kind of impurities such as stains, inorganic contamination, rust, surface oxides and other contaminations are removed by a chemical reaction of the surface and the pickling solution. The final result of this pickling process would be that all layers of impurities dissolves as ions into the acid solution (Kittisupakorn, 2005).

The sulfuric, nitric, hydrochloric or phosphoric acid solution can be used for pickling process. Sulfuric acid was widely used by galvanizing companies for a long period of time, however, in recent years sulfuric acid has been replaced by hydrochloric acid for pickling process (Tang, 2012). Although purchasing hydrochloric acid is more expensive compared to purchasing sulfuric acid, but hydrochloric acid tends to be a more preferred type of acid to be used for pickling process due to its waste disposal cost which is cheaper compared to disposing sulfuric acid as scheduled waste. Phosphoric acid is overall more expensive compared to both these acids (Chandler, 1985). Throughout this project, the focus will be on hydrochloric acid which is a commonly used acid in hot dip galvanizing companies in Malaysia for the surface treatment of steel products.

There are many advantages in using hydrochloric acid for pickling process compared with sulfuric acid. These advantages have been discussed by Tang (2012) and in (Surface Preparation of Structural Steel-Part 2 Communication from the Stichting Nederlands Corrosie Centrum). Hydrochloric acid is considered to be the better acid to allow faster cleaning rate at normal temperatures compared to other acids used for pickling process. The galvanizers can attain better quality of galvanized product with complete coating and without visible patches by subjecting their products through the pickling process. Although this is just for visual enhancement, but materials that are not subjected to pickling will not look as attractive as the one that are subjected to pickling process. A complete coating will determine the galvanized materials standard.

2.2 Hydrochloric Acid as Scheduled Waste

The pickling bath is used in hot dip galvanizing process to remove impurities from the surface of steel and produce a clean surface (McLay, 2007). The concentration level and the contamination level of the hydrochloric acid that is used for this process will change and once it reaches an unaccepted level, it need to be disposed or discarded by sending to licensed specialist treatment operators to be neutralized using alkaline waste. This waste product which needs to be disposed is referred to as spent pickle liquor or acid waste. Spent pickle liquor or acid waste is the main source of waste in hot dip galvanizing industry. The corrosive nature and presence of residual acid as well as high metal content are other reasons why spent pickling liquors are considered as hazardous wastes. Treatment of hazardous wastes involves costs and it's a job where regulations and certain rules need to be followed strictly. It cannot be taken for granted as the consequences can be very dangerous.

2.3 Methods for Regeneration of Hydrochloric Acid

Regeneration of spent pickling liquors is a process that involves reduction in the volume of hydrochloric acid wastes to be generated (Tang, 2012). Implementation of regeneration process or any type of a recovery process in hot dip galvanizing industry usually involve some extra investment and it is very important to ensure that skillful operators are deployed to handle the task so that the objective can be achieved. There are many regeneration methods available in galvanizing industry due to the interest shown by the industry owners to develop a better recovery process of waste acid.

2.3.1 Pyrohydrolysis

Agrawal (2009) have discussed on Pyrohydrolysis which is a process where the spent pickle liquor will be thermally decomposed in order to convert the spent pickle liquor back into hydrochloric acid and iron oxide. This process is carried out at a very high temperature plus with water vapor and oxygen. The spent pickle liquor is pumped into a pyrohydrolysers which will convert the Fe_2Cl_2 into components of Fe_3O and hydrochloric acid.

Regeneration of hydrochloric acid using pyrohydrolysis method is usually considered by companies operating in very big scale because this method is considered to be costly, due to the high energy cost involved in the installation and operation of pyrohydrolysers. This method is not environmental friendly due to the corrosive chloride and fluoride salts that exist in the dust emitted by this process. As such, any company that would like to install this system will also need to install dust collection system which will incur more cost (Agrawal, 2009).

2.3.2 Crystallization

According to Brown (2006), initially, regeneration using crystallization method was used for regeneration of waste sulphuric acid. However, in the long run, regeneration using crystallization was also able to be performed for hydrochloric acid waste. The applicability of regeneration using crystallization for hydrochloric acid have been confirmed upon conducting some technical feasibility tests. It was also concluded that multi-stage crystal-lization need to be conducted in a series of CSTR-type crystallizers. The hydrochloric acid waste also needs to go through crystal recycling process in order to yield impurity-free.

This regeneration process via crystallization of ferrous sulphate, which involves a standard technique, does not have a size limitation. The newly regenerated hydrochloric acid might have some impact on the pickling process due to the dead-load of sulfate. This problem can be eliminated by adjusting the conditions of pickling rates to be at least equal to pure hydrochloric acid with an acceptable surface finish. (Magdalena, 2010 and Brown, 2006)

2.3.3 Hydrolytic Precipitation

Based on George (2008), the regeneration of hydrochloric spent pickling liquors using hydrolytic precipitation method involves the process of vapor distillation under evaporative hydrolysis conditions at temperatures as high as 250°C. When there are no other chloride salts present, hydrolytic distillation process proceeds to completion at around 175°C. However, when Magnesium chloride is present, a higher temperature is required for the hydrolytic distillation process be completed.

2.3.4 Solvent Extraction Route

The solvent extraction route method is a popular regeneration method. This regeneration method is preferred because it produces less hazardous byproducts in the process of treating spent pickling liquors. By using the solvent extraction route method $FeCl_2$ and $ZnCl_2$ can be separated from hydrochloric acid. This process can be a little costly compared to the normal disposal of spent pickling liquors. Since this method requires waste water treatment which not all galvanizing company gives priority to, it can incur more cost. The byproduct produced from the regeneration of hydrochloric spent pickling liquors need to go through post-treatment before it can be discarded (Kerney, 1994).

2.3.5 Kleingarn Acid Management System

By adopting this regeneration method, the costs of replacement of the spent pickling liquors with new could be reduced. This method needs less initial investment. Application of Kleingarn acid management system as regeneration method in hot dip galvanizing company helps in reducing waste volume by saving the amount of hydrochloric acid being used. This regeneration method also may ease the recycling of acid wastes (Stocks, 2005). Kleingarn acid management system needs less initial investment and at the same time it helps in reducing spent pickling liquors volume. Regeneration of spent pickling liquor using Kleingarn acid management system can assist in increasing the acid strength and reducing the iron concentration at the same time. Experiments need to be carried out in order to obtain the optimum pickle rate using this regeneration method. This regeneration process can be repeated until the dedicated hydrochloric acid bath tank needs to be emptied for cleaning or repair. Once the dedicated hydrochloric acid bath tank is emptied, fresh solution should be made up using partly spent acid from other tanks plus fresh acid. The regeneration of hydrochloric acid using Kleingarn acid management system has many efficient and ecological advantages.

3.0 Materials and Methods

The problem was identified as need for reduction of the extra cost spent on hydrochloric acid disposal by optimising the hydrochloric acid usage. Project proceeds with the site visit at the galvanizing company to enable to see the overall process including the problem area and to ensure the understanding on the overall process flow. Focus was on the current hydrochloric acid pickling process and the hydrochloric acid waste disposal process. Specifically four methods were proposed to the galvanizing company to decide on applicability upon completion of literature review. After a brief discussion on the most appropriate method that can be applied for regeneration of hydrochloric acid, Kleingarn acid management system was chosen.

This experiment is conducted on one dedicated hydrochloric acid tank. This dedicated tank was used throughout the project experimentation. Next step would be conducting experiment of regeneration of Hydrochloric acid using Kleingarn acid management system to reduce the spent acid waste. The sample size of acid is taken on weekly basis in order to get the hydrochloric acid strength level and to determine the level of iron present in the dedicated tank.

Once the acid sample is taken from the dedicated hydrochloric acid tank, it is sent to the lab in the galvanizing company to test the hydrochloric acid strength level and iron level. This is done to confirm that the hydrochloric acid level and iron level are within the range set by the company. Once it is confirmed that the hydrochloric acid level and iron level are within the range set by the company, project goes ahead and continue with pickling process.

Once the hydrochloric acid strength and the iron content level is tested and found to be within the intended range which is set by the company the galvanizing process will follow the existing process flow. The pickling process will resume as usual. In this case, the pickled product is rinsed in the tank containing water and goes on to zinc bath and finally it is subjected to inspection.

However, if the hydrochloric acid level and iron level are not within the range set by the company, the regeneration of Hydrochloric acid methodology is applied. Fresh hydrochloric acid is added into the dedicated hydrochloric acid tank in order to increase the hydrochloric acid level and reduce the iron level. The amount of fresh hydrochloric acid to be added is determined using the equation as per Kleingarn acid management calculation.

Upon adding the amount of fresh hydrochloric acid, the new acid sample is taken from the dedicated hydrochloric acid tank and sent to the lab in the galvanizing company once again to test the new hydrochloric acid strength level and iron level. This is done to reconfirm that the hydrochloric acid level and iron level are within the range set by the company after adding in fresh hydrochloric acid.

This step is followed by collection of experiment data to validate the reduction rate of spent acid waste. The short and long term cost reductions are calculated by tabulating the experiment data collected for 20 weeks. The experiment data and calculation of cost reduction is being used to answer the second objective of this project which is to test the effectiveness of the chosen method for regeneration of hydrochloric acid.

4.0 Results and Discussion

The regeneration of hydrochloric acid using Kleingarn acid management system was considered to be more feasible and practical method to be applied for disposing hydrochloric acid as scheduled waste in galvanizing company. This is because this method is conducted by topping up the existing hydrochloric acid with fresh hydrochloric acid based on the iron and chloride level. The lab testing to obtain the experiment results incur minimum cost.

4.1 Experiment

This experiment was conducted using hydrochloric acid as the main chemical for steel pickling process. The experiment was conducted for a period of 20 weeks and the sample size of acid was taken on weekly basis. The lab facility in the galvanizing company was utilized to test the hydrochloric acid strength level and to determine the level of iron present in the spent acid waste.

4.1.1 Hydrochloric Acid Bath Tank and Hydrochloric Acid

Firstly, a dedicated hydrochloric acid bath tank was set up. The dedicated acid bath tank functions as per normal in the sense where it was fully utilized for production. The size of the acid bath tank is 6 meters length, 1.6 meters width and 2.0 meters height. The fresh hydrochloric acid that is bought by the company from their vendor is at 34% concentration level. Hydrochloric acid is a strong acid with low PH value; as such the hydrochloric acid cannot be poured into the acid bath tank directly at the concentration level of 34%. The acid bath tank is made of steel and lined with fiber glass, so, using the hydrochloric acid at this level will cause damage to the tank by corroding it due to the hydrochloric acids high level of corrosiveness (Davis, 2000).

That is the reason why the hydrochloric acid is diluted from 34% of acid concentration to 16% of acid concentration. During the dilution process, the acid will be added into water contained in the acid bath tank instead of adding the water into the concentrated hydrochloric acid. This is done in this manner because adding water into concentrated hydrochloric acid can cause strong reaction and may cause acid splash which can be dangerous to the worker who is handling the dilution process (Olmsted, 1997).

Although the acid bath tanks height is 2.0 meter, but the hydrochloric acid solution will not be filled at the height of 2.0 meter. This is because, the hydrochloric acid solution in the acid bath tank needs some room to raise once the steel that needs to be pickled is immersed into the acid bath tank. This is the reason why the total amount of hydrochloric acid diluted in water is set to be at the height of 1.6 meter in the acid bath tank instead of the actual height of the acid bath tank which is 2.0 meter.

4.1.2 Pickling Process

Iron should be present in the acid bath tank in order to help kick off the pickling process and to make the pickling process perform faster. Diluting the hydrochloric acid using the water taken from rinsing tank where there is iron present will help to expedite the pickling process. The optimum level of iron and hydrochloric acid need to be maintained because in case the solubility limit of iron in hydrochloric acid is exceeded then pickling will not take place.

When the pickling process takes place, the iron concentration of the pickle solution will increase in the acid bath tank as the acid strength decreases. Once the iron concentration increases out of the range due to pickling process, the spent pickle solution may be regenerated by the removal of a quantity of the spent acid and the addition of fresh acid.

5.0 Data Collection

The hydrochloric acid sample to be tested which is taken from the dedicated acid bath tank is collected on weekly basis. The specific day to collect the sample was set to be every Wednesday. The reason behind this setting is because the hydrochloric acid strength reductions will not be significant if the sample is taken on daily basis. Taking the sample once a week gives the hydrochloric acid tank sufficient exposure to zinc and other materials due to the continues production for a period of one week. Another reason for taking the sampling in the mid of a week is because by doing the sampling on every Wednesday, the lab testing results can be obtained by the end of the day or latest by the next day which is Thursday and the project can determine the acidic level of the hydrochloric acid in the dedicated tank to decide on the addition of fresh acid. The experiment results have been tabulated into table form and presented below in table 1.

Table 1: Experiment results

HCL TANK 1					
CHEMICALS	HCL (g/L)	Iron (g/L)	Addition Fresh HCL (tonnes)	New level of Hydrochloric acid upon top up (g/L)	New level of iron upon top up (g/L)
Range	90 – 140	60 - 90		90 – 140	60 – 90
MAX	140	90		140	90
MIN	90	60		90	60
Week					
1	135.00	78.00			
2	86.00	93.00	3.73	132.00	78.71
3	118.00	78.00			
4	75.00	91.00	4.11	128.00	77.02
5	129.00	78.00			
6	83.00	94.00	3.84	134.00	79.56
7	80.00	98.00	3.94	126.00	82.94
8	123.00	78.00			
9	83.00	92.00	3.84	127.00	77.86
10	98.00	78.00			
11	87.00	91.00	3.69	131.00	77.02
12	121.00	78.00			
13	96.00	78.00			
14	79.00	95.00	3.97	133.00	80.40
15	103.00	78.00			
16	88.00	92.00	3.66	126.00	77.86
17	104.00	78.00			
18	94.00	78.00			
19	84.00	99.00	3.80	134.00	83.79
20	85.00	91.00	3.76	125.00	77.02

5.1 Results with Acceptable Range Of Hydrochloric Acid Strength

For this project the hydrochloric acid level was maintained at the range of 9% to 14% under normal condition with iron present in the acid bath tank. The iron content level was maintained at the range of 6% to 9% (Hornsby, 1995).

Theoretically the hydrochloric acid solution in the acid bath tank was calculated to achieve 16% of hydrochloric acid concentration; however, the lab test result confirmed that the hydrochloric acid strength was at 13.5% with iron present and the iron content was at 7.8% as per the lab test result noted in week 1. This is because distilled water was not used, whereas rinsing water which already contains certain level of iron chloride was used in the process for diluting the hydrochloric acid. Rinsing water is the water in the tank where the metal which has already gone through pickling process will be rinsed in. Since hydrochloric acid is corrosive, it tends to least corrode the metal immersed in it during pickling process.

Once the pickled metal is dipped into the rinsing tank for washing the metal, elimination process of pickling reaction products takes place. Example of the pickling reaction products are namely iron salts and iron oxides. These pickling reaction products will be stacking in the rinsing water tank (Taylor, 2002). In week 1, the fresh hydrochloric acid was not added to the acid bath tank because both the hydrochloric acid strength and iron content were within the intended range.

Once both the hydrochloric acid strength and the iron content are out of the intended range, the pickle solution needs to be regenerated. This is done by removing a volume of the spent pickle solution and adding it with an equivalent volume of fresh 34% of hydrochloric acid in order to produce a pickle solution with strength of 9% to 14% and iron content at the range of 6% to 9%.

5.2 Results with Low Hydrochloric Acid Strength

Referring to the data obtained from the chemical lab test at week 2, the hydrochloric acid strength and the iron content showed 8.6% and 9.3% each. This value is out of the acceptable range, where the hydrochloric acid strength needs to be within 9% to 14% and iron content needs to be at the range of 6% to 9%.

Since the lab test data shows that the hydrochloric acid strength and the iron content are out of the intended range, certain quantity of pickled acid needs to be removed from the dedicated acid bath tank and replaced with fresh hydrochloric acid at the concentration of 34% to retain the hydrochloric acid strength and to enable the pickling process to take place at normal rate.

Refer to the calculation below for determining the volume of spent pickle solution to be removed and the iron concentration of the regenerated spent pickle waste:

$$Volume\ spent\ pickle\ solution\ = 6m\ \times 1.6m\ \times 1.6m$$
$$Volume\ spent\ pickle\ solution\ = 15.36\ m^3$$
$$Volume\ regenerated\ acid\ = 6m\ \times 1.6m\ \times 1.6m$$
$$Volume\ regenerated\ acid\ = 15.36\ m^3$$
$$Concentration\ of\ spent\ pickle\ solution\ = 8.6\%$$
$$Concentration\ of\ fresh\ acid\ = 34\%$$
$$Concentration\ of\ regenerated\ acid\ = 16\%$$

The volume of spent pickle waste to be removed, r according to Eq. 1:

$$r = [(Concentration\ of\ regenerated\ acid \times Volume\ regenerated\ acid) - (Concentration\ of\ spent\ pickle\ solution \times Volume\ regenerated\ acid)] \div (Concentration\ of\ fresh\ acid\ - Concentration\ of\ spent\ pickle\ solution) \quad (1)$$

$$r = [(16\% \times 15.36m^3) - (8.6\% \times 15.36m^3)] \div (34\% - 8.6\%)$$
$$r = 4.475\ m^3 \div 1.2$$
$$r = 3.73\ tonne$$

To achieve a regenerated solution with a concentration of 16% of hydrochloric acid, 3.73 tonnes of spent pickle waste need to be removed from the acid bath tank and toped up with 3.73 tonnes of fresh 34% of hydrochloric acid. The amount of spent pickle waste that needs to be removed varies from week to week. The average amount of spent acid waste to be removed and topped up is 3.834 tonnes per week. The topping up process did not occur very often. There were weeks when fresh acid top up was not required as in week 1. The iron concentration of the regenerated spent pickle solution; z can be calculated using Eq. 2:

Volume of remaining pickle solution will be = $15.36m^3 - 4.475m^3 = 10.885m^3$

$$z = [(Iron\ concentration\ of\ spent\ pickle\ solution \times Volume\ of\ remaining\ spent\ pickle\ solution) + (Iron\ concentration\ of\ fresh\ acid \times Volume\ of\ fresh\ acid)] \div Volume\ of\ regenerated\ solution \quad (2)$$

$$z = [(90 \times 10.885) + (0 \times 4.475)] \div 15.36$$

$$z = 63.78$$

The newly regenerated solution should contain 63.78 gram/liter of iron. The new regenerated spent acid waste solution therefore should contain 16% of hydrochloric acid strength and about 63.78 gram/liter of iron. These figures are based on the theoretical calculation. The hydrochloric acid strength and iron content in actual galvanizing industry varies due to the presence of other components in the acid bath tank such as iron chloride.

Upon subjecting the regenerated pickle solution to lab test, it was found that the new regenerated spent acid waste contains 13.2% of hydrochloric acid concentration and about 78.71 gram/liter of iron content. Although there are some differences in the theoretical value compared to the actual value, the hydrochloric acid strength and iron content are still within the intended range.

It was also observed during the experimentation that whenever the acid concentration in the hydrochloric acid tank decreases, the iron content will increase. This experiment was started with hydrochloric acid strength at a high side then as the time passes by and production continues, the acid concentration reduces as it converts iron oxides to iron chloride (Peter Maa, 2011). *From the experiment data, it can be noticed that the fresh acid top up process is not done on weekly basis. In average the top up process is done every alternate week.*

5.3 Waste Minimization

The experiment results can be divided into five months. Table 2 displays the comparison between hydrochloric acid usage before and after implementing regeneration of spent acid waste using Kleingarn acid management system.

Table 2: Comparison of hydrochloric acid usage before and after implementing regeneration of spent acid waste using Kleingarn acid management system

Top up per month (consist of 4 weeks)	Usage of hydrochloric acid upon implementing Kleingarn acid management system (tonnes)	Usage of hydrochloric acid by using traditional method (tonnes)	Savings (tonnes)
Month 1	7.84	12.00	4.16
Month 2	7.78	12.00	4.22
Month 3	7.53	12.00	4.47
Month 4	7.63	12.00	4.37
Month 5	7.56	12.00	4.44
Average	**7.67**	**12.00**	**4.33**

It is proven that prior to implementing Kleingarn acid management system, an average of 12.00 tonnes of hydrochloric acid is used in the pickling process. This data was taken by averaging the total amount of hydrochloric acid used for a period of 11 months. Whereas after implementation of Kleingarn acid management system, the average amount of hydrochloric acid used in a month has reduced to 7.67 tonnes.

By comparing the data obtained, we can witness that the project has achieved average savings of 4.33 tonnes of hydrochloric acid per month through implementation of Kleingarn acid management system. Although the fresh hydrochloric acid with 34% of concentration top up process involves some lab testing to be carried out, but the minimization rate of the hydrochloric acid used in a month proofs its worth.

5.3.1 Cost Calculation

Average usage of 12 tonnes of fresh hydrochloric acid for 4 weeks is also equivalent to usage of 3 tonnes of fresh hydrochloric acid per week. Average usage rate of fresh hydrochloric acid through implementation of Kleingarn acid management system is 7.67 tonnes. Once the usage rate is divided into 4 weeks, it is equivalent to 1.9 tonnes per week. Table 3 shows summary of the cost calculation for hydrochloric acid disposal before and after implementing regeneration of acid using Kleingarn acid management system.

Table 3: Cost calculation for hydrochloric acid disposal before and after implementing regeneration of acid using Kleingarn acid management system

For 20 weeks	**Before regeneration method**	**After regeneration method**
Volume of spent acid waste at RM625.00 per tone	12 tonnes per month	7.67 tonnes per month
Treatment time	5 – 10 mins	15 mins
Spent acid waste dump Frequency in weeks	6 weeks once for every 18 tonne	9.5 weeks once for every 18 tonne
Steel Pickled (according to plant capacity)	1000 tonnes	1000 tonnes

Note: 1 tonne = 1000kgs

Currently 18 tonnes of hydrochloric acid is being bought every 6 weeks once to be used as the pickling acid. However, upon implementing the Kleingarn acid management system, 18 tonnes of acid can be bought every 9.5 weeks once. By implementing this regeneration method, the acid purchase time have been extended from 6weeks to 9.5 weeks. As such, the fresh hydrochloric acid with 34% concentration's purchase frequency is reduced because the usage time is extended.

The amount of steel pickled in both cases is maintained at 1000 tonnes so that the comparison will be fair and not affected by any external factors. Disposal of spent acid waste is carried out every 9.5 weeks once for 18 tonnes of acid after implementation of regeneration method.

Implementation of regeneration using Kleingarn acid management system also helps to extend the hydrochloric acid dumping frequency. The hydrochloric acid dumping frequency has been extended from 6 weeks once for every 18 tonnes of spent acid waste to 9.5 weeks once for every 18 tonnes of spent acid waste.

Although the acid dumping frequency has only been extended for 3.5 weeks, in the long run, this value will contribute to a large amount of savings to the environment. This extension is healthy for the environment as lesser hazardous waste will be disposed in the future. Figure 1 helps to illustrate the comparison of volume of spent acid waste and spent acid waste dumping frequency before and after implementing regeneration of spent acid waste using Kleingarn acid management system

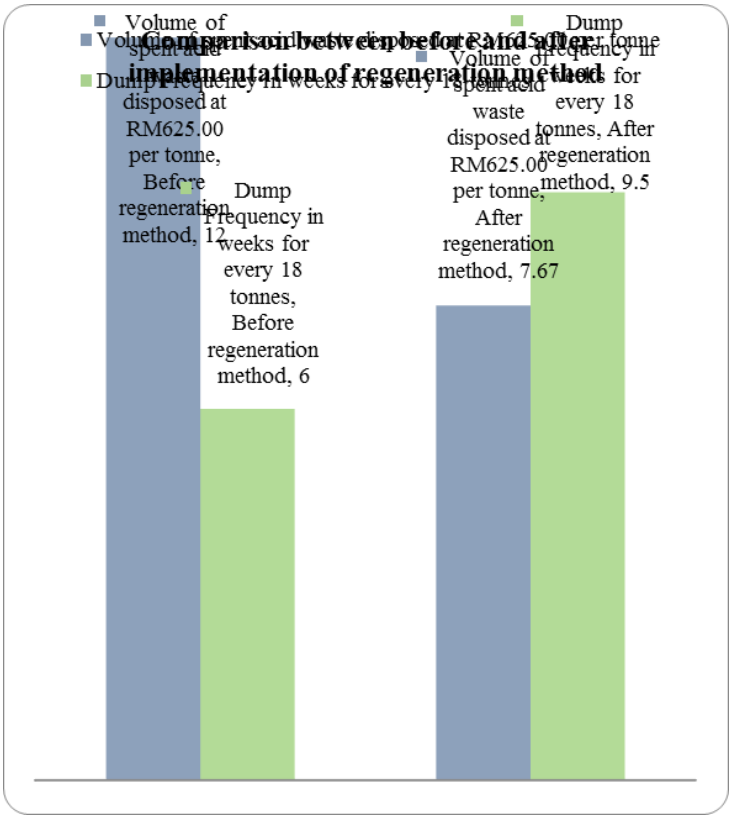


Figure 1: Comparison implementation of regeration method

6.0 Conclusion

The effectiveness of the Kleingarn acid management system in reducing the scheduled waste was proven by extending the acid purchase time and by calculating the savings in monetary value. This project can be used by galvanizing company as a guidance in the process of scheduled waste minimization. Implementation of Kleingarn acid management system has helped to extend the existing acid purchase time from current duration of 6 weeks to a new extended duration of 9.5 weeks. Once the acid purchase time has been extended, the fresh hydrochloric acid purchase frequency can be reduced.

The amount spent for hydrochloric acid disposal as spent acid waste before implementation of regeneration using Kleingarn acid management system came up to RM7500.00 per month. The amount spent for hydrochloric disposal after implementation of regeneration using Kleingarn acid management system came up to RM4750.00 per month. Savings of RM2750.00 per month was observed. This savings is possible for the galvanizing company that implements Kleingarn acid management system to treat their spent acid waste. Although this savings does not look like a large sum, but in the long run, it will save the galvanizing companies a huge chunk of their expense for hydrochloric acid disposal as spent acid waste.

Once acid consumption is reduced, it automatically helps to extend the hydrochloric acid dumping frequency. By implementing Kleingarn acid management system, the acid dumping frequency has been extended from the original 6 week to extra 3.5 weeks. Extending the acid disposal time also means that lesser spent acid waste are being produced. This extension is healthy for the environment as lesser hazardous waste will be disposed in the future.

Application of the Kleingarn acid management system reduces waste volume, saves hydrochloric acid usage rate and increases the company's financial returns. The method used is simple, does not involve high costing and it is practical to be applied by any galvanizing company.

7.0 References

[1] The Effects and Economic Impact of Corrosion, ASM International. Corrosion: Understanding the Basics, (2000).

[2] Volovitch. P, Vu.T.N, Allély.C, Abdel Aal, Ogle.K (2011). Understanding corrosion via corrosion product characterization: II. Role of alloying elements in improving the corrosion resistance of Zn–Al–Mg coatings on steel, 53 page 2437–2445.

[3] Johannes Fresner, Hans Schnitzer, Gernot Gwehenberger, Mikko Planasch, Christoph Brunner, Karin Taferner, Josef Mair (2006). Practical experiences with the implementation of the concept of zero emissions in the surface treatment industry in Austria, Journal of Cleaner Production 15, Page 1228 – 1239.

[4] Graham.A (1970). "Focus on zinc-4: Hot dip galvanizing", Anti-Corrosion Methods and Materials, Vol. 17, 10, page16.

[5] Hall.W.L (1963). "Corrosion Prevention —: Hot-dip galvanizing", Anti-Corrosion Methods and Materials, Vol. 10 Iss: 7, pp.173 – 182.

[6] Bing Tang, Wen Su, Jing Wang, Fenglian Fu, Guojun Yu, Jianyin Zhang (2012). “Minimizing the creation of spent pickling liquors in a pickling process with high-concentration hydrochloric acid solutions: Mechanism and evaluation method”. Journal of Environmental Management 98 (2012), 147-154.

[7] Paisan Kittisupakorn, Pornsiri Kaewpradit. (2003). “Integrated Data Reconciliation with Generic Model Control for the Steel Pickling Process”. Korean J. Chem. Eng., 20(6), 985-991.

[8] Paisan Kittisupakorn, Pantapong Tangteerasunun, Piyanuch Thitiyasook. (2005). “Dynamic Neural Network Modeling for Hydrochloric Acid Recovery Process”. Korean J. Chem. Eng., 22(6), page 813-821.

[9] 1962. "Surface Preparation of Structural Steel-Part 2 Communication from the Stichting Nederlands Corrosie Centrum", Anti-Corrosion Methods and Materials. Vol. 9 Iss: 4, page 104 – 105.

[10] Steward.F.A, Connie Glover Ritzert. (1995). “Waste Minimization and Recovery Technologies”. vol.93. no.1 746-768.

M13: Rekabentuk dan Fabrikasi Sateportwo

Abdul Rahim Md Tahir[1] ,Norman Kusin[2] ,Asziman Sukran[3]
Pusat Latihan Teknologi Tinggi (ADTEC)
Km 8 Jalan Tanjung Laboh Batu Pahat, Johor

aim8439@yahoo.com

Abstrak

Inovasi 'Satay Grill Machine' yang dinamakan SATEPORTWO merupakan penciptaan alat pemanggang satay separa automatik . Sateportwo terdiri dari penghantar yang dipasang bersebelahan dengan burner infra red sebagai pemanas dengan pelbagai peranti lain. Setiap peranti yang dipasang di gunakan untuk memegang lidi satay semasa proses memanggang berlaku. Kadar suhu infra red boleh dilaraskan mengikut kehendak dan keperluan satay yang hendak di bakar . Satay yang siap dipanggang akan jatuh sendiri kebekas tersedia dibantu oleh daya tarikan graviti. Mesin yang berat 36 kg ini boleh beroperasi sehingga lebih 8 jam tanpa henti dan mampu mengeluarkan sehingga 1200 cucuk satay dalam tempoh 1 jam tanpa menggunakan arang dan tidak mengeluarkan asap yang banyak. Inovasi terbaru yang direka khas mengunakan infra red dengan gas sebagai bahan bakar serta DC motor 12v sebagai pemacu serta struktur di perbuat daripada keluli tahan karat "Stainless Steel" grade 304 sesuai untuk produk berasaskan makanan yang berkonsepkan makanan segera bercucuk lidi seperti bebola ikan, udang, serta sangat sesuai bagi pengusaha peniaga Satay di pasar malam, Restoran terbuka, dan aktiviti BBQ.

Keyword : *Mesin Gril Satay, Makanan Segera, Gril Satay.elem Pemanas.*

1.0 Pengenalan

Satay adalah makanan paling terkenal di Malaysia. Kebiasaannya satay ini di makan dengan kuah kacang, ketupat , timun dan bawang. Terdapat pelbagai jenis satay iaitu satay ayam, satay kambing, satay lembu, satay rusa, satay arnab satay perut dan pelbagai jenis lagi. Pemakanan satay di Malaysia telah berkembang di seluruh negara dan di gemari oleh pelbagai kaum. Dari segi pemasarannya, ia boleh didapati di pasar-pasar malam, di kedai-kedai makan dan di restoran yang khusus penjualan satay seperti Satay Kajang. Satay ini di gril melalui kaedah tradisional dengan menggunakan arang kayu sebagai bahan pembakar, terdapat pelbagai masalah yang di hadapi antaranya ialah:-

i. Tempat menggril satay sangat kompleks dan sukar untuk mengekalkan suhu dan sukar untuk mengekalkan kebersihan satay yang di gril.
ii. Melalui kaedah menggril tradisional menggunakan api arang, satay perlu di terbalikkan secara manual untuk mengelakkan menggril tidak sekata.
iii. Keadaan tidak bersih daripada asap dan abu dari bara api yang terbang ke daging satay ketika pengendali menyemarakkan api dengan kipas tangan untuk membuat arang dibakar lebih kuat dan memberi kesan bahang panas kepada individu yang terlibat.
iv. Kaedah ini tidak sesuai untuk premis perkhidmatan makanan tertutup kerana asap yang berlebihan dikeluarkan dari proses menggril.
v. Satay yang di hasilkan akan terbakar dan terdapat kesan karbon (arang) pada satay dan boleh menjejaskan kesihatan.

Jika di perhalusi konsep gril satay secara tradisional (Gambar 1) mendatangkan beberapa masalah antaranya asap yang banyak semasa operasi yang mana sangat tidak sesuai untuk beroperasi di tempat yang tertutup selain memerlukan kemahiran untuk menggril bagi memastikan satay di gril dengan sempurna. Masalah kebersihan juga amat ketara apabila menggril satay dengan cara tradisional kerana di gril di atas tempat yang tercemar dengan kotoran dan kebarangkalian berlakunya keracunan makanan di samping kesan karbon pada satay yang di bakar akan membawa kepada masalah kanser. Kemungkinan kemalangan boleh berlaku yang menyebabkan berlakunya kecederaan contohnya melecur dan terbakar di sebabkan bahang yang panas semasa menggril satay (Gambar 2).

Gambar 1:
Memanggang Satay dengan kaedah Tradisional

Gambar 2 : Nyalaan api kuat menyebabkan bahang kepada orang yang menggril satay

2.0 Kajian Lapangan

Dalam usaha menambahbaik pendekatan penyediaan satay kaedah tradisi, usaha untuk mencipta dan merekabentuk sebuah mesin pembakar satay separa automatik yang selamat dan mudah di gunakan telah di laksanakan . Pemerhatian di lokasi peniaga satay telah di lakukan untuk mengkaji aspek keselamatan, kebersihan (hygiene), mengenalpasti tempoh optima menggril pelbagai jenis satay dan menganalisa kos bahan bakar. Carian keratan akhbar (Gambar 4), dokumen paten dilakukan dan sebahagian dokumen paten berkaitan proses menggril [1], [2], [3], [4], [5], [6] dianalisa untuk dikenalpasti kesesuaian berkaitan kebaikan dan kekurangan rekacipta berkenaan seperti Jadual 1 dan Jadual 2. Hasil dari pemerhatian di lokasi peniaga satay serta analisa dokumen paten, satu rekabentuk Mesin Pembakar Satay telah dibuat dengan bermatlamat mengatasi masalah yang timbul dari pendekatan penyediaan satay kaedah tradisi.

2.1 Ciri –ciri teknikal Sateportwo.

Mesin yang di reka khas ini (Gambar 5), mengandungi komponen tapak dan rangka utama berbentuk bersegi tiga dimana terdapat ruang untuk memuatkan satay ke peranti pemegang (Gambar 7)dan ruang memunggah keluar di lokasi bertentangan. Infra red burner dengan ekalan bahan bakar Gas memasak dipasang bersebelahandengan rangka berbentuk bersegi tiga. Semasa satay dibawa menggunakan sistem penghantar (Gambar 6) melalui ruang pemanas, ia bergerak dengan operasi tanpa perlu membalikkan satay. Satay tidak berputar semasa proses menggril berterusan kerana mesin ini di lengkapi infra red burner di sebelah atas dan kedua-dua bahagian bawah. Satay akan melalui laluan pemanasan dalam menyerong ke atas dan kemudian turun secara menegak ke bawah, selepas itu, satay secara automatik terlepas dari peranti pemegang jatuh pada pelongsor untuk terus ke dalam dulang disebabkan oleh daya graviti (Gambar 8).

Mesin yang di lengkapi dengan *infra red burner* dalam keadaan seragam yang di kawal oleh pelaras untuk mendapatkan kepanasan yang di kehendaki.Tahap yang dikehendaki bagi kemasakan di tentukan oleh kelajuan sistem penghantar dan kawalan bahan bakar. Mudah alih dan menggunakan bekalan kuasa bateri 12 v untuk mengerakan motor dan Gas sebagai bahan bakar. Kapasiti menggril bagi mesin ini adalah 1200 cucuk satay setiap satu jam. Sateportwo ini telah di patenkan [7] bagi memberi perlindungan harta intelek.

3.0 Penyelesaian Masalah

Dengan adanya mesin ini, ia dapat memudahkan kepada peniaga dan pengusaha restoran menggunakannya kerana hasil rekaan mesin ini mampu mengatasi permasalahan yang di kenal pasti seperti Jadual 3 :-

i. Masalah asap dan abu dari bara api dapat di kurangkan kerana mesin yang di rekabentuk ini mengunakan infra red dan mengaplikasikan konsep *Green Technology*.
ii. Kebersihan satay yang di bakar diutamakan kerana keseluruhan mesin ini di buat daripada keluli tahan karat iaitu *food grade stainless steel 304* berbanding dengan kaedah tradisional mengunakan bekas yang boleh karat dan terdedah kepada pencemaran.
iii. Masalah kemahiran menggril satay juga dapat di atasi, dimana penguna tidak perlu untuk memantau tahap kemasakan satay tersebut. Mesin ini menampilkan larasan suhu dan tempoh satay berada didalam ruang pemanggangan dimana satay masak sepenuhnya ketika sampai keruang pemunggahan ('unloading') dan ianya jatuh tanpa memerlukan pemerhatian khusus.
iv. Aspek keselamatan kesukaran seperti berhadapan dengan bahang panas juga dapat di atasi kerana ruang pemanggangan pada mesin ini direkabentuk secara tertutup dan selamat.
v. Aktiviti membakar satay secara *out door* dapat dapat mengurangkan pencemaran asap yang banyak terhadap orang awam atau pengunjung.
vi. Mesin ini amat mesra penguna kerana struktur nya di bina bersaiz kecil dengan hanya 36 kg (Gambar 9).
vii. Sumber bahan bakar yang rendah iaitu Rm 32.00 kos pengunaan gas yang mampu menampung selama 1 minggu atau RM 4.57 sehari berbanding dengan pengunaan arang kayu iaitu sebanyak RM 14.00 untuk kos 2 bag arang kayu setiap kali beroperasi untuk tempoh yang sama selama 8 jam.

4.0 Keputusan dan Analisis

Ujian kebolehgunaan adalah satu proses penilaian prestasi keatas produk yang dihasilkan. Ujian ini adalah penting dimana kita akan mengetahui samada produk dihasilkan itu berfungsi dengan baik atau sebaliknya. Bagi produk yang telah berjaya di hasilkan, didapati tiada masalah yang timbul serta berfungsi dengan baik dan memuaskan. Antara ujian yang telah di lakukan ialah :-

4.1 Ujian pembakaran

Gambar 3 : Ujian pembakaran

Kajian terhadap masa yang dicatat semasa proses pembakaran satay bergantung kepada kualiti dan kuantiti satay yang di hasilkan seperti Jadual 4.

4.2 Faedah yang di perolehi daripada mesin Sateportwo

i. Sesuai untuk dalaman cawangan perkhidmatan makanan seperti mahkamah makanan, hotel dan restoran.
ii. Sesuai untuk pendekatan layan diri
iii. Mudah alih, ia boleh digerakkan untuk fungsi luar.
iv. Mudahan dalam operasi dan penyelenggaraan
v. Memanggang satay secara berterusan dengan suhu yang dikehendaki bagi menentukan kadar kemasakan kelajuan penghantar.

5.0 Perbincangan

Berdasarkan kepada hasil ujian yang di lakukan maka dapat di rumuskan bahawa dengan kadar suhu 320º - 350 ºc bersama *DC Gear Motor 12v 4 w variable speed* di gunakan ini dapat membakar satay mengikut keperluan dan mampu membakar dengan penghasilan minima sebanyak 1200/jam.Selain daripada itu ujian yang di lakukan di lapangan membuktikan bahawa tiada ganguan asap semasa membakar berbanding menggunakan kaedah tradisional.Oleh yang demikian perbandingan dapat di kesan dengan jelas apabila di buat perbandingan dengan kaedah tradisional seperti Jadual 3.

6.0 Kesimpulan

Kesimpulan penghasilan projek ini adalah berjaya dan mencapai objektif yang di sasarkan dan di dapati bahawa setiap penghasilan produk perlu menitik beratkan beberapa aspek seperti kebersihan,keselamatan,pengeluaran,mesra alam dan mesra pengguna serta mampu mengubah konsep perniagaan satay kepada konsep santai.

7.0 Rujukan

[1] Yoshio Natsumi, Hideko Natsumi, 'Revolving spit-grilling apparatus' (US5669290 A)

[2] Chun Kong Ian Cheung, 'Rotisserie oven' (US7036426 B2)

[3] Michael G. Boosalis, Thomas D. Wason,'Apparatus for heating and dispensing food articles'(US4034661)

[4] Bennett et al. ' Rotisserie Broiler' (US2011283893A1)

[5] Lucas Johannes Henricus, Jacobus Petrus Slijkerman, 'Grill Satay' (NL1019707C1)

[6] Razali Jalaludin, Mohd Zainal Ismail, 'Satay grilling apparatus'(PI20060358)

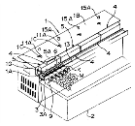
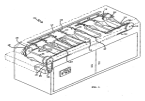
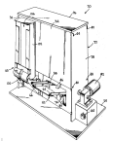
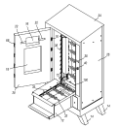
[7] Norman Kusin, Abd Rahim Md Tahir, 'Satay Grill Apparatus' (PI2012002191)

LAMPIRAN

Jadual 1: Ringkasan Analisa Paten

Novelty of product

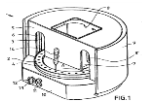
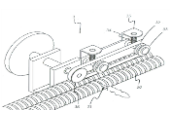
SUMMARY OF PATENT ANALYSIS FOR GRILLING APPARATUS (SATAY)

PATENT NUMBER	US5669290 REVOLVING SPIT-GRILLING APPARATUS	EP1306042B1 /US7036426B2 ROTISSERIE OVEN	US4034661 Apparatus for heating and dispensing food articles	US2011283893A1 ROTISERRIE BROILER
ILLUSTRATIVE DRAWING				
MAIN BODY	**A main body having a base portion, having plurality of holding cartridges**	A main body having a base portion with longitudinal conveyor system	Housing means including portions defining a feed opening and portions defining a discharge opening	Housing means including portions defining a feed opening and portions defining a discharge opening
HEATING MEANS	Adjacent to the holding cartridges	Between the conveyor system	Vertically spaced adjacent to said conveyor means along said path	Adjacent to the vertical path of travel and the vertical conveyor assembly
CONVEYOR MEANS	NO	YES	YES	YES
Type of conveyor	NO	A PAIR OF PARALLEL CHAINS	A PAIR OF PARALLEL CHAINS	A PAIR OF PARALLEL CHAINS
SKEWER ATTACHMENT DEVICE	YES	YES (Fixed to one of the conveyor)	Driving means operatively associated with said conveyor means for moving said conveyor means along said path	A plurality of bar plates having lift arms disposed upon each rotisserie chain assembly to receive and lift an end of a skewer
DETACHMENT DEVICE	YES (A retracting device at partitioned station)	YES (A release mechanism adjacent to conveyor means)	YES	YES
TURNING DEVICE	At least one partition station so that said cartridges members simultaneously revol.ve	A respective turning device attached to each attachment device for rotating each food-support device.	Skewer support means including bearing means for rotatable supporting one end of the skewer.	A tension bar assembly disposed vertically to maintain a tension between a skewer and a serrated bar to rotate the skewer.
Rotation of skewer	YES	YES	YES	YES
Clamping/holding of skewer	One end	Both end	Both end	Both end

Jadual 2: Ringkasan Analisa Paten

Novelty of product

SUMMARY OF PATENT ANALYSIS FOR GRILLING APPARATUS (SATAY)

PATENT NUMBER	NL1019707C1 Grill Satay	PI20060358 Satay grilling apparatus
ILLUSTRATIVE DRAWING		
MAIN BODY	Round	Rectangle
HEATING MEANS	Adjacent to the inner side wall of the apparatus	Adjacent to the conveyor system
CONVEYOR MEANS	NO (Circular track mechanism with a driving system)	YES
Type of conveyor	CIRCULAR TRACK FIXTURE	A PAIR OF PARALLEL SCREW
SKEWER ATTACHMENT DEVICE	NO	A pair of parallel screw act as skewer attachment device
DETACHMENT DEVICE	NO (manually)	YES
TURNING DEVICE	NO	YES
Rotation of skewer	YES	YES
Clamping/holding of skewer	One end	One end

Design of INVENTION	SATAY GRILL MACHINE (PI2012002191)
ILLUSTRATIVE DRAWING	
MAIN BODY	Triangle
HEATING MEANS	Adjacent to the conveyor system
CONVEYOR MEANS	YES
Type of conveyor	CHAIN CONVEYOR
SKEWER ATTACHMENT DEVICE	YES
DETACHMENT DEVICE	NO
TURNING DEVICE	NO
Rotation of skewer	NO
Clamping/holding of skewer	One end

BERITA HARIAN Sabtu 28 April 2012 NASIONAL 15

MARDI bangun teknologi baru

Mesin proses makanan tradisional dapat sambutan hangat pengusaha PKS

Oleh Haryani Ngah
aryani@bharian.com.my

'RENYAH' mungkin itu yang terbayang di fikiran apabila memikirkan proses yang perlu dilakukan untuk menghasilkan sajian makanan tradisional. Jika ramuan tidak diadun dengan baik dan proses memasak tidak mengikut cara betul pastinya sajian yang cuba dihasilkan itu tidak menjadi.

Jadi tidak hairanlah kenapa ramai di kalangan usahawan Perusahaan Kecil Sederhana (PKS) yang menjalankan perusahaan makanan tradisional tidak mampu menghasilkan produk dalam kuantiti yang banyak bagi menampung permintaan pelanggan terutama pada musim perayaan di samping masalah kekurangan tenaga buruh turut menjadi kekangan buat usahawan ini terus maju dalam bidang perniagaan ini.

Bagi mengatasi masalah ini, Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI) menerusi Pusat Penyelidikan Mekanisasi dan Automasi meningkatkan aktiviti penyelidikan dan pembangunan mesin dan peralatan pemprosesan makanan.

Menerusi aktiviti penyelidikan ini, MARDI telah berjaya membangunkan beberapa mesin yang bukan saja dapat mempelbagaikan dan merancakkan aktiviti fabrikasi tempatan, malah dapat membantu memodenkan perusahaan yang dijalankan oleh PKS.

MESIN pemanggang sate ciptaan MARDI membantu pengusaha PKS meningkatkan produktiviti pengeluaran selain menjimatkan masa dan mengurangkan masalah tenaga kerja.

Mesin pemanggang sate yang berharga RM25,000 ini mempunyai kapasiti pemanggangan sehingga 1000 cucuk sate dalam masa satu jam.

Mesin pencucuk sate dibangunkan MARDI mendapat sambutan baik di mana dengan menggunakan mesin ini usahawan dapat meningkatkan pengeluaran memandangkan mesin ini berupaya mencucuk sehingga 3,000 cucuk sate sehari

Mohd Zainal Ismail
Pengarah Pusat Penyelidikan Mekanisasi dan Automasi MARDI

ngan menggunakan mesin pencucuk sate dan seterusnya di bakar dengan menggunakan mesin pemanggang sate MARDI," katanya.

Mesin pemanggang sate yang berharga RM25,000 ini mempunyai kapasiti pemanggangan sehingga 1000 cucuk sate dalam masa satu jam.

ingin membeli mesin ini, sekarang adalah masa yang sesuai memandangkan Ramadan hampir tiba tidak lama lagi.

Mesin pembuat keropok lekor sememangnya diakui mempunyai banyak kelebihan kerana ia mampu menghasilkan 3,600 batang keropok

Gambar 4: Mesin pemanggang satay MARDI yang bersaiz besar dan kos yang tinggi

Gambar 5:
Mesin Pembakar satay (SATEPORTWO)

Gambar 6:
Sistem Penghantar

Gambar 7: Proses memuat satay ke peranti pemegang

Gambar 8: Ruang memungah keluar

Jadual 3: Perbandingan Kaedah Tradisional Dengan Sateportwo

No	KRITERIA	PEMBAKAR TRADISIONAL	SATEPORTWO
1	Kebersihan	Kurang bersih,berasap,arang dan abu.	Bersih kurang asap,tiada abu dan arang.
2	Kos Bahan Bakar bagi 8 jam operasi.	Harga 1 Bag Arang RM 7.00 x2 Bag RM 14.00 utk 8 Jam operasi = Rm 98.00/Minggu@ RM 392 Sbln	1 Tong Gas RM 31.00 /1 Minggu = RM 4.42/hari utk 8 jam operasi x7 = 31.00/Minggu@ RM 124 .00 sbln
3	Keselamatan Pengguna	Kurang Selamat berhadapan dengan api dan bahang panas	Selamat tidak berhadapan dengan bahang api.
4	Pengeluaran Produk untuk 1 jam.	50 cucuk 6 min 500 cucuk /jam = 4000 cucuk/8jam	120 cucuk 6 min 1200 cucuk /Jam = 9600 cucuk/8 jam
5	Kemahiran Kendalian	Perlu	Tidak Perlu
6	Mudah Alih	Ya	Ya
7	Penyelenggaraan	Ya	Tidak/Kurang
8	Pencemaran Alam Sekitar	Mengeluarkan asap dan abu	Tidak mengeluarkan asap
9	Mesra Pengguna	Tidak	Ya
10	Kesihatan	Kesan daripada karbon akan menyebabkan kanser	Baik
11	Kualiti Hasil	Kurang Sekata	Sekata

Gambar 9: Spesifikasi Rekabentuk

Nama produk : Sateportwo
Lebar : 420 mm
Panjang : 920 mm
Ketinggian : 970mm
Berat : 36 kg
Bekalan Kuasa : Gas Butane ,DV 12 V.
Suhu pembakaran : 250-350°c
Kelajuan Motor : *Variable Speed Control.*
Binaan Struktur : Stainless Steel Gred 304.

Jadual 4 : Jadual pengujian pembakaran

Bil	Ujian DC Motor	Suhu	Tempoh (Ayam)	Hasil	Suhu	Tempoh (Daging)	Hasil
1.	Kelajuan Pertama ¾ rpm	320ºC	3 minit	Satay masak garing. produk 1200/jam	350ºC	3 minit	Satay masak garing produk 1200/jam
2.	Kelajuan Kedua 4/5 rpm	320ºC	2.5 minit	Satay masak secukupnya. produk 1440/jam	350ºC	2.5 minit	Satay masak secukupnya produk 1440/jam
3.	Kelajuaan Ketiga 5/6 rpm	320ºC	2. minit	Satay kurang masak. produk 1800/jam	350ºC	2. minit	Satay kurang masak produk 1800/jam

Gambar 10: Gold Medal ITEX 15

M14: Technology Management of Galvanised Iron in Active Fire Protection Components and System

Azisyarina Azizan[1], M.KamarulazwanM.Zain[2]
Institut Latihan Perindustrian Pedas[1], Faculty of Engineering, Universiti Putra Malaysia[2]

azisyarina@gmail.com

Abstract

From the beginning in the middle of the last century and right up to the present day, high-rise buildings have always been a dominant landmark in the townscape, visible from far and wide and has always been an ideal means of displaying power and influence in the community. However, these structures pose serious challenges to firefighters during emergencies in high-rise structures. Design can be tailored to better meet operational needs, thereby reducing the time it takes to mitigate an incident. The objective of the study is to analyse the development of galvanised iron that use for piping in dry riser system, wet riser system, hose reel system and sprinkler system and the rapid growth of technology related to the usage of galvanised iron. The paper represents a conceptual analysis embedded with comparative analysis of the piping for water-based fire protection system, evolution of the galvanised iron as a material that used for the pipe and development in technology to produce galvanised iron. The conclusion drawn from the study was active fire protection system is designed by using high fire resistant material preferably galvanised iron as a consequence of durability and reliability of the material to survive in the event of fire.

Keywords: *Technology management, galvanised iron, fire protection, fire component*

1.0 Introduction

Most of the pipes in dry riser system, wet riser system, sprinkler system and hose reel system are made up from galvanised iron. All of this systems use water to extinguish fire. Water based suppression systems utilize the inexpensive and readily available medium of water to discharge onto flames through a normally fixed piping system. Cast iron has a long history of satisfactory service. Pipes were made exclusively of cast iron in many larger systems until manufacture of cast iron pipes was discontinued in the early 1980's. Since this pipe can no longer be manufactured; little will be used in the future. The systems which formerly used cast iron pipes are now converting to ductile iron pipe. Ductile iron is now used in many systems where cast iron pipe was formerly used. Ductile iron pipes have certain advantages over other pipe materials. The pipes are strong and ductile which is able to be drawn out and formed into a certain shape.

Finally, due to the development in chemical technology, galvanised iron can be produced. Galvanizing is a process of coating iron or steel with zinc in order to provide greater protection against corrosion for the ironer steel base. These piping systems shall comprise galvanised iron pipe work as specified, with necessary galvanised iron fittings and accessories. Galvanised iron pipe with taraplast may also be used, where unavoidable to connect the underground piping system to the riser pipe in the form of distant piece. Revolution of piping system was started in 1555 for domestic use to water distribution. Then, as parallel to the development technology development and the construction of high-rise building, the piping system not just only used to distribute water for domestic use but it also use for water-based fire suppression system.

2.0 Objectives

The objective of this paper is to analyse the development of galvanised iron that use for piping in dry riser system, wet riser system, hose reel system and sprinkler system. Besides, this paper also provides the development in technique to produce galvanised iron.

3.0 Background

It is probably not practical to design buildings that under no circumstances will any occupant be trapped in case of fire. It is also not possible to secure absolute safety in buildings, generally because of human failure to maintain the protection installations or to do the right things right when an emergency arises. The architects, engineers and building designers are therefore faced with the constraints of balancing life safety and fire integrity against practicality, aesthetic design, fire regulations and material of fire protection equipment. As per rule of thumb, fire starts with four factors – fuel, oxygen, heat and chemical reaction. Thus, high fire resistant material namely galvanised steel needed for fire equipment mainly for the pipework. Figure 1 shown fire safety objectives as a reference in material innovation.

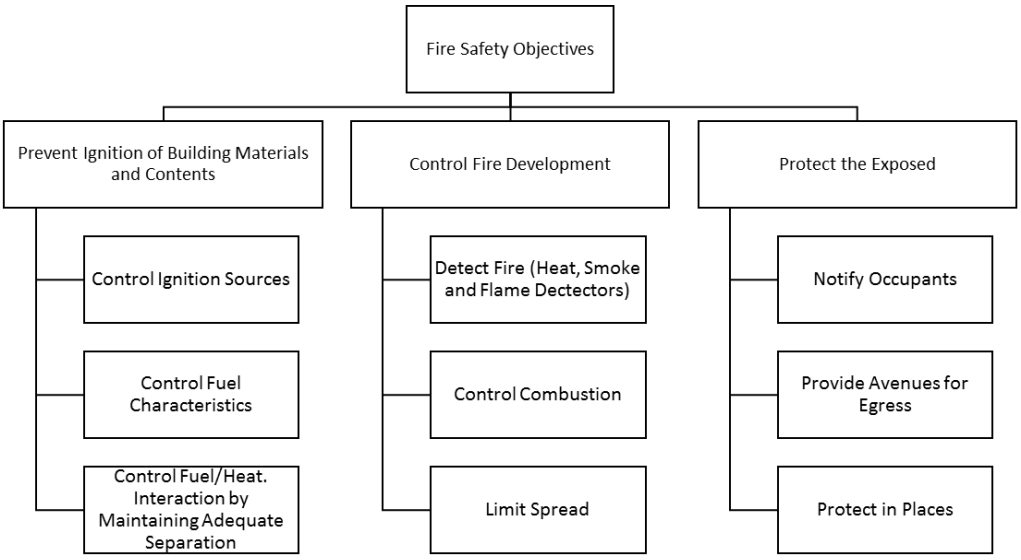


Figure 1: Fire safety objectives
Source: Watson (2000)

The ability of zinc to inhibit the rusting of steel depends on a natural phenomenon. A French chemist discovered in 1740 that zinc could protect steel from the effects of rust. However, it would be almost 100 years before the practical problems of coating steel with zinc would be solved. In 1887, a French engineer secured a patent for hot dip galvanizing. It is basically on today's techniques have been developed. Since its development in the nineteenth century, hot dip galvanizing has proven to be a very effective and economical means of protecting iron and steel against corrosion. It is an environmentally friendly process because it helps to save resources from the damaging effects of corrosion [1].

3.1 Sprinkler Systems

A fire sprinkler system is an active fire protection measure, consisting of a water supply system, providing adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected. The world's first modern recognizable sprinkler system was installed in the Theatre Royal, Drury Lane in the United Kingdom in 1812 by its architect. The system was designed by William Congreve was covered by patent No 3606 dated the same year. The apparatus consisted of a cylindrical airtight reservoir of 400 hogsheads (~95,000 litres) fed by a 10-inch (250 mm) water main which branched to all parts of the theatre. A series of smaller pipes fed from the distribution pipe were pierced with a series of ½-inch (13 mm) holes which pour water in the event of a fire. From 1852 to 1885, perforated pipe systems were used in textile mills throughout New England as a means of fire protection. However, they were not automatic systems; a person had to operate the system. Inventors first began experimenting with automatic sprinklers around 1860. The first automatic sprinkler system was patented by Philip W. Pratt of Abington, MA, in 1872. Henry S. Parmalee of New Haven, Connecticut is considered the inventor of the first automatic sprinkler head. Parmalee improved upon the Pratt patent and created a better sprinkler system. In 1874, he installed his fire sprinkler system into the piano factory that he owned. Frederick Grinnell improved Parmalee's design and in 1881 patented the automatic sprinkler that bears his name. He continued to improve the device and in 1890 invented the glass disc sprinkler, essentially the same as that in use today.

Until the 1940s, sprinklers were installed almost exclusively for the protection of commercial buildings, whose owners were generally able to recoup their expenses with savings in insurance costs. Over the years, fire sprinklers have become mandatory safety equipment in some parts of North America, in certain occupancies, including, but not limited to newly constructed hospitals, schools, hotels and other public buildings, subject to the local building codes and enforcement.

An automatic sprinkler system is intended to detect, control and extinguish a fire, and warm the occupants of the occurrence of fire. The installation comprises fire pumps, water storage tanks, control valve sets, sprinkler heads, flow switches, pressure switches, pipework and valves. The system operates automatically without human intervention. The sprinkler head has a liquid filled glass bulb that breaks due to the heat of the fire and releases water that sprays over the fire.

Figure 2 shows the schematic diagram for typical water sprinkler system. The various types of sprinkler systems are as follows:

i. Wet pipe installation where the pipework is filled with water and ready to discharge once the sprinkler bulb breaks.
ii. Dry pipe installation where the pipe is always filled with air under pressure. Air is released when the sprinkler bulb breaks and water fills the pipe and is discharged at the sprinkler head.
iii. Pre-action installation where the pipework is normally charged with air under pressure and a valve is opened to fill the system with water when fire is detected by smoke or heat detectors. Water is discharged only when the sprinkler bulb breaks.
iv. Deluge installation where the sprinkler head has no bulb and water is discharged simultaneously from all heads when the fire is detected and the deluge valve is opened.

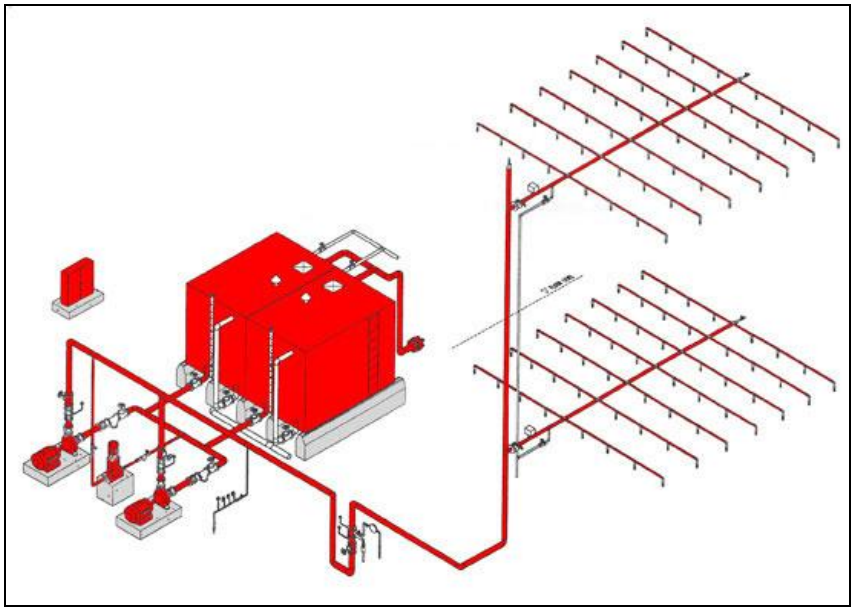


Figure 2: Typical Water Sprinkler System
(Sources: Fire Fighting Systems, http://www.shahfiresafety.in/)

3.2 Hose Reel Systems

A fire hose is a high-pressure hose that carries water or other fire retardant (such as foam) to a fire to extinguish it. Outdoors, it attaches either to a fire engine or a fire hydrant. First fire hose was used in Amsterdam, 1673. The Superintendent of the Fire Brigade, Jan van der Heyden, and his son Nicholaas took firefighting to its next step by using 50-foot (15 m) lengths of leather were sewn together like a boot leg. In the United States, fire hose was introduced in Philadelphia in 1794. This canvas hose proved not durable enough and sewn leather hose was then used. The sewn leather hose tended to burst so the fabricated of leather fastened together with copper rivets and washers was invented by members of Philadelphia's Humane Hose Company.

Around 1890, unlined fire hoses made of circular woven linen yarns began to replace leather hoses. They were certainly much lighter. As the hose fibres, made of flax, became wet, they swelled up and tightened the weave, causing the hose to become watertight. Unlined hoses, because of their lack of durability, were rapidly replaced with rubber hoses in municipal fire service use. It continued to be used for use on interior hose lines and hose racks until the 1960s and is still used in some areas for forestry applications.

Following the invention of the vulcanization process as a means of curing raw soft rubber into a harder, more useful product, the fire service slowly made the transition from bulky and unreliable leather hose to the unlined linen hose, then to a multi-layer, rubber lined and coated hose with an interior fabric reinforcement. This rubber hose was as bulky, heavy, and stiff as leather hose but was not prone to leaking. It also proved more durable than unlined linen hose. Its wrapped construction resembled some hose used today by industry, for example, fuel delivery hose used to service airliners.

Modern fire hoses use a variety of natural and synthetic fabrics and elastomers in their construction. These materials allow the hoses to be stored wet without rotting and to resist the damaging effects of exposure to sunlight and chemicals. Modern hoses are also lighter weight than older designs, and this has helped reduce the physical strain on firefighters. Various devices are becoming more prevalent that remove the air from the interior of fire hose, commonly referred to as fire hose vacuums. This process makes hoses smaller and somewhat rigid, thus allowing more fire hose to be packed or loaded into the same compartment on a fire fighting apparatus.

Hose reel systems is intended for the occupant to use during the early stages of a fire and comprises hose reel pumps, fire water storage tank, hose reels, pipe work and valves. Hose reel should comply with MS 1447. Pipework for hose reel system is generally customised from galvanised steel medium grade (Class B) minimum for above ground piping and heavy grade (Class C) for underground pipes. Figure 3 shows the schematic diagram for typical hose reel system.

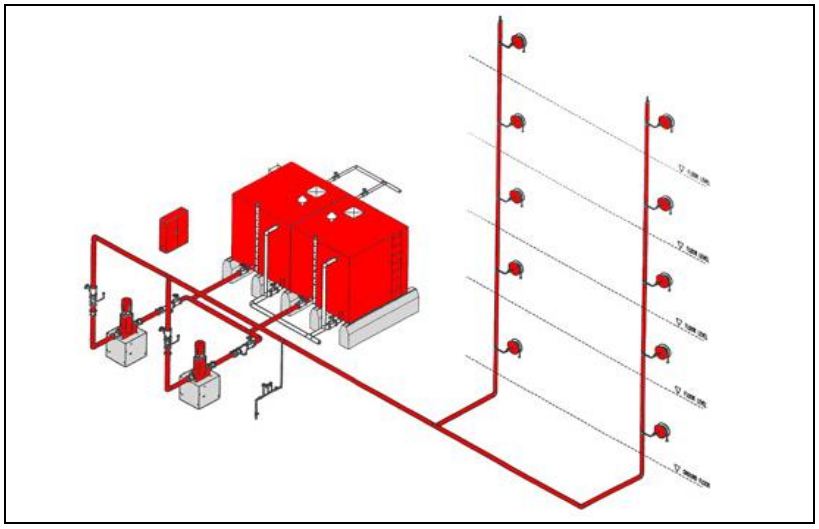


Figure 3: Typical Hose Reel System
(Sources: Fire Fighting Systems, http://www.shahfiresafety.in/)

Prior to 1929, chemical process industries faced perplexing and growing problems. As more and more corrosive chemicals and compounds came into use, the need for a reliable and durable method of protecting mild steel and iron products against corrosion become imperative. The rubber industry, which was till then engaged in the technology development of consumer rubber products starting from erasers and other consumer products; to engineering products, became alert to these problems of the chemical industry and introduced the first lining in 1929. Since the advent of the first rubber lining, research and development work continued and today's rubber technology took a different shape from eraser to a more sophisticated high technology discipline known as anticorrosive rubber. Today with the ability to perform in higher temperature operation and with more complex and critical duty condition, vulcanization technology is embedded in producing hose reel. Vulcanization is considered as a process whereby a material of different compositions and a bad conductor of heat is subjected to the process with an intention of producing a uniform product having improved physical properties.

3.3 Rising Mains

Rising main systems have been part of our fire protection system for more than 100 years. The basic concept of a rising main system has not changed extensively since the original NFPA standard was adopted in 1915 [2]. Systems are used in high-rise buildings, large commercial, retail, and industrial buildings; places of public assembly, and other areas where advancing hose lines would be difficult due to the building size.

There are two main types of rising main, dry riser systems and wet riser systems. Both of these systems consists of breeching inlet; riser pipe; landing valve and canvas hose attached with nozzles. However for wet riser systems have extra components i.e. wet riser pumps; wet riser tanks and pump starters control panels.

Figure 4(a) shows schematic diagram for dry riser system and Figure 4(b) shows schematic diagram for wet riser systems.

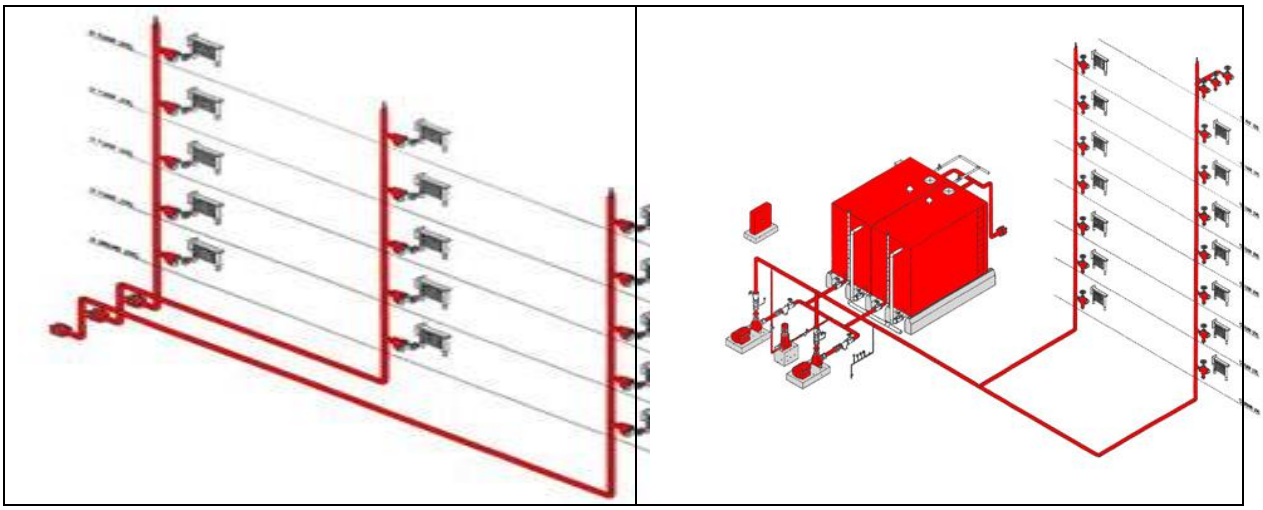


Figure 4(a): Dry Riser System **Figure 4(b): Wet Riser System**

(Sources: Fire Fighting Systems, http://www.shahfiresafety.in/)

4.0 Methodology

The paper represents a conceptual analysis of the piping for water-based fire protection system, evolution of the galvanised iron as a material that used for the pipe and development in technology to produce galvanised iron. This paper also use the method of comparative analysis and deduction based on the literature review and the lecture of technology management standardization papers.

5.0 Finding

Today, most of the components in these systems are made up from galvanised iron [3, 4]. Galvanization, or galvanisation, is the process of applying a protective zinc coating to steel or iron, to prevent rusting. The most common method is hot dip galvanization, in which parts are submerged in a bath of molten zinc. Galvanizing protects in two ways:

1) It forms a coating of corrosion resistant zinc which prevents corrosive substances from reaching the more delicate part of the metal.
2) The zinc serves as a sacrificial anode so that even if the coating is scratched, the exposed steel will still be protected by the remaining zinc.

5.1 Revolution Of Galvanised Iron

Ductile Iron Pipe (DIP) evolved from its forefather, Gray Cast Iron Pipe (CIP). CIP was reportedly first used in 1555 in Germany. King Louis XIV used it in France in 1664 when he installed a 15 mile run of CI to supply water to town fountains. That pipe was in service for more than 330 years [5]. However, the lifespan of iron pipe was too short due to the corrosion process because exposing to the corrosion agent. In 1742, French chemist Paul Jacques Malouin found the way how to reduce the corrosion problem for piping system. Since then, the development of technology become wider and parallel with the human innovation to produce pipe. Cast iron pipe is then substitute with galvanize iron. The following shows the development of galvanised iron to substitute the use of grey Casting Iron (CI) for piping system [6]:

1) In 1742, French chemist Paul Jacques Malouin described a method of coating iron by dipping it in molten zinc in a presentation to the French Royal Academy.
2) In 1772 Luigi Galvani (Italy), galvanizing's namesake, discovered the electrochemical process that takes place between metals during an experiment with frog legs.
3) In 1801 Alessandro Volta furthered the research on galvanizing when he discovered the electropotential between two metals, creating a corrosion cell.
4) In 1836, French chemist Stanislas Sorel obtained a patent for a method of coating iron with zinc, after first cleaning it with 9% sulfuric acid (H_2SO_4) and fluxing it with ammonium chloride (NH_4Cl).

5.2 Revolution In Technique For Galvanize Iron Production

Galvanizing has been used to protect iron and steel from rusting for over a hundred years. Galvanizing is simply coating of zinc over steel. Like paint, galvanizing protects steel from rusting by forming a barrier between the iron and the environment, but galvanizing goes one giant step further than paint. It also provides electrochemical protection of the iron. Since zinc is electrochemically more reactive than steel, it oxidizes to protect the iron near it; as a result, even if a galvanised iron surface is scratched down to the bare iron, the galvanizing coating will prevent the iron from rusting. Galvanised iron is, therefore, a superior product to iron with any other type of coating on it since it protects the iron even when the coating is damaged in handling or in service. The development of technology changes the technique in production of galvanised iron.

5.3 Casting Iron

Casting Iron production is relatively unsophisticated [7]. It mostly involves re-melting charges consisting of pig iron, steel scrap, foundry scrap, and ferroalloys to give the appropriate composition. The cupola, which resembles a small blast furnace, is the most common melting unit. Cold pig iron and scrap are charged from the top onto a bed of hot coke through which air is blown. Alternatively, a metallic charge is melted in a coreless induction furnace or in a small electric-arc furnace. There are two basic types of cast iron, namely white casting iron and grey casting. Figure 5 shows the summary process to produce pipes by using casting iron process.

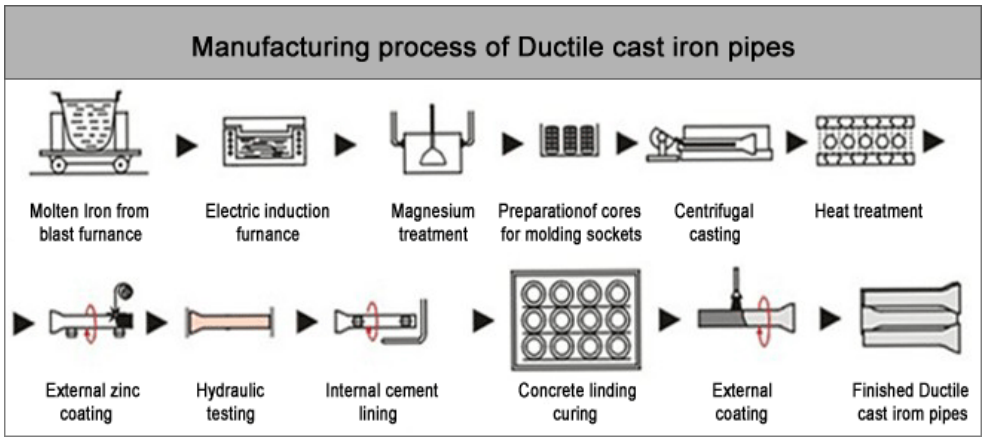


Figure 5: Casting Iron Process
(Sources: Bellowman Technology, http://www.bellowman.com/)

5.4 Hot Dip Galvanizing

The process of hot dip galvanizing results in a metallurgical bond between zinc and steel with a series of distinct iron and zinc alloys. The resulting coated steel can be used in much the same way as uncoated. Figure 6 shows the summary of hot dip galvanizing process to produce pipe. A typical hot dip galvanizing line operates as follows [8]:

1) Steel is cleaned using a caustic solution. This removes oil/grease, dirt, and paint.
2) The caustic cleaning solution is rinsed off.
3) The steel is pickled in an acidic solution to remove mill scale.
4) The pickling solution is rinsed off.
5) A flux, often zinc ammonium chloride is applied to the steel to inhibit oxidation of the cleaned surface upon exposure to air. The flux is allowed to dry on the steel and aids in the process of the liquid zinc wetting and adhering to the steel.
6) The steel is dipped into the molten zinc bath and held there until the temperature of the steel equilibrates with that of the bath.
7) The steel is cooled in a quench tank to reduce its temperature and inhibit undesirable reactions of the newly formed coating with the atmosphere.

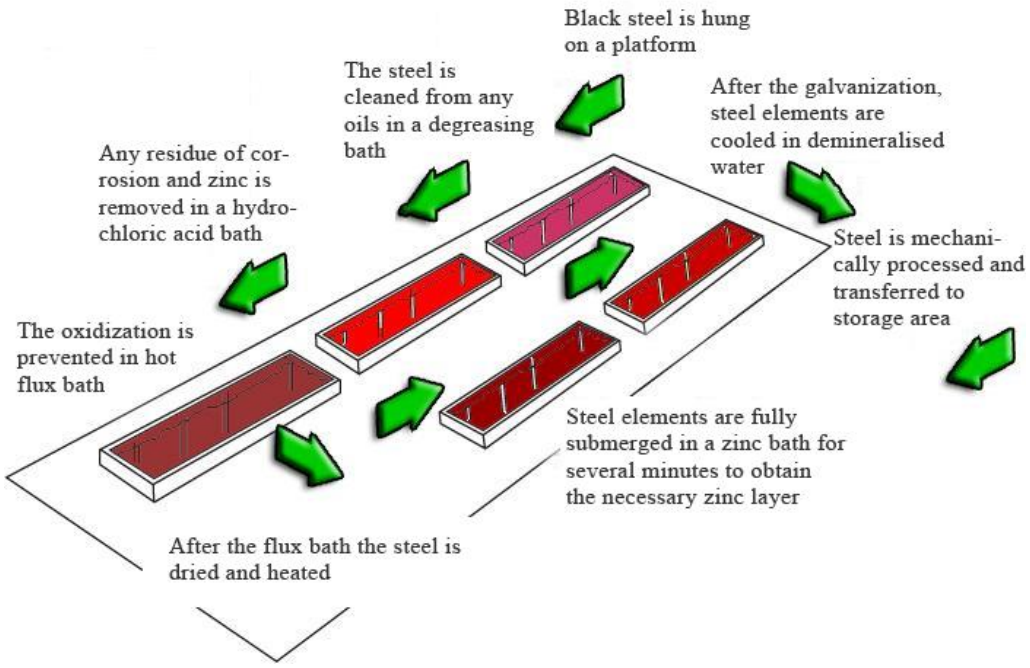


Figure 6: Hot Dip Galvanizing Process
(Source: Hot Dip of Galvanizing in Steel, http://www.znmetals.lv/)

5.5 Electro Galvanizing Iron

Electro galvanizing is a process in which a layer of zinc is bonded to steel in order to protect against corrosion. The process involves electroplating, running a current of electricity through a saline or zinc solution with a zinc anode and steel conductor [9]. Zinc electroplating maintains a dominant position among other electroplating process options, based upon electroplated tonnage per annum.

According to the International Zinc Association, more than 5 million tons are used yearly for both hot dip galvanizing and electroplating. The Plating of zinc was developed at the beginning of the 20th century. At that time, the electrolyte was cyanide based. A significant innovation occurred in the 1960s, with the introduction of the first acid chloride based electrolyte. The 1980s saw a return to alkaline electrolytes, only this time, without the use of cyanide.

Figure 7 shows the electro galvanizing process of pipes. Compared to hot dip galvanizing, electroplated zinc offers these significant advantages:

1) Lower thickness deposits to achieve comparable performance
2) Broader conversion coating availability for increased performance and color options
3) Brighter, more aesthetically appealing, deposits

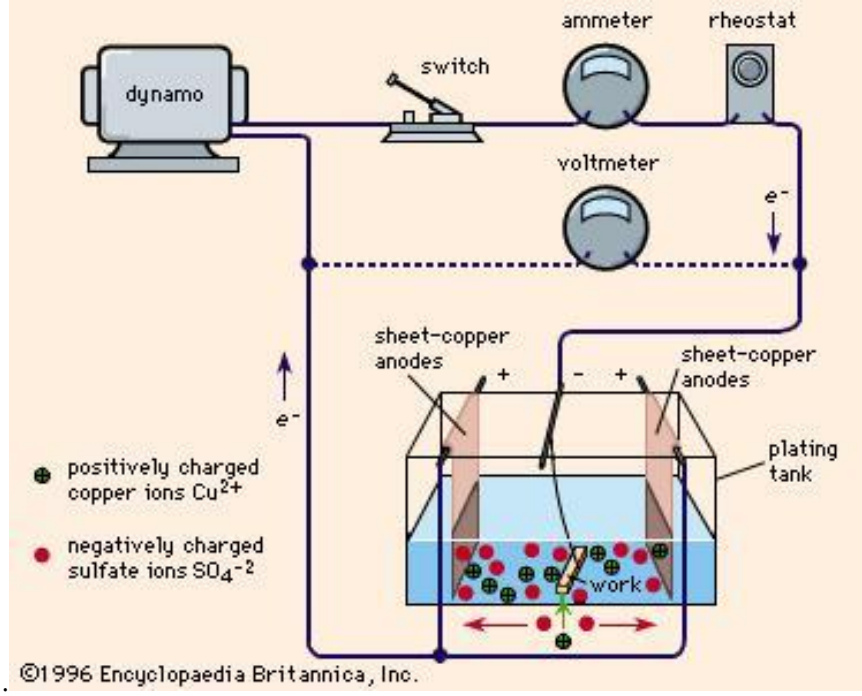


Figure 7: Electro galvanizing Process
(Source: Electro galvanizing: Electroplating Process, http://www.britannica.com)

6.0 Discussion

Process of galvanizing pipes has evolved and changed over the years, while the principal objective is unchanged which is to clean the steel and metallurgical bond a zinc coating of specified thickness to the pipe surfaces (inside and outside). Throughout the process, we can finds that the application of technology management applied helps to create value for the organizations to solve problems and improve effectiveness of pipes that being used in fire safety. Generally, the process of galvanizing steel pipes usually cost less than other common methods used to protect steel because it requires less manual labour. This will depend on the management side on how to manage the production of galvanised pipes without making the labour work extensively. The galvanised iron has a longer life span than the uncoated pipes. Literature shows that galvanised steel pipe can last for 50 years in rural areas and 25 years in and coastal environment. This process makes the galvanised steel pipe more valuable and worth for the money, even provides strong safety precautions in implementing the usage of it in fire safety components and systems.

Galvanizing coating process makes the pipes very rugged through its unique metallurgical composition. Hence, it will prevent from any damages during transporting, assembling and also servicing. Aside than that, usage of galvanised pipes in fire safety components and systems is very essential because less effort is needed to maintain it. With the lack of fire safety experts and consultants, this could create another advantages for using galvanised steel pipes in fire safety components so that it can still works efficiently throughout the year with minimum care of maintenance. The inspection process for galvanised pipe and fittings is also simple and direct. The thickness can be examined by eye and by non-destructive methods. As for example, if a galvanised coating pipes appears to be intact and functioning well, by all means, it is safe to use it. This would make it easier for anyone to determine whether the systems is reliable or not.

Due to the advanced technology in galvanizing steel, the process has provides a cathodic or sacrificial protection to the pipes that gives an extra protection to the small area of the structure that have been exposed to damage. Different types of coating does not provide the same level of protection which make the exposed areas vulnerable unless they're recoated. Galvanizing process provides total protection to every parts of the structure with 360 degree protection that one cannot find with any other coating. Another advantages of using the galvanised steel is that the product is ready to be used once it is being manufactured. There is no other process needed to inspect the coating surface and others.

The management of the use of technology in the galvanizing process provides lots of advantage to human kind. With this innovations, there is lots of improvement that can be made in fire safety components and system which will provides the comfort and safe working environment and living places. Diffusion of innovation theory suggest that all innovations follow a similar diffusion pattern which is known today in a form of an "s" curve. Generally, the terms "s" curve propose four phases of a technology life cycle that includes *emerging*, *growth*, *mature* and *aging*. S-Curves are commonly used in technology forecasting. They show the paths of product performance in relation to time or investment in R&D. It is a useful tool to describe the inflection points and the limit of improvement of a technology. Companies use this information to base their innovation strategies. Figure 4 shows the S-curves for revolution in galvanize iron for piping systems. Figure 4 shows the S curve of technology development to produce galvanised iron for piping system.

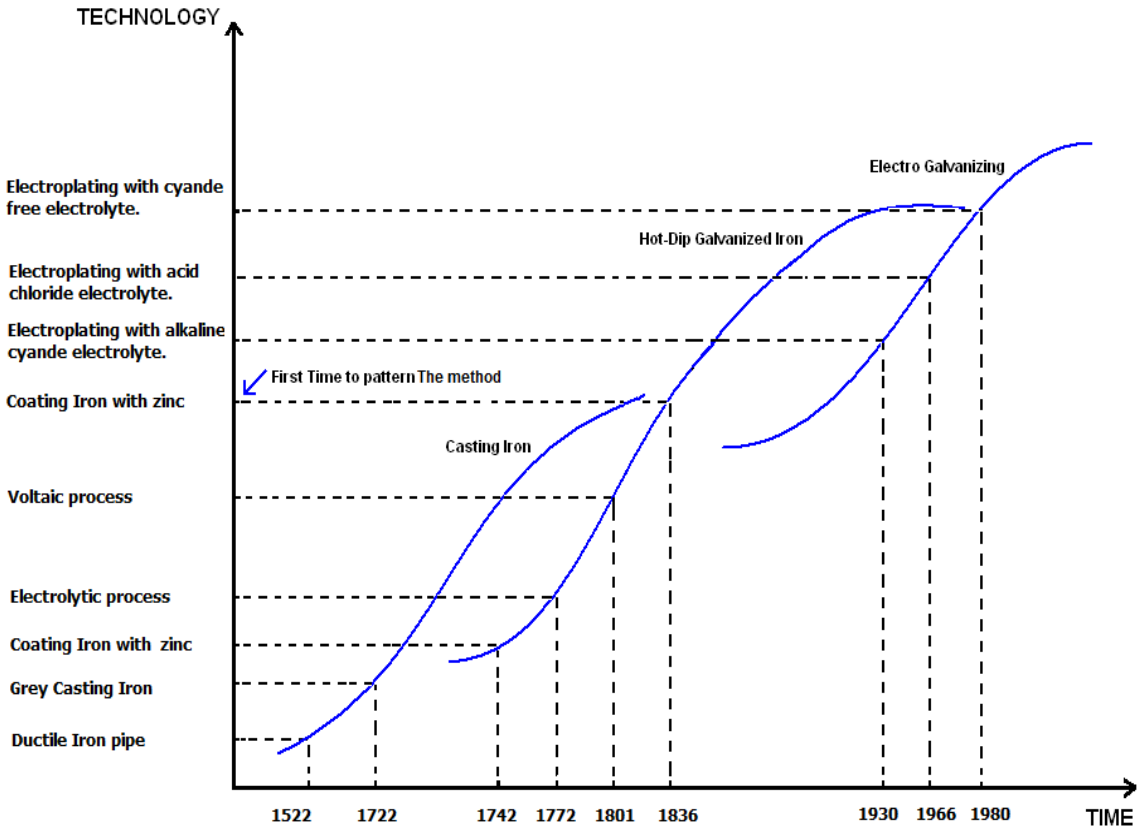


Figure 8: S-Curve for Galvanised Iron's Development
(Source: Self Developed Based on History of Galvanizing, http://www.leedsgalvanising.co.uk/)

7.0 Conclusion

Fire tests have proven that all combustible materials when burnt, will produce some asphyxiating or poisonous gases and nearly all produce smoke which hinder vision. Many plastic materials produce highly poisonous vapours and very dense smoke. It is important for engineers, architecture and building designers to check on features of certain materials before installing into the building. Regarding this issue, active fire protection system is designed by using high fire resistant material preferably galvanised iron as a consequence of durability and reliability of the material to survive in the event of fire. Therefore, there is a high demand for galvanised iron in fire safety components and systems.

However, the usage of galvanised piping for housing will eventually need to be replaced within 50 to 70 year life expectancy. To prolong lifespan of the galvanised iron's usage in piping system, epoxy resin is used to coat the outer surface layer of galvanised iron. Epoxy resin has excellent mechanical properties, electrical insulation, resistance properties and bonding properties of drugs can be used as coatings, casting materials, moulding materials, adhesives, laminated materials in the form of direct or indirect use to infiltrate from the daily necessities to high-tech sectors in all aspects of the national economy.

The popular solution to corrosion problem within fire protection systems is usually using galvanised iron. But the main concern nowadays is that, the quality of the galvanised pipe is not the same as made decades ago. When designing a galvanised fire system, one should consider to adapting it to the whole system and not only on the straight pipe. The concerns is when the black steel fitting combines with galvanised pipe, it has the potential to attack the zinc finish by the black steel. Same problems occurs when welding a black steel branch coupling to a galvanised pipes, it will burns away the internal zinc protective coating which will initiate higher localized pitting.

The popularity of galvanised piping is declining in many industries but still being used extensively in the fire protection industry. There are still problems in using galvanised iron or steel in fire safety components, but as technology develop through the time there will be lots of improvement can be made in production and operations management, project management, computer applications, quality control, and also safety and health issues so that the technology in galvanising pipe will expand further.

8.0 References

[1] Dato' Hamzah Bin Abu Bakar, (2006), "*Guide to Fire Protection in Malaysia*", The Instituition of Fire Engineering (UK) Malaysia Branch (IFEM).

[2] Fire Standpipe Systems – See more at: http://www.apexfire.ie/dry-and-wet-riser-hydraulic-testing/ (accessed on May 27, 2015).

[3] Wet Riser Systems-Designing Building– See more at: http://www.designingbuildings.co.uk/wiki/Wet_riser (accessed on May 27, 2015).

[4] Dry Riser Systems-Designing Building - See more at:

[5] http://www.designingbuildings.co.uk/wiki/Dry_riser(accessed on May 27, 2015).

[6] Ductile Iron Pipe – See more at: http://www.all-about-pipe.com/Ductile-Iron.html (accessed on May 27, 2015).

[7] A Pipe History Lesson – See more at: http://www.stlpipesupply.com/blog/a-pipe-history-lesson/ (accessed on May 27, 2015).

M17: Study And Analyze The Optimum Parameters Of Wirecut-EDM (Sodick VZ 500l) For SKD11 Tool Steel Machining

Amer Isyraqi Bin Hussin[1], Abdul Jalil Bin Hassan[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Kulim, Kedah
amer@jtm.gov.my, jalil@jtm.gov.my

Abstract

WEDM machine is widely used, particularly in the field of mold and die manufacturing. This machine is capable of cutting hard materials and gives high accuracy cutting dimension compared with other machines. However, there is one major problem for machinist on how to get the optimum parameters for each cutting. The objective of this study is to find the optimum parameters of WEDM machine for cutting SKD11 tool steel. There are many parameters that must be controlled for each type of material and thickness using different parameters. For this study, SKD11 tool steel is used and 4 main parameters were investigated which is Duration Pulse, Pulse Interval, Servo Voltage and Current Pulse Ignition using Taguchi method. The influence of four parameters, such as MRR, SR and KERF Width is analyzing using ANOVA to determine the level of importance for each of these parameters and thus the optimum parameters can be obtained. Result of confirmation test showed that the percentage improvement by using optimum parameter is increased 3.36% for MRR, 1.02% for kerf width and 7.32% for surface roughness. Finally, the findings of this study will hopefully help machine manufacturers and researchers to determine the best combination of parameters which in turn leads to optimize machining performance.

1.0 Introduction

In mould and die industry, the tool steel is the most widely uses material to produce mould and die. In stamping process for example, the punch and die plate is the most suitable to fabricate from tool steel. So, the WEDM process is use during manufacturing process. However, the machining process is disrupted due to the frequency of wire breakage. A lot of study have been done by researchers and many of them have conclude that the reason of this problem is comes from the WEDM Machine Parameters.

The most machining performance of WEDM that been studied are material removal rate (MRR), surface roughness and kerf width. All these responds are depend on various machining parameters such as pulse on, pulse interval, servo voltage, dielectric fluid pressure, wire tension etc. Selection of parameters combination to optimized machining performance is a challenging task. It is not only for experience machinist but for researchers as well. This is due to the presence of large numbers of variables.

The objectives of this studies is to analyze the significant parameters and percentage of contribution to the machining characteristics on material removal rate (MRR), kerf width and surface roughness (SR) by using analysis of variance (ANOVA). Second, is to find the optimum machining parameters such as pulse duration, pulse interval, servo voltage and ignition pulse current by using Taguchi Method.

2.0 Experiment procedures

The experiments were performed by VZ500L linear motor 4-axis CNC WEDM, which manufactured by Sodick Inc. Ltd. Exermined parameters had been input in NC programme manually.

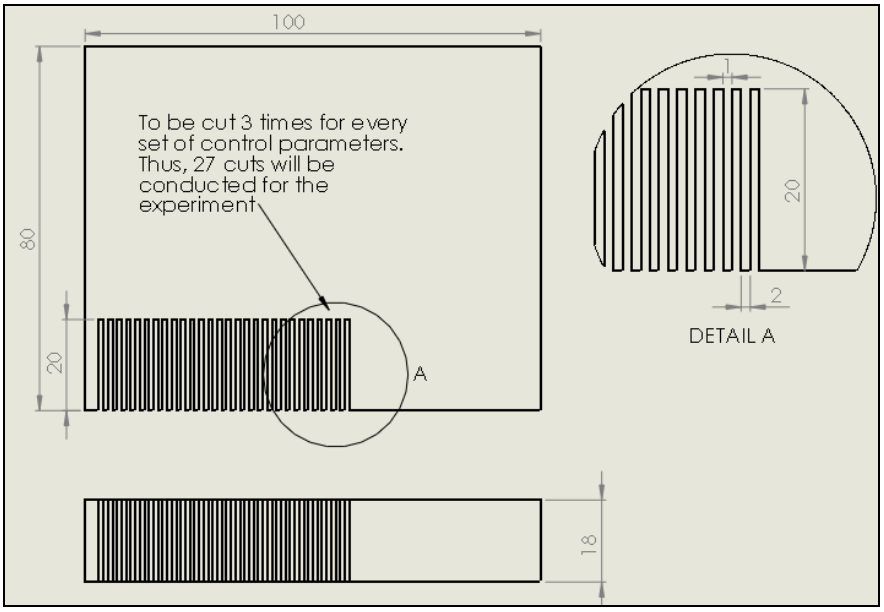


Figure 3.1: Cutting methods of SKD11 workpiece

Design of experiments is based on Taguchi Method and it also to be used for optimizing the cutting parameters. Analysis of variance (ANOVA) was employed to recognize the level of significance of the machining parameters on the performance characteristics of material removal rate and surface roughness. The level and machining parameters are shown in Table 3.1. Others parameters were set as constant (Table 3.2). The parameters value is determined by referring to the related journals and Sodick Machine Manual Book.

Table 3.1: Levels and WEDM parameters

No	Parameters	Level		
		Lo	Med	Hi
1	Pulse duration [µs]	0.45	0.55	0.65
2	Pulse interval [µs]	6.0	7.5	9.0
3	Servo voltage [V]	10	15	20
4	Ignition pulse current [A]	8	12	16

Table 3.2: Constant WEDM Parameters

No	Parameter	Value
1	Machining voltage[V]	8
2	Wire tension [kg]	0.5
4	Injection pressure [bar]	10

Input process parameters such as pulse duration (ON), pulse interval (OFF), ignition pulse current (IP), servo voltage (SV), used in this study are shown in Table 3.1. Each factor is investigated at three levels to determine the optimum settings for the WEDM process. Taguchi method was used to determine the combination of control parameters as shown in the Table 3.3. For each set of parameter there will be three trial experiments will be conducted. The experimental results were converted into a signal-to-noise (S/N) ratio. There are many types of S/N ratios available but it depends to the type of characteristics that we are seeking for. In this study, for MRR, the characteristic that higher value represents better machining performance is called 'higher is better'. In contrary, for surface roughness, the characteristic that lower value represents better machining performance is called 'lower is better'. For kerf width, 'nominal the best' was used. Therefore, from above mentioned characteristic the optimum machining parameters were defined for obtaining optimum machining performance.

The S/N ratio can be calculated as a logarithmic transformation of the loss function as shown below.

S/N ratio for MRR *bigger is better* = -10 log10 [$\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y^2}$]

S/N ratio for SF *lower is better* = -10 log10 [$\frac{1}{n}\sum_{i=1}^{n}y^2$]

S/N ratio for kerf width *nominal the best* = 10 log 10 $\left[\frac{\bar{y}^2}{s^s}\right]$

Table 3.3: Design of experiments matrix

Experiments Number	Pulse Duration [µs]	Pulse Interval [µs]	Servo Voltage [v]	IP Current [amp]
1	0.45	6.0	10	8
2	0.45	7.5	15	12
3	0.45	9.0	20	16
4	0.55	6.0	15	16
5	0.55	7.5	20	8
6	0.55	9.0	10	12
7	0.65	6.0	20	12
8	0.65	7.5	10	16
9	0.65	9.0	15	8

The volume (length of cutting X thickness X kerf width) was measured as well as time taken to cut the work piece. The following equation will be used to calculate the MRR value:

$$\text{MRR} = \frac{volume}{machining\ time} = \frac{t \times l \times x}{Tm}\ (\text{mm}^3/\text{min}) \qquad \text{(Equation 1)}$$

Where, *t* is thickness, *l* is length of cut and *x* is kerf width. *Tm* is machining time and calculated in minutes.

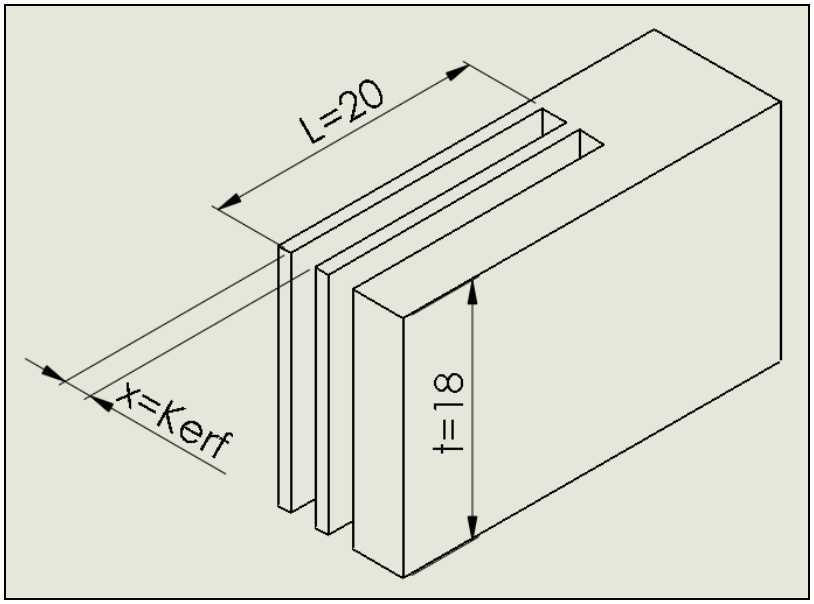


Figure 3.2: Dimensions for length, thickness and kerf width used for MRR calculation

3.0 Results and discussions.

For the respond of material removal rate (MRR), the experiments were performed according to Taguchi method and results for each set of parameters is shown in Table 4.1

Table 4.1: Experimental design and MRR result

Exp No	A [µs]	B [µs]	C [v]	D [amp]	Trial 1 MRR [mm³/min]	Trial 2 MRR [mm³/min]	Trial 3 MRR [mm³/min]	Ave MRR [mm³/min]	S/N ratio [db]
1	0.45	6.0	10	8	10.2837	10.2112	10.3036	10.2662	20.2280
2	0.45	7.5	15	12	11.9809	12.0672	12.1212	12.0564	21.624
3	0.45	9.0	20	16	12.5579	12.5389	12.5350	12.5439	21.9687
4	0.55	6.0	15	16	17.9747	17.9605	17.9123	17.9492	25.0809
5	0.55	7.5	20	8	18.5483	18.4184	18.6031	18.5233	25.3541
6	0.55	9.0	10	12	17.9274	17.5615	17.5898	17.6929	24.9548
7	0.65	6.0	20	12	24.2121	24.0354	24.2631	24.1702	27.6654
8	0.65	7.5	10	16	19.1403	19.5229	19.5201	19.3994	25.7524
9	0.65	9.0	15	8	21.1700	20.7721.	21.3600	21.1007	26.4842

Table 4.2: S/N ratio response table for material removal rate (MRR) – Larger is better

Level	Pulse Duration [µs]	Pulse Interval [µs]	Servo Voltage [V]	IP Current [Amp]
1	21.27	24.32	23.65	24.02
2	25.13	24.24	24.40	24.75
3	26.63	24.47	25.00	24.27
Delta	5.36	0.23	1.35	0.73
Rank	1	4	2	3

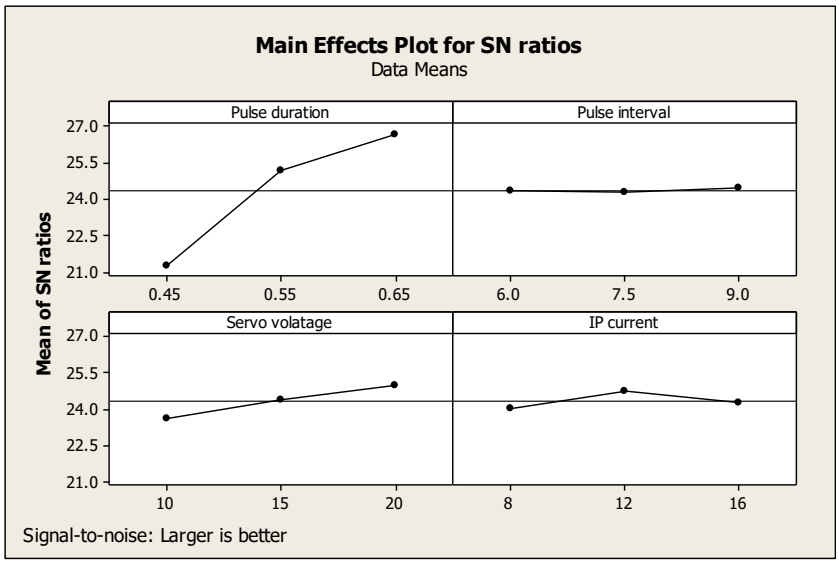


Figure 4.1: Effect of control parameters to material removal rate (MRR)

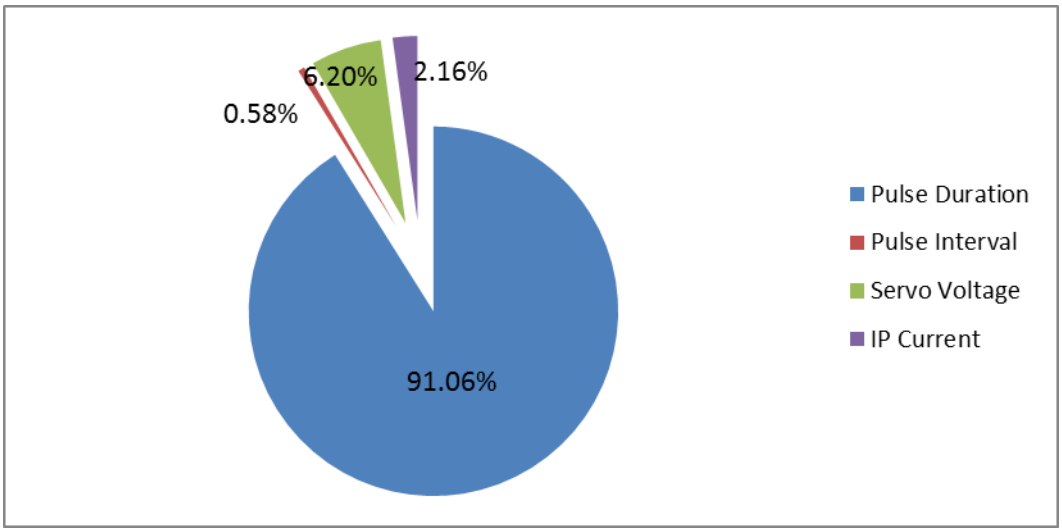


Figure 4.2: Parameter's contributions to MRR (analysis by ANOVA)

Therefore, from the analysis done by using Taguchi method, the parameters optimizations for the material removal rate (MRR) are as follows:

i. Pulse duration, Level 3, 0.65 µs
ii. Pulse interval, Level 3, 9.0 µs
iii. Servo Voltage, Level 3, 20 V
iv. Ignition pulse current, Level 2, 12 Amp

For the respond of kerf width, the experiments were performed according to Taguchi method and results for each set of parameters are shown in Table 4.4.

Table 4.4: Experimental design and Kerf Width Result

Exp No	A [µs]	B [µs]	C [v]	D [amp]	Trial 1 Kerf Width [mm]	Trial 2 Kerf Width [mm]	Trial 3 Kerf Width [mm]	Ave Kerf Width [mm]	S/N ratio [db]
1	0.45	6.0	10	8	0.2145	0.2441	0.2436	0.2341	35.4181
2	0.45	7.5	15	12	0.2410	0.2402	0.2468	0.2427	48.8695
3	0.45	9.0	20	16	0.2484	0.2459	0.2564	0.2502	45.2167
4	0.55	6.0	15	16	0.2129	0.2123	0.2198	0.2150	47.6020
5	0.55	7.5	20	8	0.2248	0.2245	0.2276	0.2256	55.3412
6	0.55	9.0	10	12	0.2203	0.2177	0.2167	0.2182	54.6176
7	0.65	6.0	20	12	0.2388	0.2364	0.2441	0.2398	48.0902
8	0.65	7.5	10	16	0.2238	0.2241	0.2293	0.2257	50.1939
9	0.65	9.0	15	8	0.2343	0.2393	0.2384	0.2373	51.4854

Note : *A : Pulse Duration, B : Pulse Interval, C : Servo Voltage, D : Ignition Pulse Current*

Table 4.5: S/N ratio response table for kerf width – Nominal is best

Level	Pulse Duration [µs]	Pulse Interval [µs]	Servo Voltage [V]	IP Current [Amp]
1	43.17	43.70	46.74	47.41
2	52.52	52.47	49.32	50.53
3	49.92	50.44	49.55	47.67
Delta	9.35	7.76	2.81	3.11
Rank	1	2	4	3

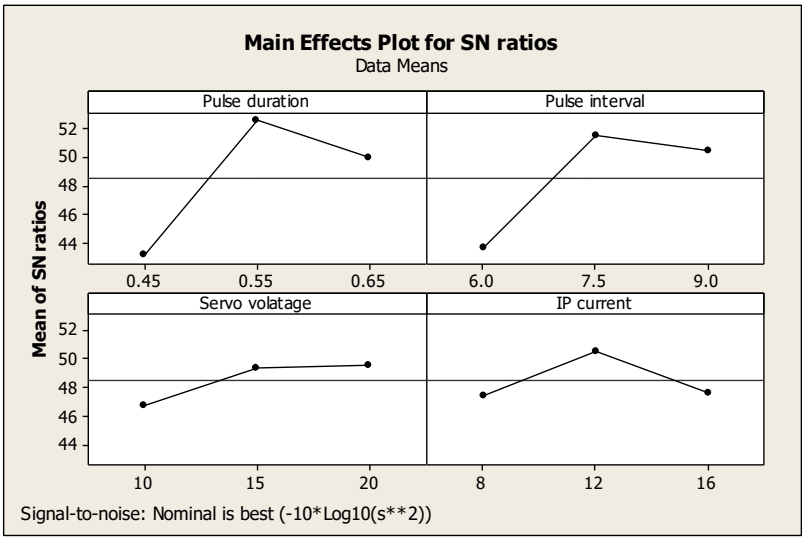


Figure 4.3: Effect of controls parameters to kerf width

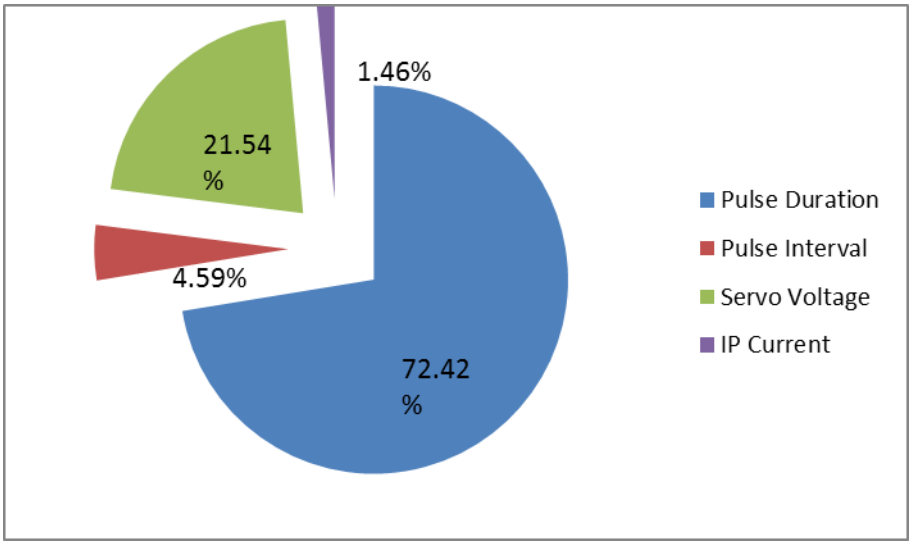


Figure 4.4: Parameters contribution to kerf width (analysis by ANOVA)

From the analysis done by using Taguchi method, the parameters optimizations for the material kerf width are as follows:

i. Pulse duration, Level 2, 0.55 µs
ii. Pulse interval, Level 2, 7.5 µs
iii. Servo Voltage, Level 3, 20 V
iv. Ignition pulse current, Level 2, 12 Amp

For the respond of surface roughness (SR), the same design of experiment is used by using Taguchi method and results for each set of parameters are shown in table 4.7.

Table 4.7: Experimental design and surface roughness result

Exp No	A [µs]	B [µs]	C [v]	D [amp]	Trial 1 Ra [µm]	Trial 2 Ra [µm]	Trial 3 Ra [µm]	Ave Ra [µm]	S/N ratio [db]
1	0.45	6.0	10	8	1.9056	1.8996	1.9206	1.9086	-5.6144
2	0.45	7.5	15	12	1.9996	1.8174	1.6181	1.8117	-5.1937
3	0.45	9.0	20	16	1.9003	1.7071	1.8611	1.8228	-5.2240
4	0.55	6.0	15	16	3.3621	3.3356	3.6124	3.4367	-10.7285
5	0.55	7.5	20	8	3.3108	3.1068	3.3069	3.2415	-10.2187
6	0.55	9.0	10	12	2.7677	2.6429	2.7557	2.7221	-8.6999
7	0.65	6.0	20	12	2.2304	2.3381	2.6034	2.3906	-7.5889
8	0.65	7.5	10	16	2.4644	2.9321	2.7531	2.7165	-8.7021
9	0.65	9.0	15	8	2.7326	2.9015	2.466	2.7000	-8.6465

Note: *A : Pulse Duration, B : Pulse Interval, C : Servo Voltage, D : Ignition Pulse Current*

Table 4.8: S/N ratio response table for surface roughness (SR) – Smaller is better

Level	Pulse Duration [µs]	Pulse Interval [µs]	Servo Voltage [V]	IP Current [Amp]
1	-5.344	-7.977	-7.672	-8.160
2	-9.882	-8.038	-8.190	-7.161
3	-8.312	-7.523	-7.677	-8.218
Delta	-4.538	0.515	0.517	1.057
Rank	1	4	3	2

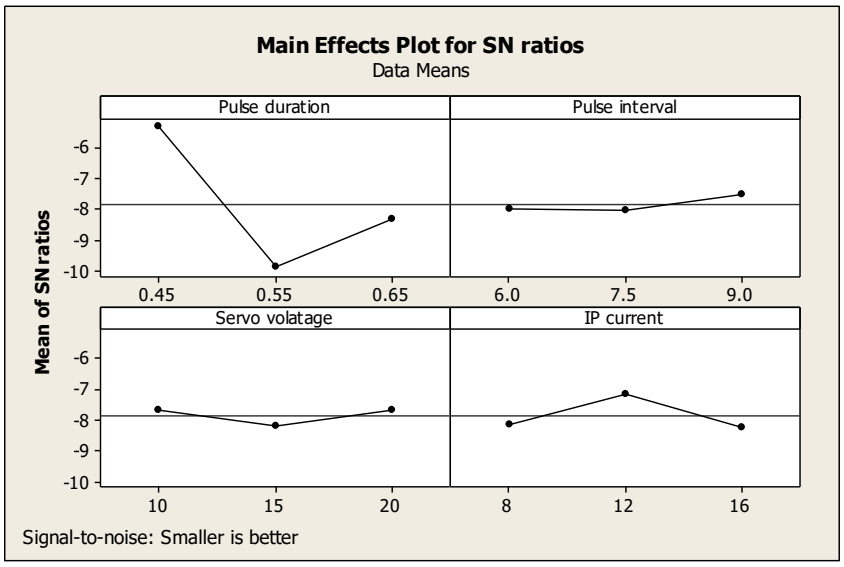


Figure 4.5: Effect of control parameters to surface roughness (SR)

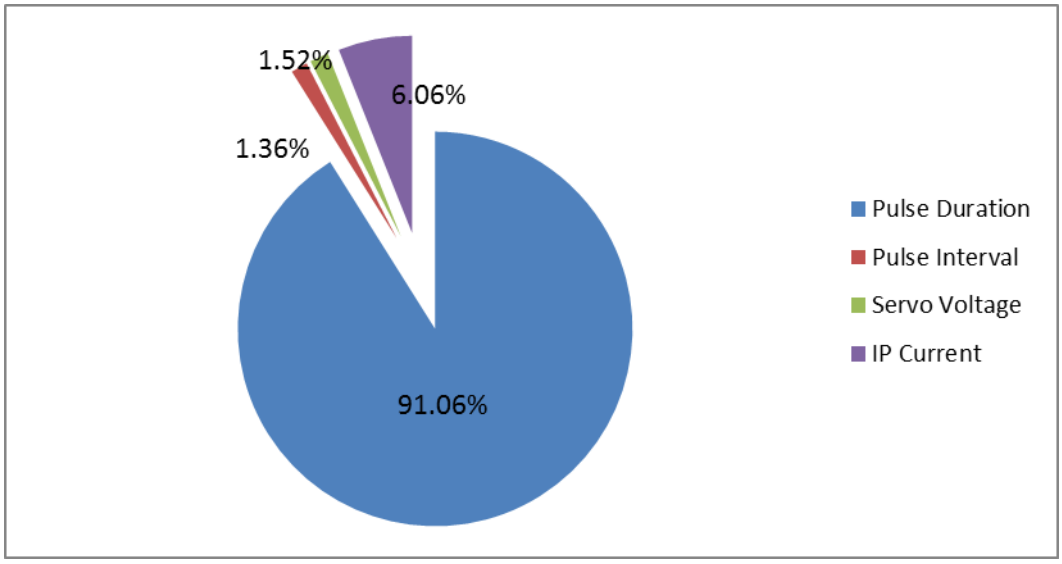


Figure 4.6: Parameters contribution to surface roughness (analysis by ANOVA)

Thus, from the analysis that been done, by using Taguchi method's optimization the optimal parameters for surface roughness are as follow:

i. Pulse duration, Level 2, 0.55µs
ii. Pulse interval, Level 2, 7.5 µs
iii. Servo voltage, Level 2, 15 V
iv. Ignition Pulse Current, Level 3, 16 Amp

4.0 Confirmation test

In order to verify the optimal combination of machining parameters obtained from the Taguchi method, another test cut is run by using this optimum result and the result is recorded. Three confirmation test runs were conducted and the result is compare as shown in the Table 4.10.

Table 4.10: Optimal parameter for machining and conformation test result

	Optimal parameter								
Exp. No.	Pulse Interval [µs]	Pulse Duration [µs]	Servo Voltage [V]	IP Current [Amp]	Opt. Average MRR [mm³/min]	Opt. Average Kerf Width [mm]	Opt. Average SR [µm]	Max. value during trial	Percentage of improvement [%]
1	0.65	9.0	20	12	25.0773			24.2631	3.36
2	0.55	7.5	20	12		0.2435		0.2410	1.02
3	0.55	7.5	15	16			1.6790	1.8117	7.32

From the results of the three response studies, the main parameters that affect the most are pulse duration. Theoretically, pulse duration is the current used for cutting the work piece. The region in which pulse duration (discharge) occurs is heated extremely high temperature, so that the work surface is melted and removed. The strength and hardness of the work material are not factors in EDM. Only melting point of the work material is an important property. When the gap voltage is sufficiently large and reaches the breakdown voltage of dielectric fluid, high power spark is produced, which increase the temperature about 10,000 degrees Celsius. The others three parameters are given less factor as compare to the pulse duration.

Results from this study were in agreement with findings in literature. Y.H Guu [1] suggests an excellent machined finish for AISI D2 steel can be obtained by setting the machine parameters at low pulse energy. Low pulse energy reduces the frequency of bursts of dielectric fluid and melt expulsions. It also reduces tensile residual stress. The EDM process induces damage such as pinholes, micro voids, and craters in the surface layer.

For the MRR, the results also in agreement with S.V Subrahmanyam [2] for cutting H13 hot die steel. It suggested that to increased MRR, the pulse duration value also need to be increased during machining. However, it will affect the surface roughness values.

5.0 Conclusions

In this study, an attempt is made to determine the optimal parameters for surface finish under varying conditions through the use of the Taguchi parameter design process in the WEDM of tool steel. The following conclusions are drawn based on the experiments.

i. The pulse durations, are significant parameter affect the MRR, kerf width and surface roughness compare the other three parameters. The capability of the WEDM process in machining SKD11 tool steel has been found to reach 25.0073 mm/min of MRR, which is increase 3.36% compare to maximum result during trials.

ii. For kerf width, the most significant value is pulse duration where it contributes about 72.42%. Optimal parameters for kerf width have been found at 0.2435mm, which differ 1.02% with average value of kerf width 0.2410mm.

iii. Good surface roughness can be obtain by using level 2 pulse duration, pulse interval, servo voltage and level 3 IP Current. This mean that for rough cut of SKD11 tool steel, the optimum parameter for better surface finish by using 0.55µs pulse duration, 7.5µs pulse interval, 15V servo voltage and 16Amp IP current. The most significant parameter is pulse duration where it was proved by ANOVA. 91.06% contribution comes from pulse duration and follows by IP current, servo voltage and last pulse interval. From the confirmations test, the percentage increased about 7.32%.

6.0 References

[1] Y.H Guu, H. Hocheng, C.Y Chou, C.S Deng (2003). Effect of Electrical Discharge Machining On Surface Characteristics and Machining Damage of AISI D2 Tool Steel. Deparment of Mechanical Engineering, National Tsing

[2] S V Subrahmanyam, M. M. M. Sarcar (2013). Evaluation of Optimal Parameters for machining with Wire cut EDM Using Grey-Taguchi Method. International Journal of Scientific and Research Publications, Volume 3, Issue 3, March 2013, ISSN 2250-3153.

M19: Effect of Wire-EDM Parameters on Machining Characteristics of Titanium Alloy (Ti6Al4V) Using Taguchi Method

Noor Azam[1], Mohd Amran Md Ali[2]
Pusat Latihan Teknologi Tinggi (ADTEC) Kulim, Kedah[1],Universiti Teknikal Malaysia Melaka(UTeM) [2]

noorazam7411@yahoo.com,mohdamran@utem.edu.my

Abstract

Wire electrical discharge machining (WEDM) is a modification of electro discharge machining (EDM) which has been widely used for a long time in producing mold, die and other machine parts of conductive materials. Capability of cutting variety of conductive materials with intricate shapes makes it important in the market. Now, WEDM is extensively used in the field of mold making, medical, aerospace, and automobile industries. But, selection of optimum machining parameter is challenging task in WEDM due to the presence of a large number of process variables and stochastic process mechanism. In this study, WEDM of Titanium alloy (Ti6Al4V) is experimentally studied. The influence of pulse duration, pulse interval, servo voltage and ignition pulse current on material removal rate (MRR), surface roughness (SR) and kerf width is studied using Taguchi method. Analysis of variance method (ANOVA) has been used for recognizing the level of significance of WEDM cutting parameter for optimizing the above mentioned machining performance. Finally the results are particularly useful for machine manufacturers and researchers to determine the best combination of parameters which lead to the optimization of the machining performance.

Keywords: *WEDM, Titanium alloy (Ti6Al4V), Taguchi Method, ANOVA, MRR, SR, kerf width*

1.0 Introduction

Electrical Discharge Machining (EDM) was first discovered by the English scientist Joseph Priestly in 1770, but its advantages were utilized completely only in the year 1943 by the Russian scientists and it was commercially developed in the year 1970 (Basil Kuriachen et.al 2012). EDM is a non-traditional thermoelectric process which erodes material from the work piece by a series of discrete sparks between a work and tool electrode immersed in a liquid dielectric (non-conductive) medium. These electrical dis-charges melt and vaporize minute amounts of the work material, which are then ejected and flush away by the dielectric fluid. Most commonly used dielectric fluids are kerosene and de-ionized water. The wire and work piece must be electrically conductive. When a continuously travelling wire used as the tool electrode in EDM, the process is called wire electro-discharge machining (WEDM). Fig. 1 shows the basic features of the WEDM machine. The movement of wire is controlled numerically to achieve the desired three-dimensional shape and accuracy of the work piece. Typically wires electrode are made from thin copper, brass, tungsten or sometimes has been coated for expanding the wires capability. The wire sizes are in diameter, ranging from 0.05 to 0.3 mm.

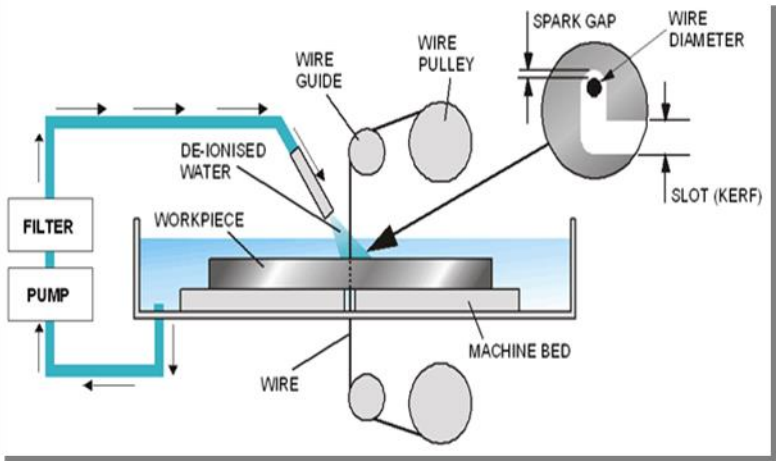


Figure 1: Schematic illustration of WEDM process

WEDM was first introduced to the manufacturing industry in the late 1960s due to seeking a technique to replace the machine electrode used in EDM. In the present scenario the technology of WEDM is improved significantly to satisfy the requirements in many area of manufacturing fields. According to K.H.Ho et al.(2004) WEDM supposes gain higher machining rate with the desired accuracy, reduced wire breakage and minimum surface damage. However, due to a large number of machining parameter, i.e. the frequency and energy of the electrical pulses, the wire electrode diameter and its tension, the length of cut, the wire speed, dielectric flow rate etc., it is difficult to establish the machining parameters, even for an experience operator.

Meanwhile, titanium and titanium alloys (e.g. Ti6Al4V) has a resistivity on the order of five times larger than steel. Titanium alloys have relatively high melting temperature, low thermal conductivities and high electrical resistivity when compared to other common materials, but electrical resistivity is highly dependent on the temperature. It also classified as difficult to machine materials by conventional machining method (Shajan Kuriakose et al 2004). The main reasons are rapid tool wear and high cutting temperatures. Therefore for machining these materials unconventional machining such as WEDM is recommended. But according to K.K.Ho et al (2004) parameters setting that provided by manufacturers are only for the common steel grades. Other than that material, most of the machining parameters are came from the machinists through their experience during handling with WEDM machine. Therefore the parameter setting for advance materials machining such as Titanium alloys have to be further optimized experimentally. This material has been widely used in medical, aerospace, military, sport and commercial applications.

The most machining performance of WEDM that been studied by many researchers are material removal rate (MRR), surface roughness (SR) and kerf width. All these responds are depend on various machining parameters such as pulse on, pulse interval, servo voltage, dielectric fluid pressure, wire tension etc. Selection of parameters combination to optimized machining performance is a challenging task. It is not only for experience machinist but for researchers as well. This is due to the presence of large numbers of variables.

2.0 Problem statement

The parameter setting that provided by manufacturers for machining is only for common steel grades (K.H.Ho et al. 2004). The correct parameter setting for newly developed materials or advanced materials is not readily available. Currently, most of machinist who deals with this kind of materials, usually they utilize their experiences in term of selecting parameters when do machining processes.

In WEDM, the selection of parameters plays a main role in producing good surface quality and high material removal rate (MRR). This study aims to examine the influence of four important parameters viz. ‘pulse on‘, ‘pulse interval‘, ‘servo voltage‘ and ‘ignition pulse current’ on material removal rate and surface roughness of titanium alloys Ti6Al4V. Spark gap or kerf width of machining area also will be measured. Deeper studies of these selected different parameters which are able to deliver better results in terms of surface quality and material removal rate of this particular material. The problem might be interfered the result in this experiment when the selection of the parameters are not suitable and improper to investigate on these machining characteristics.

3.0 Experimental setup

In this work, the experiments were performed at VZ500L linear motor 4-axis CNC WEDM, which manufactured by Sodick Inc.Ltd (Figure 2). Experiment parameters has been input in NC program manually. Work piece material is Titanium alloy (Ti6Al4V, density 4.42g/cm3, Composition: C=0-0.08%, Fe=0-0.25%, Al=5.5-6.76%, O=0-0.2%, N=0-0.05%, V=3.5-4.5%, H=0-0.375%, balance Ti) and the size is 260 mm x 60 mm x 4 mm. Brass wire was used for cutting the work piece.

Nine sets of parameters of experiments were conducted to determine all responds i.e. material removal rate (MRR), surface roughness (SR) and kerf width. For each set of parameters the work piece was cut for a length of 20 mm as Figure 3. Each set will consist of three trials of cutting.

Figure 2: VZ500L Sodick WEDM

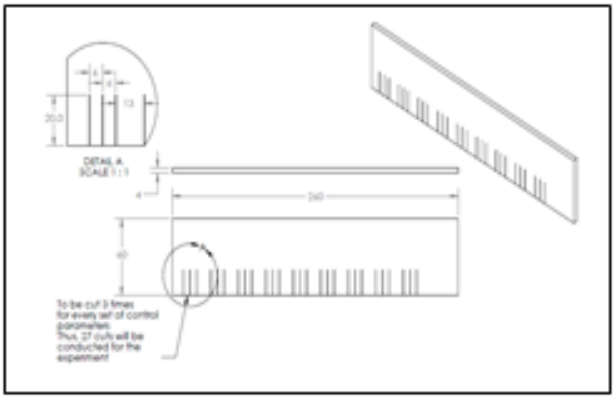


Figure 3: Cutting method of work

Weight before and after cutting proses was measured as well as time taken to cut the work piece. The following equation will be used to calculate the MRR value:

$$MRR = \frac{Wa - Wb}{Tm} \ (g/min) \qquad \text{----------} \qquad \text{(Equation 1)}$$

Where,

Wb is weight of work piece material before cutting
Wa is weight of work piece material after cutting
Tm is machining time (minute)

After that, each piece was cleaned and the surface roughness was measured as Ra value by using Surftest 400V Mitutoyo. SR value will be measured for length 8 mm at cutting surface and three readings was taken before average it. Lastly, kerf width was measured by using Mitutoyo microscope as the sum of the wire diameter and twice wire work piece gap as Figure 4.

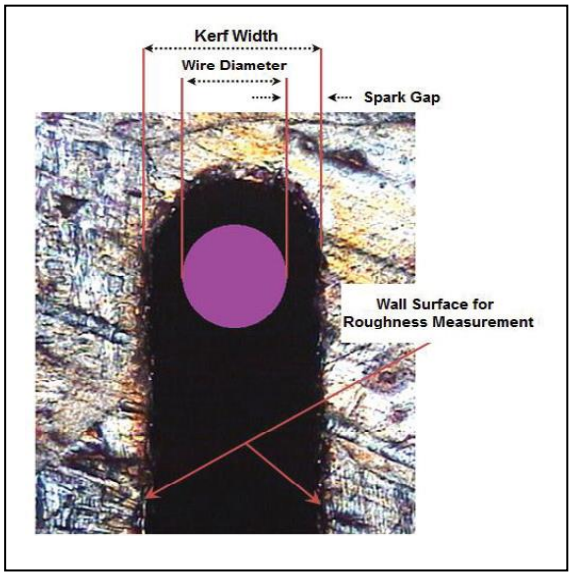


Figure 4: Measurement of kerf width (Aniza Alias et al.2012)

Design of experiment is based on Taguchi Method and it also to be used for optimizing the cutting parameters. Analysis of variance (ANOVA) was employed to recognize the level of significance of the machining parameters on the performance characteristics of material removal rate, surface roughness and kerf width. Software used is Minitab 16.

The level and machining parameters are shown in Table 3.1. Others parameters were set as automatic.

Table 3.1: Levels and WEDM parameters

Control parameters

No	Parameters	Level		
		Lo	Med	Hi
1	Pulse on [µs]	0.5	0.6	0.7
2	Pulse interval [µs]	10	15	20
3	Servo voltage [V]	30	40	50
4	Ignition pulse current [Amp]	8	16	24

Constant parameters

No	Parameter	Value
1	Machining voltage[V]	80
2	Wire tension [kg]	1.2
3	Injection pressure [bar]	10

In the experiments, Taguchi method was used to determine the combination of control parameters. The selection of factors was based on the journals and the suggestion from the handbook recommended by the machine manufacturer.

The experimental results were converted into a signal-to-noise (S/N) ratio. In this study, for MRR, the characteristic that higher value represents better machining performance is called 'higher is better'. In contrary, for surface roughness, the characteristic that lower value represents better machining performance is called 'lower is better'. For kerf width, 'nominal the best' was used. Therefore, from above mentioned characteristic the optimum machining parameters were defined for obtaining optimum machining performance.

The S/N ratio can be calculated as a logarithmic transformation of the loss function as shown below.

S/N ratio for MRR $_{bigger\ is\ better}$ = -10 $\log_{10}$ [$\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y^2}$]

S/N ratio for SF $_{lower\ is\ better}$ = -10 log10 [$\frac{1}{n}\sum_{i=1}^{n}y^2$]

S/N ratio for kerf width $_{nominal\ the\ best}$ = 10 log 10 $\left[\frac{\overline{Y^2}}{s^s}\right]$

5.0 Result and discussion

4.1 Effect on material removal rate (MRR)

For the respond of material removal rate (MRR), the experiments were performed according to Taguchi method and result for each set of parameter is shown in Table 4.1.

Table 4.1: Experimental design and MRR result

Exp. no	A [µs]	B [µs]	C [V]	D [amp]	Trial 1	Trial 2	Trial 3	Ave MRR [g/min]	S/N ratio [db]
1	0.5	10.0	30.0	8.0	0.038	0.036	0.040	0.038	-28.47
2	0.5	15.0	40.0	16.0	0.043	0.041	0.042	0.042	-27.56
3	0.5	20.0	50.0	24.0	0.033	0.029	0.031	0.031	-30.15
4	0.6	10.0	40.0	24.0	0.039	0.040	0.042	0.040	-27.93
5	0.6	15.0	50.0	8.0	0.036	0.039	0.037	0.037	-28.60
6	0.6	20.0	30.0	16.0	0.040	0.040	0.039	0.040	-28.02
7	0.7	10.0	50.0	16.0	0.040	0.038	0.041	0.039	-28.08
8	0.7	15.0	30.0	24.0	0.040	0.041	0.042	0.041	-27.76
9	0.7	20.0	40.0	8.0	0.041	0.041	0.040	0.040	-27.87

Note: *A: Pulse duration, B: Pulse interval, C: Servo voltage, D: Ignition pulse current*

Software MINITAB 16 was used to determine which levels of control parameter is ideal to be chosen for optimizing the MRR. After putting the data from Table 4.1, the following Signal to Noise (S/N) ratio response table for MRR and respond graphs was obtained.

Table 4.2: S/N ratio response table for MRR – Bigger is better

Level	Pulse duration [µs]	Pulse Interval [µs]	Servo Voltage [V]	IP Current [Amp]
1	-28.75	-28.18	-28.09	-28.33
2	-28.19	-27.98	-27.79	-27.90
3	-27.91	-28.69	-28.96	-28.63
Delta	0.84	0.71	1.17	0.73
Rank	2	4	1	3

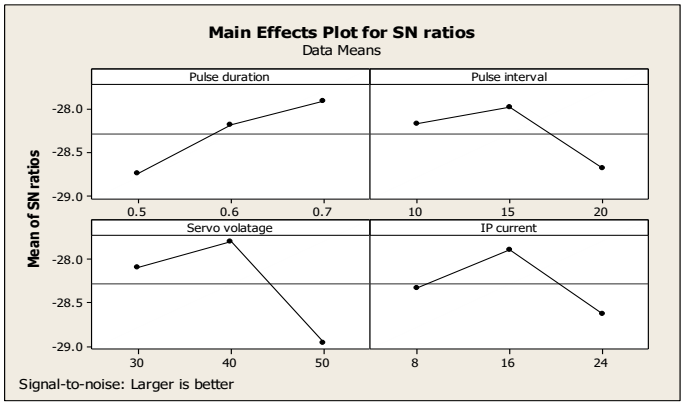


Figure 4.1: Effect of control parameters to material removal rate (MRR)

According to the characteristic that higher value represents better machining performance, the higher value of S/N ratio is the most optimum parameters. From Table 4.2, which reveals that the optimal parameters for each control parameter is as follows: the level 3 pulse duration following by level 2 pulse interval, level 2 servo voltage and level 2 ignition pulse current. Delta between the higher and lower value of S/N ratio of control parameter represents which parameter gives most significant affect to the respond of material removal rate (MRR).

From Table 4.2, it reveals that in case of material removal rate (MRR), the rank of significant parameters that affecting the material removal rate (MRR) are servo voltage and following by pulse duration, ignition pulse current and pulse interval. Figure 4.1, shows graphically the effect of four control parameters on material removal rate (MRR) respectively. It can be observed that the optimal values are stated in top of graphs.Analysis of variance (ANOVA) can be utilized to determine the level of significance of the control parameters on the performance characteristics of MRR. After adding data from Table 4.1 to the software MINITAB 16 the following Table 4.3 had been obtained. This table shows the result of ANOVA for MRR and then converted to pie chart as Figure 4.2 for better visualization on control parameters contribution to the MRR.

Table 4.3: ANOVA for material removal rate (MRR)

Factors	Contribution (%)	Level
Pulse duration	22.15	2
Pulse Interval	16.32	4
Servo Voltage	45.04	1
Ignition Pulse Current	16.49	3

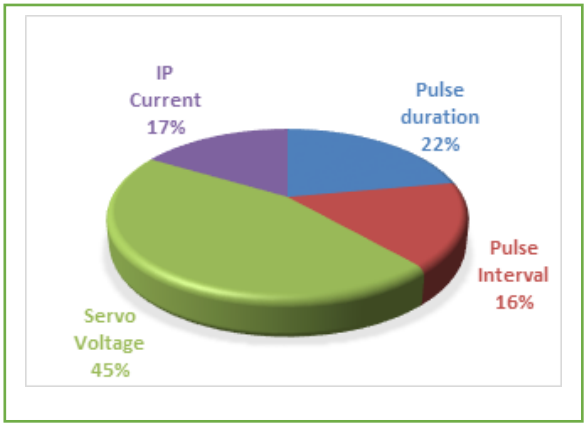


Figure 4.2: Parameter's contribution to MRR

Table 4.3 and Figure 4.2 reveal that servo voltage significantly affects MRR following by pulse duration, ignition pulse current and pulse interval. Higher values of servo voltage will increase the MRR. This is because the increase in servo voltage means more collisions between ions and electrons which lead to a lot of removal of eroded particles from the cutting area. This factor contributes 45% in MRR. Pulse duration is another main factor that influenced MRR. As indicated in Figure 4.1, when pulse duration increased, MRR also increased. Increasing the pulse duration means increasing time of each current discharge time and raised the MRR. This factor contributed 22% in MRR. These results are in agreement with Vamsi Krishna Pasam et al. (2010) and Kuriakose et al. (2005). Other than that, pulse duration and ignition pulse current give contribution 17% and 16% respectively to the MRR.

Therefore, from the analysis that been done, by using Taguchi method's optimization the optimal parameter for MRR are as follows.

i. Pulse duration , Level 3, 0.7 µs
ii. Pulse interval , Level 2, 15 µs
iii. Servo voltage, Level 2, 40 V
iv. Ignition pulse current, Level 2, 16 Amp

4.2 Effect on surface roughness (SR)

For the respond of SR, the experiments were performed according to Taguchi method and result for each set of parameter is shown in Table 4.4.

Table 4.4: Experimental design and surface roughness result

Exp no	A [µs]	B [µs]	C [V]	D [amp]	Trial 1	Trial 2	Trial 3	Ave SR [µm]	S/N ratio [db]
1	0.5	10.0	30.0	8.0	2.45	2.49	2.27	2.40	-7.61
2	0.5	15.0	40.0	16.0	2.46	2.19	2.36	2.34	-7.39
3	0.5	20.0	50.0	24.0	2.24	1.82	2.15	2.07	-6.35
4	0.6	10.0	40.0	24.0	3.00	2.86	3.04	2.97	-9.45
5	0.6	15.0	50.0	8.0	2.80	2.68	2.98	2.82	-9.01
6	0.6	20.0	30.0	16.0	2.64	2.78	2.86	2.76	-8.83
7	0.7	10.0	50.0	16.0	2.86	3.49	3.28	3.21	-10.15
8	0.7	15.0	30.0	24.0	3.30	3.10	3.00	3.13	-9.92
9	0.7	20.0	40.0	8.0	3.33	3.15	2.99	3.16	-10.00

Note : *A : Pulse duration, B: Pulse interval, C: Servo voltage, D: Ignition pulse current*

Same steps as previously taken to analyze the MRR, the obtained data from Table 4.4 was added to software MINITAB 16 to determine which levels of control parameter is ideal to be chosen for optimizing the SR. After putting the data from Table 4.4, the following Signal to Noise (S/N) ratio response table for SR and respond graphs had been obtained.

Table 4.5: S/N ratio response table for SR - Smaller is better

Level	Pulse duration [µs]	Pulse Interval [µs]	Servo Voltage [V]	IP Current [Amp]
1	-7.115	-9.073	-8.787	-8.875
2	-9.098	-8.774	-8.948	-8.788
3	-10.026	-8.392	-8.504	-8.575
Delta	2.912	0.681	0.443	0.3
Rank	1	2	3	4

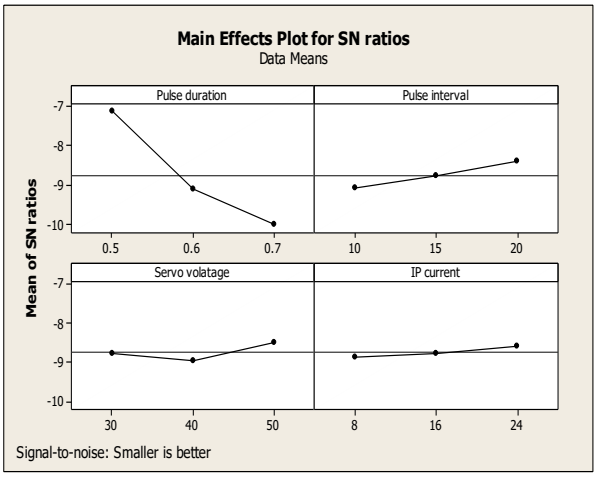


Figure 4.3: Effect of control parameters to SR

Base to the characteristic that higher value represents better machining performance, the higher value of S/N ratio is the most optimum parameters. From Table 4.5, it clearly reveals that the optimal parameters for each control parameter are as follows: the level 1 pulse duration following by level 3 pulse intervals, level 3 servo voltages and level 3 ignition pulse current. From the delta difference of S/N ratio value, it can be understand that the significant parameter which influence the surface roughness in priority rank are as follows. First is pulse duration, secondly pulse interval and following by servo voltage and ignition pulse current. Figure 4.3, shows graphically the effect of four control parameters on SR respectively. ANOVA is used to demonstrate the level of significant of the control parameters on the performance characteristics of surface roughness. By using MINITAB 16 and after adding data from Table 4.4, ANOVA for surface roughness (Table 4.6) had been obtained and then converted graphically as Figure 4.4.

Table 4.6: ANOVA for SR

Factors	Contribution (%)	Level
Pulse duration	93.41	1
Pulse Interval	4.31	2
Servo Voltage	1.72	3
Ignition Pulse Current	0.57	4

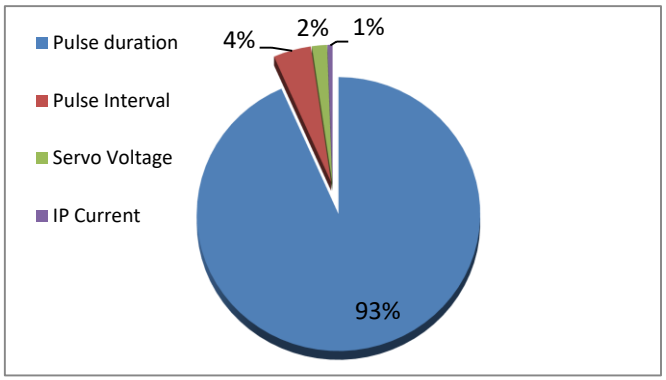


Figure4.4: Parameter's contribution to SR

From ANOVA analysis, the most significant parameters that influences surface roughness is pulse duration followed by pulse interval. Figure 4.3 demonstrate that increase of pulse duration will detriorate the SR. SR value Ra increased when the pulse duration increased due to longer time for machining, which led to higher posibility of double sparking and localized sparking to occur. This phenomenon can produce poor surface finish. According to Table 4.6 pulse duration contributed 93.41% in influencing SR. Therefore as mention by Kuriakose et al. (2004) for SR the lower pulse duration is better.

Thus, from the analysis that been done, by using Taguchi method's optimization the optimal parameter for SR are as follows.

i. Pulse duration , Level 1, 0.5 µs
ii. Pulse interval , Level 3, 20 µs
iii. Servo voltage, Level 3, 50 V
iv. Ignition pulse current, Level 3, 24 Amp

4.3 Effect on kerf width

For the respond of kerf width, the experiments were performed according to Taguchi method and result for each set of parameter is shown in Table 4.7.

Table 4.7: Experimental design and kerf width result

Exp no	A [µs]	B [µs]	C [V]	D [amp]	Trial 1	Trial 2	Trial 3	Ave kerf width [mm]	S/N ratio [db]
1	0.5	10.0	30.0	8.0	0.284	0.287	0.274	0.282	32.58
2	0.5	15.0	40.0	16.0	0.288	0.275	0.274	0.279	31.44
3	0.5	20.0	50.0	24.0	0.276	0.275	0.279	0.277	41.97
4	0.6	10.0	40.0	24.0	0.268	0.268	0.265	0.267	42.85
5	0.6	15.0	50.0	8.0	0.268	0.269	0.278	0.272	33.81
6	0.6	20.0	30.0	16.0	0.279	0.277	0.276	0.277	44.07
7	0.7	10.0	50.0	16.0	0.278	0.275	0.277	0.276	46.73
8	0.7	15.0	30.0	24.0	0.275	0.276	0.272	0.274	41.89
9	0.7	20.0	40.0	8.0	0.278	0.273	0.278	0.276	40.27

Note : *A : Pulse duration, B: Pulse interval, C: Servo voltage, D: Ignition pulse current*

Again, software MINITAB 16 was used to determine which levels of control parameter is giving more influences to kerf width. After putting the data from Table 4.7, the following Signal to Noise (S/N) ratio response table for kerf width and respond graphs had been obtained.

Table 4.8: S/N ratio response table for kerf width – Nominal is best

Level	Pulse duration [µs]	Pulse Interval [µs]	Servo Voltage [V]	IP Current [Amp]
1	35.33	40.72	39.52	35.55
2	40.24	35.71	38.19	40.75
3	42.97	42.11	40.84	42.24
Delta	7.63	6.39	2.65	6.68
Rank	1	3	4	2

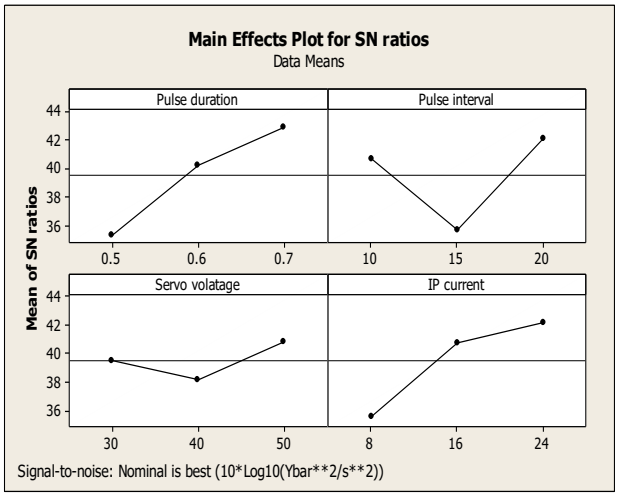


Figure 4.5: Effect of controls parameters to kerf width

From Table 4.8 and Figure 4.5, it clearly can be understood that, when increased pulse duration, the kerf width decreased. Same pattern can be seen when ignition pulse current increased the kerf width decreased.

Similarly as MRR and SR, ANOVA was used to demonstrate the contribution of each control parameter on the performance characteristics of kerf width. By adding data from Table 4.7, ANOVA for kerf width (Table 4.9) had been obtained and then converted graphically as Figure 4.6.

Table 4.9: ANOVA for kerf width

Factors	Contribution (%)	Level
Pulse duration	37.09	1
Pulse Interval	28.03	3
Servo Voltage	4.35	4
Ignition Pulse Current	30.53	2

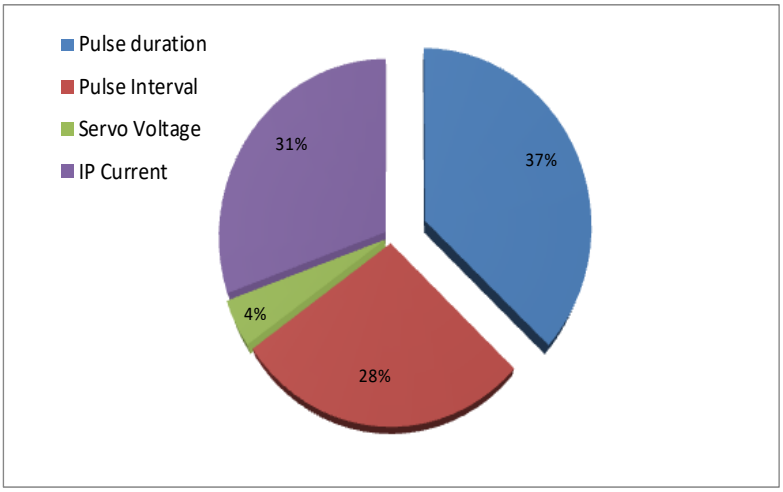


Figure 4.6: Parameter's contribution to kerf width (analysis by ANOVA)

From the result of ANOVA it has been determined that the most significant parameter with respect to the respond of kerf width are found to be pulse duration 37%, following by ignition pulse current 31% , pulse interval 28% and servo voltage 4%. It seems that servo voltage gave a least influence to the respond of kerf width.

Thus, from the analysis that been done, by using Taguchi method's optimization the optimal parameter for kerf width are as follows.

i. Pulse duration , Level 3, 0.7 µs
ii. Pulse interval , Level 3, 20 µs
iii. Servo voltage, Level 3, 50 V
iv. Ignition pulse current, Level 3, 24 Amp

6.0 Conclusion

From the present study, issues of machining characteristic or response with several of WEDM parameters has been investigated. Following conclusion may be drawn from this work.

i. The most significant parameters for material removal rate is servo voltage followed by pulse duration. Material removal rate tend to increase with increasing of servo voltage and pulse duration. Increased of servo voltage will influence on increasing the numbers of ion and electrons which leads to increase the numbers of collision between them. Increased on number of collisions will lead to increase of material removal rate from work piece. Furthermore, pulse duration influences on each current discharge time, where it will extend the time for current discharged and raised the material removal rate. The optimal parameters for material removal rate have been found to reach 0.044g/min, which is 4.76% up compare to maximum result during trial experiments.

ii. For surface roughness, the most significant parameter is pulse duration. ANOVA has proved that 93.41% contribution is comes from pulse duration. Lower pulse duration is desired because exposure to the long discharge time will deteriorate the surface. Optimal parameters for surface roughness have been found at 1.980 µm, which 4.35% better than previous result during trial experiment.

iii. For kerf width, the most significant parameter is pulse duration followed by ignition pulse current and pulse interval. Servo voltage gave least influences to kerf width. The optimal parameters for kerf width have been found at 0.275mm, which is differs 0.036 percent with average value of kerf width 0.276mm.

7.0 Future plan

Base on the characteristics that has been discussed, in future it is recommended to extend this study by using coated wire as an electrode and to consider the dielectric flow and wire feed rate as control parameter to cut the thickness of 4 mm Titanium alloy.

8.0 References

[1] Aniza Alias, B.A.N.M.A. (2012) 'Influence of machine feed rate in WEDM of Titanium Ti6Al4V with constant current (6A) using brass wire', Shah Alam.

[2] Basil Kuriachen, D.J.P.D.J.M. (2012) 'Modelling of Wire Electrical Discharge Machining Parameters Using Titanium Alloy (Ti6Al4V)', International Journal of Emerging Technology and Advanced Engineering, vol. 2, no. 4, April.

[3] Daniel Ghodsiyeh, M.A.L.G.G.M.r.G. (2012) 'Optimizing Rough Cut in WEDMing Titanium Alloy (Ti6Al4V) by brass using the Taguchi Method', Journal of Basic and Applied Scientific Research, vol. 8, no. 2, pp. 7488-7496.

[4] Mt.Antar, S. D. (2011). 'Productivity and workpiece surface integrity when WEDM aerospace alloys using coated wire', Procedia Engineering, 3-8.

[5] Vamsi Krishna Pasam, S.B.B.M.V.P.S.M. (2010) 'Optimizing Surface Finish in WEDM Using the Taguchi Parameter Design Method', Journal of Braz.Soc.Mechanical Science and Engineering, vol. XXXII, no. 2/207, April-June.

[6] S.S Mahapatra, A.P. (2006) 'Optimization of wire electrical discharge machining (WEDM) process parameters using Taguchi method', International Journal of Advanced Manufacturing Technology.

M20: Mesin Bebola Daging Menggunakan Sistem Empat Penggelek

Noorazmi Bin Abd. Rahman,
Pusat Latihan Teknologi Tinggi (ADTEC) Taiping, Perak Darul Ridzuan

Noorazmi@*jtm.gov.my*

Abstrak

Mesin Bebola Daging adalah satu penggunaan teknologi makanan yang boleh diaplikasikan dalam Industri Kecil Sederhana (IKS). Mesin ini dilengkapi dengan system empat penggelek dikawal oleh motor power window untuk menghasilkan bebola daging yang mempunyai bentuk yang sekata dan bersih. Terbahagi kepada tiga peringkat; peringkat permulaan ,peringkat pemotongan campuran bebola daging dan peringkat penggelek. Pengaturcaraan proses ini dibentuk dengan menggunakan ladder diagram daripada kawalan Programmable Logic Controller (PLC) model CPM1E. Untuk melaksanakan projek ini beberapa penyambungan litar elektrik telah digunakan untuk memastikan mesin mendapat bekalan yang cukup dan selamat. Operasi bermula daripada tempat simpanan doh daging, silinder yang pertama akan menolak doh daging tersebut dan dipotong menggunakan silinder kedua. Doh yang dipotong akan dibawa menggunakan conveyor dan digelek menggunakan empat papan penggelek bagi mendapatkan bentuk yang sekata. Projek ini mampu mengeluarkan bebola daging yang berkualiti serta cepat dalam penghasilan.

Kata kunci : *motor power window, PLC, ladder diagram, CPM1E, conveyor*

1.0 Pengenalan Kajian

Melihat kepada kepentingan inovasi, maka kepelbagaian produk berinovasi perlu wujud di dalam pelbagai bidang atau sektor. Oleh itu, kelebihan sesuatu produk yang inovatif boleh mengubah sesebuah industri menjadi lebih maju. Dimana,pencarian idea yang bermula dari biasa dan dipandang ringan, setelah diinovasikan akan menjadi hebat dan luar biasa (Mohd Faizal Aziz, 2010). Dengan ini, inovasi di dalam pembuatan bebola dilihat satu perkara yang baru bagi masyarakat. Alat-alat yang baru dicipta bagi membantu pengusaha kecil bebola dalam menyelesaikan masalah proses pembuatan bebola mampu diselesaikan dengan penghasilan produk yang diinovasikan.

Pada masa kini, bebola merupakan snek makanan yang digemari ramai terutamanya bebola daging. Ada yang menjadikannya makanan untuk minum petang dan ada yang memilih hidangan ini untuk dimakan bersama nasi. Maka, tidak hairanlah bebola kini menjadi kegemaran ramai dan sering mendapat tempat di pasaran. Lazimnya cara bebola daging dibuat adalah secara manual iaitu pekerja akan menguli dan bentukkan doh menjadi kecil serta bulat seperti bola pingpong Namun, ia mempunyai masalah kerana mereka perlu menguli dan bulatkan doh dalam kuantiti yang banyak dalam satu masa. Kerja tersebut menyukarkan mereka kerana membentuk doh menjadi bulat adalah sesuatu kerja yang agak leceh dan lambat. Selain itu faktor kebersihan juga menjadi satu elemen yang penting dalam memastikan bebola yang terhasil bersih dan berkualiti.

Penghasilan mesin ini bertujuan untuk memudahkan para pengusaha bebola daging menghasilkan bebola dalam kapasiti yang banyak dalam satu masa. Dengan menggunakan sistem pembuatan bebola daging yang sistematik dan berjadual atau dengan lebih mudah lagi menggunakan mesin bermasa ia mampu menyelesaikan masalah ini. Penggunaan mesin ini memudahkan pengusaha dan juga lebih efisien kerana ia menghasilkan bebola dalam kapasiti yang banyak dalam satu masa. Proses yang lambat dapat diubah menjadi lebih pantas berbanding proses secara manual. Selain itu, tenaga pekerja dapat dijimatkan. Melihat kepada pekentingan penjagaan kualiti dan kebersihan makanan, lampu UV perlu diletakkan berfungsi sebagai alat untuk membunuh kuman dan bacteria. Lampu UV memancarkan sinar Ultraviolet yang memiliki kemampuan untuk mempengaruhi fungsi sel makhluk hidup dengan mengubah DNA sehingga makhluk tersebut mati.

2.0 Latar Belakang Kajian

Kaedah menggunakan tangan adalah cara tradisional untuk menghasilkan bebola daging. Masa yang diambil untuk menyiapkan bebola daging dalam kuantiti yang banyak tidak menentu dan polanya lebih menunjukkan kepada pertambahan setiap kali rekod diambil bergantung kepada keadaan pekerja dan persekitaran ketika itu. Dalam satu ujian yang telah dilakukan ke atas pekerja secara rawak, bebola daging yang mampu dihasilkan oleh pekerja adalah antara 200-250 biji bebola daging satu shif dengan bentuk fizikal bebola daging yang tidak sekata dan boleh menyebabkan pertikaian oleh pembeli. Disamping itu tahap kebersihan dan kualiti makanan yang dihasilkan tidak diyakini dan boleh mendatangkan keraguan. Rajah 1 menunjukkan terdapat juga pengusaha yang menggunakan bekas berbentuk bebola untuk memudahkan proses pembentukkan bebola namun masih memerlukan tenaga insani untuk menyiapkannya.

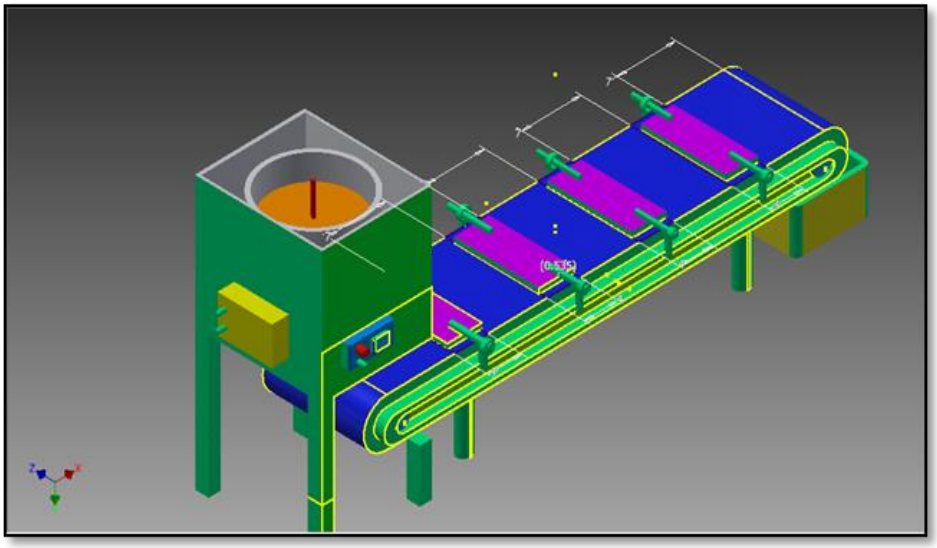
Rajah 1 : Acuan Bebola Daging

Kebanyakkan mesin-mesin bebola yang ada di pasaran diimport dari luar Negara dan kos mesin serta penghantaran menyebabkan sesetengah pengusaha tidak mampu untuk memilikinya. Rajah 2 menunjukkan contoh mesin buatan negara Cina. Selain faktor kos, mesin ini juga menggunakan air panas bagi memastikan bentuk dan kualiti bebola daging terjamin. Namun air yang terlalu panas akan menyebabkan bentuk bebola menjadi tidak sekata dan akan merekah sedikit demi sedikit

Rajah 2: Mesin Bebola Daging Buatan China

3.0 Rekabentuk dan spesifikasi mesin

Rekabentuk mesin ini dilakar dengan menggunakan perisian Autodesk Inventor 2013



Rajah 3 : Lukisan Isometrik Mesin

Rajah 4: Mesin Bebola Daging dengan Empat Penggelek

Jadual 1: Spesifikasi Mesin

Bil	Perkara	Spesifikasi
1	Dimensi mesin	194cm x 71.1cm x 171 cm
2	Kuasa Motor (conveyor)	DC Brushless Planetary Gear Motor,60W
3	Kuasa Motor (penggelek)	12V
4	Spesifikasi bebola daging	Φ30~35mm
5	Berat	70~90 kg
6	Kapasiti Pengeluaran	30~50 / min
7	PLC	CP1E (AC)
8	Pemotong doh	Double Acting Cylinder, 5/2 way directional valve single solenoid
9	Penderia	Optical sensor (transmitter-receiver)
10	Lampu UV	HITACHI G4 T5 Germieidal Tube
11	Lain-lain	Mempunyai roda untuk senang dibawa, ringan, rekacipta yang menarik dan selamat digunakan.

4.0 Operasi Sistem

Sistem mesin ini hampir keseluruhannya dikawal oleh PLC OMRON CP1E . Aturcara program menggunakan Ladder Diagram dan banyak menggunakan pemasa dan pembilang untuk memastikan kuantiti bebola per minit diperolehi dengan tepat.

Rajah 6: PLC OMRON CP1E

Berikut merupakan spesifikasi bagi PLC ini:

- 90mm x 79 mm x 86mm, kecil, ringan serta mudah dipasang pada mesin.
- Bilangan I/O yang mencukupi untuk projek ini (12 input dan 8 output)
- menggunakan kabel USB
- Arahan boleh sehingga ke 200
- Berat 370g
- Voltan masukan 100 -240 VAC 50/60 Hz
- Bahasa Pengaturcaraan = Ladder Diagram
- Kapasiti program = 2K steps
- Kapasiti Memori Data = 2K words

Untuk menggerakkan penggelek, motor *power window* 12 V digunakan berdasarkan kesesuaian kelajuan motor itu sendiri. Menggunakan *relay* 12 Volt sebagai pengawal gerakan motor. Pendawaian bagi motor ini dipasang berasingan dengan PLC kerana masukan voltan yang berbeza.

5.0 Keputusan dan Perbincangan

Produk yang dihasilkan :

i. Bebola daging yang bersih dan bentuk sekata.
ii. Bebola daging dapat dihasilkan 30 -50 biji atau lebih dalam 1 minit.
iii. Sebagai sebuah syarikat pembuatan,Pengeluaran mesin bebola daging dapat dihasilkan dalam kadar 5 buah mesin dalam tempoh masa 6 bulan.Selain itu,mesin bebola daging dihasilkan berdasarkan permintaan dari Industri kecil sederhana (IKS) yang memerlukannya

6.0 Rujukan

[1] Abdul Rahim, Ruzairi and Abdul Rahim, Herlina (2010) *Asas Pengawal Logik Boleh Atur Cara (PLC).* Penerbit UTM, Skudai, Johor Bahru. ISBN 9789835207273.

[2] Http:// WWW.Utusan.Com.My/Utusan/Produk/201130805/Pr_02/Mesin-Bebola

[3] Van Valkenburgh (1982, 2002, 2002), Asas Elektrik, Penerbit UTM, Skudai, Johor Bahru ISBN: 9789679500516.

M21: Mould Insert Surface Roughness Optimization by Orthogonal Array Methodology in Electrical Discharge Machining

Mohd Nazri bin Salim[1,] Mohamad bin Minhat [2]
Institut Latihan Perindustrian (ILP) Ledang, Johor
Universiti Teknikal Malaysia Melaka (UTeM)

nazri@jtm.gov.my,mohdm@utem.edu.my

Abstract

The surface qualities of injection molding parts are related to the mold insert surface roughness. Mould insert is typically made from tool steel. The most common method in machining the mold insert cavity is through Electrical Discharge Machining (EDM) as it enables complex geometry to be machined on hard materials such as tool steel, and super alloy. Surface roughness plays an important role in mould manufacturing as it decides on the time and ultimately cost. The effect of current, voltage, and jump speed to surface roughness are investigated through the use of Orthogonal Array Method. It is found that through orthogonal array method, the current parameter contributes significant effect on the surface roughness as compared to other EDM parameter studied with 8.8% error from the theoretical value.

Keywords: *Surface Roughness, Electrical Discharge Machining (EDM), Orthogonal Array Method*

1.0 Introduction

Electrical Discharge Machining (EDM) is one of the earliest non-traditional machining processes. It is based on thermoelectric energy between the workpiece and an electrode. Various types of products, such as molds and dies can be produced through EDM. During EDM process, large amount of heat is generated, which affects the surface characteristics of the metals. However, this phenomenon is unavoidable during EDM of metals, and some technical problems remain unsolved in the area of surface integrity of the machined workpiece. EDM is also used to shape hard metals and form deep and complex-shaped holes by electro-erosion in all types of electro-conductive materials (Ghrib, et al., 2009). As a consequences, surface finish and integrity are two different facets of the cavity quality, but both play an important part in the characteristics of the mold insert.

In EDM process, the performance is determined by material removal rate (MRR), electrode wear, surface roughness, surface quality and dimensional accuracy. A series of investigations has been conducted to study the surface quality, MRR, electrode wear rate, and dimensional accuracy of mold steels in EDM. The effect of the machining parameters on MRR, relative wear ratio, and surface roughness in EDM of tungsten carbide had been studied using different electrode materials and concluded that copper yields the better results than brass (Soni & Chakraverti, 1995). It is also understood that the copper electrodes have a minimal wear rate and provide the smallest roughness values.

Surface roughness (*Ra*) is a significant parameter that is being used comprehensively in the manufacturing system especially in the injection molding industry. Therefore, characterization, prediction, and modeling of quality of EDM mold inserts surface roughness play a vital role to determine the quality of the finished plastic products. Machined components that have good surface roughness, improves the fatigue strength, wear resistance and corrosion resistance of the surface. *Ra* depends on different EDM machining parameters and its prediction and control is a must for any machinist.

2.0 Theoretical Framework

The main objective of this research is to evaluate the quality of the surface roughness through different parameter and to find the significant EDM parameter that influences the surface roughness, *Ra*, using the orthogonal array method to the mold insert. The schematic flow of the overall research is shown in Figure 1.

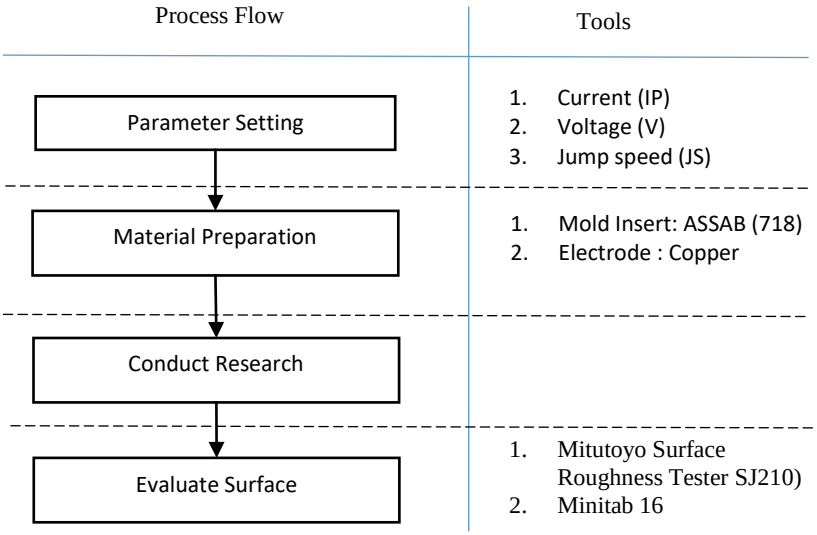


Figure 1: Schematic Flowchart of the Overall Research

The experimental setup of the research is shown in Table 1 and Table 2 respectively. This research is conducted according to the orthogonal array layout. Eight (8) experiments or trials will be carried out throughout the research. Table 2 shows the level of process parameters that are used in the research.

Table 1: Level of Process Parameter for Copper Electrode

Parameter	Low	High	Unit
Current (IP)	2.5	7.3	A
Voltage (Volt)	21	22	V
Jump Speed (JS)	10	20	m/min

Table 2: Orthogonal Array Table

Trial#	A	B	C	AB	AC	BC	ABC	Response
1	-	-	-	+	+	+	-	
2	+	-	-	-	-	+	+	
3	-	+	-	-	+	-	+	
4	+	+	-	+	-	-	-	
5	-	-	+	+	-	-	+	
6	+	-	+	-	+	-	-	
7	-	+	+	-	-	+	-	
8	+	+	+	+	+	+	+	
Average of (+)								
Average of (-)								

Table 3: Orthogonal Array Table for Experiment

Trial#	IP	V	JS	Response
1	2.5	21	10	
2	7.3	21	10	
3	2.5	22	10	
4	7.3	22	10	
5	2.5	21	20	
6	7.3	21	20	
7	2.5	22	20	
8	7.3	22	20	

Copper is used as the EDM electrode because it is an excellent thermal conductor and used for fine surface finish (Gopalakannan & Senthilvelan, 2012). The present research examines the effects of the intensity of discharge current of electrodes on surface roughness in the ASSAB 718 (AISI P20) pre-hardened mold steel for plastic injection mold insert. The mold insert material is 80 x 100 x 25 mm in dimensions.

The EDM machine used in this research is Mitsubishi EX-30 Electrical Discharge Machine. Table 4 shows the condition parameters used in this entire research and kept constant.

Table 4: Machine condition parameters

EDM Parameter	Condition
Electrode polarity	Positive
Work material polarity	Negative
Machining mode	Standard
Di-electric fluid	Kerosene
Pulse duration (µsec)	1.6

The parameters that are used is Current (IP), voltage (Volt) and jump speed (JS). A rectangular copper electrode is used to erode a workpiece with a 25 mm thickness. Kerosene is used as the dielectric fluid to separate both the workpiece and the electrode. Table 1 shows the machine parameters.

For surface roughness evaluation, the Mitutoyo SJ210 is used. An evaluation length of 0.25 mm is used with the stylus speed of 0.1 mm/s is used throughout the measurement. In this research, the arithmetic mean surface roughness (Ra) is used as a desired measurement values. The measured values are in µm.

3.0 Results and discussions

The surface roughness of the workpiece is measured using a portable surface roughness tester Mitutoyo SJ210. Table 5 shows the results after the experiment.

Table 5: Surface Roughness (*Ra*)

Trial #	Current (IP) (Ampere)	Voltage (Volt)	Jump Speed (JS) (m/min)	Average (Ra) µm
1	2.5	21	10	2.52
2	7.3	21	10	8.36
3	2.5	22	10	2.68
4	7.3	22	10	7.49
5	2.5	21	20	3.81
6	7.3	21	20	5.64
7	2.5	22	20	3.04
8	7.3	22	20	6.78

The average *Ra* in Table 5 is used in Statistical Software Minitab 16 for analysis. Figure 2 shows the normal probability plot of the effects which includes Current (IP), Voltage (V) and Jump Speed (JS). Active effects are effects that are significant or important to the experiment. In the normal probability plot, points that do not fall on the line indicates important effects, whereas important effects fall farther away from the fitted line. From Figure 2, it is clear that the significant factor is A which is current (IP). Insignificant effects tends to be small and concentrated near zero.

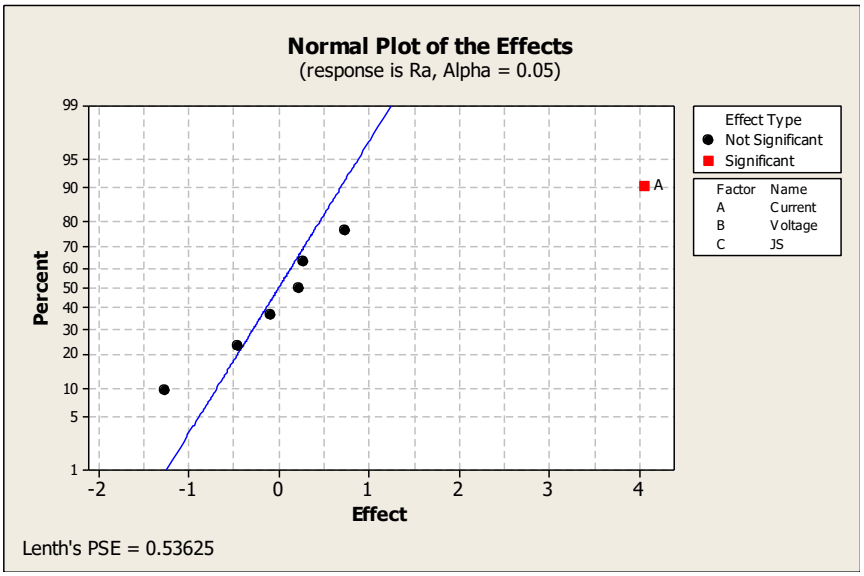


Figure 2: Normal Probability Plot of the Effects *Ra*

The main effects of individual process parameter is experimentally analyzed and shown in Figure 2. It indicates that Current (IP) is the best level setting that influences the surface roughness. A main effect occurs when the mean response changes across the level of a factor. Notice the plots (Figure 2), the main effects of V and JS are much smaller compared to IP.

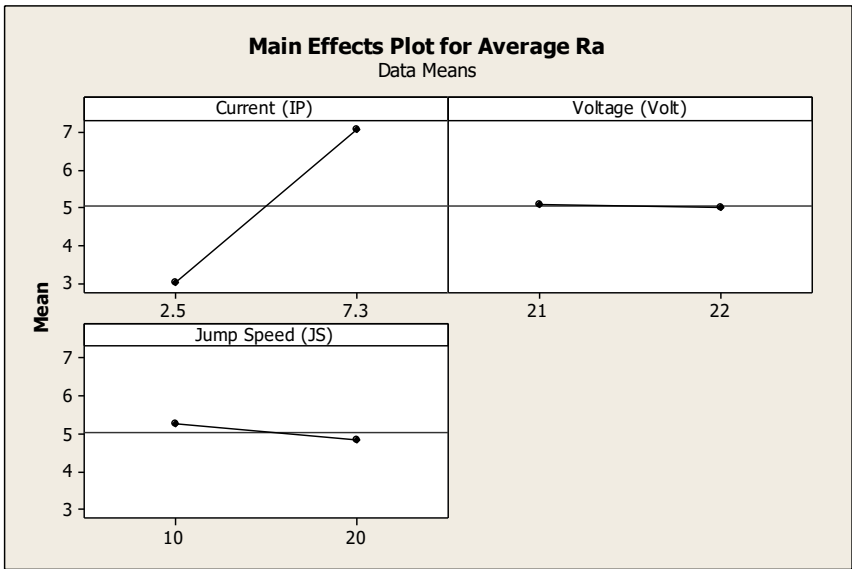


Figure 3: Mean Effects Plot (mean) for *Ra*

A Pareto chart is used to help in determining the active effects. Effects that extends past the reference line is considered as important. Figure 4 clearly indicates that the current (IP) is the most significant factor that influenced the surface roughness.

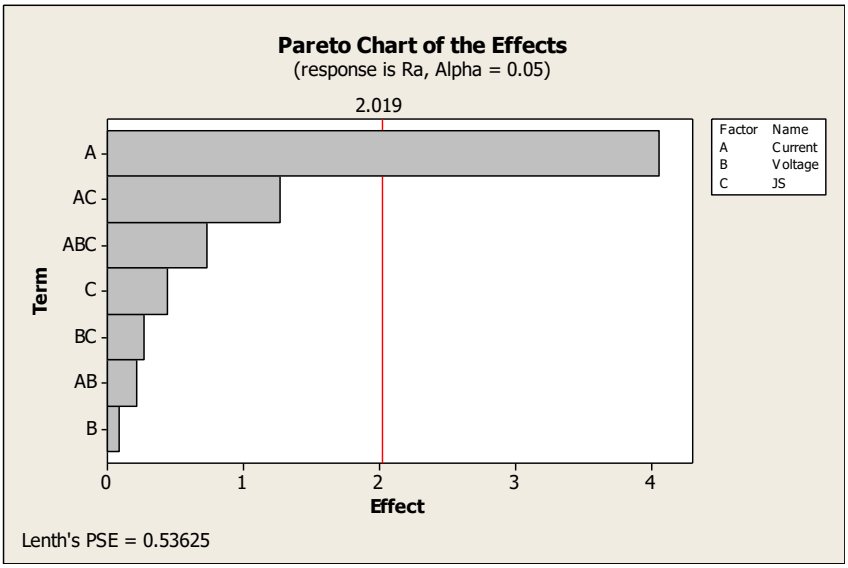


Figure 4: Pareto Chart of the Effects

Figure 5 shows the three-factor cube plot with a response variable. The cube plot shows the relationship between the factors and viewing the factor with response. Table 6 is the summary of the cube plot.

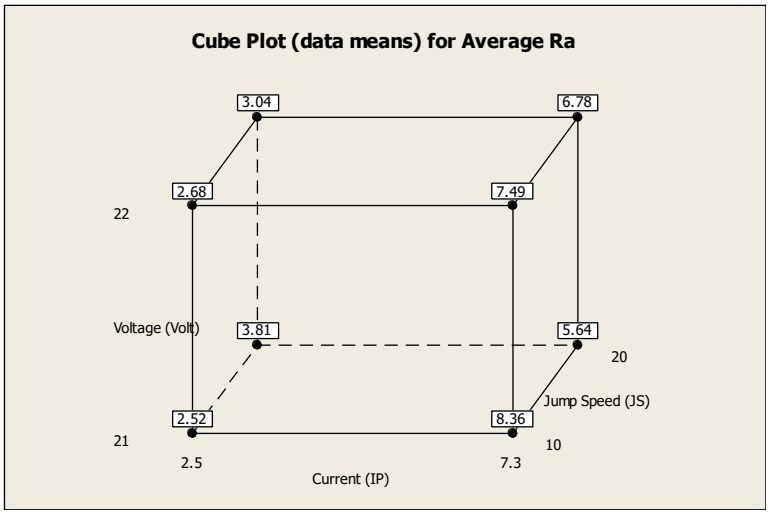


Figure 5: Cube Plot (data means) for *Ra*

Table 6: Summary of Cube Plot in Relations to Current (IP) and Surface Roughness

Surface Roughness (*Ra*) µm	Current (IP)	Voltage (Volt)	Jump Speed (JS)
2.52	2.5	21	10
8.36	7.3	21	10

Table 7 shows the Analysis of variance (ANOVA) balanced for Ra and Current (IP). The model satisfactorily explains the total variance in Current (IP) parameter and it is also reasonably a good fit (R^2 = 86.90%; R^2 adj. = 84.71%).

Table 7: ANOVA for *Ra* and Current (IP)

Analysis of Variance for Average Ra

Source	DF	SS	MS	F	P
Current (IP)					
	1	32.886	32.886	39.79	0.001
Error	6	4.959	0.827		
Total	7	37.845			

S = 0.909153 R-Sq = 86.90% R-Sq(adj) = 84.71%

Table 8: Estimated Coefficients

Estimated Coefficients for Ra using data in uncoded units

Term	Coef
Constant	0.900521
Current (IP)	0.744792

Through mathematical models, the coefficient is used to estimate the linear regression equation. From Minitab tabular output of the non-replicated experiment, the equation can be created as follows:-

Equation 1

$$\text{Surface roughness} = 0.900521 + 0.844792 \times \text{IP}$$

From the data, it is found that the current (IP) influenced the surface roughness. The value of *Ra* increased with the increasing of IP through the copper electrode. Poor surface roughness is due to the high material removal rate due to high current thus creating deep large and deep crater on the machine surface (Gopalakannan & Senthilvelan, 2012).

From Equation 1, it can be estimated that the surface roughness is as follows (Table 9).

Table 9: Sample Calculation based on Equation 1

Current (IP)	**Calculation**	Verdict
2.5A	$\text{Surface roughness} = 0.900521 + 0.744792 \times \text{IP}$ $\text{Surface roughness} = 0.900521 + 0.744792 \times 2.5$ $\text{Surface roughness} = 2.762501\ \mu\text{m}$	Low
7.3 A	$\text{Surface roughness} = 0.900521 + 0.744792 \times \text{IP}$ $\text{Surface roughness} = 0.900521 + 0.744792 \times 7.3$ $\text{Surface roughness} = 6.486461\ \mu\text{m}$	High

The above results clearly indicates that IP is the significant factor that influenced the mold insert surface roughness. At higher current, the impact of discharge on the mold insert surface became more intense and leads to the deterioration of the surface roughness (Kiyak & Çakır, 2007).

Conclusions

The current studies develops the surface roughness *Ra* model for the parameters of current intensity, electrode type and workpiece material for an EDM process using the orthogonal array method. The experimental results can be used in industry to select the most suitable parameter combination for obtaining required surface roughness values for products.

It is found that current intensity has significant effects on surface roughness *Ra*. Confirmation runs are performed to check the adequacy of the developed model. The predicted and measured values from confirmation runs are compared by checking the variation in the percentage error.

The variation in percentage errors for *Ra* were found within 8.8%. It can be concluded that the models are valid and can be used to predict the machining responses within the experimental region. This experimental research leads to the following main conclusions:

- The mathematical model, which precisely determines surface roughness, is a tool for cutting parameters and has been obtained by the experimental design method. It enables a high quality range in analyzing experiments and achieving optimal exact values
- The surface roughness equation shows that the current intensity is the main influencing factor on roughness
- The surface roughness contours are useful in determining the optimum cutting conditions.

References

[1] Ghrib, T., Salem, B. S. & Noureddine, Y., 2009. EDM effects on the thermal properties of 36NiCrMo16 steel. *EDM effects on the thermal properties of 36NiCrMo16 steel, Tribology International,* 42(3), pp. 391-396.

[2] Gopalakannan, S. & Senthilvelan, T., 2012. Effect of electrode materials on electric discharge machining of 316L and 17-4 PH stainless steel. *Journal of Minerals and Materials Characterization and Engineering,* Volume 11, pp. 685-690.

[3] Kiyak, M. & Çakır, O., 2007. Examination of machining parameters on surface roughness in EDM of tool steel. *Journal of Materials Processing Technology,* 191(1-3), pp. 141-144.

[4] Lee, S. & Li, X., 2003. Study of the surface integrity of the machined workpiece in the EDM of tungsten carbide. *Journal of Materials Processing Technology,* Volume 139, pp. 315-321.

[5] Soni, J. & Chakraverti, G., 1995. Effect of Electrode Mate-rial Properties on Surface Roughness and Dimensional Accuracy in Electric-Discharge Machining of High Car-bon High Chromium Die Steel. *Journal of Industrial and Engineering,* Volume 76, pp. 46-55.

KATEGORI TEKNOLOGI KEJURUTERAAN PERCETAKAN / BUKAN LOGAM / HAL EHWAL LATIHAN KEMAHIRAN

O1: Pelaksanaan *Welding Qualification Test (WQT)* di Institusi Latihan Jabatan Tenaga Manusia(ILJTM)

Wan Shaiful Hasrizam Wan Muda[1], Shamsudin Hamzah[2,], Ab Rahman Mohd Said[3], Kamal Abu @ Ahmad[4], Abd Rahim Tahir[5], Mior Md Salleh Mior Yusoff[6] dan Waji Risman[7]

[1,2]*InstitutLatihanPerindustrian Kuantan*
[3]*Institut Latihan Perindustrian Selandar*
[4]*Ibu Pejabat, Jabatan Tenaga Manusia*
[5]*Pusat Latihan Teknologi Tinggi Batu Pahat*
[6]*Pusat Latihan Teknologi Tinggi Shah Alam*
[7]*Institut Latihan Perindustrian Kuala Lumpur*

[1]*wanshaiful@jtm.gov.my* , [3]*p.ilpselandar@mohr.gov.my*, [4]*kamalabu@mohr.gov.my* , [6]*mior@jtm.gov.my*, [7]*wajirisman@gmail.com*

Abstrak

Kertas ini menjelaskan sistem pentauliahan professional yang dilaksanakan oleh Jabatan Tenaga Manusia (JTM) bagi pelajar-pelajar semester akhir bidang kimpalan dalam melahirkan jurukimpal bertauliah. Berdasarkan Statistik RMK 9 yang telah dikeluarkan oleh JTM, secara puratanya JTM telah mengeluarkan seramai 674 jurukimpal setahun bermula daripada 2006 sehingga 2010. Namun begitu, ianya masih belum mampu menampung jumlah keperluan pasaran kerja yang memerlukan jurukimpal yang mepunyai tahap kemahiran tinggi dan bertauliah. Sistem pentauliahan yang digunakan ketika ini adalah tidak mencukupi dalam mencerminkan kemahiran sebenar jurukimpal yang dihasilkan kerana tidak melaksanakan apa yang dipraktikkan oleh industri iaitu melalui Welding Qualification Test (WQT). Bermula pada sesi 2/2012, JTM telah melaksanakan WQT kepada pelajar-pelajar semester akhir bidang kimpalan mengikut kod & piawaian antarabangsa sebagai tambahan kepada persijilan sedia ada. Pelaksanaan WQT ini merupakan satu usaha inovasi dan trasnformasi latihan kemahiran yang dilakukan oleh JTM. Ianya juga telah menjadikan JTM sebagai pelopor kepada pelaksanaan WQT secara menyeluruh dan sistematik di institut latihan kemahiran awam (ILKA). Terdapat tujuh welding procedure specification (WPS) yang terdiri daripada pelbagai proses, kedudukan dan kod rujukan telah dibangunkan oleh JTM bagi melaksanakan WQT ini. Sehingga 12 Ogos 2015, JTM telah mengeluarkan 800 jurukimpal bertauliah yang mana masing-masing terdiri daripada 496 jurukimpal (6G-SMAW), 192 jurukimpal (3G-SMAW), 57 jurukimpal (6G-GTAW) dan 55 jurukimpal (6G-GTAW-SMAW). Mengikut rekod, jumlah ini merupakan 43 peratus daripada keluaran sebenar pelajar bidang kimpalan JTM sejak WQT mula dilaksanakan.

Kata kunci: *Welding Qualification Test (WQT), Jabatan Tenaga Manusia (JTM), Pemeriksa Kimpalan (WI), Jurukimpal bertauliah*

1.0 Pengenalan

Bidang Kimpalan merupakan satu bidang yang amat popular dan sering saja menjadi pilihan para remaja lepasan sekolah untuk mengikuti program latihan kemahiran. JTM telah menawarkan program kemahiran di dalam bidang ini sejak awal penubuhannya lagi dan sehingga kini terdapat 19 Institusi Latihan Jabatan Tenaga Manusia (ILJTM) di seluruh negara yang telah menjalankan program latihan di dalam bidang kimpalan.

Pada masa ini, pelajar-pelajar lepasan ILJTM akan dianugerahkan Sijil Juruteknik Perindustrian serta Sijil Kemahiran Malaysia (SKM) Tahap 3 bagi mereka yang mengikuti latihan di Institut Latihan Perindustrian (ILP), dan Diploma Teknologi serta Diploma Kemahiran Malaysia (DKM) atau Diploma Lanjutan Kemahiran Malaysia (DLKM) bagi mereka yang mengikuti latihan di Pusat Latihan Teknologi Tinggi (ADTEC). Berdasarkan Statistik RMK 9 yang telah dikeluarkan oleh JTM, secara puratanya JTM telah mengeluarkan seramai 674 jurukimpal setahun bermula daripada 2006 sehingaa 2010 sepertimana yang dinyatakan dalam jadual 1 di bawah.

Jadual 1: Statistik keluaran jurukimpal oleh JTM 2006 – 2010 [1]

KOD	KURSUS	ENROLMEN				
		2006	2007	2008	2009	2010
	BIDANG MEKANIKAL DAN PENGELUARAN					
A01	Mekanik Industri	596	526	544	631	368
A02	Pemesinan Am	438	340	281	422	276
A03	Pemesinan CNC	354	264	306	291	214
A04	Pembuat Acuan dan Alat Pemotong	132	115	110	137	113
A05	Pembuat Acuan Pembentuk	121	88	69	87	46
A06	Teknologi Foundri	55	38	36	16	13
A08	Kimpalan Arka dan Gas	683	617	708	836	527
A09	Fabrikasi Logam	274	226	257	339	269
A10	Pemasangan Paip Gas	142	126	250	244	177
A11	Automotif	434	430	413	548	210
A12	Rekabentuk Produk Industri	126	116	172	87	203
A13	Kenderaan Perdagangan Berat	89	92	82	104	41
A14	Kejuruteraan Jaminan Mutu	35	42	30	14	21
A15	CADD Mekanikal	146	169	178	241	161
	JUMLAH	3,625	3,189	3,436	3,997	2,639
	BIDANG AVIATION					
B12	Avionic	-	-	23	22	33
A16	Mechanical	-	-	97	97	82
	JUMLAH	-	-	120	119	115

Walaupun jumlah jurukimpal yang dikeluarkan adalah ramai namun ianya masih belum mampu menampung jumlah keperluaan pasaran kerja yang memerlukan jurukimpal berkemahiran tinggi. Sistem pentauliahan yang digunakan pada ketika ini tidak mencerminkan kemahiran sebenar jurukimpal yang dihasilkan kerana tidak menlaksanakan apa yang dipraktikkan oleh industri iaitu melalui WQT.

Pada ketika ini, hanya Akademi Binaan Malaysia (ABM) yang telah mempraktikan WQT secara rasmi bagi menentukan tahap kemahiran pelajar-pelajar mereka melalui kerjasama mereka dengan The Weding Institute (TWI) dengan mengeluarkan persijilan CSWIP. ABM menawarkan kursus kimpalan kepada belia-belia lepasan sekolah dan juga personel-personel yang terlibat dalam industri pembinaan. Bagi institut kemahiran awam yang lain seperti ILJTM, Institut Kemahiran Mara (IKM) dan Institut Kemahiran Belia Negara (IKBN) tiada perlaksanaan secara rasmi serta menyeluruh untuk WQT. Sebagai contoh, ILJTM telah bekerjsama dengan pihak industri iaitu Malaysia Marine & Heavy Engineering (MMHE) dan hanya menjalankan WQT bagi pelajar-pelajar yang telah tamat latihan untuk diserapkan bekerja di MMHE. Selain itu terdapat juga inisiatif yang dilakukan sendiri oleh pengajar-pengajar institut kemahiran dalam melaksanakan WQT bersama industri dan termasuk juga mendaftarkan pelajar-pelajar mereka bagi mengikuti latihan personel binaan yang dikelolakan oleh ABM.

Antara persijilan jurukimpal bertauliah yang diadakan di Malaysia adalah:

a. AWS Certified Welder
   Dilaksanakan oleh SIRIM dengan kerjasama dengan American Welding Society (AWS).

b. CSWIP Certified Welder Dilaksanakan oleh TWI.

c. Common Welder Certification Scheme
   Dilaksanakan oleh Institut Bahan Malaysia (IMM) dengan kerjasama Asian Welding Federation (AWF).

Oleh itu, perlaksanaan WQT perlulah diterapkan secara menyeluruh ke dalam sistem pembelajaran tanpa meminggirkan sistem sedia ada bagi melahirkan jurukimpal bertauliah seiring dengan keperluan industri.

Sistem Pembelajaran Bidang Kimpalan Di ILJTM Sebelum Pelaksanaan WQT

Pembelajaran di ILJTM dalah berteraskan kepada *National Occupational Skill Standard* (NOSS) yang dikeluarkan oleh Jabatan Pembangunan Kemahiran (JPK). Sistem pembelajaran di ILJTM adalah berteraskan 70 peratus amali serta 30 peratus teori pada peringkat sijil dan 60 peratus amali serta 40 peratus teori bagi peringkat diploma. Sepanjang latihan pelajar akan sentiasa dinilai tahap kemahiran serta pengetahuan mereka melalui tugasan ataupun ujian amali dan teori. Pada akhir semester penilaian pengetahuan dan kemahiran ditentukan melalui peperiksaan akhir yang dijalankan serentak di seluruh ILJTM. Peperiksaan akhir dipantau oleh Pegawai Pengesah Luaran (PPL) yang dilantik oleh JPK. Walaubagaimanapun, bermula pada 2014 JTM telah diberikan kelulusan khas oleh JPK untuk pelaksanaan penilaian kendiri. Pelajar yang berjaya akan dianugerahkan dengan sijil / diploma kemahiran dan sijil / diploma teknologi yang mana masing-masing dikeluarkan oleh JTM dan JPK.

Gambaran pelaksanaan sistem pembelajaran bidang kimpalan di ILJTM sebelum pelaksanaan WQT adalah seperti rajah 1.

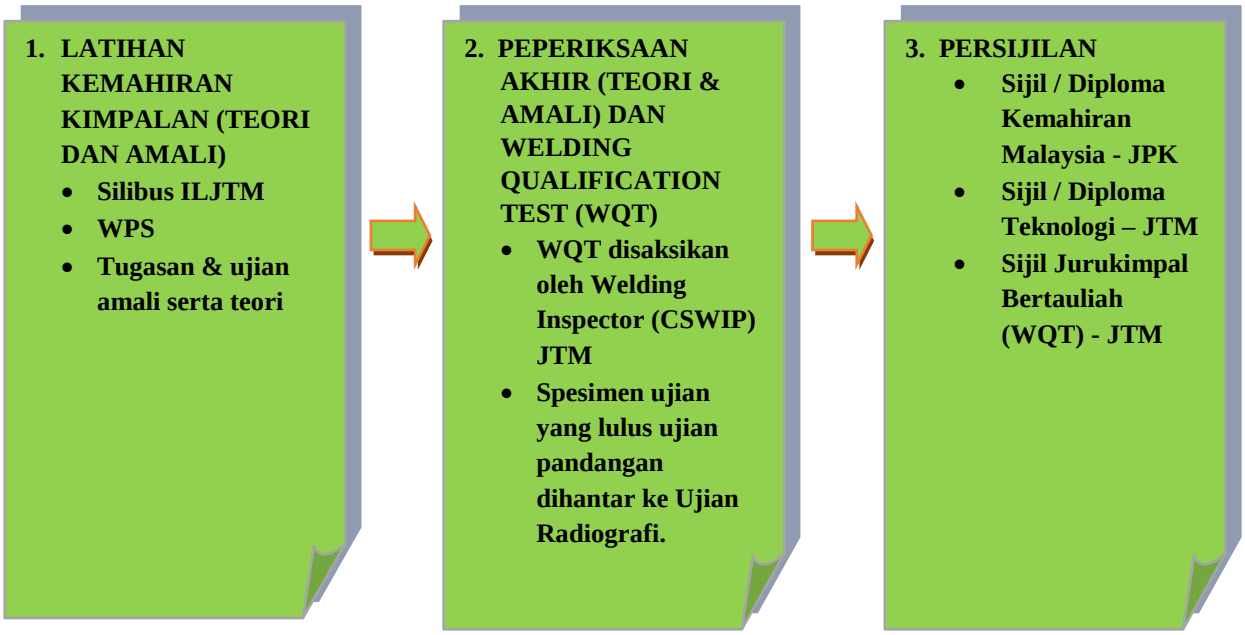
Rajah 1: Sistem pembelajaran bidang kimpalan di ILJTM sebelum pelaksanaan WQT.

Sistem Pembelajaran Bidang Kimpalan Di ILJTM Selepas Pelaksanaan WQT

Pelaksanaan WQT yang dilaksanakan di ILJTM tidak menganggu sistem latihan sedia ada. Ianya ditambah baik dengan memasukkan elemen WPS sebenar di dalam pembelajaran teori dan amali. WPS ini dijadikan sebagai rujukan untuk mengimpal projek / spesimen latihan amali. WQT dilaksanakan serentak dengan peperiksaan akhir amali. Oleh itu, ianya tidak menganggu takwim latihan ILJTM. *Welding Inspector* (WI) yang mempunyai kelayakan CSWIP 3.1 ditugaskan memantau pelaksanaan WQT ini. Pada masa yang sama juga WI juga telah diberikan kuasa sebagai Pegawai Pengesah Luaran (PPL) untuk menilai projek ujian amali yang lain. Spesimen WQT yang melepasi ujian pandangan akan dihantar untuk ujian radiografi. Pelajar yang melepasi ujian pandangan dan ujian radiografi akan dianugerahkan dengan persijilan WQT dan diiktiraf sebagai jurukimpal bertauliah.

Melalui pelaksanaan WQT ini, keluaran pelajar kimpalan ILJTM yang berkemahiran tinggi dapat dikenalpasti. Pelajar yang mempunyai sijil / diploma kemahiran atau sijil / diploma teknologi dapat dikategorikan sebagai pelajar yang mempunyai pengetahuan serta kemahiran teori dan amali dalam kimpalan. Manakala pelajar yang mempunyai sijil tambahan iaitu sijil jurukimpal bertauliah ianya dikategorikan sebagai pelajar yang berkemahiran tinggi.

Gambaran pelaksanaan sistem pembelajaran bidang kimpalan di ILJTM selepas pelaksanaan WQT adalah seperti rajah 2.



Rajah 2: Sistem pembelajaran bidang kimpalan di ILJTM selepas pelaksanaan WQT

Penggunaan WPS Dalam Latihan Di ILJTM

Sehingga 25 September 2014, JTM telah membangunkan tujuh WPS yang merujuk kepada pelbagai kod dan piawaian bagi digunakan dalam latihan dan WQT. Jadual 2 menunjukkan WPS yang telah digunakan di ILJTM dalam latihan kimpalan. Pembangunan WPS ini telah mengambil kira keperluan kod dan piawaian antarabangsa dalam mentauliah jurukimpal. Sebagai contoh, menurut garis panduan yang ditetapkan oleh ASME IX: 2013 [2] melalui petikan *QW-103.1 Welding* ianya menyatakan jelas bahawa setiap organisasi mestilah melaksanakan ujian yang diperlukan dalam seksyen ini untuk mengesahkan prosedur kimpalan yang digunakan dalam menjalankan kerja-kerja kimpalan, prestasi jurukimpal dan operator kimpalan yang menggunakan prosedur ini.

Sehingga kini, empat WPS yang dibangunkan pada 4 Ogos 2011 telah dijadikan rujukan sepenuhnya oleh pengajar dan pelajar dalam latihan kemahiran. Keempat-empat WPS ini juga telah merekodkan calon yang menduduki ujian WQT. WPS/JTM/SMAW-001 merupakan elemen utama dalam latihan kemahiran di ILJTM. Pihak JTM juga telah menetapkan setiap pelajar semester akhir wajib menduduki WQT yang melibatkan WPS ini. WPS ini juga dijadikan sebagai tanda aras kepada kualiti sebenar pelajar kimpalan keluaran JTM. Manakala tiga WPS yang dibangunkan pada 25 September 2014 masih belum mempunyai calon yang menduduki WQT. Ianya dijangka akan mula menerima calon pada sesi 1/2016.

Jadual 2: WPS yang dibangunkan oleh JTM Welding Inspector (WI)

NO	NO. WPS	PROSES	BAHAN	KEDUDUKAN	KOD RUJUKAN	TARIKH DIBANGUNKAN
1	WPS/JTM/SMAW-001	SMAW	CARBON STEEL PIPE 6" SCH. 80	6G	ASME IX	4 OGOS 2011
2	WPS/JTM/SMAW-002	SMAW	CARBON STEEL PLATE 9mm	3G	ASME IX	4 OGOS 2011
3	WPS/JTM/GTAW-003	GTAW	CARBON STEEL PIPE 2" SCH. 40	6G	ASME IX	4 OGOS 2011
4	WPS/JTM/GTAW-SMAW-004	GTAW-SMAW	CARBON STEEL PIPE 8" SCH. 80	6G	ASME IX	4 OGOS 2011
5	WPS/JTM/SMAW-005	SMAW	CARBON STEEL PIPE 8" SCH. 80 & 120	6GR	AWS D1.1	25 SEPTEMBER 2014
6	WPS/JTM/FCAW-006	FCAW	CARBON STEEL PLATE 12mm	3G	BSEN 15607 & ISO 15609	25 SEPTEMBER 2014
7	WPS/JTM/GTAW-007	GTAW	STAINLESS STEEL PIPE 2" SCH. 80	6G	ASME IX	25 SEPTEMBER 2014

WI merupakan tunjang kepada proses pelaksanaan WQT ini. Mereka berperanan untuk memantau proses WQT dan melakukan ujian pandangan. WI tertakluk kepada kod dan piawaian yang digunakan. JTM telah menetapkan syarat bahawa hanya pengajar yang mempunyai kelayakan CSWIP 3.1 dan CSWIP 3.2 sahaja akan bertugas sebagai WI. Pelaksanaan ini mengambil kira kepada amalan yang dilakukan di industri. Ianya juga bertujuan menjaga kualiti jurukimpal yang dikeluarkan.

Setakat ini, JTM telah mempunyai seramai 28 orang pengajar yang mempunyai kelayakan CSWIP 3.1 dan 3 orang pengajar yang mempunyai kelayakan CSWIP 3.2. Kesemua mereka ini telah dilantik sebagai WI dan bertugas mengikut jadual yang dikeluarkan oleh JTM. Penjadualan WI mengambil kira faktor institut asal WI tersebut. WI tidak dibenarkan bertugas di institut asal bagi mengelakkan konflik kepentingan.

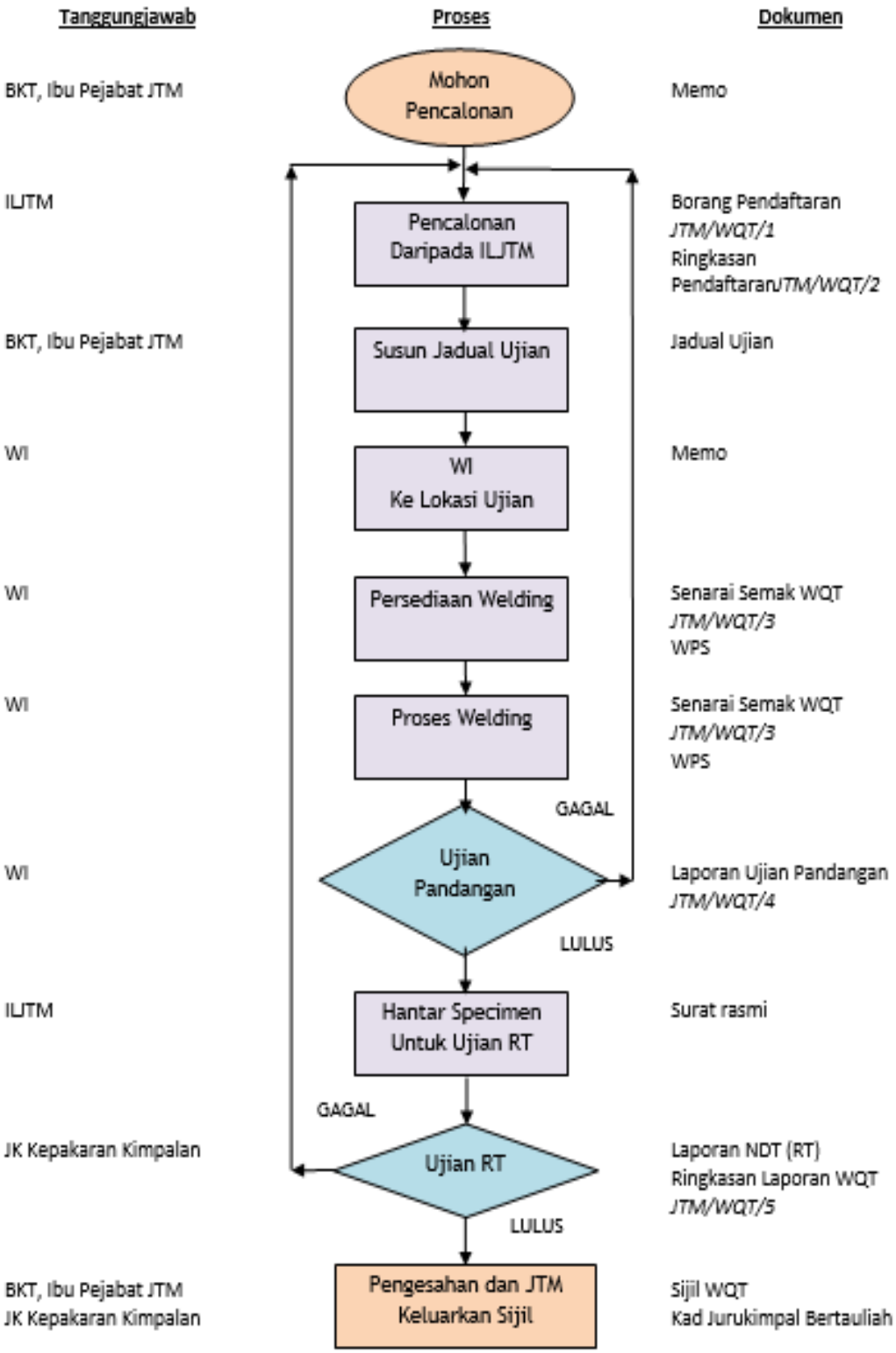
2.0 Prosedur Pelaksanaan WQT

JTM telah membangunkan prosedur yang menggariskan proses-proses kerja untuk WQT di ILJTM. Prosedur ini digunapakai untuk melaksanakan WQT di ILJTM bagi memenuhi kehendak pelanggan. Prosedur ini melibatkan beberapa pihak iaitu ILJTM, Bahagian Kawalan Teknikal (BKT) JTM, Jawantakuasa Kepakaran Kimpalan (JKK) dan WI. Rajah 3 menunjukkan carta alir prosedur pelaksanaan WQT di JTM.

BKT akan mengeluarkan memo kepada ILTJM bagi mengemukakan nama-nama calon yang terlibat dengan WQT. ILJTM akan menghantar senarai calon yang telibat menggunakan Borang Pendaftaran JTM/WQT/1 dan Ringkasan Pendaftaran JTM/WQT/2. Penjadualan WI yang bertugas dilaksanakan oleh BKT dan surat arahan bertugas diedarkan kepada WI dan ILJTM berkenaan selewat-lewatnya 7 hari sebelum tarikh ujian. WI yang bertugas dikehendakai memberi taklimat kepada calon sebelum ujian, mengawasi perjalanan ujian dan membuat pemeriksaan ujian pandangan ke atas spesimen yang telah disiapkan. WI juga dikehendaki merekod segala penemuan semasa penyaksian dan pemeriksaan WQT ke dalam Senarai Semak WQT (JTM/WQT/3) dan Laporan Ujian Pandangan (JTM/WQT/4).

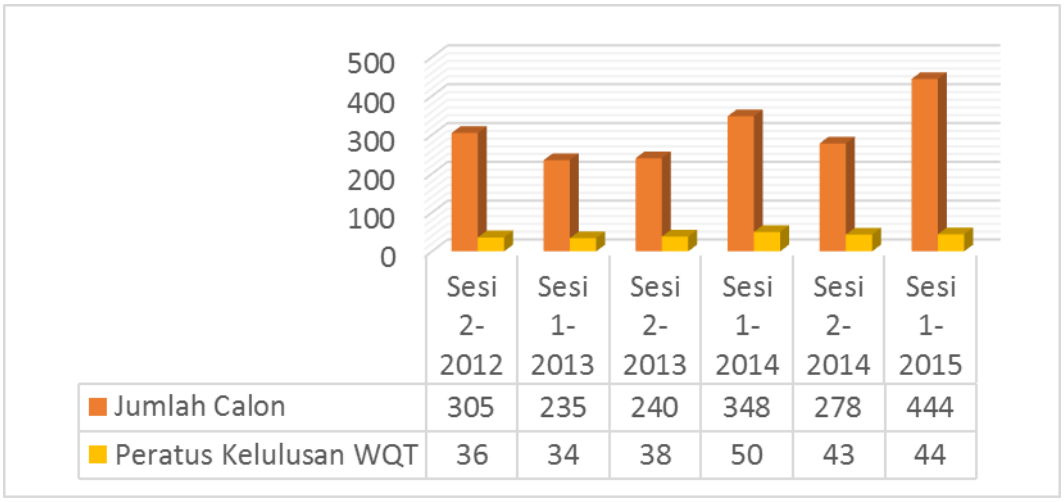
Spesimen yang lulus ujian pandangan akan dilakukan ujian radiografi. Kesemua keputusan ujian pandangan dan radiografi direkod ke dalam borang Ringkasan Laporan WQT (JTM/WQT/5). Mesyuarat bagi mengesahkan keputusan WQT dilakukan oleh JKK dan laporan keputusan rasmi dihantar kepada BKT. Keputusan ujian kelayakan jurukimpal (WQT) beserta Sijil dan Kad WQT diedarkan ke ILJTM selewat-lewatnya 2 bulan selepas tarikh ujian.

Rajah 3: Carta alir prosedur pelaksanaan WQT di JTM.



3.0 Pencapaian Pelajar Dalam WQT

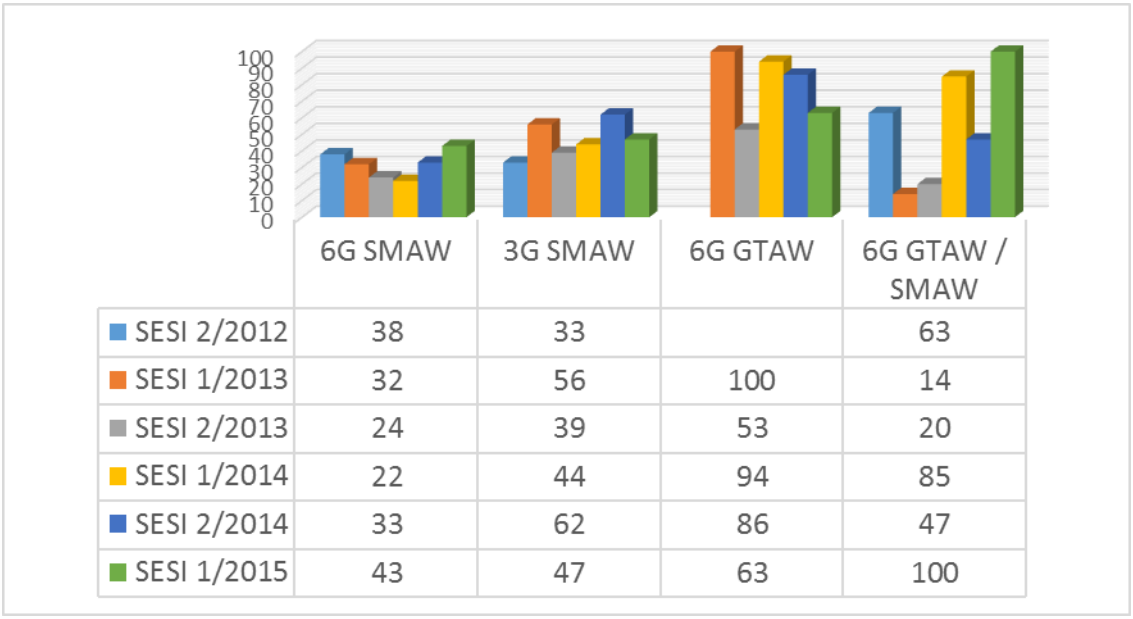
Seramai 1,850 pelajar telah menduduki ujian WQT sejak ianya mula dilaksanakan pada sesi 2/2012. Namun begitu hanya 800 pelajar telah berjaya dan diktiraf sebagai jurukimpal bertauliah. Peratus kelulusan keseluruhan adalah sebanyak 43 peratus. Ianya boleh dikategorikan sebagai sederhana. JTM telah mensasarkan 50 peratus sebagai tanda aras kepada pelaksanaan WQT ini. Rajah 4 menunjukkan prestasi pelajar ILJTM secara keseluruhan dalam WQT. Pada peringkat awal pelaksanaan kelulusan hanyalah berada di antara 36 hingga 38 peratus. Pada sesi 1/2014 kelulusan yang tertinggi telah berjaya direkodkan iaitu 50 peratus. Walaubagaimanapun, kelulusan ini merosot pada sesi 2/2014 dan menunjukkan sedikit peningkatan pada sesi 1/2015.



	Sesi 2-2012	Sesi 1-2013	Sesi 2-2013	Sesi 1-2014	Sesi 2-2014	Sesi 1-2015
Jumlah Calon	305	235	240	348	278	444
Peratus Kelulusan WQT	36	34	38	50	43	44

Rajah 4: Prestasi pelajar ILJTM secara keseluruhan dalam WQT

Manakala rajah 5 pula menunjukkan kelulusan pelajar mengikut pecahan proses, kedudukan dan WPS yang diambil dalam pelaksanaan WQT.



	6G SMAW	3G SMAW	6G GTAW	6G GTAW / SMAW
SESI 2/2012	38	33		63
SESI 1/2013	32	56	100	14
SESI 2/2013	24	39	53	20
SESI 1/2014	22	44	94	85
SESI 2/2014	33	62	86	47
SESI 1/2015	43	47	63	100

Rajah 5: Peratus kelulusan pelajar ILJTM mengikut pecahan proses, kedudukan dan WPS

Fokus utama pelaksanaan WQT di ILJTM adalah untuk memastikan setiap pelajar semester akhir berjaya dalam WQT yang menggunakan WPSWPS/JTM/SMAW-001 (6G SMAW). Ini kerana teras latihan kemahiran kimpalan di ILJTM adalah bersandarkan proses SMAW. Jika diperhatikan kelulusan yang direkodkan oleh pelajar yang menduduki proses 6G SMAW ianya bermula dengan sederhana pada peringkat permulaan dan terus menunjukkan kemerosotan sehingga ke sesi 1/2014. Peningkatan mula ditunjukkan pada sesi 2/2014 iaitu sebanyak 33 peratus dan seterusnya 43 peratus bagi sesi 1/2015. Peningkatan ini berkemungkinan berkait rapat dengan usaha yang telah dilakukan oleh JKK dalam menangani permasalahan ini. Antara usaha yang dilakukan adalah mengadakan kursus peningkatan kemahiran pengajar, membuat lawatan ke institut yang mengalami peratus kelulusan yang rendah dan menggalakkan pengajar menduduki ujian WQT.

Jadual 3 pula menunjukkan pencapaian pelajar semester akhir WQT 6G SMAW mengikut ILJTM. Berdasarkan jadual tersebut bilangan calon dan peratus kelulusan bagi setiap sesi tidak begitu konsisten. Namun begitu, ILP Kuala Lumpur, Bukit Katil, Labuan, Ledang, Mersing, Kuantan dan Labuan boleh dikatakan sebagai ILJTM yang menunjukkan prestasi yang cemerlang.

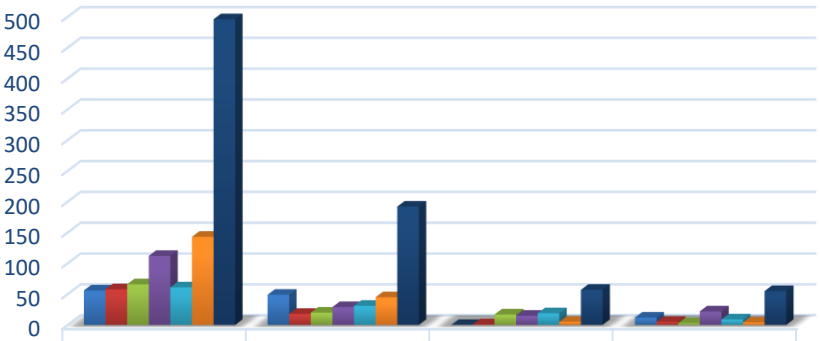
Jadual 3: Pencapaian pelajar semester akhir ILJTM dalam WQT 6G SMAW

ILJTM	SESI											
	2/2012		**1/2013**		**2/2013**		**1/2014**		**2/2014**		**1/2015**	
	Bil. Calon	**% Lulus**	**Bil. Calon**	**% Lulus**	**Bil. Calon**	**% Lulus**	**Bil. Calon**	**% Lulus**	**Bil. Calon**	**% Lulus**	**Bil. Calon**	**% Lulus**
JITRA	-	-	16	31	12	25	14	0	3	0	13	54
PRAI	-	-	-	-	-	-	17	0	9	0	12	8
IPOH	-	-	-	-	-	-	13	62	15	13	29	24
K. LUMPUR	9	100	21	29	10	20	12	83	-	-	16	69
S. ALAM	23	26	17	0	12	0	14	7	14	14	22	9
PEDAS	-	-	-	-	-	-	1	0	18	11	22	9
B. KATIL	17	47	29	62	14	56	18	50	11	82	15	67
LEDANG	13	38	22	14	17	6	14	50	17	29	29	48
B. PAHAT	28	21	21	5	-	-	30	30	6	67	32	53
P. GUDANG	-	-	-	-	-	-	14	100	15	47	17	47
MERSING	17	59	24	58	11	9	16	44	14	21	30	87
KUANTAN	2	100	-	-	24	63	14	71	8	38	9	33
K. BAHRU	10	10	15	20	-	-	14	64	6	33	12	42
K. SAMARAHAN	-	-	9	0	15	40	17	29	-	-	24	13
LABUAN	9	89	7	100	15	67	5	100	-	-	1	100
SANDAKAN	18	6	-	-	6	33	18	28	10	30	13	23

Statistik Jurukimpal Bertauliah JTM

Pelaksanaan WQT telah melahirkan jurukimpal bertauliah keluaran JTM. Sehingga 12 Ogos 2015, JTM telah mengeluarkan 800 jurukimpal bertauliah yang mana masing-masing terdiri daripada 496 jurukimpal (6G-SMAW), 192 jurukimpal (3G-SMAW), 57 jurukimpal (6G-GTAW) dan 55 jurukimpal (6G-GTAW-SMAW). Mengikut rekod, jumlah ini merupakan 43 peratus daripada keluaran sebenar pelajar bidang kimpalan JTM sejak WQT mula dilaksanakan.

Rajah 6 menunjukkan pecahan jurukimpal bertauliah yang telah dilahirkan melaui program WQT ini.



	6G SMAW	3G SMAW	6G GTAW	6G GTAW / SMAW
SESI 2/2012	56	49	0	12
SESI 1/2013	58	18	1	5
SESI 2/2013	66	20	17	3
SESI 1/2014	112	29	15	22
SESI 2/2014	61	31	19	9
SESI 1/2015	143	45	5	4
JUMLAH	496	192	57	55

Rajah 6: Pecahan jurukimpal bertauliah yang telah dilahirkan melaui program WQT

Selain daripada calon dalaman ILJTM, program WQT ini turut diikuti oleh calon luar daripada ILJTM. Melalui program latihan kemahiran secara separuh masa, terdapat beberapa syarikat luar yang telah berminat menduduki ujian WQT JTM. Antara syarikat yang terlibat adalah Akar Indah Sdn. Bhd. yang mengikuti program di ADTEC Shah Alam. Manakala Jabatan Penjara Malaysia dan Perodua (M) Sdn. Bhd. pula telah mengikuti program ini di ILP Kuala Lumpur.

Jumlah keseluruhan calon luar yang terlibat sehingga kini adalah seramai 16 orang. Manakala, jumlah jurukimpal bertauliah yang dikeluarkan bagi calon luar adalah seramai 8 orang. Peratus kelulusan yang direkodkan adalah sebanyak 50 peratus.

4.0 Kesimpulan

Secara umumnya pelaksanaan WQT telah berjaya meningkatkan kualiti latihan bidang kimpalan di ILJTM. Manakala secara khususnya pula, ianya telah memberi impak yang positif kepada pengajar, pelajar dan industri. Melalui WQT pengajar akan lebih bersedia untuk melaksanakan latihan kemahiran kerana pematuhan kepada WPS yang dibangunkan merupakan perkara utama yang perlu dititikberatkan.

Oleh itu, pengajar akan memastikan diri mereka mempraktikkan dahulu saranan WPS sebelum melakukan pengajaran. Pelajar yang menduduki WQT akan terdedah dengan budaya kerja sebenar di industri. Justeru, pelajar-pelajar ILJTM semsetinya tidak kekok untuk menduduki WQT di industri kerana telah biasa menghadapinya semasa latihan. Manakala bagi industri pula, mereka boleh mengenalpasti dengan mudah pelajar yang berkemahiran tinggi.

Melalui sijil dan kad jurukimpal bertauliah yang dikeluarkan pihak industri boleh mengenalpasti mereka dengan lebih mudah. Selain itu, pihak industri dapat menjimatkan masa untuk melatih semula pelajar-pelajar ini bagi menduduki WQT di industri. Justeru, pelaksanaan WQT di ILJTM merupakan satu usaha inovasi dan trasnformasi latihan kemahiran yang dilakukan oleh JTM bagi melahirkan tenaga kerja yang berdaya saing.

Rujukan

[1] Jabatan Tenaga Manusia. *Statistik RMK 9 Jabatan Tenaga Manusia, Kementerian Sumber Manusia*. Putrajaya. 2012.

[2] American Society of Mechanical Engineers. *Boiler & Pressure Vessel Code*. New York, ASME IX. 2013.

O6: e-JUST (e-JTM Unified Sources Transaction): Manifestasi Terhadap Pusat Sumber dan Multimedia ILJTM

Ismawi Bin Ismail
Pusat Latihan Teknologi Tinggi (ADTEC) Kemaman

ismawi@jtm.gov.my

Abstrak

Sejumlah besar peruntukan telah disalurkan kepada ILJTM sediada bagi memiliki bahan rujukan di perpustakaan/pusat sumber dan multimedia di kesemua 33 ILJTM seluruh negara. Namun demikian, masih terdapat juga ILJTM yang mempunyai kurang bahan rujukan atas pelbagai faktor yang tidak dapat dielakkan sehingga menyebabkan kurangnya pendedahan pelajar kepada rujukan pembelajaran teras dan umum mahupun diperingkat capaian professional walaupun prasarana komunikasi digital pada keadaan terbaik untuk capaian pelajar. Penyelesaian kepada sumber rujukan dengan kaedah capaian maklumat secara cepat, sah dan mudah akan menjadikan pembelajaran lebih berkesan, persediaan pelajar dan pengajar menjadi mantap, sistem penilaian dan carian maklumat lebih pantas serta rujukan sahih, lengkap dan bermanafaat dapat melengkapkan kitaran pembelajaran efektif. Dalam jangkamasa panjang, e-JUST dapat mempersiapkan semua ILKA/ILKS ke arah pembentukan kampus pembelajaran kemahiran bersifat global serta menguntungkan industri pembelajaran TVET nasional ke peringkat global.

Kata kunci: Penilaian kendiri, pembelajaran berorientasikan pelajar, kitaran pembelajaran efektif

PENGENALAN

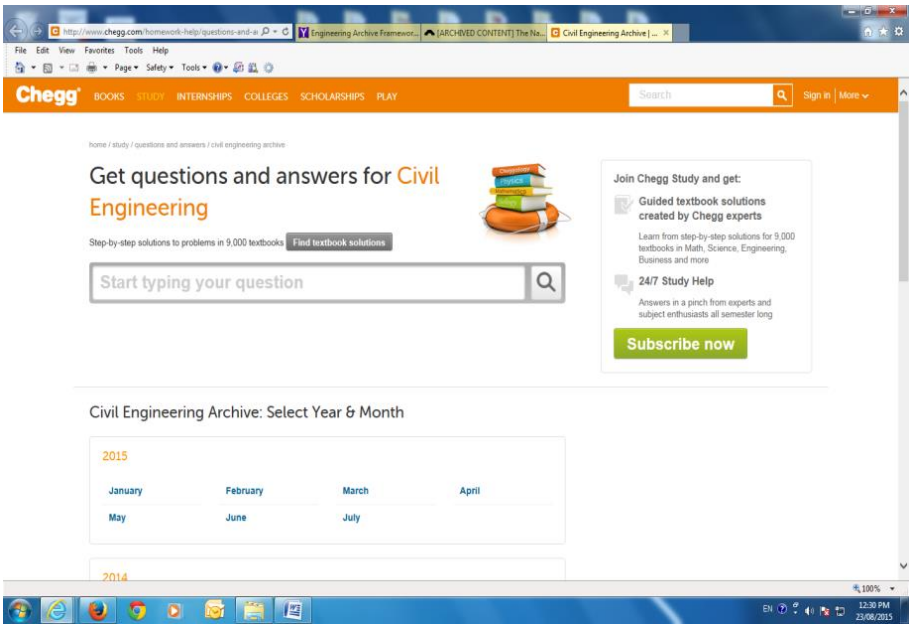
Masalah bajet sering menjadi halangan kepada pemerolehan aset buku dan bahan rujukan wujud di mana-mana organisasi menyebabkan pelbagai alternatif digunakan bagi menjadikan pusat sumber/ perpustakaan/multimedia relevan sebagai tempat mendapatkan maklumat yang dicari. Pelajar diajar untuk memanafaatkan pusat sumber/perpustakaan/multimedia sebagai tempat rujukan utama untuk melengkapkan ilmu pengetahuan tambahan selain yang terdapat apada nota penerangan di bilik kuliah.

Selain itu, peranan pusat sumber/perpustakaan/multimedia sepatutnya juga menjadi arkib untuk menyimpan laporan Projek Tahun Akhir (PTA) setelah graduan tamat pembelajaran di institut. Pengakhiran kepada pengumpulan bahan-bahan ilmiah ini mewujudkan masalah ruang penyimpanan kerana terdapat juga perolehan buku-buku baru dan sedia ada sehingga berlaku keciciran atau ketidakendahan kepada hasil kerja graduan yang amat berguna kepada pelajar seterusnya dan juga arkib institut masing-masing. Pernyataan masalah ini juga diburukkan lagi dengan ketidakupayaan institut untuk membuat transaksi semula bahan ilmiah PTA selepas 5 hingga 10 tahun penyimpanan dibuat di pusat sumber/perpustakaan/multimedia.

Melalui kertas pembentangan yang lepas bertajuk " Pengintegrasian Modul Sejarah Kejuruteraan Dalam Kaedah Pembelajaran Vokasional dan Teknik" (*NCET Vol. 1 No. 1, 2011 ms. 429*), pembelajaran dan latihan vokasional perlu juga mengambilkira sejarah pemula (*early history*) setiap fakta/maklumat yang diperolehi agar dapat dijadikan panduan dalam mengecapi pembaharuan baru yang dicadang untuk dihasilkan. Pengwujudan e-JUST menjadi platform bagi pelajar, pendidik, industri dan pihak berkepentingan untuk mengesan (*tracing*) dan menilai semua kesahihan (*verify*), catatan dan pengalaman berguna, catatan permasalahan, misi dan halatuju dan seribu satu macam misi yang semuanya menjurus kepada maksud mencapai darjah kemampanan ilmu yang dipupuk, dipelihara, dipertahan dan diguna semula atas apa jua tujuan dan matlamat bagi jangka masa panjang.

1.0 METHODOLOGI

Di negara maju, pusat sumber/multimedia/perpustakaan bukan saja tempat mengkatalog, klasifikasi dan disusun buku-buku secara kemas di atas rak, bahkan dijadikan isi kandungan buku-buku yang dapat dijadikan transaksi oleh individu secara atas talian (internet-based) atau tidak (intranet) yang mana bersesuaian terhadap topik-topik yang ingin dirujuk samada bercorak umum ataupun yang telah disenarai pendek melalui pengkelasan topik.

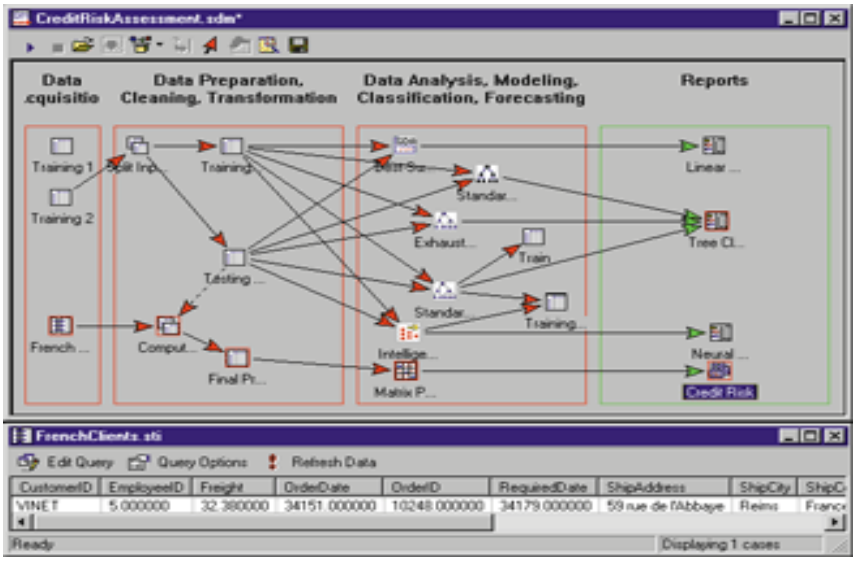


Rajah 1: Contoh penggunaan Data Mining menggunakan laman sesawang

Apa yang diperkatakan sebagai Perlombongan Data atau *Data Mining* adalah merujuk kepada “satu proses analisis yang direka untuk meneroka data (biasanya bersaiz besar - di cabang perniagaan atau berkaitan pasaran - juga dikenali sebagai "data yang besar (*Big Data*) untuk mencari corak yang konsisten dan/atau hubungan sistematik antara pemboleh ubah, dan kemudian memperbaiki data dengan menggunakan pola yang dikesan kepada subset baru data. *Data Mining* sering dianggap sebagai "gabungan statistik, AI (kecerdasan buatan), dan pangkalan data penyelidikan" (*Pregibon, 1997, ms. 8*), yang sehingga baru-baru ini bukanlah lagi diiktiraf sebagai satu bidang yang menarik untuk ahli statistik secara mutlak. Bidang ini muncul sebagai lapangan yang berkembang pesat dan utama (juga dalam statistik) di mana kemajuan teori penting sedang dijalankan (sebagai contoh, Persidangan Antarabangsa bagi Knowledge Discovery dan Data Mining yang dianjurkan oleh Persatuan Statistik Amerika).

Terdapat 3 peringkat dalam pocess melombong data iaitu jelajah mula, pembangunan model atau corak pengenalan berpengesahan dan penggunaan model aplikasi data baru bagi menjana ramalan (*prediction*). Bagi e-JUST, peringkat jelajah mula adalah dengan menggunakan penggunaan ayat kunci *(key sentence*) berbanding kata kunci kerana sesuatu perkara/proses/sistem yang dicari hendaklah berasakan aplikasi utama yang terlibat bagi sesuatu projek (spt cth: *waste water filtering technique* berbanding *waste filtering/water filtering/filtering/waste*) kerana bersifat umum sekiranya melibatkan pengkhususan bagi pelajar yang mengikuti kursus Diploma Penyelenggaraan Fasiliti & Bangunan (BOM).

1.1 Struktur Proses Melombong Data

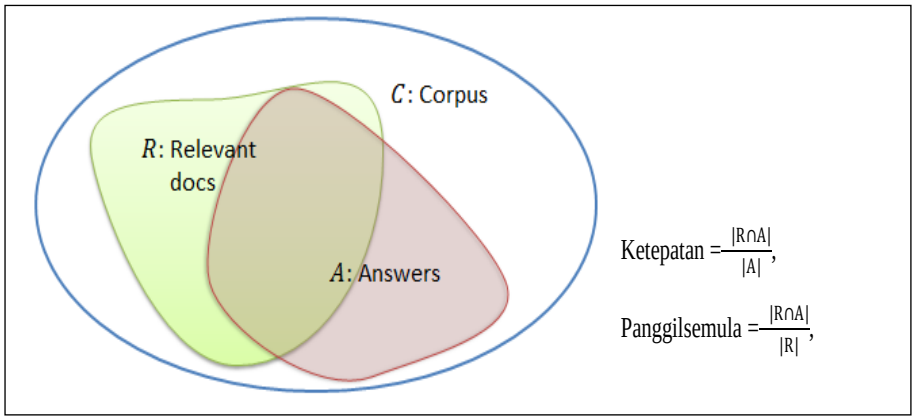


Rajah 2: Struktur penyelesaian pencarian dengan e-JUST

Daripada struktur pada Rajah 2, e-JUST juga mampu berperanan sebagai metodologi pengesanan latihan (*tracer study/training methodology)* yang membantu pengajar, pelajar, majikan (industri/syarikat) dan komuniti mengesan kemajuan projek, sumber dapatan penghasilan projek, kesahihan item/komponen, corak dan gabungan minda dan kerja tangan serta misi dan visi projek serta rujukan penambahbaikan (enhancement) masa hadapan kerana maklumat-maklumat akan dimasukkan oleh pelajar yang berdaftar sebagai "hakcipta" selain memenuhi salah satu syarat untuk tamat latihan mengikut peringkat (DKM/DLKM). Ini sejajar dengan apa yang didefinasikan sebagai "*a tracer study as an impact assessment tool where the impact on target groups is traced back to specific elements of a project or program so that effective and ineffective project components may be identified."* (ILO Thesaurus 2005).

1.2 Keberkesanan & ketepatan pencarian data.

Keberkesanan pencarian data e-JUST, secara asasnya bergantung ke atas dua topik utama iaitu kualiti hasil carian kembali dari sudut perkaitan dan ujian dalam talian dengan penilaian pengguna sepertimana yang disyorkan oleh Dr. Gjergji Kasneci , *Introduction to Information Retrieval* , WS 2012-13.



2.0 KEPUTUSAN PEMERHATIAN

Usaha pengumpulan data melibatkan volume yang besar akan menjadi sia-sia tanpa sambutan yang hangat dari pengguna selain tahap kesedaran akan kehadiran perkhidmatannya untuk kemudahan semua pihak. e-JUST yang disyorkan untuk dibangun dan diadaptasi oleh pelajar berlandaskan perkhidmatan dalam talian diharap memberi impak besar bukan sahaja semata-mata mengatasi masalah perbelanjaan besar melalui kewangan yang banyak tetapi juga memberi nafas baru kepada persepsi peranan pusat sumber/perpustakan/multimedia di institut kemahiran yang lengang, sunyi serta membosankan.

Melalui kajian yang dijalankan oleh Indiana University South Bend, AS, [5], "*this study succeeded in showing several points. The first was the correct assumption in applying the technology acceptance model when determining individual user acceptance of digital libraries."* yang menerangkan maksud utama ke arah pencapaian yang cemerlang atas kepenggunaan e-JUST sekiranya dilaksanakan di semua ILKA/ILKS dan ILJTM khususnya.

Satu tinjauan rawak yang diadakan di BPSM ADTEC Kemaman, mendapati peratusan pengunjung (dari 465 pelajar) ke lokasi tersebut amat rendah dan memerlukan tindakan bagi menggalakkan lebih ramai pelajar berkunjung bukan sahaja atas kehendak akademik tetapi juga sebagai pusat setempat memperolehi pengetahuan am, berita semasa, bersosial, bertukar fikiran dan idea serta merehatkan minda. Namun demikian, melayari internet adalah satu perkara yang tidak ditinggalkan pada setiap hari tinjauan dibuat.

Jadual 1: Kadar pengunaan pusat sumber seminggu oleh pelajar

Bilangan Hari	Bilangan Pengunjung	Tujuan	Peratusan
Hari 1	12	Membaca suratkhabar, Menonton tv, melayari internet, berehat.	2.58
Hari 2	18	Membaca majalah, menonton tv, mengguna komputer, melayari internet.	3.87
Hari 3	22	Membaca majalah, mencari rujukan, menonton tv, melayari internet, berehat.	4.73
Hari 4	25	Membaca majalah, melayari internet.	5.37
Hari 5	17	Membaca suratkhabar, melayari internet, menonton tv, berehat.	3.86

Ekoran itu, sekiranya melayari internet telah membudayai aktiviti pelajar/individu, sekurang-kurangnya ia memberi petanda positif kerana bertepatan dengan analisa oleh *Information Policy & Access Center (iPAC), College of Information Studies at the University of Maryland*, iaitu individu yang memiliki kadar celik digital (digital literacy) berupaya tinggi untuk menyesuaikan persekitaran digital yang diwujudkan untuk faedah dan sasaran yang ditetapkan, Bertot, J. C., Jaeger, P. T., & McClure, C. R. (Eds.) *Public libraries and the Internet: Roles, perspectives, and implications. Westport, CT: Libraries Unlimited.*

Apa yang penting untuk diberi penekanan terhadap e-JUST adalah kepakaran/kemahiran individu untuk menguasai kaedah pencarian data yang diperlukan seperti mana yang disarankan melalui [5] "*The key ingredient for successful use of a digital library may well be the user's expertise with search functions. Users need to possess the knowledge of the topic being searched. The more knowledge a user has about the topic, the more successful their search will be. However, the ability of a user is often overlooked as part of the search function".*

4.0 KESIMPULAN

Dengan peratusan capaian internet berkelajuan tinggi yang disediakan oleh syarikat komunikasi (*telco*) samada secara perhubungan tanpa wayar atau gentian optik sebanyak 57.4% dengan sasaran sehingga 75% pada tahun 2015**, keupayaan pembangunan satu bentuk penyimpanan data yang merangkumi rujukan, hasil kerja, maklumat am berkenaan topik latihan tidak mustahil untuk dibangunkan dan boleh dikongsi oleh semua pihak berkepentingan melalui kaedah transaksi secara digital.

Kerajaan berupaya untuk menjimatkan belanja pembangunan pusat sumber/multimedia/perpustakaan terutama sekali bagi pusat latihan kemahiran sekiranya komuniti digital antara pusat latihan yang ditubuh dan dikendalikan oleh pelbagai agensi dan kementerian dapat disatukan sehingga membentuk komuniti sektor kemahiran secara pintar, kurang birokrasi dan mampu bersaing dengan institut dunia di negara luar yang sudah mencapai taraf antarabangsa. Ini akan menjadikan pembelajaran TVET (Technical Vocational Education and Training) menarik, dipercayai dan memberi impak terhadap kualiti insan berkemahiran, inovasi, kreativiti dan sahih akan pencapaian pekerja yang dilahirkan melalui sistem TVET acuan Malaysia.

Harapan utama pengwujudan e-JUST adalah komitmen kerajaan untuk menyediakan akses percuma kepada workstation dan capaian internet oleh pelajar/pengajar/industri dan seterusnya menjawab persoalan berkenaan mekanisme penghasilan bakal pekerja bertaraf dunia, berupaya menyesuaikan diri, kreatif dan inovatif tidak kira di pelosok mana mereka bekerja atau dalam sektor apa yang diceburi.

5.0 RUJUKAN

[1] Pregibon, D. (1997). *Data Mining*. Statistical Computing and Graphics, 7, 8.

[2] Han, J., Kamber, M. (2000). *Data mining: Concepts and Techniques*. New York: Morgan-Kaufman.

[3] Xindong Wu; Xingquan Zhu; Gong-Qing Wu; Wei Ding, *Data mining with big data*, Knowledge and Data Engineering, IEEE Transactions, vol.26, no.1, pp.97,107, Jan. 2014

[4] Ugwuonah G.E. & Omeje K.C. (1998) *Final Report of Tracer Study Research Project on Higher Education and Work. Institute for Development Studies*, University of Nigeria, Enugu Campus.

[5] Ganesh Vaidyanathan, Asghar Sabbaghi, Michael Bargellini, *User Acceptance of Digital Library: An Empirical Exploration of Individual and System Components.* Issues in Information Systems, Volume VI, No.2, 2005.

[6] **News Release, *TM INTRODUCES NEW BROADBAND PACKAGES TO DRIVE BROADBAND PENETRATION* , 16 April 2015.

O10: Assessing Acceptance Sampling Application in Manufacturing Electrical and Electronics Products

Chua Yee Peng[1]
Institut Latihan Perindustrian Pedas, Negeri Sembilan

chua.y@jtm.gov.my

Abstract

This paper discusses the application of acceptance sampling technique as a practical tool for quality assurance applications to decide whether the lot is to be accepted or rejected. In Malaysia, single attribute acceptance sampling plan is widely practiced for quality assurance purposes in manufacturing companies. Literature showed that majority of past studies on acceptance sampling had focused on the development and establishment of new methods for acceptance sampling application. However, there is none that had investigated the relationship between acceptance sampling plan selection and effectiveness of the selection. Therefore, in this study, the authors had analyzed the effectiveness the acceptance sampling plan application method and its implementation problems in manufacturing electrical and electronics products. The study was conducted by using case study methodology at three manufacturing companies' coded names: company A, B and C. In this paper, the authors would like to share the case study companies' experienced of acceptance sampling plan selection and difficulties that they had faced during the course of implementing acceptance sampling, in their production lines. The result from the three case study companies showed by implementing acceptance sampling they could easily investigate and diagnose their suppliers' product quality immediately upon their arrival at the company premise. All the three case study companies agreed that acceptance sampling implementation had improved their product's quality in the market place.

Keywords: acceptance sampling plan; implementation; quality assurance; effectiveness.

1.0 Introduction

Sampling plans are hypothesis tests of the product that has been submitted for an appraisal and subsequently resulted with acceptance or rejection (SQC Groups, 2000). A sample is selected and checked for various characteristics. The product may be grouped into lots or may be a single piece from a continuous operation. For products grouped into lots, the entire lot is accepted or rejected. The decision is based on the specified criteria and the amount of defective units found in the sample. Sampling at the end of manufacturing process provides a confirmation on the adequacy of the quality control procedures in a manufacturing department. If the process has been controlled satisfactorily, the product would be accepted and passed to the customer. If the process or quality controls have broken down, the sampling procedures will prevent defective products from going any further or leakage to the customer. The manufacturing department, as part of the process or quality control program uses sampling techniques for quality monitoring purposes (Besterfield, 2004). Effective acceptance sampling involves effective selection of the products and the application of specific rules for lot inspection that follows the standards. Thus, the acceptance sampling plan applied on a lot by lot basis becomes an element in the overall approach to maximize the quality level at minimum cost (Schilling 1982).

1.1 Research Objectives

The research was conducted with the below objectives:

a. To review the application of acceptance sampling in manufacturing electronics and electrical products;
b. To identify the level of sampling plan characteristics chosen based on the manufactured products;
c. To review the sampling results regularly. The companies shall have a clearer picture on the sampling plan effectiveness; and
d. To compare the performance of acceptance sampling plan implementation from 3 selected companies. It will provide them better room for improvements in the companies.

From the research, the selected companies meet or satisfy the intangible customer requirements. Customer satisfaction has now become a visible and manageable value to the company. This method will assist the company to perform a self-assessment process and improve its internal quality performance, after the company had compared themselves against its competitors.

2.0 Literature Review

Acceptance sampling had become an important field of statistical quality control was popularized by Dodge and Romig (Schilling 1982). This sampling technique was originally applied by the U.S. military to the testing of bullets during World War II. If every bullet was tested in advance, no bullets would be left to ship. On the other hand, if none were tested, malfunctions might occur in the battle field with potentially disastrous results (Military Standard 105E, 1989). Dodge reasoned that a sample should be picked at random from the lot based on the basis of information that was yielded by the sample (Schilling, 1982). A decision should be made regarding the disposition of the lot. In general, the decision is either to accept or reject the lot. This process is called Lot Acceptance Sampling or Acceptance Sampling (Nist, 2006). There are two major classifications of acceptance plans: attributes ("go, no-go") and by variables (Saidel, 1997). The attribute type is the most commonly used for acceptance sampling (Ng, 2005). Attribute inspection is done based on physical characteristics such as appearance, colour, feel and taste. It results in classification of products into categories such as good/bad, bright/dark, tight/loose, smooth/rough and so on (Krishnamoorthi, 2006). In measurement inspection, a characteristic is measured by using an instrument. The sampling plans for attribute inspection will specify the number of defectives that can be tolerated in a sample of specified size to accept lots (Griffith, 2003). The sampling plans for variables usually require calculation of an average, range or standard deviation before deciding to accept or reject a lot. Thus, implementation of sampling by variable is rather complicated and may require specially trained personnel. However, variable sampling plan are more efficient in the sense that they require less sampling compared to attribute plans (Krishnamoorthi, 2006).

2.1 Methods for Products Inspection

Selecting product for appraising the quality characteristics can be done by a number of different methods. There are six types of methods: no inspection, 100% inspection, constant percentage sampling, random spot inspection, audit sampling (no acceptance and rejection criteria) and acceptance sampling based on probability. In acceptance sampling, the risks of making a wrong decision are known. When inspection is performed by attributes (product is classified as good or defective), five types of acceptance sampling plans may be used (will be explained further in Section 2.5). Lot-by-lot single sampling plan is the most popular application in industry. This is because they are easier to administer and implement compared to other plans. Acceptance sampling application shows effective results in Griffith's (2003) research on manufacturing processes.

2.2 Sampling Plan Categories

According to Schilling (1982), acceptance sampling plan falls into five categories: single, double, multiple, sequential and skip lot sampling plans. Single sampling plan happens when one sample of items is selected at random from a lot and the disposition of the lot is determined from the resulting information. These plans are usually denoted as (n, c) plans for a sample size n, where the lot is rejected if there are more than c defectives. These are the most common and easiest plans to use, even though it is not the most efficient in terms of average number of samples needed. Double sampling plan happens after the first sample is tested, there are three possibilities: accept the lot, reject the lot and no decision. If the outcome is no decision, and a second sample is taken, the procedure is to combine the results of both samples and make a final decision based on that information. Multiple sampling plans are extension of the double sampling plan where more than two samples are needed to reach a conclusion. The advantage of multiple sampling is smaller sample sizes. Sequential sampling plans is the ultimate extension of multiple sampling where items are selected from a lot one at a time and after inspection of each item a decision is made to accept or reject the lot or select another unit. Skip lot sampling plan means that only a fraction of the submitted lots are inspected. Making the final choice between single or multiple sampling plan that has acceptable properties is a matter of deciding whether the average sampling savings gained by the various multiple sampling plans justify the additional complexity of these plans (Pearn and Wu, 2007). According to Taylor (2005), one should follow this approach if you are uncertain of not knowing how much sampling, inspection will be conducted on a day-by-day basis.

2.3 Previous Studies on Acceptance Sampling

Acceptance sampling could help to improve system reliability by improving component reliability through more stringent acceptance sampling plan selection (Graves et al. 2000). This is done by specifying a prior distribution on the number of defects in a lot, and revising the distribution based on information in the acceptance sample. Then, transform a given system on the number of defects in the posterior distribution into a reliability distribution. There were several researches conducted regarding acceptance sampling. The critical review for past researches of application of acceptance sampling in the manufacturing industry is summarized in Table 1.

As a summary, it was found that past studies did not investigate the relationship between acceptance sampling selection and their effectiveness. Selecting the correct types of acceptance sampling level is very important prior to the start of any inspection. The wrong selection will cause the leakage of failed products to customers and increase the products failure risks, thus rework costs incurred for screening the products. Therefore, in the authors' opinion it is a necessity to conduct a research on the application of acceptance sampling in Malaysian electrical and electronics products manufacturing industries. This is to ensure the electrical and electronics products passed or marketed to the customers are assured in terms of their quality and reliability.

Table 1 : Critical reviews of previous acceptance sampling studies

No.	Researcher	Research Topic
1.	Wu and Pearn, 2007	Process reliability index, Cpk sampling
2.	Gonzalez and Palomo, 2003	Bayesian sampling follows to Poison distribution
3.	Baker et al. 1996	Bayesian attribute sampling comparison of statistical and classical confidence levels of data
4.	Kwon, 1996	Improve the test duration of Bayesian sampling plan
5.	Kaya and Engin, 2007	Genetic algorithms sampling in multi-stage process
6.	Cheng and Chen, 2007	Genetic algorithms in design of attribute double sampling
7.	Sohn and Jang, 2001	Degradation sampling with fitted model
8.	George, 1994	Sampling application for exported products from overseas supplier
9.	Pearn and Wu, 2006	Process capability indices (PCI) sampling
10.	Klaassen and Chris, 2001	Credit based acceptance (CBA) sampling
11.	Balasooriya et al., 2000	Weibull distribution with asymptotic distribution theory sampling for reliability
12.	Legan et al., 2001	Microorganisms concentration controlled by attributes sampling
13.	Pendrill, 2006	Comparison of sampling by variables and attributes
14.	Borget et al., 2006	Control of chemotherapeutic batches in an hospital pharmacy
15.	Kobilinsky and Bertheau, 2005	Grain control with application to genetically modified organism (GMO) detection

In this research, electronic and electrical manufacturing industries have been chosen amongst the Malaysian industries to study the application and implementation of acceptance sampling. The main reasons of this selection are electronics and electrical industries had contributed a total 12% of Malaysian industries and majority of Electronics and Electrical manufacturing industries are performing acceptance sampling test due to the high daily production volume. If conducted 100% inspection will be very time consuming.

3.0 Research Methodology

The research consists structure consists of identify the research topic and research scope, Preliminary study and literature review of journal and conference papers case study questionnaires and case study protocol design, distribution of questionnaires and conduct interview with plant personnel in electronics and electrical manufacturing industries, analyze results: data analysis, review and compare; and conclusion and suggestions for improvements.

Case study methodology was used in this research. It involves an in-depth investigation and appropriate when trying to answer the 'how' and 'why' questions of research (Yin, 1994). Case study evidence may be in the form of qualitative (e.g. words), quantitative (e.g. numbers) data or both, the combination of both data types is believed to be highly synergistic. This is in-line with the main research objective, that is to answer some of the 'how' and 'why' questions in acceptance sampling implementation.

In this study, the main aim of case study methodology was to extract detailed information about how and why a production line for manufacturing electrical and electronics products had used the acceptance sampling technique. Data was collected by conducting structured interviews on the company's production engineers and managers using a set of questionnaire. Case study research relies on multiple sources of evidence. The six sources of evidence most commonly used in case study research are: documents; archival records; observations; physical artifacts; focused interviews and open-ended interviews. The researcher must be able to use these different sources of evidence in a converging manner by defining the 'facts' of the case and to get such convergent, the researcher must ask the same questions on 'multiple sources of evidence' (Yin 1994). The case study questionnaire was designed in a way to provide details response and feedback from the industries as needed for data collection and improvements to the product quality. The questionnaires include information about the acceptance sampling plan selection, production process failure, difficulty of the acceptance sampling plan and suggestions (open ended questionnaires). The questionnaire design was based on the steps and procedures adapted from William (1981).

A successful questionnaire requires careful planning, methodological application, and detailed analysis of the results. The questionnaire's basic objective is to determine the company's performance (doing right or wrong), determine the areas of improvement, benchmark with other competitors, and how to serve the customer better (Bhave, 2002). The well-known phrase GIGO (garbage in, garbage out) is considered as one of the measuring tools, as it has more accurate questionnaire design. The questionnaire design is part of the important stage in the process to get the best results and analysis. The research process is listed as follows: designing the structured interviews questionnaire; interviewing production engineers and managers; conduct plant tours to verify collected data, questions and understand the production line operations, and finally, analyze the results obtained.

By completing the above research methodology steps, the final comparing of the case studied company could be carried out. The comparing method had helped the case study companies to identify the acceptance sampling application in production lines and assist them in the continuous improvement.

4.0 Results and Discussions

The case study structured interview questionnaires were administrated at three large foreign multinational companies with more than 1,500 employees. They are code named, Company A, Company B and Company C. The case study structured interview questionnaires consists of three parts: first, the company background information; second, studying and analyzing the company's application of acceptance sampling; and finally, reviewing the effectiveness and benefits of acceptance sampling application. All the three selected case study companies are located in the state of Selangor, Malaysia. For the past 20 years, they were involved in manufacturing electrical and electronics products in Malaysia. All the three companies' have similar backgrounds in terms of products they produced and the manufacturing processes used. Therefore, the authors had chosen these three companies as the benchmark companies for acceptance sampling adoption and implementation in Malaysian companies. The case study was carried out using verbal interview with the engineer and manager of each company. On overall, all the three companies had adopted and implemented acceptance sampling in their inspection process.

The summary of each case study company background is as shown in Table 2.

Table 2 : Summary of Case Study Companies Background

Company	Company Type	Products Manufactured	Acceptance Sampling
A	Japanese	Disk drives, DVD camera	Yes
B	European	Heat ventilation products	Yes
C	Japanese	Audio products, camcorders	Yes

All the three companies had adopted the application of acceptance sampling plan with Military Standard 105E attribute single sampling plan for both incoming and outgoing inspection as shown in Table 3.

Table 3 : AQL inspection level for the case study companies

Acceptance Sampling	Company A	Company B	Company C
AQL Level Normal Tighten Loosen	Incoming AQL Level II 0.4% 0.1% 1.0%	Incoming AQL Level II 0.6% 0.4% 1.0%	Incoming AQL Level II 0.4% 0.1% 1.0%
AQL Level Normal Tighten Loosen	Incoming AQL Level II 0.4% 0.1% 1.0%	Incoming AQL Level II 0.6% 0.4% 1.0%	Incoming AQL Level II 0.4% 0.1% 1.0%
AQL Level Normal Tighten Loosen	Incoming AQL Level II 0.4% 0.1% 1.0%	Incoming AQL Level II 0.6% 0.4% 1.0%	Incoming AQL Level II 0.4% 0.1% 1.0%
Review Frequency	Yearly	Yearly	Yearly

There are two types of data used for comparisons:

a. Incoming inspection: incoming inspection results (Acceptance sampling plan);
b. Production result: production process 100% inspection results
(Leakage of failure detection by incoming inspection)

Company A

The major products of this company are disk drive for desktop computer, notebook and also DVD camera. There are two major categories of products: electrical parts and mechanical parts. The defect classification follows to Military Standard 105E: major, minor and critical. Judgment major is given when the item cause failure or did not function as intended. Judgment minor is given when the item lower or impaired the efficiency, shortened the useful life time or reduce the value of the item. Judgment critical is given when the item result in hazardous or unsafe conditions for individuals using or maintaining the product. Each type of defects is assigned with acceptable sampling plan as final products judgment.

All parts inspection in Company A should comply with Approved Part List (APL) and Approved Supplier List (ASL). The suppliers and part lists have been approved and acknowledged by the designer in headquarter in Japan. All incoming lots and parts shall be recognized by stamping at the Incoming Delivery Order (IDO) for the palletized lots. For incoming reject lots and parts, the Incoming Delivery Order attached on the palletized lots shall be stamped with red ‘REJECT’ stamp for identification.

The review on the effectiveness of acceptable sampling plan to detect supplier's products defect failure is conducted by data collection from previous month inspection result. Figure 1 and Figure 2 shows the comparison of electrical and mechanical parts inspection result and production rejection results (after incoming inspection).

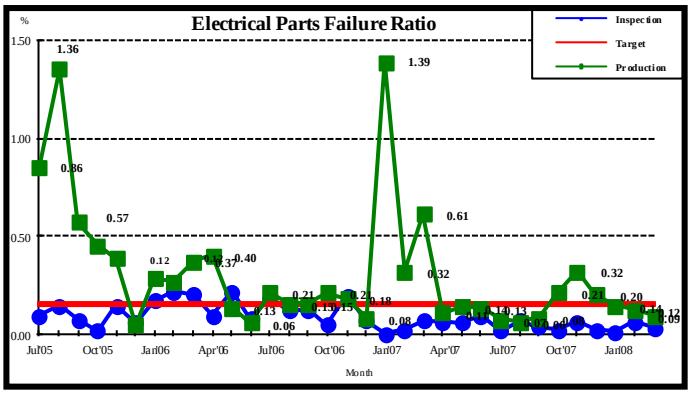


Figure 1 : Electrical parts inspection result and production rejection result (after incoming inspection) comparison data at Company A

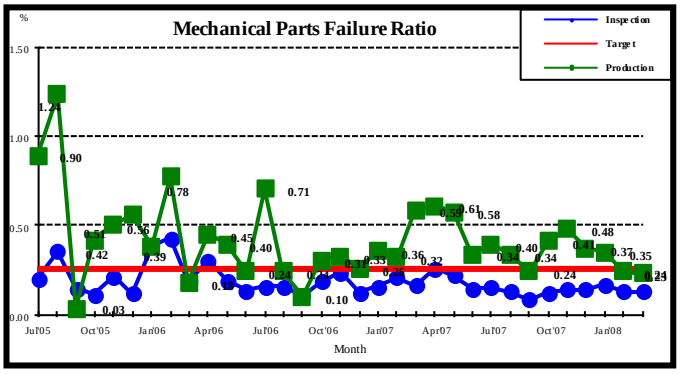


Figure 2 : Mechanical parts inspection result and production rejection result (after incoming inspection) comparison data at Company A

The analysis found that sampling inspection plan of this company is insufficient to detect the parts failure delivered from supplier. The incoming inspection was observed to be under control at AQL 0.15%. However, the production rejection failure was found not achieving the target at AQL 0.15%. The weak point of the parts failure leakage was identified in Table 4. From the verbal interview, the authors' conclude that the respondent was unsatisfied with the current production rejection failure result.

As for the production leakage data, the data shows that there are out of target rejection occurred in every month. Based on the respondent's explanation, it was discovered that new series of products were launched during this period. The unstable new material quality in new series of products had caused the acceptance sampling plan failure to detect the defect efficiently.

Table 4 : Reasons of parts failure in incoming and production

	Incoming Inspection	Production Rejection
Electrical parts	Suppliers have transferred the production process to sub-contractors	New models with problems
Mechanical parts	Parts higher precision hard to control	Low quality parts purchased from China

Company B

All the parts purchased from suppliers are mechanical or semi-finished assembly products. Additional sample size code (e.g. C, D, E etc.) will be assigned to the products in order to find the applicable code letter for inspection in the particular lot or batch size. Sample size code is selected based on the mechanical precision requirement for each product. Higher precision of parts will require more quantities to be inspected.

For visual inspection, the visual standard is based on the limit sample, which is a unit of product showing the worst condition for it to be acceptable. If the product appearance inspection is found worse than the limit sample, the judgment of this product is rejected. The limit sample must be agreed in between suppliers and customers for standard judgments. The limit sample needs to have validity date and both parties' endorsement on the sample. For equipment measurement inspection, the parts are measured with a standard gage and some are coupled with specially made gage for fixture confirmation. To maintain the equipment and fixture precision, re-calibration for equipment and fixture need to be conducted by following to the preventive maintenance scheduling.

Figure 3 shows the comparison of parts inspection result and production rejection results (after incoming inspection). On overall, it was found that the production has higher rejection, compared to incoming sampling inspection.

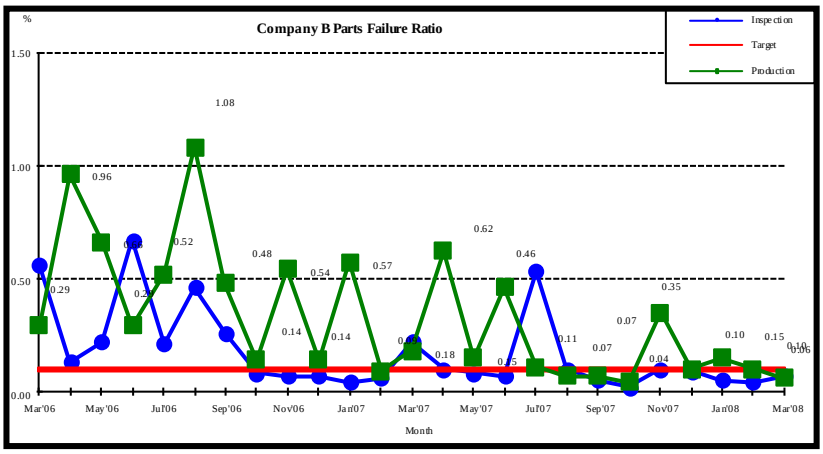


Figure 3 : Company B parts inspection result and production rejection result (after incoming inspection) data

The production rejection failure did not achieve the target percentage, i.e. AQL 0.10%. From the verbal interview, the respondent explained that this company was unsatisfied with the current production rejection failure result. Currently, the heat ventilation products are unstable in term of quality performance. In total, there are three suppliers of these products. All the parts suppliers are sourcing them from China. These parts are purchased at very low prices. As the results, Company B found the qualities of the parts supplied from China are at lower quality level if compared to the parts purchased locally in Malaysia.

In total, there are three suppliers of these products. All the parts suppliers are sourcing them from China. These parts are purchased at very low prices. As the results, Company C found the qualities of the parts supplied from China are at lower quality level if compared to the parts purchased locally in Malaysia.

Due to the poor quality of parts supplier, the acceptance sampling inspection operators have to work hard to detect the parts failure efficiently. Based on Figure 3, it was observed that the operators' inspections are inconsistency to detect the failure. Some of months the operators are able to detect the failure, but in some of months the operators failed to detect the failure. The poor detection skills in the operators will cause the defect parts leakage in the production line.

Company C

This company is a manufacturer for audio video multimedia in the computer-related consumers and electronics products. There are two main categories of parts – mechanical and electrical. Each part has various types of testing and inspection methods. This company produced audio and video products. In this case study research, audio products has been chosen for analysis because this product had applied acceptance sampling plan for inspection in the company. For this product, the acceptance sampling level is set at AQL 0.4%. This product is tested with visual inspection, measurement, fitting, mechanical tape test and electrical inspection test.

Comparison of parts inspection results and production rejection results (after incoming inspection) were collected and shown in Figure 4. Overall, it was found that the production line had slightly higher rejection, compared to incoming sampling inspection.

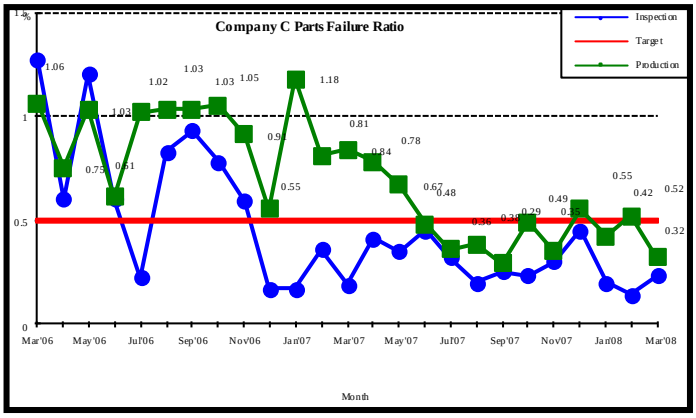


Figure 4 : Company C parts inspection result and production rejection result (after incoming inspection) comparison data

From the interview, the respondent explained that Company C was unsatisfied with the current production rejection failure result. The respondent explains that their audio products were inspected with electrical automated machine. The electrical automated machine is unable to cover all the functional failure on the integrated circuit. The selection of printed circuit board detection points to be inspected in the automated machine is based on the previous products failure history. For example, the new model's integrated circuit has total 200 inspection points which needed to be inspected. However to reduce the inspection duration and cost, these products are required to inspect only 50 points. The decision of this 50 points to be inspected are based on the history of previous failure occurred in the production and the responsible risk of failure. Additional inspection points will be later added in future from time to time, if there are any failure occurred in the production.

As the continual improvement activity, company C has started to applied Failure Mode Effect Analysis (FMEA) study to understand the potential failure might occur in designing new electrical automated machine stage start June 2007. Suitable number of inspection points will be selected based on the circuit potential failure analysis. This activity is more efficient compare to previously, where the selection of inspection points is based on older models failure history experience.

4.1 Benefits of Acceptance Sampling Application

All the three companies agreed that the application of acceptance sampling can improve the productivity and quality of their products. Figure 5 shows the perception of the engineers and managers at the three case study companies for acceptance sampling implementation in their company.

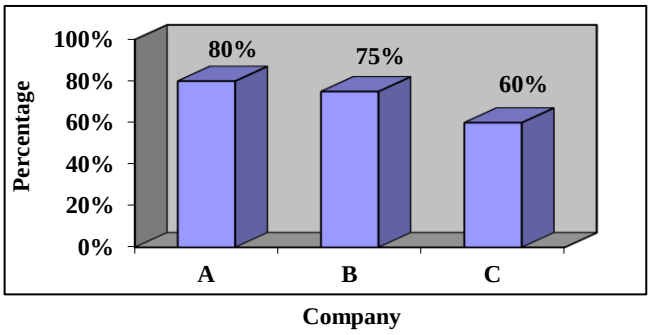


Figure 5 : Case study companies' perception of acceptance sampling implementation

From the interviews, the authors found each company had spent considerable amount of cost and time to develop and implement the acceptance sampling plan. The inspection costs include manpower cost and equipment purchased for inspection and improve the factory facilities. All the respondents believed the money and time spent are worthwhile with the results they obtained through acceptance sampling. The results of improvements through acceptance sampling implementation are faster delivery (follow to just-in-time, JIT standard), better quality, lower products cost and higher reputation for company's products. From the interviews with the plant personnel, it is understood that the application of just-in-time (JIT) activities is no longer applied only to Japanese companies but also to European company. For further improvement of the company's productivity and deliveries, the European company had also benchmark and learned from Japanese company on how to apply and implement the JIT activities. The European company had started to apply all others relevant acceptance sampling activities which could further improve their effectiveness and efficiency of their production lines. In this regards, there are few suggestions and feedbacks from the respondents to improve the acceptance sampling application.

The respondents of the interviewed companies suggested the company's top management should regularly review and improve supplier parts detection through:

a. Conduct tightened inspection continuously for all new parts for the first 5 lots of delivered from the supplier;
b. Conduct on-site inspection to suppliers' plant for checking process capability and consistency confirmation, and thus conduct necessary improvement activity immediately;
c. Review the current acceptance sampling plan regularly; and
d. Review the inspection methods (electrical, measurement or visual inspection) regularly. Add the inspection methods (if necessary) to improve the detection process.

4.2 Suggestions for improvement

The questionnaires collected results from all the companies found that they agreed acceptance sampling is a necessity in the electronics manufacturing industry. Acceptance sampling application has assisted the production to receive quality products and continue the production process smoothly.

Many manufacturing companies had started to apply acceptance sampling. According to the respondents from three interviewed companies, the reasons of acceptance sampling application are to improve the products quality, to produce the products with better revenue to enhance business expansion, to become a world class manufacturing, improve the incoming parts and manufacturing quality and to improve global competitiveness.

In this regards, there are few suggestions and feedbacks from the respondents to improve the acceptance sampling application. The respondents of the interviewed companies suggested the company management should regularly review and improve supplier parts detection through:

a. Conduct tightened inspection continuously for all new parts for first 5 lots delivery;
b. Conduct on-site inspection to suppliers' plant for checking process capability and consistency confirmation, and thus conduct necessary improvement activity immediately;
c. Review the current acceptance sampling plan regularly; and
d. Review the inspection methods (electrical, measurement or visual inspection) regularly. Add the inspection methods (if necessary) to improve the detection process.

The encouragement and support from the top management is very important in order to make sure an activity succeed. The approval of top management will ensure in the money, manpower and capabilities of the quality assurance department to carry out the job confidently and successfully.

5.0 Conclusions

Effective acceptance sampling involves effective selection and the application of specific rules for lot inspection. The acceptance sampling plan applied on a lot by lot basis becomes an element in the overall approach to maximize quality at minimum cost. Since different sampling plans may be statistically valid at different times during the life of a process, therefore all sampling plans should be periodically reviewed. From the case study, it was found that the companies have clear vision of their strengths, weaknesses, opportunities and threats analysis. The three case study companies' have performed assessment on their acceptance sampling plan and relates its effectiveness to the achievement on their products quality. The continuous improvement and review of acceptance sampling plan is important to improve the products quality and ensure continuous customer satisfaction.

6.0 Acknowledgements

The authors would like to thank the Ministry of Science Technology and Environment (MOSTE) Malaysia and Universiti Kebangsaan Malaysia for their support in providing the research grant for the project entitled "Development of a tool for benchmarking implementation in manufacturing SMEs" (Science Fund 06-01-02-SF0345).

7.0 References

ASQC, American Society for Quality Standards Committee. 1993. American National Standard : Sampling Procedures and Tables for Inspection by Attributes ANSI/ASQC Z1.4-1993, *American Society for Quality, Milwaukee*.

ASQC, American Society for Quality Standards Committee. 1981. Sampling Procedures and Tables for Inspection by Attributes, *American Society for Quality, Milwaukee*.

Baker, J.R., Lattimore, P.K. and Matheson, L.A. 1996. Quality Control and Social Processes : A Case for Acceptance Sampling, *Benchmarking for Quality Management & Technology*, **Vol.3 (2)**, pp. 51 – 67

Balasooriya, U., Veeresh, G. and Sutaip, L. C. W. 2000. Progressively Censored Reliability Sampling Plans for the Weibull Distribution. *Technometrics,* **Vol.42 (2),** pp. 160 – 164

Besterfield, D.H. 2004. Quality Control Seventh Edition, *Pearson Prentice Hall*, pp. 347-440

Bhave, A. 2002. Customer Satisfaction Measurement. *Quality & Productivity Journal*.

Borget, I., Laville, I., Paci, A., Michiels, S., Mercier, L., Desmaris, R. P. and Bourget, P. 2006. Application of an Acceptance Sampling Plan for Post-Production Quality Control of Chemotherapeutic Batches in an Hospital Pharmacy, *European Journal of Pharmaceutics and Biopharmaceutics*, **Vol.64**, pp. 92-98

Cheng, T.M. and Chen, Y.L. 2007. A GA Mechanism for Optimizing the Design of Attribute Double Sampling Plan. *Automation in Construction,* **Vol.16**, pp. 345 – 353

George, T. 1994. Economic Acceptance Sampling by Variables with Quadratic Quality Costs, *IIE Transactions*, **Vol.26 (8)**, pp. 26

Gonzalez, C. and Palomo, G. 2003. Bayesian Acceptance Sampling Plans following Economic Criteri a: An Application to Paper Pulp Manufacturing, *Journal of Applied Statistics*, **Vol.30 (3)**, pp. 319 – 333

Graves, S.B., Murphy, D.C. and Ringuest, J.L. 2000. Acceptance Sampling and Reliability : the Tradeoff between Component Quality and Redundancy, *Computer & Industrial Engineering*, **Vol.38**, pp. 79 – 91

Griffith, G.K. 2003. The Quality Technician's Handbook Fifth Edition, *Prentice Hall*, pp. 384-405

Kaya, I. and Engin, O. 2007. A New Approach to Define Sample Size at Attributes Control Chart in Multistage Processes : An Application in Engine Piston Manufacturing Process, *Journal of Materials Processing technology*, **Vol.183 (1)**, pp. 34 – 38

Klaassen, K. and Chris, A.J. 2001. Credit in Acceptance Sampling on Attributes, *Technometrics,* **Vol.43 (2)**, pp. 212 – 215

Kobilinsky, A. and Bertheau, Y. 2005. Minimum Cost Acceptance Sampling Plans for Grain Control with Application to GMO Detection, *Chemometrics and Intelligent Systems,* **Vol.75**, pp. 189 – 200

Krishnamoorthi, K.S. 2006. A First Course in Quality Engineering : Integrating Statistical and Management Methods of Quality, *Pearson Prentice Hall*, pp. 363-392

Kwon, Y.I. 1996. A Bayesian Life Test Sampling Plan for Non-repairable Products Sold under Warranty, *International Journal of Quality & Reliability Management*, **Vol.40 (10)**, pp. 13 – 15

Legan, J. D., Vandeven, M. H., Dahm, S. and Cole, M. B. 2001. Determining the Concentration of Microorganisms Controlled by Attributes Sampling Plans, *Food Control,* **Vol.12**, pp 137 – 147

Military Standard 105E. 1989. Sampling Procedures and Tables for Inspection by Attributes. *Washington D.C.: U.S. Government Printing Office*.

Nist, S. 2006. What is Acceptance Sampling, *Engineering Statistics Handbook* http://www.itl.nist.gov/div898/handbook/pmc/section2/pmc21.htm (22 July 2007)

Ng, S. H. K. 2005. Journal of Online Mathematics and its Applications : Introduction to Attribute Acceptance Sampling Plan, *The Mathematical Association of America.*http://mathdl.maa.org/mathDL/4/?pa=content&sa=viewDocument&nodeId=428&bodyId=418 (22 July 2007)

Pearn, W.L., and Wu, C.W. Jan 2006. Critical Acceptance Values and Sample Sizes of a Variables Sampling Plan for Very Low Fraction of Defectives, *The International Journal of Management Science*, **Vol.90 (12)**, pp.34 – 37

Pearn, W.L. and Wu, C.W. 2007. An Effective Decision Marking Method for Product Acceptance, *The International Journal of Management Science*, **Vol.35**, pp. 12 – 21

Pendrill, L.R. 2006. Optimised Measurement Uncertainty and Decision-Making When Sampling by Variables or by Attribute, *Measurement*, **Vol.39**, pp. 829 – 840

Saidel, W. 1997. A Possible Way Out of the Pitfall of Acceptance Sampling by Variables: Treating Variances as Unknown, *Computational Statistics & Data Analysis*, **Vol.25**, 207 – 216

Schilling, E.G. 1982. Acceptance Sampling in Quality Control, *American Society for Quality, Milwaukee*, pp.277 – 306

Sohn, S.Y. and Jang, J.S. 2001. Acceptance Sampling Based on Reliability Degradation Data, *Reliability Engineering & System Safety*, **Vol. 73 (1)**, pp 67 – 72

Taylor, W.A. 2005. Selecting Statistically Valid Sampling Plans, *Variation.* http://www.variation.com/techlib/as-7.html (31 July 2007)

SQC Groups. 2000. Acceptance Sampling, *SQCOnline.com.* http://www.sqconline.com/acceptance-sampling-plans.html (22 July 2007)
.
William, A.B. 1981. The Design and Understanding of Survey Questions, *Gower Publishing Co. Ltd.*, pp. 47 – 342

Wu, C.W. and Pearn, W.L. 2007. A Variable Sampling Plan Based on Cpmk/Cpk for Product Acceptance Determination, *European Journal of Operational Research*, **Vol.10**, pp. 10 – 16

Yin, R.K. 1994. Discovering the Future of the Case Study Method in Evaluation Research, *Evaluation Practice*, **Vol.15 (3)**, pp. 283 – 290

O12: Kenaf-Epoxy Composites: Effects of Fiber Content and Kenaf Treatment on Mechanical Properties

Hadi N. S. H.
Polymer Engineering Department, Faculty of Material Engineering University Malaysia Perlis, Malaysia.

ninasakina87@yahoo.com

Abstract

In this study, the reinforced kenaf fibers using epoxy resin composites were processed through hand lay-up method. The effects of fiber loading on the mechanical properties of this composite were investigated. Two types of fibers were used, namely treated fibers (where some of the fibers were treated with sodium hydroxide) and untreated fibers. Different concentration of sodium hydroxide was used in this treatment. The untreated kenaf and treated kenaf were characterized by FTIR and SEM. The presence of sodium hydroxide in alkalization treatment improved the interfacial bonding between the epoxy and kenaf fibers, as evidenced by Scanning Electron Microscopy (SEM). Mechanical properties (tensile and flexural) were investigated for the composites samples. It was found that treated kenaf reinforced epoxy composite exhibit better mechanical properties than untreated kenaf reinforced epoxy composites. The increments of fiber loading improve mechanical properties. For the most interesting by develop kenaf fiber reinforced composites is utilizing its availability and readiness to be used with various manufacturing process.

Keyword: *kenaf-epoxy composite, mechanical properties, fiber content and treatment*

1.0 Introduction

Over a few decades, there has been a growing interest in the use of natural fibers such as sisal, jute, kenaf and coir in composite applications. There are several reasons for this growing interest is that natural fibers have a higher specific strength than glass fiber and almost similar specific modulus also have lower density (1.2 - 1.6g/cm3) than glass fiber (2.4 g/cm3) which ensures lighter composites for production. Furthermore, it is low production cost, low resin consumption, renewable sources, environmental friendly, and biodegradability. Besides that, there are also have some disadvantages between hydrophilic natural fibers and hydrophobic thermoplastics and thermosets matrices requiring appropriate use of physical and chemical treatments to enhance the adhesion between fiber and the matrix [1].

Kenaf is one type of the natural plant fibers used as reinforcement in Polymer Matrix Composites (PMCs). It has been found to be an important source of fiber for composites, and other industrial applications. Kenaf is known as a cellulosic source with both cellulosic and ecological advantages where in 3 month (after sowing the seeds), kenaf is able to grow under a wide range of weather conditions, to a height more than 3m and base diameter of 3-5cm. [2]

Kenaf exhibits a low density, non-abrasiveness during processing, high specific mechanical characteristics and also biodegradability. Nowadays, kenaf has been used as an alternative of raw material to wood and pulp in order to avoid the destruction of forests, and as non-woven in automotive industries. However, the appearance of melting properties and high hydrophilic properties limit the further application of kenaf fiber in composites. The hydrophilic of kenaf result in poor interfacial interaction with hydrophobic polymer matrices (thermoset and thermoplastics) [6].

2.0 Experimental Procedure

This paper describes details of processing of the composites and the experimental procedures followed for mechanical characterization. This study involves several stages of processes. The first process is the preparation of kenaf fiber. The kenaf fiber undergoes some phases before it is prepared to be used in the kenaf fiber reinforced composites. Chemical treatment then will take place which is treating the fiber under different percentage of Sodium Hydroxide. The second stage of this study is the sample preparation. The mould to make a kenaf fiber reinforced must be designed and fabricated by the specific dimension according to the standard. The fabrication of the various composite materials is carried out through the hand lay-up process. The fibers which in mat form are reinforced epoxy resin. Then, the mixture will be pressed by using the compression molding in order to make the test specimen with desired thickness. The last stage of this study is the mechanical and physical testing of the specimen. During this stage, the specimen of kenaf fiber reinforced composite will be tested in flexural (ASTM D 790), tensile (ASTM D 638) , water absorption (ASTM D 570), Fourier Transform Infrared Spectroscopy (FTIR) to identify hydroxyl group in the fibers, Scanning Electron Microscopy (SEM) to investigate interfacial adhesion between the fiber and matrice.

In this study, kenaf-epoxy composite with concentration of materials and chemical is shown in the Table 2.1.

Table 2.1: Concentration of compounding

Materials	Untreated Kenaf	Kenaf (Alkaline Treatment)
Epoxy	100 gram	100 gram
Hardener	60 gram	60 gram
Kenaf Fiber	10 gram (1 Layer)	10 gram (1 Layer)
	20 gram (2 Layer)	20 gram (2 Layer)
NaOH % solution	-	2,4,6

3.0 Result and Discussion

3.1 Fourier Transform Infrared Spectroscopy (FTIR)

In this study, FTIR was used to confirm that hemicelluloses were removed by the alkali treatment. Furthermore, the effects of fiber treatment on the different between untreated and treated kenaf fiber with different concentration (2,4,6%) of sodium hydroxide (NaOH) as shown in Figure 3.1.

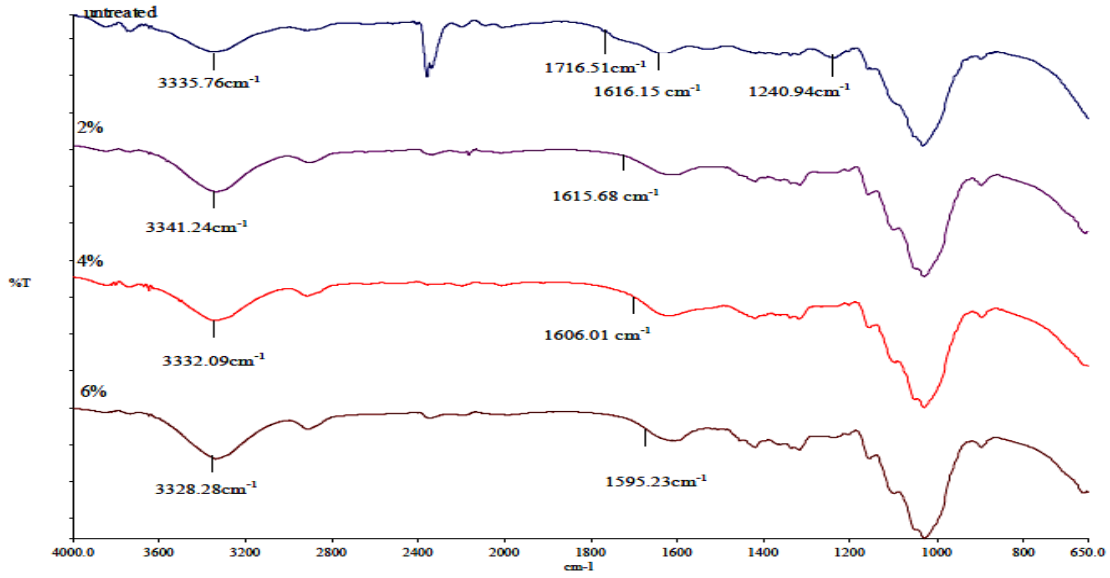


Figure 3.1: Infrared Spectra of the untreated kenaf fiber, kenaf fiber treated with 2, 4 and 6% of NaOH

The broad band in the untreated kenaf fiber as shown in figure 3.1 above, demonstrates the absorption peak around 3335.76cm^{-1} corresponding to the OH stretching vibration of free and hydrogen bonded –OH group. The absorbance peaks observed around 1716.51 cm^{-1} is attributed to the C=O stretching of the acetyl groups of hemicelluloses in untreated kenaf fiber, was almost missing in spectrum of alkali treated fiber, indicating the elimination of hemicelluloses occurred by alkali treatment [4,5].

The peak at 1616.15 cm^{-1} is due to C=O bonds on hemicelluloses. Due to the presence of hydroxyl group and physically absorbed water molecule, this hydroxyl group may tends to enhanced water absorption enter the composite. In untreated kenaf, the peak at 1240.94 cm^{-1} was associated to the C-O stretching of the aryl group in lignin. In 6% of NaOH treatment, this peak disappears due to the removal of lignin after chemical treatment [4,5].

Peak at 1616.15 cm-1 has been reduced after alkaline treatment in all percentage of sodium hydroxide concentration which is shown in figure 3.1. This region is represents the C=O bonds on hemicelluloses and is further evidence that hemicelluloses is removed from the fiber surfaces by alkali treatment. The peak at 1234.57cm-1 in the kenaf fibers is a C-O stretch of the acetyl group of lignin and is reduced (different with untreated kenaf 1240.94cm^{-1}). It is because lignin is partially removed from the fiber and removed in alkali treated fibers [3, 8].

3.2 Scanning Electron Microscopy (SEM)

In this study, kenaf fibers untreated and treated were examined to observe the changes of their morphology. It can be seen that NaOH treatment removes the impurities of kenaf fiber because the impurities only observed on the surface on untreated kenaf fiber [13]. It is shown in figure 3.2,3.3,3.4 and 3.5 below.

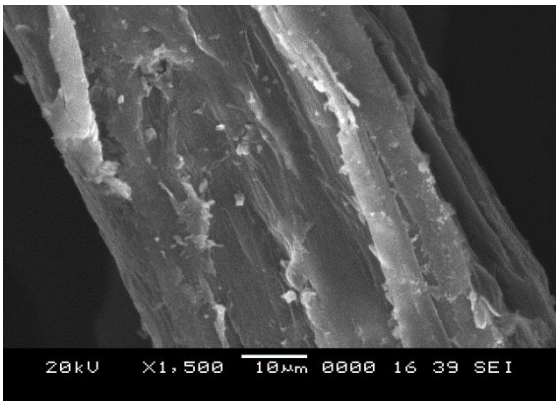


Figure 3.2: Untreated Kenaf Fiber

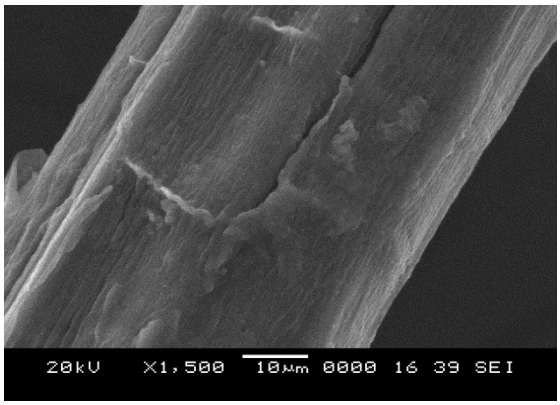


Figure 3.3: Kenaf Fiber treated with 2% NaOH

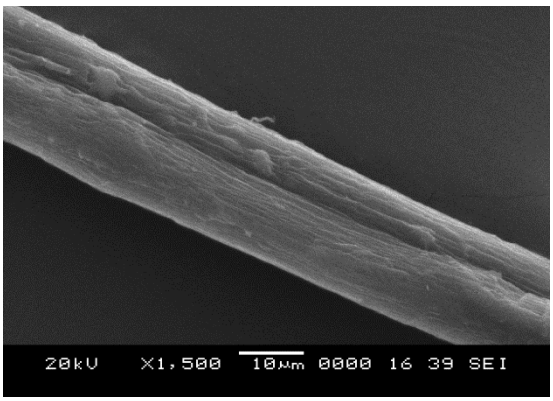


Figure 3.4: Kenaf Fiber treated with 4% NaOH

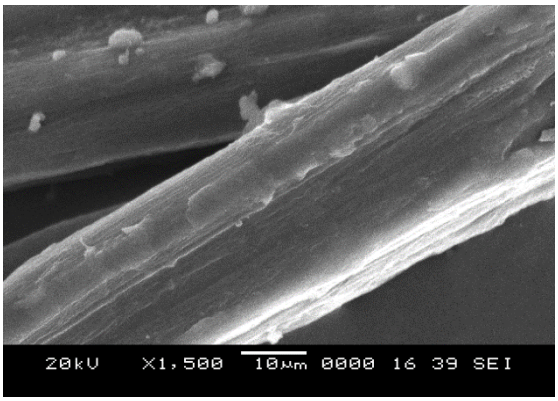


Figure 3.5: Kenaf Fiber treated with 6% NaOH

3.3 Mechanical Properties

3.3.1 Tensile Properties

The tensile properties of composite are markedly improved by adding fibers into a polymer matrix since fiber have much higher strength and stiffness. There are many factors that influenced the performance of kenaf fiber reinforced epoxy composites. The most important factor is the lack of good interfacial adhesion between fiber and the matrix [1]. Figure3.6 shows the tensile strength of treated and untreated kenaf fiber reinforced epoxy and different fiber loading specifically 1 layer and 2 layer of kenaf fiber.

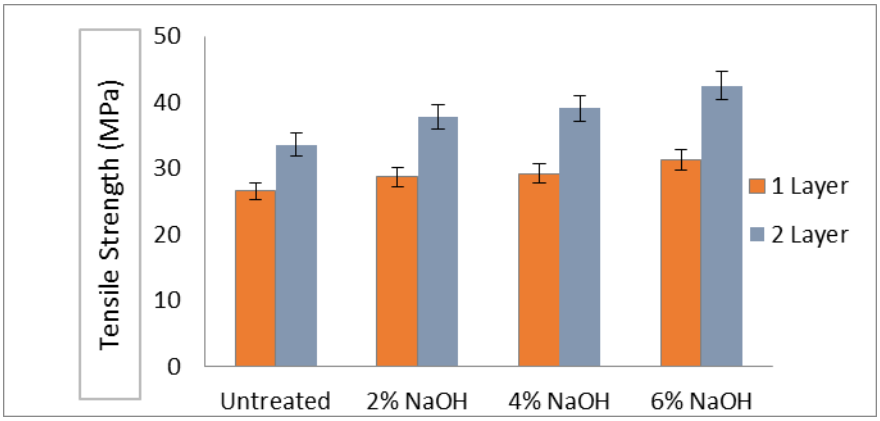


Figure 3.6: Tensile Strength of untreated and treated Kenaf Fiber reinforced Epoxy resin composite with different fiber loading

The tensile strength was found to be gradually increased among untreated and treated kenaf fiber. It is because, after kenaf fiber undergoes alkali treatment for surface treatment, it makes the fiber more hydrophobic. It is also leads to the development of a rough surface topography that improve the fiber matrix interface adhesion and allowed better fiber wetting of fiber with matrix [9, 12]. As shown in figure 3.6, as the percentage of NaOH concentration increase, the tensile strength is gradually increased. Alkali treatment improves fiber surface by removing impurities of fiber which consist of fibrils components. Compatibility of fibers and matrices occur base on high crystalline of composite. In that term, crystalline of composite causing no motion occurs between them even load was applied it remain in actual state until reach the failure [7].

For untreated kenaf fiber of 1 layer and 2 layer reinforced epoxy composite indicated the lowest tensile strength (26.562MPa and 33.609MPa) while for treated kenaf fiber with 6%NaOH for both fiber loading shows the highest tensile strength (31.36MPa and 42.49MPa). As more fibers were added into composites, the fibers were distributed homogenously throughout the composites, thus increase the tensile strength [14].

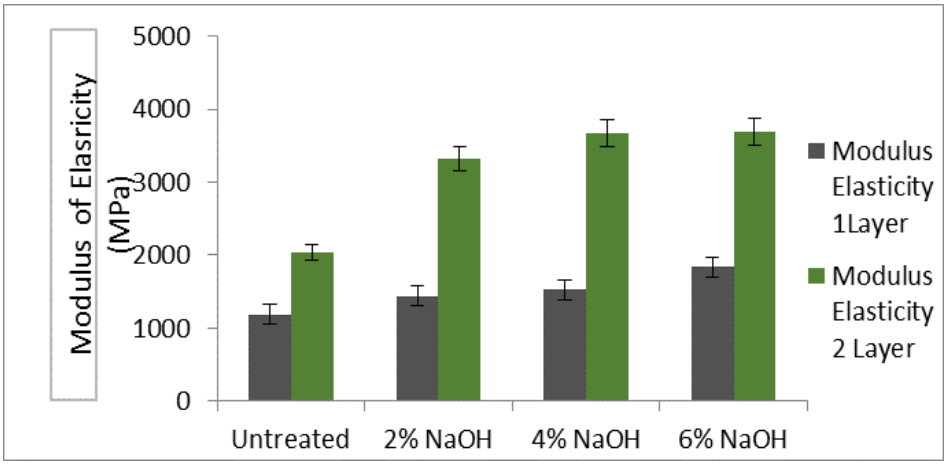


Figure 3.7: Tensile Modulus of untreated and treated Kenaf Fiber reinforced Epoxy resin composite with different fiber loading

The modulus was found to be increased with the increase of fiber loading and concentration of sodium hydroxide for fiber treatment. Figure 3.7 shows the tensile modulus of with different loading of fiber and NaOH concentration. Based on the figure 3.7, it is shows that the untreated kenaf fiber layer reinforced epoxy composite exhibit low tensile modulus rather than all treated kenaf fiber reinforced epoxy composite. Treatment of 6% NaOH indicates high value of tensile modulus for both 1 layer and 2 layer kenaf fiber with 1841.064 MPa and 3689.067 MPa. The increment of percentage of NaOH concentration was increased the tensile modulus.

3.3.2 SEM of Fracture Surface of Tensile Specimens

Based on figure 3.8 (a), it shows the SEM micrograph of fracture surface of untreated kenaf fiber composites after undergo tensile testing. It clearly shows that the resin was not uniformly distributed around the kenaf, which leads to poor tensile strength [10]. Furthermore, untreated fiber consists of bubble and voids which due to poor interfacial adhesion between fiber and matrix.

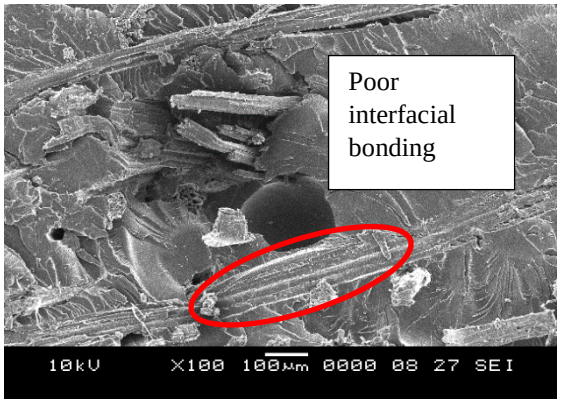


Figure 3.8 (a): Scanning Electron micrographs of tensile fracture surfaces for untreated kenaf fiber/epoxy composites (100 x magnifications)

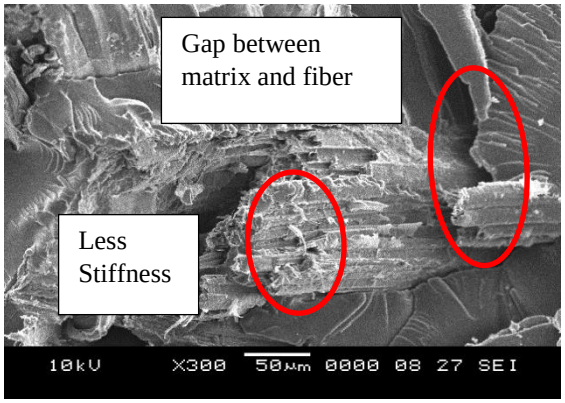


Figure 3.8 (b): Scanning Electron micrographs of tensile fracture surfaces for untreated kenaf fiber/epoxy composites (300 x magnifications)

Figure 3.8 (b) shows poor interaction between matrix and fiber. Poor interaction will display gap between matrix and fiber under 300x magnifications [26]. The surface of the fiber is not smooth indicating that the compatibility between fibers and epoxy matrices is poor [2].

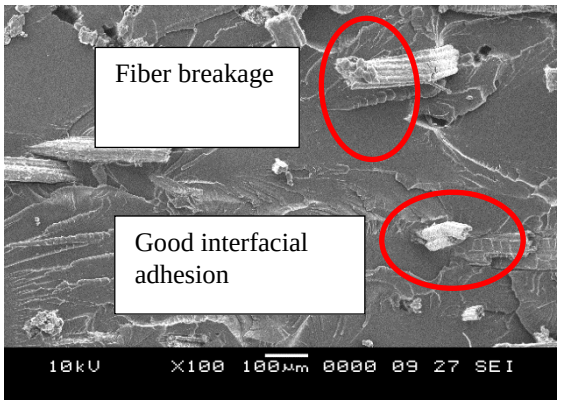


Figure 3.9 (a): Scanning Electron micrographs of tensile fracture surfaces for 2 layer kenaf fiber/epoxy composites for 6%NaOH kenaf fiber treatment (100x magnifications)

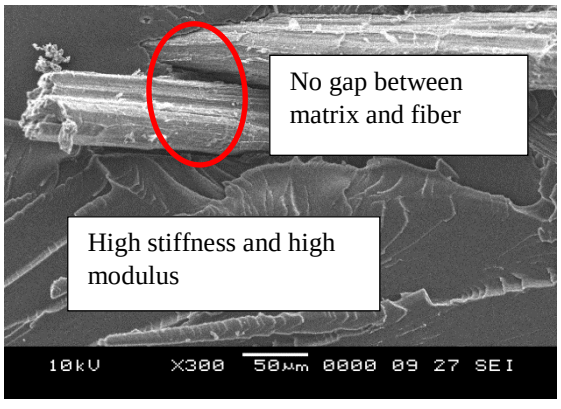


Figure 3.9 (b): Scanning Electron micrographs of tensile fracture surfaces for 2 layer kenaf fiber/epoxy composites for 6%NaOH kenaf fiber treatment (300x magnifications)

Treated kenaf fiber reinforced epoxy composite with increased of fiber loading was indicated high tensile properties. Figure 3.9 (a) and (b) shows the SEM micrograph of kenaf fiber/ epoxy composites with 2 layer of 6% NaOH treated kenaf fiber. Due to figure 3.9 (a), the distribution of the fiber was fine in the matrix. As the fiber loading increase, the tensile strength of the composites increased accordingly. By added more fiber into the composites, the fiber will distribute homogenously throughout the composites and increase tensile properties [14]. Figure 3.9 (b) shows that there is no gap between fiber and matrix. As the matrix transfer the force to the fibers, which will carry most of the applied force thus fibers help to strengthen the composites [14]. Figures 3.10 (a and b), 3.11 (a and b) shown in Annex A.

3.3.3 Flexural Properties

The flexural properties of untreated kenaf fiber reinforced epoxy and treated kenaf fiber reinforced epoxy composites are showed in figure 3.12 below. The epoxy composite were reinforced with 1 layer and 2 layer of kenaf fiber with different concentration of sodium hydroxide (NaOH) percentage fiber surface treatment.

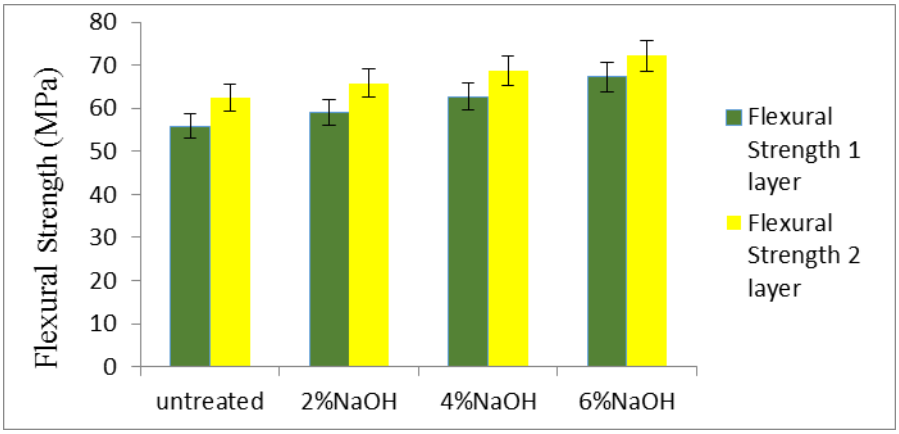


Figure 3.12: Flexural Strength of Untreated and treated Kenaf Fiber reinforced Epoxy composites with different fiber loading

From the results, it can be seen that the flexural strength has slightly increased with the increase of percentage of sodium hydroxide [5]. Untreated kenaf fiber showed the lowest flexural strength with 55.85MPa and 62.367MPa while kenaf fiber treated with 6%NaOH was exhibit the highest flexural strength with 67.32MPa and 72.27MPa.

The flexural strength of kenaf fiber reinforced epoxy composite highly influenced by the kenaf surface characteristics. By using alkaline treatment, highly enhanced of interfacial adhesion between the fiber and the matrix leads better flexural strength compared to untreated kenaf fiber. Treated the kenaf fibers with 6%NaOH split the kenaf fiber bundles into fine fibers which can allow epoxy resin to penetrate into kenaf fiber lead to high interlocking of the fibers in the matrix. The porosity of the treated kenaf fibers reinforced epoxy composites was lower than untreated fiber reinforced epoxy composites which can be another reason of better flexural strength [12].

The high flexural strength is due to the high adhesion between fiber and composite. Alkaline treatment breaks down the bundle fiber into smaller fiber form. It has been proven by increases the effective surface area available for contact with the matrix. It showed that alkali treatment were reduced fiber diameter. Therefore, the improvement of a rough surface topography offer better fiber-matrix interface adhesions and increase flexural strength [1, 7].

This enhancement in kenaf fiber reinforced epoxy composites flexural strength due to the ability of fiber to resists bending force. The lower the flexural strength at lower fiber content (1 layer kenaf fiber) may attribute to the lower loads transferred from the matrix to the fibers thus resulting in lower load carried by fibers. However, slightly increased in flexural strength at 2 layer kenaf fiber reinforced epoxy composites, is due to the increase in stress transferred to the fiber as a result of increased bonding at the fiber-matrix interface [15].

The failure mode of flexural modulus was due to the different stress distribution among matrices and fiber. If compatibility achieve among matrices and fiber, the stress transferred uniformly. [11].

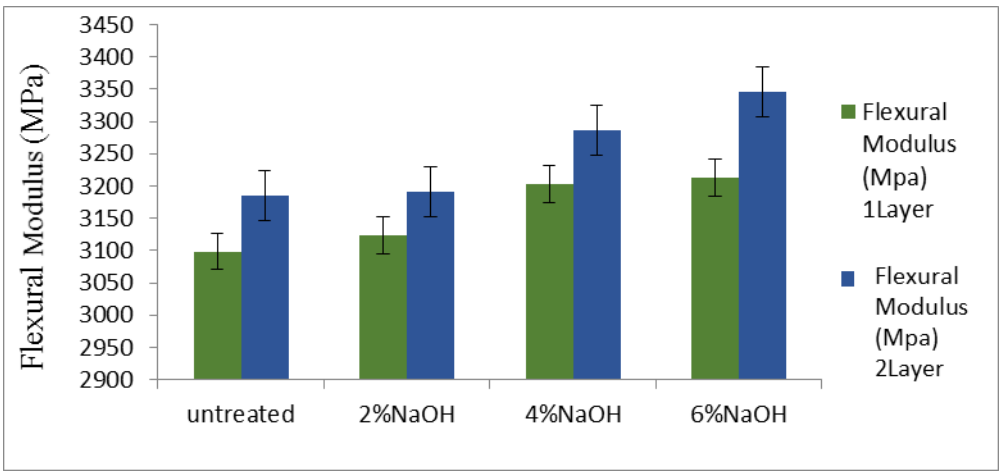


Figure 3.13: Flexural Modulus of 1 and 2 Layer Kenaf Fiber reinforced Epoxy resin composite plotted as a function fiber surface treatment

Based on figure 3.13, it shows the same trend as flexural strength increased by increment of NaOH concentration and fiber loading. In 1 layer kenaf reinforce epoxy composites, load on the composites was not distributed evenly from fiber through the matrix and catastrophic failure of composites was observed because of poor wetting of the fibers [11]. It can be seen clearly that composites with treated fiber indicate high modulus rather than untreated fiber reinforced epoxy composites in both fiber loading. The alkalization treatment of fibers helps in improving the chemical bonding between the resin and fiber resulting in better flexural properties. By increasing the percentage of sodium hydroxide, thus flexural modulus becomes increase. The treatment enhances the interfacial adhesion of the fiber with the matrix and allowing resins to enter the fiber during manufacturing processing. The remotion of the impurities, in kenaf fiber led to increase the roughness of the fiber surface and create good interlocking mechanism with the surface of the matrix [12].

3.3.4 Water Absorption

Figure 3.14 illustrate the effect of fiber content on untreated and treated kenaf fiber reinforces epoxy composites. The result shows that percentage of water absorption increase in time of immersion for all samples. The water uptake rate is linear and very rapid in the beginning of the exposure, after which it become slightly slow down and reaches the saturation level.

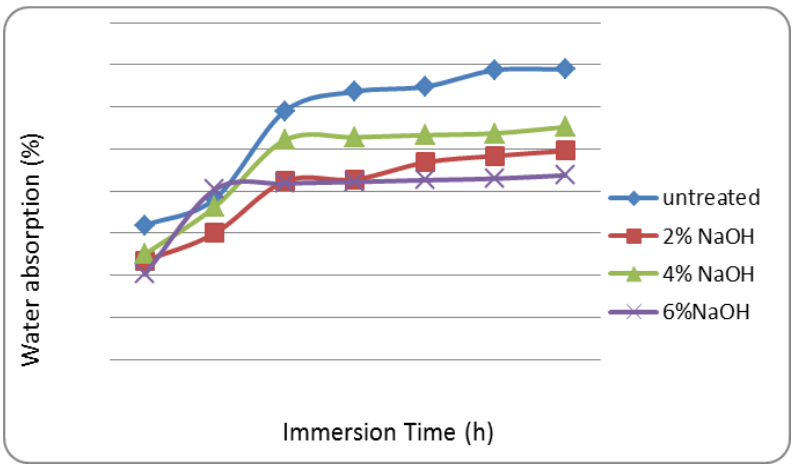


Figure 3.14: Percentage of water absorption versus time of untreated and treated kenaf/epoxy composites (1Layer)

Untreated kenaf fiber reinforced epoxy composite exhibit high percentage of water absorption as the time of soaking is 168 hour. Water will enter easily into the composites through such pores and this water is absorbed by polar OH groups of composites. Water absorption of natural fibers also depends on the hydroxyl groups which present in cellulose and hemicelluloses which accessible by water [16].

The percentage of water absorption in the composite will directly affected by the presence of voids inside the composite, leading to higher water absorption. With the presence of voids on the surface treated kenaf fiber (4%NaOH) absorbs more water. The weight of composite will increase by trapping water inside the voids [16]. Figure 3.14 shows percentage of water absorption between untreated and treayted kenaf/epoxy composites.

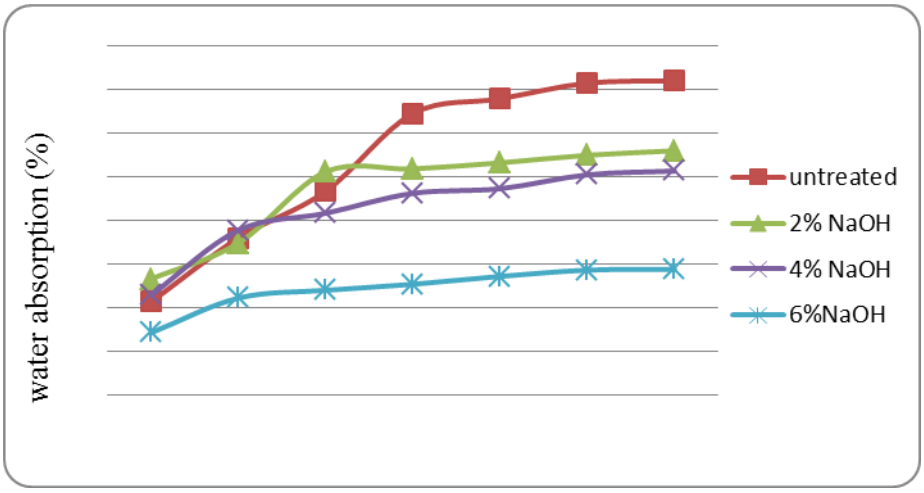


Figure 3.15 Percentage of water absorption versus time of untreated and treated kenaf/epoxy composites (2Layer)

From figure 3.15 above, it can be observed that water absorption increase by increases of fiber content compare with figure 3.13. This result is expected due the hydrophilic nature of cellulose fibers. Because of the hydrophilic nature of cellulose fibers, composites reinforced with cellulose fibers always tend to absorb more water than other types of composites. However, by increase of percentage of NaOH, water absorption becomes decrease [15].

This is also due to the interfacial adhesion between fiber and matrix. Treated kenaf with 6% NaOH shows percentage of the lowest water absorption after all the contaminant reduces. The alkaline treatment has reduced the water absorption by the composites [41]. Alkaline treatment has removed some of hemicelluloses and reduces oil content.

4.0 Conclusion

In this study, effect of fiber content and kenaf treatment on mechanical properties of kenaf-epoxy composite was successfully conducted. The results are summarized as follows:

i. The alkalization treatment has improved the mechanical properties of the composites as compared to the composites with untreated kenaf fiber.

ii. A general trend of the mechanical performances of alkalized kenaf fiber composites observed showed increase with the increments of NaOH concentration.

iii. In addition, with the increment of fiber loading into epoxy matrices, the tensile and flexural provide better properties.

5.0 References

[1] H.M Akil, M. O. (2011). Materials & Design. *Kenaf Fiber Reinforced Composites: A Review* , 4107-4112.

[2] S.Kindo. (2010). *study On mechanical Behaviour of Coir Fiber Reinforced Polymer Matrix Composites* , 2-6.

[20] N.Sgriccia, M. h. (2008). *Characterization of Natural Fiber Surfaces and Natural Fiber Composites* , 1632-1634, Composites: Part A. N.Sgriccia, M. h. (2008). *Characterization of Natural Fiber Surfaces and Natural Fiber Composites* , 1632-1634, Composites: Part A.

[21] H.H. Young and Seok Ok Han, D. C.-I. (2008). *Dynamic Mechanical Properties of Natural Fiber/Polymer Biocomposites: The Effect of Fiber Treatment with Electron Beam* , 253-256, Macromolecular Research.

[22] D.Harekrishna, M. M. (2012). *Renewable Resource Based "All Green Composites" from Kenaf Biofiber and Poly(Furfuryl Alcohol) Bioresin* , 94-99, Industrial Crops and Products.

[23] Chao Chen, M. c.-W.-D. (2012). *Thermo Plasticization and Characterization of Kenaf Fiber by Benzylation* , 1107-1109, Journal of Industrial and Engineering Chemistry.

[24] Y.Cao, S. K. (n.d.). Kenaf Fiber Treatments. *Effects of Heat and Alkali Treatments On Mechanical Properties of Kenaf Fibers* , 2-4, 16th International Conference On Composite Materials.

[25] Mehdi Jonoobi, J. h. (2009). *Chemical Composition, Crystallinity, and Thermal Degradation of Bleached and Unbleached Kenaf Bast (Hibiscus Cannabinus) Pulp and Nanofibers* , 633-634.

[28] H.Aziz Sharifah, M. P. (2003). *The Effect of Alkalization and Fibre Alignment on The Mechanical and Thermal Properties of Kenaf and Hemp Bast Fiber Composites: Part 1 - Polyester Resin Matrix* , 1220-1226, Composites Science and Technology

[29] K.Mohanty, M.M. (2005). Natural Fibers, Biopolymers, and Biocomposites. Raton: CRC Press

[30] A.Sawpan Moyeenuddin, K. L. (2011). *Flexural Properties of Hemp Fibre Reinforced Polylactide and Unsaturated Polyester Composites* , 520-521, Composites: Part A.

[31] B.F. Yousif, A. C. (2012). *Flexural Properties of Treated and Untreated Kenaf/Epoxy Composites* , 378-384, Materials and Design

[35] N. P., Nor Azwin Bt Ahad. (2009). *Effect of Chemical Treatment on The Surface of Natural Fiber* , 155-157, Journal of Nuclear and Related Technologies.

[36] A.G Supri, B. (2009). *Effect of Treated and Untreated Filler Loading on The Mechanical, Morphological, and Water Absorption Properties of Water Hyacinth Fibers-Low Density Polyethylene Composites* , 85-90, Journal of Physical Science.

[38] H.Alamri, I. L. (2012). *Mechanical Properties and Water Ansorption Behaviour of recycled Cellulose Fibre Reinforced Epoxy Composites* , 621-625, Polymer Testing.

[40] H.P.S. Abdul Khalil, M. A. (2011). *Woven Hybrid Composites: Water Absorption and Thickness Swelling Behaviours* , 1045-1048.

[41] H. S.-J. ,Byoung-Ho Lee, (2009). Carding Process. *Bio-Composites of Kenaf Fibers in Polylactide: Role of Improved Interfacial Adhesion in the carding process* , Composites Science and Technology, 25.

Annex A

SEM of Fracture Surface of Tensile Specimens

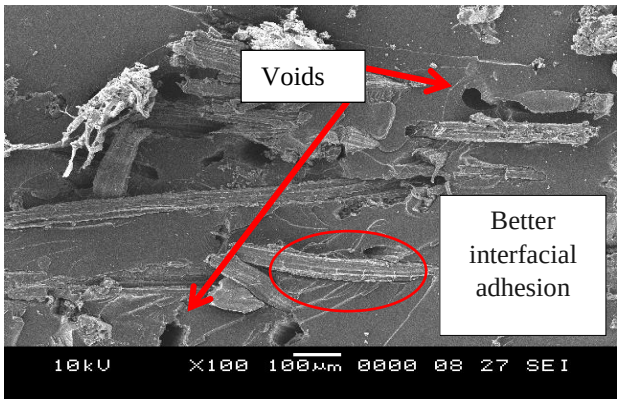


Figure 3.11 (a): Scanning Electron micrographs of tensile fracture surfaces for kenaf fiber/epoxy composites for 2%NaOH kenaf fiber treatment (100 x magnifications)

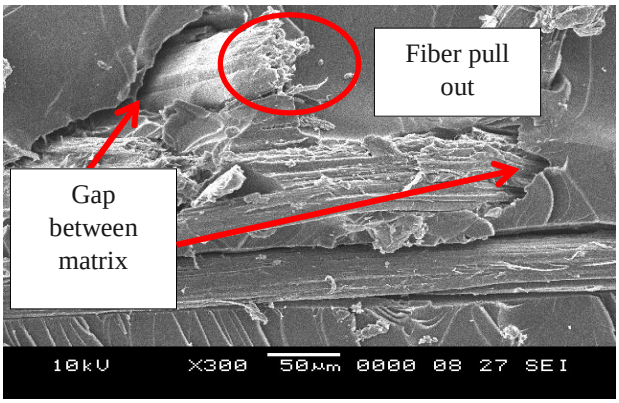


Figure 3.11 (b): Scanning Electron micrographs of tensile fracture surfaces for kenaf fiber/epoxy composites for 2%NaOH kenaf fiber treatment (300 x magnifications)

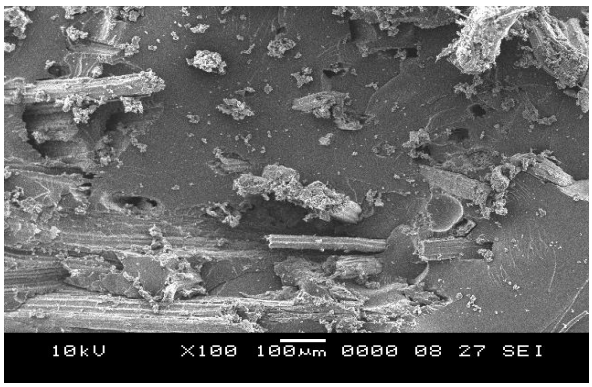


Figure 3.12 (a): Scanning Electron micrographs of tensile fracture surfaces for kenaf fiber/epoxy composites for 4%NaOH kenaf fiber treatment (100 x magnifications)

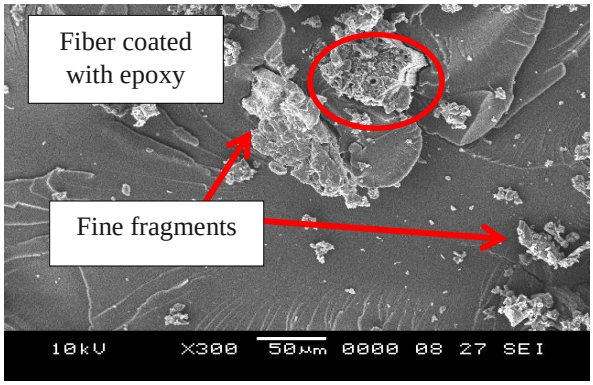


Figure 3.12 (b): Scanning Electron micrographs of tensile fracture surfaces for kenaf fiber/epoxy composites for 4%NaOH kenaf fiber treatment (300 x magnifications)

O13: Flame Retardant Composite Product Via Pultrusion Process

Zulkiflee Bin Mad Atari
Pusat Latihan Teknologi Tinggi (ADTEC) Taiping, Perak

Abstract

A fire retardant is a substance that reduces flammability of fire or delays their combustion. Fire retardants are mixed into polymeric resin materials either as additives or reactive materials. It has previously been reported that fire retardant additive such as Alumina tri-hydrate (ATH), can be loaded as a fire retardant agent in composite systems. ATH is compounded with the resin systems such as polyester or vinyl ester. The result shows that ATH fire retardants improved flame properties accordance with BS 476:Part 7 Class One when incorporate with common matrix resins. The fire and mechanical properties of this ATH has been characterized on pultruded composites product and the processability in polyester resin systems has been tested. The burning test range limit is 75mm to 165mm with spread of flame at 1.5 minutes using fire test chamber equipment.

Keywords*: Alumina tri-hydrate (ATH); Unsaturated Polyester Resin; Brookfield viscosity meter*

1.0 Introduction

The existing technology using Antimony Trioxide as the flame retardant additive for FRP product resulted relatively high smoke and toxic fume when it catch fire. An Aluminium Trihydroxide (ATH) is the most widely used inorganic flame retardant in plastic industry. It is able to decompose and release water that forms envelop around the flame, which tends to exclude air and dilute the flammable gases. It also offers the capability of suppressing smoke evolution. But, high loading of this compound is necessary and this may affect the physical properties of the plastic.

Experimental Method

An Aluminium Trihydroxide (ATH) was used to mix with low viscosity unsaturated polyester resin as the main components to produce the fire retardant FRP Flat sheet panel product. A total of 100 phr Aluminium Trihydroxide (ATH) 5 micron**,** 80 phr Aluminium Trihydroxide (ATH) 3.5 micron and 80 phr Aluminium Trihydroxide (ATH) 1 micron with other mixture parameters ratio were prepared by batch to producer liquid resin mixture parameter for pultrusion process. The viscosity meter equipment was used to measure the viscosity of resin mixture (Sp4/60rpm/25°C) to ensure the formulation was able to run at pultrusion machine.The mixing time was controlled at 15 minutes to 20 minutes at room temperature 27°C.

The pultrusion machine parameters and quantity of roving and filament mats were set in accordance to Flat sheet panel settings and requirements [2]. Roving and filament mats that mixed with liquid resin were continuously brought and pulled through a heated die to produce the panel. The flat sheet panel sample was cut into few specimen sizes (885mm x 270mm) for flame spread test accordance with (BS 476: Part 7) Class one[4].

Characterization

The fire spread test and mechanical properties of this Aluminium Trihydroxide (ATH) has been characterized on pultruded composites product and the process ability in polyester resin systems has been tested. The burning test range limit is 75mm to 165mm with spread of flame at 1.5 minutes for class one requirement using fire test chamber equipment [4].

1.1 Fiberglass Parameter setting

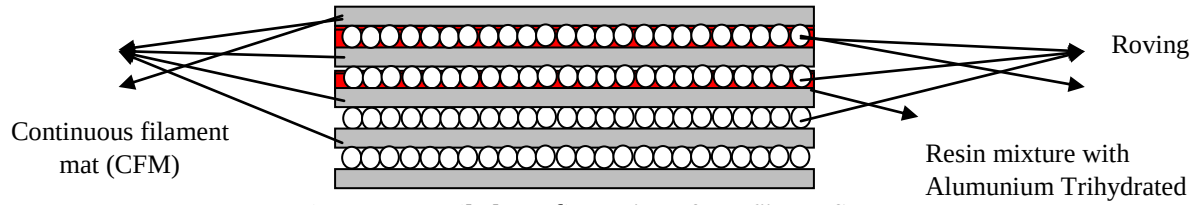
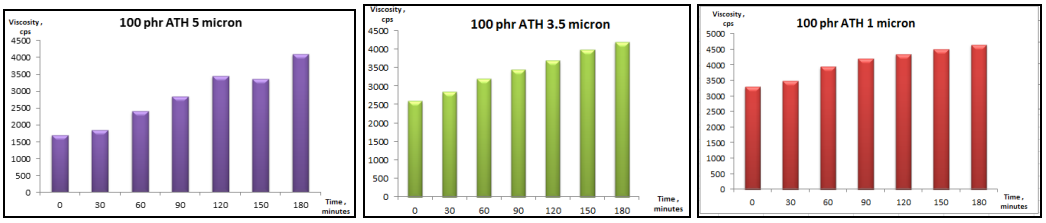


Figure 1: Detailed Configuration of the 6" Flat Sheet

Results and Discussion

1.2 Viscosity Range Analysis

The Brookfield viscosity meter was used to measure the resin mixture viscosity with different types of an Aluminium Trihydroxide (ATH) sizes.A 100 phr of ATH were used as a main formulation for the sample ATH 5 micron. Fig.2 (a), shown the viscosity of ATH 5 micron was increase at 3000cps at 2 hours which is suitable to run on pultrusion machine[1]. The viscosity of resin mixture ATH 3.5 micron, Fig.2 (b) and 1 micron Fig.2 (c), was increased more than 3500 cps after 2 hours which is not suitable for pultrusion process.To solved the problems both of formulation for ATH 3.5 micron and 1 micron was changed to 80 phr to reduce the viscosity.



(a) (b) (c)

Figure 2: Comparison of Aluminium Trihydroxide (ATH) viscosity range

An amount of 100 phr ATH 5 micron, 80 phr ATH 3.5 micron and ATH 1 micron powder was used to mix with unsaturated polyester resin and other additives to produce a test sample for each types of mixture. 20 piece of 6" flat sheet panel was produced using 5 layers of continuous filament mat (CFM) and roving quantity of 160 as shown at (Figure 1). The sample was pulled using 3 tons pultrusion machine force.

Table 1: Classification of Surface Spread of Flame

Classification	Spread of flame at 1.5 min.		Final spread of flame	
	Limit (mm)	Limit for one specimen in sample (mm)	Limit (mm)	Limit for one specimen in sample (mm)
Class 1	165	165 + 25	165	165 + 25
Class 2	215	215 + 25	455	455 + 45
Class 3	265	265 + 25	710	710 + 75
Class 4	Exceeding the limits for class 3			

2.0 Test Results

2.1 Conditioning of Sample Prior To Test:

Specimens were conditioned at a temperature of, t = 23 ± 2 °C and relative humidity, RH = 50 ± 10% and maintained until required for testing [3]

Table 2: Surface Spread of Flame test result accordance with BS476:P7

No	Material	Burning range,mm	Results
1.	Aluminium Trihydroxide (ATH) 5 micron 100 phr	165mm – 190mm	Class 1
2.	Aluminium Trihydroxide (ATH) 3.5 micron 80 phr	240mm – 265mm	Class 2
3.	Aluminium Trihydroxide (ATH) 1 micron 80 phr	215mm – 240mm	Class 2

3.0 Conclusion

The test results at table 2 shown the 100 phr Aluminium Trihydroxide (ATH) 5micron was meet the class one for surface spread of flame test accordance with BS476:P7 via pultrusion process. An Aluminium Trihydroxide (ATH) 3.5 micron and 1 micron achieved class 2 accordance with test standard requirement [4].

4.0 Reference

Aaron C. Small, CCT-M, Thomas Plaisted, Martin Rogers,Frances Davis and Lisa Sterner, Luna Innovations Incorporated. A Non-Halogenated Flame Retardant Additive for Pultrusion,composite research journal,volume 2,2008

Maurine Reyne,Composite Solition Thermosets and Thermoplastics,JEC2006

International Journal on Engineering Performance-Based Fire Codes, Volume 3, Number 2, p.67-86, 2001

BS476: Part 7: 1997, Fire tests on building materials and structure, Part 7, Method of test to determine the classification of the surface spread of flame of products, British Standards Institution, London, UK (1997).

O14: Kemahiran *Employability* Pelajar Diploma Teknologi Komputer Rangkaian di ILJTM

Eza Binti Monzaid
Pusat Latihan Teknologi Tinggi (ADTEC) Batu Pahat

eza@adtecbp.go.my

Abstrak

Kajian ini dijalankan bagi mengenalpasti tahap kemahiran *employability* pelajar berdasarkan persepsi dalam kalangan pelajar Diploma Teknologi Komputer Rangkaian serta mengenalpasti tahap kemahiran *employability* berdasarkan jantina. Kajian berbentuk tinjauan deskriptif kuantitatif yang menggunakan instrumen set borang soal selidik serta dianalisis dengan menggunakan pendekatan Model Rash iaitu perisian *Winsteps* versi 3.69.1.11. Populasi kajian merupakan pelajar Diploma Teknologi Komputer Rangkaian di Institut Latihan Jabatan Tenaga Manusia (ILJTM) seramai 77 orang pelajar semester 5 yang akan menjalani latihan industri. Data kajian dinyatakan dalam bentuk min, sisihan piawai serta berdasarkan nilai *t* dan p untuk melihat persepsi tahap kemahiran *employability* pelajar berlainan jantina. Hasil dapatan kajian menunjukkan bahawa terdapat perbezaan tahap kemahiran antara pelajar adalah tinggi kecuali kemahiran asas. Kualiti personal adalah paling dominan kerana mempunyai skor min tertinggi manakala kemahiran asas mempunyai skor min paling rendah. Tiada perbezaan yang signifikan antara pelajar lelaki dan perempuan antara kesemua tahap kemahiran kecuali bagi kemahiran sistem dan teknologi, Secara keseluruhannya, hasil kajian telah menunjukkan bahawa kemahiran *employability* adalah sangat penting bagi kebolehkerjaan pelajar serta mampu bersaing di peringkat global.

Kata kunci: Kemahiran *employability*, pelajar Diploma Teknologi Komputer Rangkaian, tahap kemahiran

PENDAHULUAN

Kemahiran *Employability* berdasarkan *Employability Skills 2000+* oleh *The Conference Board of Canada* dinyatakan sebagai ”*kemahiran kritikal yang diperlukan di tempat kerja sama ada bekerja sendiri atau bekerja untuk orang lain. Kemahiran Employability yang dimaksudkan adalah termasuk kebolehan berkomunikasi, penyelesaian masalah, sikap dan tingkahlaku yang positif,keupayaan menyesuaikan diri, bekerja dengan orang lain, kemahiran sains dan teknologi serta kemahiran matematik.”* Kemahiran *Employability* yang turut dikenali sebagai Kemahiran Insaniah (KI) dalam Modul Pembangunan Kemahiran Insaniah bagi Institusi Pengajian Tinggi Malaysia (KPT, 2006) menggariskan bahawa tujuh kemahiran telah ditetapkan perlu ada merangkumi kemahiran komunikasi, pemikiran kritis, kemahiran menyelesai masalah, kemahiran kerja berpasukan, pembelajaran berterusan dan pengurusan maklumat, kemahiran keusahawanan, etika dan moral profesional dan kemahiran kepimpinan.

PERNYATAAN MASALAH

Berdasarkan Laporan Kaji Selidik Pengesanan Graduan Institut Latihan Jabatan Tenaga Manusia (ILJTM) 2012 didapati berlaku pengangguran dengan kadar peratusan graduan yang masih mencari pekerjaan sebanyak 290 (11.53%) graduan dan meningkat kepada 421 (20.69%) graduan bagi keluaran sesi 1/2012. Laporan Kaji Selidik Pengesanan Graduan Institut Latihan Jabatan Tenaga Manusia (ILJTM) 2013 juga didapati berlaku pengangguran dengan kadar peratusan graduan yang masih mencari pekerjaan sebanyak 367 (12.56%) graduan dan meningkat kepada 604 (22.80%) graduan bagi keluaran sesi 1/2013. Bagi graduan keluaran sesi 1/2014 dan sesi 2/2014 Diploma Teknologi Komputer Rangkaian di ADTEC Batu Pahat juga mempunyai peratusan graduan menganggur sebanyak 31.67% dan *missmatch skill* sebanyak 14.63%. Kementerian Pengajian Tinggi (2012) juga melaporkan bahawa walaupun lambakan graduan berlaku, kekosongan pekerjaan di sektor swasta tidak dapat diisi disebabkan wujudnya jurang kemahiran antara keperluan industri dan kelayakan graduan. Dalam pasaran buruh terutamanya di sektor swasta memerlukan graduan yang mempunyai lebih kelayakan dalam bidang sains dan teknologi. Walaubagaimanapun graduan didapati kurang kemahiran komunikasi, kemahahiran teknikal dan pengetahuan walaupun mempunyai kelayakan yang cukup untuk sesuatu pekerjaan.

Tinjauan Pellizari dan Fichen (2013) mendapati bahawa jurang kemahiran boleh menyebabkan berlakunya kekurangan atau lambakan kemahiran dalam ekonomi seterusnya menyumbang kepada pekerjaan yang kurang berkesan. Berdasarkan Organisation for Economic Co-operation and Development, OECD (2013) juga, jurang kemahiran didapati berlaku antara penawaran buruh tidak mempunyai kesediaan pekerjaan. Kurikulum yang ditawarkan di universiti, kolej, dan sekolah-sekolah teknikal di Malaysia mempunyai perspektif industri yang kurang dan mempengaruhi kualiti graduan yang dikeluarkan. Isu ini berlaku dalam kalangan graduan ILJTM seperti yang dinyatakan pada perenggan sebelumnya. Kesan jurang kemahiran turut dinyatakan oleh *American Society for Training* & *Development* (ASTD) (2012) bahawa sesebuah organisasi menjadi tidak produktif kerana pekerjaan yang kritikal tidak boleh diisi dengan pekerja yang mempunyai pengetahuan dan kemahiran yang betul. Isu jurang kemahiran seterusnya memberikan kesan terhadap ekonomi global, pembangunan manusia dan menjejaskan prestasi perniagaan.

SOROTAN KAJIAN

Kahirol (2010), menyatakan kemahiran *employability* merupakan kemahiran penting bagi mendapatkan sesuatu pekerjaan serta menjamin kedudukan seseorang pekerja selain daripada kemahiran teknikal. Berdasarkan Rajah 1 di lampiran 1, industri dan ILJTM (Institut Latihan Jabatan Tenaga Manusia) berkait rapat dalam menghasilkan modal insan yang mempunyai kemahiran *employability.* Dalam Teori Modal Insan oleh Schultz (1960) dan Cecker (1964), pelaburan modal insan terhadap pertumbuhan ekonomi mempunyai perkaitan antara satu sama lain. Berdasarkan teori tersebut, modal insan yang berkualiti dan mempunyai kemahiran *employability* boleh meningkatkan taraf hidup dan pendapatan berkapita tinggi.

Berdasarkan kerangka konsep kajian dalam Rajah 2 di lampiran 1, kemahiran *employability* pelajar akan mempengaruhi pengeluaran graduan yang akan bekerja. Kemahiran *employability* merangkumi kesemua aspek kemahiran bagi menentukan tahap kemahiran generik pelajar dan graduan seperti kemahiran asas, kemahiran berfikir, kerjasama sumber, kemahiran informasional, kemahiran interpersonal, kemahiran sistem dan teknologi dan kualiti personal (SCANS, 2001). Oleh yang demikian, jelas bahawa kemahiran *employability* mempengaruhi hasil keluaran graduan ke industri dan pasaran kerja.

ASPEK-ASPEK KEMAHIRAN YANG DIPERLUKAN OLEH MAJIKAN PELBAGAI PENGKAJI

Para majikan hari ini amat mengambil berat akan penerapan kemahiran *employability* terhadap pekerja baru serta pekerja yang bakal (lulusan teknikal) mereka terima. Ini adalah kerana sebilangan besar lulusan teknikal institusi pengajian tinggi tidak memiliki kemahiran *employability* yang diperlukan oleh majikan. Berdasarkan kajian oleh *National Association of Manufacturers* ke atas 4500 pekerja industri, majikan mendapati bahawa 88% pekerja kurang kelayakan kemahiran *employability* (Hussin, 2005).

Aspek kemahiran *employability* yang dikehendaki oleh majikan yang diutarakan oleh pengkaji (Buck dan Barrick, 1987; Lankard, 1995; Gainer, 1998; SCANS, 2001; McLeish, 2002; Yahya dan Rashid, 2004; Cotton, 2005) mempunyai kesamaan dari segi konsep tetapi tidak sama pada aspek yang terkandung dalam setiap kemahiran *employability* tersebut. Justifikasi yang dibuat melalui Jadual 2 di lampiran 2 menunjukkan SCANS, 2001 menggariskan aspek-aspek kemahiran kebolehpasaran secara menyeluruh berbanding pengkaji-pengkaji lain yang terbahagi kepada dua kategori, iaitu kemahiran generik dan kamahiran kerja.

METODOLOGI

Kajian ini adalah berbentuk deskriptif kuantitatif berasaskan soal selidik berkaitan dengan tahap kemahiran *employability* pelajar ILJTM program Diploma Teknologi Komputer Rangkaian. Populasi kajian ini terdiri daripada pelajar ILJTM yang mewakili 3 institusi yang menawarkan program Diploma Teknologi Komputer Rangkaian di seluruh ILJTM Semenanjung Malaysia. Institusi yang terlibat ialah Institut Latihan Perindustrian (ILP) Ledang, ILP Kuala Langat dan ADTEC Batu Pahat. Walau bagaimanapun sampel kajian daripada ILP Ledang telah diguna pakai sebagai kajian rintis. Terdapat juga institusi di bawah ILJTM yang menawarkan pengajian dalam bidang yang sama tetapi hanya pada peringkat sijil.

Populasi kajian adalah terdiri daripada graduan semester 5 yang akan menjalani latihan industri. Kajian ini menggunakan set borang soal selidik untuk responden yang terdiri daripada pelajar berdasarkan populasi yang ditetapkan. Populasi graduan program ini adalah seramai 94 orang. Mengikut Jadual Krejcie dan Morgan (1970), saiz sampel yang diperlukan dalam kajian ini adalah seramai 73 responden. Kajian rintis merupakan kajian awal yang dijalankan sebelum pelaksanaan kajian sebenar bagi menguji kebolehpercayaan instrument iaitu borang soal selidik yang dihasilkan. Kajian rintis akan dijalankan ke atas 17 orang pelajar daripada ILP Ledang bagi bidang yang sama iaitu Program Diploma Teknologi Komputer Rangkaian. Instrumen kajian ini ialah set borang soal selidik yang menggunakan skala Likert dengan lima pilihan jawapan iaitu Sangat Tidak Setuju (STS), Tidak Setuju (TS), Kurang Setuju (KS), Setuju (S) dan Sangat Setuju (SS).

ANALISIS DATA

Analisis data dijalankan menggunakan pendekatan Model Rasch iaitu melalui perisian *Winsteps 3.69.1.11* bagi menentusahkan nilai kebolehpercayaan item (*item realibility*), nilai *alpha Cronbach*, pengasingan item-individu, *item polarity*, *item dimensionality* dan kesesuaian item *(item fit).* Dalam kajian ini nilai *alpha* adalah 0.95 iaitu merujuk pada Jadual 1 di lampiran 2 dan item boleh digunakan dalam kajian.

Soal selidik kajian kepada responden terbahagi kepada dua bahagian iaitu Demografik Respondan dan tahap kemahiran *employability* pelajar**.** Jadual 6.1 menunjukkan profil demografi responden yang mewakili institusi, jantina dan bangsa. Responden terdiri daripada pelajar ILP Kuala Langat iaitu seramai 29 orang (39.7%) manakala daripada ADTEC Batu Pahat seramai 44 orang (60.3%). Jumlah responden perempuan keseluruhannya adalah 31 orang (42.5%) manakala responden lelaki adalah seramai 42 orang (57.5%). Jumlah pelajar berbangsa Melayu adalah seramai 64 orang, bangsa Cina seramai 2 orang (2.7%) manakala bangsa India ialah seramai 7 orang (9.6%).

Jadual 6.1 Demografi responden

Demografi	Faktor	Frekuensi	Peratus (%)
Institut	ILP Kuala Langat	29	39.7
	ILP Ledang	-	-
	ADTEC Batu Pahat	44	60.3
Jantina	Perempuan	31	42.5
	Lelaki	42	57.5
Bangsa	Melayu	64	87.7
	Cina	2	2.7
	India	7	9.6
	Lain-lain		

Bahagian dua iaitu tahap kemahiran *employability* pelajar, digunakan untuk menganalisis tahap kemahiran *employability* pelajar berdasarkan persepsi pelajar. Jadual 6.2 menunjukkan ringkasan skor min dan sisihan piawai bagi item kemahiran *employability* berdasarkan persepsi pelajar Diploma Teknologi Komputer Rangkaian di mana kemahiran asas adalah di tahap sederhana manakala kemahiran berfikir, kemahiran sumber, kemahiran informasional, kemahiran interpersonal, kemahiran sistem dan teknologi serta kualiti personal mempunyai tafsiran skor min yang tinggi. Nilai min keseluruhan ialah 3.9 iaitu (284.7 / 73 pelajar) dan sisihan piawai adalah 0.22329 iaitu (16.3 / 73 pelajar).

Jadual 6.2: Ringkasan skor min dan sisihan piawai bagi item kemahiran *employability* berdasarkan persepsi pelajar Diploma Teknologi Komputer Rangkaian

Kemahiran *Employability*	ID Item	Skor min	Sisihan piawai	Tafsiran skor min
Min Keseluruhan	K	3.9	0.22329	
Kemahiran asas	KA	3.7890	0.12739	Sederhana
Kemahiran berfikir	KB	3.9698	0.21096	Tinggi
Kemahiran sumber	KS	3.8192	0.18219	Tinggi
Kemahiran informasional	KM	4.0137	0.23425	Tinggi
Kemahiran interpersonal	KI	3.8329	0.18767	Tinggi
Kemahiran sistem dan teknologi	KT	4.0521	0.17397	Tinggi
Kualiti personal	KP	4.1219	0.24110	Tinggi

Penemuan persoalan kajian yang kedua iaitu tahap kemahiran *employability* pelajar paling dominan sebelum memasuki alam pekerjaan, analisa skor min bagi setiap tahap kemahiran *employability* telah diringkaskan *seperti* di Jadual 6.3. Item kemahiran *employability* disusun semula mengikut nilai skor min tertinggi.

Jadual 6.3: Ringkasan skor min tertinggi bagi item kemahiran *employability* berdasarkan persepsi pelajar Diploma Teknologi Komputer Rangkaian

Kemahiran Employability mengikut skor min tertinggi	ID Item	Skor min	Sisihan piawai
Kualiti personal	KP	4.1219	0.24110
Kemahiran sistem dan teknologi	KT	4.0521	0.17397
Kemahiran informasional	KM	4.0137	0.23425
Kemahiran berfikir	KB	3.9698	0.21096
Kemahiran interpersonal	KI	3.8329	0.18767
Kemahiran sumber	KS	3.8192	0.18219
Kemahiran asas	KA	3.7890	0.12739

Penemuan persoalan kajian yang ketiga iaitu tahap kemahiran *employability* pelajar berdasarkan persepsi berlainan jantina sebelum memasuki alam pekerjaan menunjukkan bahawa tiada perbezaan yang signifikan antara persepsi pelajar lelaki dan perempuan bagi kemahiran asas, kemahiran berfikir, kemahiran sumber, kemahiran informasional, kemahiran interpersonal dan kualiti personal telah diringkaskan seperti di Jadual 6.4. Walaubagaimanapun terdapat perbezaan yang signifikan antara persepsi pelajar lelaki dan perempuan bagi kemahiran sistem dan teknologi dengan nilai t=3.01 dan p=0.0028. Tahap kemahiran *employability* dianalisis menggunakan perisian *Winsteps* melalui ujian Person *DGF: DIF & DPF* bagi menganalisa perbezaan persepsi kemahiran *employability* berdasarkan jantina lelaki dan perempuan seperti di Jadual 6.4. Terdapat perbezaan yang signifikan antara pelajar lelaki dan perempuan sekiranya nilai ($t > 2.0$) dan ($p < 0.05$).

Jadual 6.4: Ringkasan perbezaan tahap kemahiran *employability* berdasarkan persepsi pelajar lelaki dan perempuan

Kemahiran *Employability*	Nilai t	Nilai p	Analisis perbezaan jantina
Kemahiran asas	0.74	0.4621	Tiada perbezaan signifikan
Kemahiran berfikir	1.24	0.2169	Tiada perbezaan signifikan
Kemahiran sumber	1.57	0.1161	Tiada perbezaan signifikan
Kemahiran informasional	0.00	1.000	Tiada perbezaan signifikan
Kemahiran interpersonal	0.87	0.3831	Tiada perbezaan signifikan
Kemahiran sistem dan teknologi	3.01	0.0028	Ada perbezaan signifikan
Kualiti personal	0.95	0.3439	Tiada perbezaan signifikan

7.0 PERBINCANGAN DAN CADANGAN

Secara keseluruhannya analisis kajian telah menepati objektif kajian pertama iaitu untuk mengenalpati tahap kemahiran *employability* pelajar Diploma Teknologi Komputer Rangkaian. Berdasarkan kajian ini pelajar didapati menguasai keenam-enam kemahiran *employability* iaitu kemahiran berfikir, kemahiran sumber, kemahiran informasional, kemahiran interpersonal, kemahiran sistem dan teknologi serta kualiti personal kerana mempunyai skor min yang tinggi bagi keenam-enam kemahiran tersebut. Penguasaan pelajar terhadap kemahiran *employability* adalah selari dengan kehendak industri.Walaubagaimanapun tahap kemahiran asas pelajar adalah di tahap sederhana dan perlu dibuat peningkatan terhadap kemahiran tersebut. Penguasaan yang tinggi terhadap kesemua kemahiran *employability* adalah penting bagi menjamin kebolehkerjaan pelajar seperti yang dinyatakan oleh Kahirol *et.al* (2010) bahawa pekerja yang mempunyai kemahiran teknikal yang tinggi tidak dapat menjamin kemajuan sesebuah syarikat dan industri melainkan jika pekerja tersebut mempunyai kemahiran *employability* yang tinggi.

Berdasarkan jadual tersebut kemahiran *employability* paling dominan dengan skor min tertinggi adalah kualiti personal manakala kemahiran rendah adalah kemahiran asas. Ini menunjukkan bahawa kemahiran yang paling dikuasai pelajar adalah kualiti personal dan manakala kemahiran asas responden adalah di tahap sederhana. Nilai skor min responden yang tertinggi iaitu kualiti personal menunjukkan responden boleh menguruskan diri dan peralatan dengan baik, boleh menyelesaikan tugasan dan kerja secara sendiri, sentiasa mematuhi arahan dan boleh mengendalikan peralatan berpandukan SOP.

Dapatan ini disokong oleh penyataan Hassan (2005) yang menyatakan bahawa semua aspek kemahiran perlu dikuasai supaya pelajar akan berdaya saing di dalam pasaran kerja. Majikan mementingkan kualiti personal bakal pekerja kerana kemahiran ini akan mempengaruhi prestasi kerja dalam organisasi. Oleh itu pengkaji berpendapat bahawa kualiti personal yang tinggi memudahkan bakal pekerja mudah diterima oleh majikan kerana mempnyai keperibadian yang dikehendaki oleh majikan.

Dapatan kajian juga menunjukkan bahawa kemahiran yang paling kurang dikuasai oleh pelajar iaitu kemahiran asas berada di tahap sederhana dan antara kemahiran asas yang kurang dikuasai pelajar ialah kemahiran menulis laporan, kemahiran mencari maklumat yang tepat, kemahiran pengasingan maklumat yang penting dan tepat, kemahiran pembelajaran secara kendiri, kemahiran perancangan pelaksanaan projek, kemahiran matematik dan kemahiran penyediaan kos yang perlu diperbaiki lagi. Justeru itu pengkaji berpendapat bahawa kemahiran asas dalam kalangan pelajar Diploma Teknologi Komputer Rangkaian perlu dipertingkatkan lagi kerana kurangnya penguasaan dalam kemahiran asas ini boleh menyebabkan permohonan kerja ditolak oleh majikan. Ini adalah kerana kemahiran asas membolehkan bakal pekerja menguasai kerja-kerja di dalam organisasi sepenuhnya.

Analisa perbezaan tahap kemahiran sistem dan teknologi antara pelajar lelaki dan perempuan juga mendapati bahawa terdapat perbezaan tahap kemahiran antara kedua-dua jantina tersebut. Dapatan menunjukkan bahawa terdapat perbezaan dalam penguasaan kemahiran sistem dan teknologi yang merangkumi kemahiran komunikasi, kemahiran kepimpinan, kemahiran pembelajaran sepanjang hayat dan pengurusan maklumat, kemahiran pemikiran kritikal dan menyelesai masalah. Perkara ini disokong oleh kajian Ramlee (2011) yang mendapati bahawa tahap kemahiran *employability* antara pelajar lelaki dan perempuan mempunyai perbezaan dari segi kemahiran komunikasi, kemahiran kepimpinan, kemahiran pembelajaran sepanjang hayat dan pengurusan maklumat, kemahiran pemikiran kritikal dan menyelesai masalah dan kemahiran kemahiran teknologi. Pengkaji berpendapat bahawa kemahiran sistem dan teknologi mempunyai perbezaan kemahiran sistem, memperbaiki pelaksanaan, kemahiran menggunakan teknologi dan kemahiran mencari punca kerosakan lebih dikuasai oleh pelajar lelaki berbanding pelajar perempuan.

8.0 KESIMPULAN

Berdasarkan perbincangan kajian, kemahiran *employability* merupakan kemahiran penting bagi pelajar untuk mendapatkan pekerjaan. Persaingan juga berlaku dan pelajar perlu melengkapkan diri dengan kemahiran tersebut supaya lebih berdaya saing. Kepentingan kemahiran ini tidak boleh disangkal lagi kerana pihak majikan bukan sahaja mementingkan lulusan atau graduan yang mempunyai kemahiran teknikal sahaja tetapi mempunyai sikap yang agresif dalam menyelesaikan masalah. Bakal pekerja yang dilengkapi dengan semua kemahiran termasuk kemahiran *employability* bagi membolehkan individu tersebut bersaing di pasaran global. Bagi menangani kurangnya kemahiran *employability* antara langkah-langkah yang boleh diambil ialah penambahbaikan sukatan latihan pendidikan.

Di Malaysia, sistem pendidikan negara telah menggariskan kemahiran generik atau *employability* yang perlu sebagai persediaan pelajar sebelum melangkah ke alam pekerjaan seperti kemahiran komunikasi, kemairan menggunakan teknologi, kemahiran merancang dan mengendalikan ativiti, kemahiran bekerja dalam kumpulan, kemahiran menyelesai masalah, kemahiran mengurus, memilih dan menganalisa maklumat, kmahiran matematik dan kemahiran budaya seperti yang digariskan oleh pusat perkembangan kurikulum, KPM (2001). Kemahiran *employability* juga boleh diterapkan melalui pelaksanaan kurikulum dan ko-kurikulum supaya pelajar dapat diserapkan dengan kemahiran tersebut.

Penekanan kemahiran *employability* sangat perlu diberi penekanan dalam institusi pendidikan ILJTM. Vidanapathirana (2001) berpendapat bahawa pihak yang terlibat dalam menaiktaraf kemahiran *employability* ini adalah majikan, bakal graduan, pihak kerajaan dan institusi. Hal ini berlaku disebabkan oleh graduan yang tidak mempunyai kecekapan, pengetahuan, kemahiran dan pengalaman yang diperlukan oleh majikan. Menurut beliau lagi majikan beranggapan bahawa graduan gagal mengisi keperluan pekerjaan dan nstitusi pendidikan pula dianggap tidak dapat menyediakan pelajar yang berkemahiran berpunca daripada kepincagan kurikulum, kaedah pengajaran dan sebagainya. Pihak kerajaan merupakan pihak yang perlu bertanggungjawab untuk mencari penyelesaian bagi masalah *mismatch skill* tersebut.

Justeru itu semua pihak perlu bekerjasama dalam meningkatkan tahap kemahiran *employability* pelajar. Oleh yang demikian pengkaji berharap cadangan – cadangan yang diutarakan di sini dapat membantu penyelidik lain untuk mengkaji dan mengembangkan hasil kajian dengan lebih berkualti dan berguna pada masa akan datang.

9.0 RUJUKAN

[1] *A. Ab Rahman, A. Esa, W.M.R Wan Ahmad (2010). "*Latihan Kemahiran di Industri Kecil dan Sederhana (IKS) Kepada Pelatih system Latihan Dual Nasional (SLDN)" Dicapai pada 29 April 2015 di www.eprints.uthm.edu.my/3157/

[2] Buntat Y (2004). "Integrasi Kemahiran Employability dalam Program Pendidikan Vokasional Pertanian dan Industri di Malaysia." UTM Skudai. Tesis PhdCox, S. & King D. (2006). Skill set: an approach to embed employability in course design. Education and training, 4894), m.s 262-274. Dicapai pada 23 April 2015

[3] *H. Azimi, U. Jegak, A. Asma (2007). "*Program Latihan Kemahiran: Perbandingan Kos, Kebolehpasaran dan Pendapatan Pelatih" Dicapai pada 6 Mac 2015 di *http://repo.uum.edu.my/695/*

[4] *H. Hanum, A. Razli, B. Azuddin (2008). "*Kemahiran Insaniah Dan Kepentingan Penerapannya Dalam Program Baktisiswa Perdana UniMAP" Dicapai pada 1 Mac 2015 di http://dspace.unimap.edu.my/dspace/bitstream/123456789/5842/1/KEMAHIRAN%20INSANIAH%20DAN%20KEPENTINGAN%20PENERAPANNYA%20DALAM%20PROGRAM%20BAKTISISWA%20PERDANA%20UniMAP.pdf.

[5] Kahiro., Ibrahim W.N.H., Sulaiman N.L., Ibrahim B., Mustafa M.Z. (2010). *Kemahiran Employability dalam Kalangan Mahasiswa dan Pensyarah : Perbandingan dengan Industri*.http://eprints.uthm.edu.my/2317/1/KEMAHIRAN_EMPLOYABILITY_DALAM_KALANGAN_MAHASISWA_DAN.pdf Dicapai pada 30 Mei 2015.

[6] *M.S A.Rahman, N. Amin, B. Bais, M.S Dzulkefly Zan, N. Abd. Aziz, M.A Mohd Ali (2008). "*Penambahbaikan Kurilukum Program Kejuruteraan Mikroelektronik Mengikut Keperluan EAC & Washington Accord" Dicapai pada 27 Febuari 2013 di *www.ukm.my/p3k/images/sppb08/c/1.pdf*

[7] *M. Seri Bunian, M. Ramlee "*Pengaruh Faktor Persekitaran Pembelajaran Terhadap Tahap Kemahiran Generik Dari Perspektif Pelajar Politeknik Kementerian Pemgajian Tinggi" pada 7 Mac 2015 di http://pdfscout.org/PENGARUH-FAKTOR-PERSEKITARAN-PEMBELAJARAN-TERHADAP-TAHAP-KEMAHIRAN.

[8] *R. Mohamad Sattar, I. Md.Yusof, I. Napsiah, R. Muhammad Rashid, A.R. Rose Amnah (2009). "*Peranan Institusi Pendidikan Teknikal Dalam Pemupukan Kemahiran 'Employability' Pelajar" Dicapai pada 4 Mac 2015 di *http://www.jurnalteknologi.utm.my/index.php/jurnalteknologi/article/view/187*

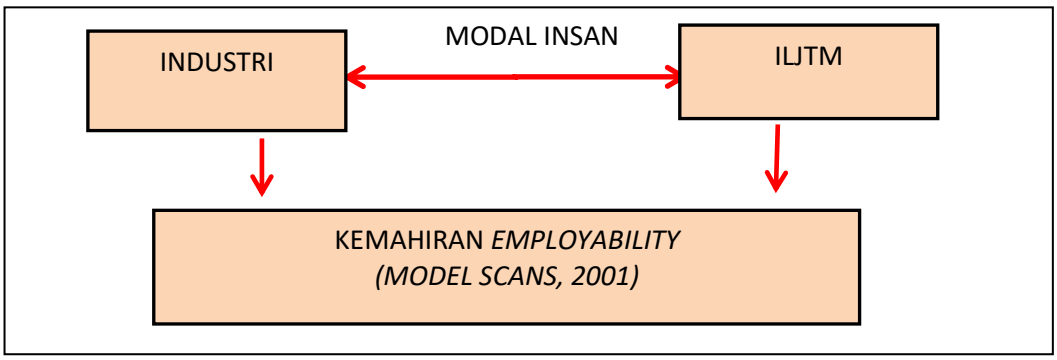
[9] A., M. Razali N.A, Hassan R. dan Madar A.R (200). Penguasaan Kemahiran Insaniah Dalam Kalangan Pelajar Politeknik Kota Bharu. dlm. Esa, A. & Mustafa, M. Z. (Ed). Kemahiran insaniah: kajian di Institusi-institusi Pengajian. Batu Pahat: Penerbit UTHM. 125 – 151.

[10] Zainudin, A.Rahman M. A., A.Ghafar M.N., Zakaria K. (2005). "Penerapan Kemahiran Generik dalam Pengajaran Kejuruteraan Di Sekolah menengah Teknik Di Terengganu." Universiti Teknologi Malaysia: Tesis Sarjana

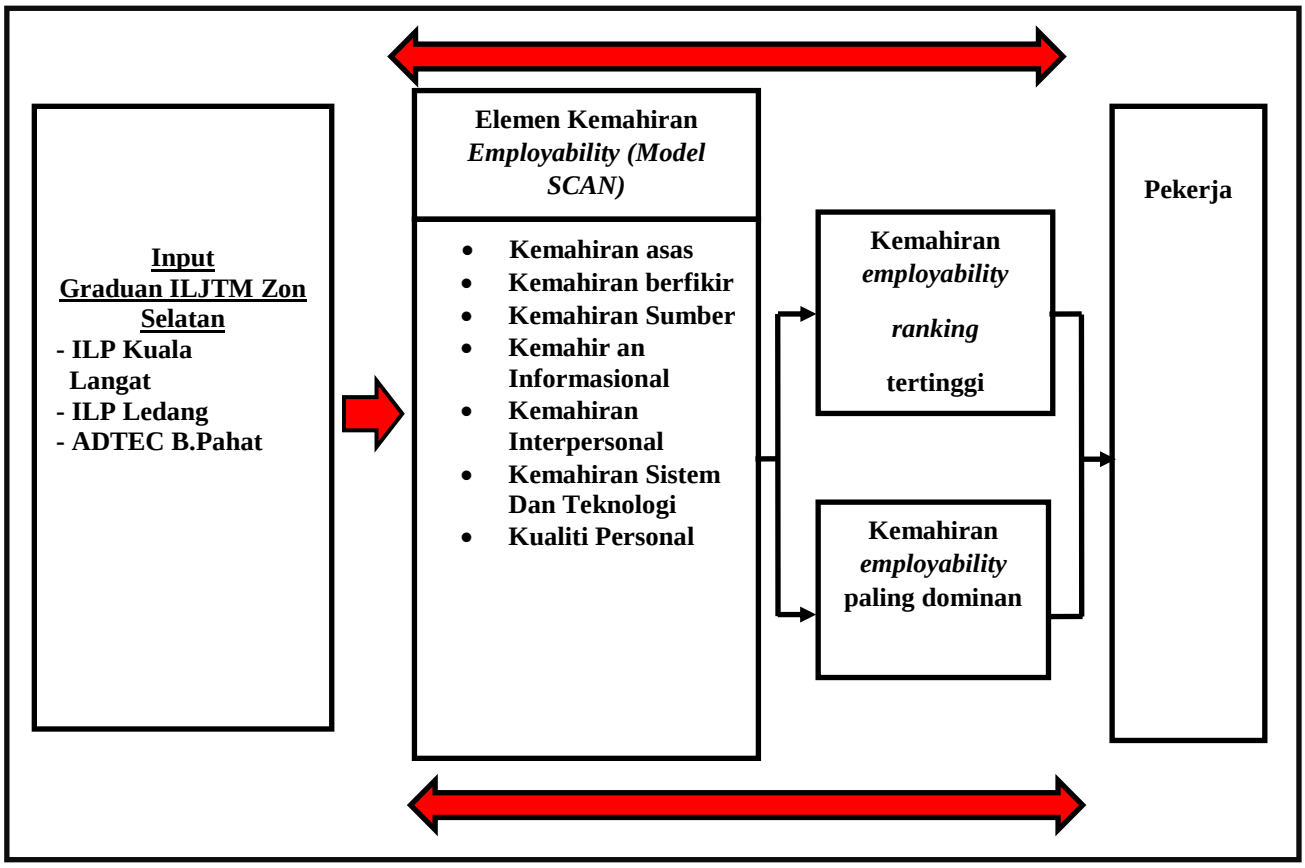
[11] *Z. Hassan, M.A Abdul Rahman, M.N Abdul Ghafar, K. Zakaria (2010). "*Keberkesanan Menjalani Latihan Industri Di Kalangan Pelajar" Dicapai pada 2 Mac 2015 di *eprints.utm.my/10559/1/5.pdf*

[12] *Z. Hassan, M.A Abdul Rahman, M.N Abdul Ghafar, K. Zakaria (2000). "*Penerapan Kemahiran Generik Dalam Pengajaran Kejuruteraan Di Sekolah Menengah Teknik Di Terengganu" Dicapai pada 25 April 2015 di *http://www.eprints.utm.my/1496/1/kertas_kerja_generik.pdf*

Lampiran 1



Rajah 1 : Kerangka Teori Kajian



Rajah 2: Model Kerangka Konsep Kajian Kemahiran Employability Diadaptasi dan diubahsuai dari Universiti Council of Ontario 1998

Lampiran 2

Jadual 1: Skor *Alpha Cronbach* (George & Mallery, 2009)

Nilai Alpha Cronbach	Penilaian
a > 0.9	Cemerlang
a > 0.8	Baik
a > 0.7	Boleh diterima
a > 0.6	Dipersoalkan
a > 0.5	Lemah
a > 0.4	Tidak boleh diterima

Jadual 2: Aspek kemhiran *employability* daripada pandangan pelbagai pengkaji

-	PENGKALI / ASPEK	Buck & Barrick (1987)	Lankard (1995)	Gainer (1998)	SCANS (2001)	McLeish (2002)	Yahya & Rashid (2004)	Cotton (2005)
Kemahiran asas	Bacaan		/	/	/	/	/	/
	Tulisan		/	/	/	/		/
	Matematik				/	/	/	/
	Pendengaran		/	/	/	/	/	
	Pertuturan		/	/	/	/	/	/
Kemahiran Berfikir	Kreatif / Inovatif		/		/	/	/	/
	Membuat keputusan		/	/	/	/	/	/
	Penyelesaian Masalah	/	/		/	/	/	/
	Melihat benda dengan mata fikiran			/	/	/	/	/
	Kemahiran belajar	/	/		/			
	Penaakulan				/		/	
Kualiti Personal	Bertanggungjawab	/	/	/	/	/	/	/
	Percaya diri	/	/	/	/	/	/	/
	Integriti	/		/	/	/	/	/
	Kecermatan		/	/	/	/	/	/
	Kemampuan adaptasi / luwes				/	/	/	/
	Kemampuan bekerja tanpa penyeliaan				/	/	/	/
	Keselamatan kerja			/	/	/	/	/

O15: Synthesis and Characterization of Porous MAS with Different Pore Content of PU Sponge For Catalyst Support Application

EingKuan Kok[1], Johar Banjuraizah[2], Zabar Yahidah[3]
[1,2]*School of Materials Engineering, University Malaysia Perlis, 02600 Kangar, Perlis, Malaysia*
[3]*Advance Materials Department (Ceramic), ADTEC Taiping, 34600 Taiping, Perak, Malaysia*

[1]kuan_kok@yahoo.com, [2]banjuraizah@unimap.edu.my, [3]yahidah@adtectaiping.gov.my

Abstract

This paper aims at studying the porous ceramics prepared by using the non-stoichiometeric composition formulation ($2.8MgO.1.5Al_2O_3.5SiO_2$) by PU sponge impregnated method. The ceramic suspension were prepared with non-stoichimeteric formulation of MAS and sintered at 1250°C, 1275°C, 1285°C, 1300°C and 1325°C.The TGA was performed to investigate prolysis of PU sponge The phase transformation of non-stoichiometeric formulation of MAS was investigated by XRD. This paper also aims to compare the effect of compression strength, porosity and density of 5wt% PEG treated PU sponge with untreated PU sponge respectively corresponding to different pore content (100ppi, 80ppi, 60ppi,and 40ppi). The pore structure was analyzed by SEM.

Keywords: *Porous ceramic, non-stoichiometeric composition formulation*

1.0 Introduction

Porous ceramic such as alumina, zirconia, titania and silica are widely famous due to their various unique properties such as excellent thermal and chemical resistance and controllable microstructure [1]. However, the membranes fabricated from those materials were very costly for monetary applications in natural innovation. Accordingly, the mineral- based membranes have been considered for their lows expenses for both raw materials cost and fabrication process expenses.

In $MgO\text{-}Al_2O_3\text{-}SiO_2$ ternary system; Cordierite (nominal composition $2MgO.\ 2Al_2O_3.5SiO_2$) is known as an advanced material to fabricate vehicles membranes instead of alumina and zirconia due to it with excellent properties, such as low thermal expansion coefficient ($3.0\ x10^{6}/^{o}C$), excellent thermal shock resistance, low dielectric constant (4.0-5.0), good chemical durability, excellent refractoriness, and mechanical properties [2]. Besides, cordierite has lower sintering temperature and lower density than the alumina, it also much cheaper and can be synthesized using mineral talc and kaolin. Catalyst support is one of the significant applications of cordierite in various processes, some of which can be found in petrochemical industry, the selective reduction of alcohol, the control of vehicles emission and control of volatile organic compounds [3].

Recently, non-stoichiometric cordierite composition ($2.8MgO.1.5Al_2O_3.5SiO_2$) has been exposed to give high purity of α-cordierite phase at lower temperature using control crystallization of glass method. The present of high concentration of secondary phase such as forsterite, spinel and mullite (which have different coefficient of thermal expansion and different volume) in cordierite synthesis using stoichiometric composition might affect the performance and its application. In this present studies this composition will be used to synthesize porous cordierite materials.

At present, the common method for porous ceramic preparation including; polymeric sponge replica, sacrificial template and direct forming methods [4]. There also several techniques were developed to fabricate porous ceramic such as sol-gel method [5], chemical vapor deposition technique [4] biomimetic synthesis, combustion synthesis [6] and etc.

In this study, porous ceramic prepared via polymeric sponge impregnated method with different pore content of sponge. The sponges; treated and untreated were compared in terms of porosity, bulk density and compression strength. Besides that, the crystalline phase of non- stoichiometric formulation cordierite at different sintering temperature was investigated and discussed.

2.0 Experimental Procedure

2.1 Sample Preparation

The powders form raw materials magnesia, MgO, alumina Al_2O_3, and silica, SiO_2 were supplied precisely weighed concurring to Table 1. Followed, the mixing process was carried out by roll mill in a PP bottle together with 1.5 inch steel ball at 120 rpm for 4 hours. The ceramic suspension was prepared by mixing 40 wt% of deionic water and 2 wt% of *polyethylene glycol* (*PEG) was added as binder before powder loading. 1-2 wt% of dispersion agent (sodium silicate) was added to fluidness the ceramic suspension. The mixed MAS slurry was soaked overnight to make sure it disperses well.*

The 100ppi, 80ppi, 60ppi and 40ppi of polyurethane sponges were dimensions in 20mm x 20mm x 20mm respectively for compression test measurement. The surface modifying of PU sponge was carried out by soaked in 20 wt% of KOH at 50 ^oC water bath for 1.5 h, subsequently, treated with 2 wt% of PEG solution for 3 h, and dried at atmosphere for 48 h. the treated and untreated sponge were the impregnation into MAS slurry for 1 minute and allows the slurry occupy to the empty space of sponge.

Followed, dried at room temperature for 48. The weight of green body was measured and average. The sintering process was carried out in slow sintering rate at 2^oC/min to 400^oC and 900^oC with soaking time 1 h respectively for the pyrolysis of PU sponge. The sequent stage was sintering the samples up to maximum temperature with heating rate of 2^oC and soaking for 2h.

Table 1: Purity and weight percentage of non- **stoichiometric of raw materials**

Raw Material	Purity (%)	Mass (g)
MgO	90.3	21.05
Al_2O_3	97.0	26.63
SiO_2	99.65	52.31

2.2 *Characterization*

Thermal gravimetric analysis (Perkin Elmer thermoanalyser) of the sponge was carried out in nitrogen gas at heating range from 0^oC to 800^oC at heating rate of 10^oC/min to confirm the primary stage of the sintering process of green body.

The phase transformation of excessive slurry sintering at different temperature was investigated by X-ray diffractometer (Model BRUKER D2 PHASER) with CuKα radiation and crystal structure analysis was carried out with whole diffraction powder pattern data by utilized Rietveld Refinement method using Xpert HighScore Plus software. The microstructure and the morphology of sintered porous ceramics were analyzed by using scanning electron microscope (JEOL JSM-6460LA)

The bulk density and total pore volume of sintered samples were carried out using helium gas pycnometer (Mircomeritics) with 10cm^3 chamber. The compression strength was determined by UTM (Instron) machine according ASTM C773

3.0 Experimental Results

3.1 Pyrolysis behaviour of polyurethane sponge.

TGA result for ceramic coated PU sponge and uncoated PU sponge was demonstrated in Figure 1. The TGA curve demonstrated three mass change zones corresponding to the mass losses phenomenon. The first zone was found in temperature interval 165^{o}C to 284^{o}C, zone B was observe between 284^{o}C to 391^{o}C and last zone was started from 391^{o}C to 610^{0}C. Three temperature interval found in TGA curve were close relative to the thermal decomposition mechanism of polyurethane. This phenomenon can be summarized in the first decomposition is resulting by corruption of hard segment, which bring about the formation of isocyanate and alcohol, primary or secondary amine and olefin, and carbon dioxide. After the first deterioration step, i.e.,when the weakest bonds in the PU have been separated, the second and third steps are much slower and rely on upon the soft segment structure and its three-dimensional plan. Different PUs having different initial thermal degradation temperature and the initial degradation temperature of the urethane depends on the structure of the isocyanate and alcohol used [7].

Besides that, the rapid mass loss was observe in TGA curve of ceramic coated PU sponge at temperature below 100^{o}C compared with TGA curve of uncoated PU sponge, which was corresponds to eliminate of the water physically adsorbed in the slurry which is part of the mixture. As can be seen, in zone A, there had mass gain in ceramic coated PU sponge at 260^{o}C; this is due to both of the PU sponge and the ceramic thermal expansion resulted by temperature increases. In zone B, the mass loss gradually in thermogram of ceramic coated sponge while loss rapidly in thermogram of uncoated sponge. This is due to the thermal degradation of PU sponge was occurring within the ceramic and causing mass loosed. Besides that, the data also marked that the shrinkage was occurring in zone B. furthermore, at temperature 340^{O}C, mass gain was observe in ceramic coated sponge, due to internal gas produce by thermal decomposition of polymeric sponge within the TGA chamber in zone B. In summarized, the PU sponge was occurring thermal degradation and shrunk rapidly and produce the internal gas pressure within the ceramic as a result the mass gained in temperature range of 284^{o}C to 391^{o}C. However, there was no shrinkage observed in zone C.

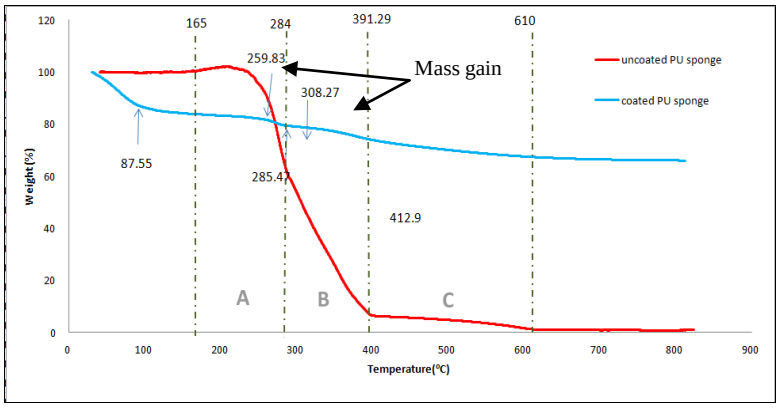


Figure 1: TGA curve of ceramic coated sponge and uncoated sponge respectively.

3.2 Phase Transformation

The XRD patterns of the samples with formulation of 2.8Mg.1.5Al_2O_3.5SiO_2 sintered at different temperature for 2 hours as soaking time was demonstrated in Figure 2. Based on the result, the high concentration of α-Cordierite (ICSD reference code:98-004-5312) depend greatly on the thermal treating heat. At 1250^{o}C, $Mg_1O_3Si_1$ proto-enstatite (ICSD reference code: 98-001-2383) was observe as mojar phase and SiO_2 cristobalite (ICSD reference code: 98-003-4657) as secondary phase in this particular thermal treating heat. With increase in temperature up to 1275^{o}C, $MgAl_2O_4$ spinel (ICSD reference code: 98-001-7568) diffraction peak was arise with absence of cristobalite phase. The cristobalite low diffraction peak was completely disappear and left behind spinel and protoenstatite diffraction peak with further increase the sintering temperature up to 1285^{o}C, on the other hand, spinel at this sintering temperature is slightly decreases.

As increase of the sintering temperature from 1285°C to 1300°C it could be noticed that the amount of spine is decrease and α-Cordierite diffraction peak was detected. This result shows that, at this particular sintering temperature the solid state reaction has begun with growth of fraction of the characteristics peaks of cordierite phase. For samples sintering at 1325°C , a further decrease in the proto-enstatite phase with α-Cordierite become major phase while spinel diffraction peak was completely disappear. Meanwhile, disappear of spinel leading formation of cordierite, due to decomposition of spinel formed enough magnesia and alumina in the mix system. On the other hand, further decomposing of proto-enstatite leads enough silica presence in the system. Due to the system presence enough of magnesia, silica and alumina at particular crystalline temperature, it leads to formation of more cordierite phase. Hence the diffraction peaks of α-Cordierite become more intensity.

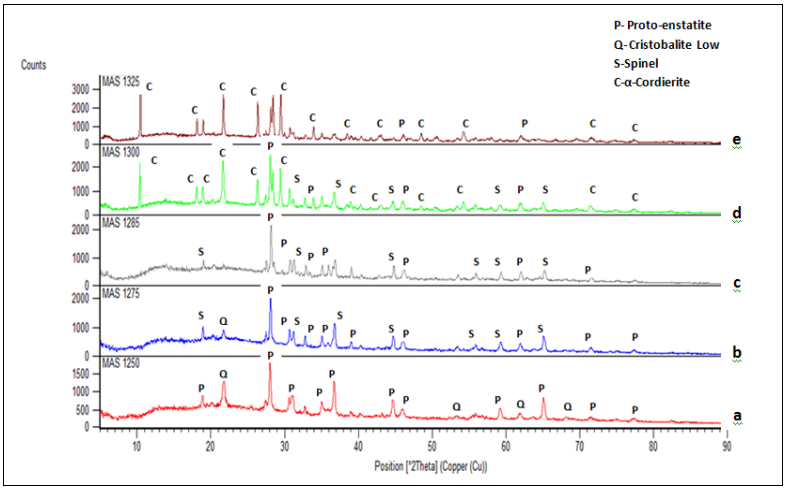


Figure 2: XRD pattern of porous ceramic sintered at (a) 1250°C, (b) 1275 °C, (c) 1285 °C, (d) 1300 °C, (e) 1325°C

3.3 Microstructure evolution

Figure 3 shows that the SEM microphotograph of the cross section porous cordierite samples fabricated with different pore content of sponge (100ppi, 80ppi, 60ppi and 40ppi). As can be seen in Figure 2, the pore was formed from the organic burn out of the sponge during the sintering process. Consequently, the pore formed within the ceramic as sponge network like structure. Obviously, the lower pore content of sponge, the larger pore size obtained due to lower pore content of sponge obtaining larger diameter strut of sponge resulting increase of pore size structure.

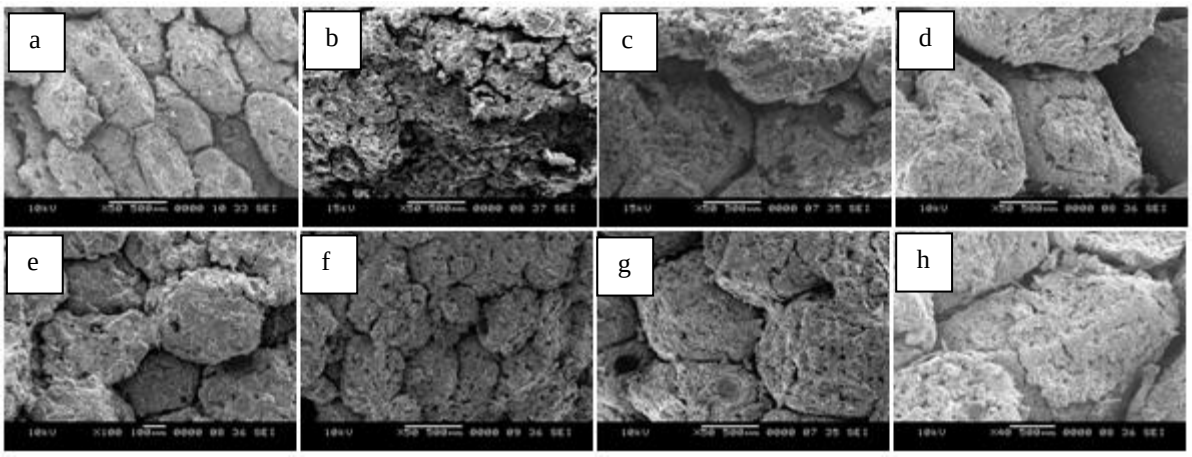


Figure 3: SEM micrograph of porous ceramic prepared form untreated sponge with pore content of: (a) 100ppi, (b) 80ppi, (c) 60ppi, (d) 40ppi and treated sponge with pore content of: (e) 100ppi, (f) 80ppi, (g) 60ppi, (h) 40ppi respectively under magnification of 50X.

As can be seen in Figure 3(a) the sintered bulks prepared by untreated sponges tend to elongate from the original shape of empty space of sponge which occupied. This is due to the unstable thermal stability of pure PU sponge shrinkage as temperature increase in the furnace and this shrinkage phenomenon resulting stressing the struts between one network connecting point of sponge with other connecting point. Hence the stressing leading bulks which occupied space between the strut becomes elongate before solidification. While, treated sponge which had better wettability resulting more slurry loading and more dense bulk occupied the empty space of sponge and resulting more sponge's empty space structure like. Hence, the pore size of treated sponge was smaller than untreated sponge.

3.4 Physical and mechanical properties of samples

The porous ceramic samples prepared by using different pore content of treated and untreated sponge respectively in term of bulk density, porosity and compression strength was summarized in Table 2. As can see, the declination of compression strength with decrease in pore content was relative to the microstructure, bulk density and porosity of the porous ceramic. The high pore content (small pore size) sponge resulting greater amount of solid loading during impregnated process and thus, the polymer sponge burned out after sintering and solid particles fused and shrinkage occurred.

As a result, the sample synthesized with higher pore content of sponge has higher shrinkage and dense sintered body. On the other hand, the lower pore content sponge lead higher porosity and larger pore size within the sample and weakened to withstand stress concentration and rapid crack propagation.

Furthermore, the lower pore content led to small quantity and weak joining neck form between the solid bulks with neighbouring bulks. This is also a reason for the compression strength dramatically dropped for samples synthesized with 60 ppi sponge although the bulk density is just slightly lower than the porous ceramic synthesized with 80 ppi sponge. The compression strength bar chat also indicated that, the compression strength of treated sponge has significantly high than untreated sponge. This is due to; the bulk density of treated sponge is higher than untreated sponge.

Table 2: The physical property of porous ceramic prepared by using varies pore content of treated and untreated sponge respectively.

Pore content		Bulk Density (g/cm^3)	Porosity (%)	Compression strength (Mpa)
100ppi	Treated sponge	2.7914	63.08	18.62
	Untreated sponge	2.7221	62.44	15.16
80ppi	Treated sponge	2.7656	63.84	15.37
	Untreated sponge	2.6919	62.79	12.52
60ppi	Treated sponge	2.7653	63.84	5.60
	Untreated sponge	2.687	62.85	3.96
40ppi	Treated sponge	2.7085	64.18	4.23
	Untreated sponge	2.6625	63.26	2.97

4.0 Conclusion.

The high α-phase cordierite porous ceramic with high interconnected pore are successfully prepared. The total pore volumes for all of the sintered samples were greater than 62% with bulk density in the range from 2.65 to 2.8 g/cm^3. The higher pore content sponge gave better densification after sintering. Obviously, the treated sponge provide better porosity and densification compare with untreated sponge as well as compression strength. The phase transformation of non- stoichiometric MAS composition through solid state reaction was investigated. Cordierite development is primarily dependent on the temperature, the first α-cordierite crystalline phase was presented at 1300^{o}C, further increasing the sintering temperature up to 1325^{o}C, the system become majority α-cordierite phase with minority enstatite phase. In order to obtain α-cordierite single phase with non-stoichiometric cordierite composition through solid state reaction, it may require better understanding for cordierite formation when such intermediate phases are responsible in developing crystalline cordierite.

5.0 Reference

[1] Yingchao Dong, Xingqin Liu, Qianli Ma and Guangyao Meng, "Preparation of cordierite-based porous ceramic micro-filtration membranes using waste fly ash as the main raw materials," *Journal of Membrane Science,* no. 285, pp. 173-181, 2006.

[2] Xingzhong Guo, Kazuki Nakanishi, Kazuyoshi Kanamori, Yang Zhu and H. Yang, "Preparation of macroporous cordierite monoliths via sol-gel process accompanied by phase separation," *Journal of the European Ceramic Society*, pp. 817-823, 2014.

[3] M. del. C. Ruiza, J. Gonzalez. P. Orosco, "Synthesis of cordierite by dolomite and kaolinitic clay chlorination. Study of the phase transformations and reaction mechanism," *Powder Technology,* no. 267, pp. 111-118, 2014.

[4] R. S. A. Lange, J. H. A. Hekkink, K. Keizer and A.J. Burggraaf. “Formation and characterization of supported microporous ceramic membranes prepared by sol-gel modification techniques”. *Journal of Membrane Science*, pp.55-57, Sept. 1995

[5] A. T. A.Kritikaki, "Fabrication of porous alumina ceramics from powder mixtures with sol-gel derives nonometer alumina: Effect of mixing method," *Journal of the European Ceramic Society,* no. 29, pp. 1603-1611, 2009.

[6] Zhenguo Su, Xiaoqing Xi, Yanjun Hu, Qi Fei, Shicheng Yu, Hui Li and Jinlon Yang, "A new Al2O3 porous ceramic prepared by addition of hollow spheres," *Journal of Porous Mater,* no. 21, pp. 601-609, 2014.

[7] Zhen Wu, Luchao Sun, Zhilin Tian, Jinyang Wang, Junning Li and Zijun Hu, "Preparation andpropertiesofreticulatedporous γ-Y2Si2O7 ceramics with," *Ceramics International,* no. 40, pp. 10013-10020, 2014.

KATEGORI TEKNOLOGI KEJURUTERAAN SIVIL

C03: Penggunaan *Glow Powder* Sebagai Bahan Tambah Pada Campuran Garisan Jalan Bagi Mengurangkan Penggunaan *Glass Beads* Dan *Cat Eyes*

Rina Erneyza Osman[1], Nurshafawati Abd Razak[2], Aznizah Ahmad Daud[3]
Jabatan Sivil & Bangunan, Institut Latihan Perindustrian (ILP) Kuala Terengganu, Terengganu

nurshafawati@jtm.gov.my[2], asnizah@jtm.gov.my[3]

Abstrak

Seiring dengan kepesatan ekonomi dan pembangunan negara, sistem rangkaian jalan raya yang baik sangat penting bagi memastikan segala aktiviti dapat berjalan lancar dan teratur. Oleh yang demikian satu bahan baru diperkenalkan sebagai bahan tambah pada cat termoplastik untuk membuat garisan jalan. Bahan ini mampu meningkatkan tahap pencahayaan garisan jalan di samping mampu menggurangkan kos penggunaan cat eyes dan lampu jalan. Dalam kajian ini tiga sampel telah disediakan iaitu satu sampel piawai dan dua sampel terubahsuai. Sampel piawai merupakan sampel campuran glass beads dan cat termoplastik dengan hasil keputusan mendapati bacaan tahap pencahayaan sebanyak 581 mcd bagi keadaan kering manakala bagi keadaan basah sebanyak 91 mcd. Bagi sampel terubahsuai yang pertama, campuran cat termoplastik dan glow powder disediakan dengan keputusan bacaan tahap pencahayaan adalah sebanyak 91 mcd pada keadaan kering dan sampel ini tidak melepasi spesifikasi garisan jalan. Sampel terakhir pula merupakan sampel terubahsuai dengan campuran cat termoplastik dan glow powder berserta glass beads. Hasil keputusan mendapati bacaan pencahayaan bagi sampel ini adalah sebanyak 1026 mcd bagi keadaan kering manakala 561 mcd bagi keadaan basah dan melepasi spesifikasi yang telah ditetapkan oleh pihak JKR. Hasil keputusan ujian pencahayaan daripada ketiga-tiga sampel yang telah dilakukan, sampel ketiga telah dipilih untuk digunakan pada garisan jalan bagi menggantikan bahan campuran yang sedia ada.

***Kata Kunci**: Cat termoplastik, pencahayaan, glass beads, glow powder*

1.0 Pengenalan

Seiring dengan kepesatan ekonomi dan pembangunan negara, sistem rangkaian jalan raya yang baik sangat penting bagi memastikan segala aktiviti dapat berjalan lancar dan teratur. Pelbagai usaha telah dilakukan oleh pihak bertanggungjawab dalam memastikan jalan raya yang dibina dapat memberikan keselesaan kepada pengguna dan pelbagai langkah keselamatan diambil agar kadar kemalangan jalan raya dapat dikurangkan. Hal ini dapat dibuktikan apabila semenjak tahun 1911 lagi, satu idea mengecat garisan tengah telah diketengahkan oleh Edward N.hines dari Michigan, Amerika Syarikat bagi mengasingkan lorong-lorong trafik dan membolehkan sesebuah jalan raya dapat dilihat dengan jelas di waktu malam dan ketika cuaca buruk.[7]

Secara umumnya cat termoplastik adalah salah satu bahan yang digunakan untuk memberikan tanda atau garis pada jalan berturap bagi mengawal aliran trafik serta mengurangkan konflik jalan raya. Cat termoplastik ini mempunyai beberapa jenis atau warna yang terdiri dari cat termoplastik warna putih, cat termoplastik warna kuning, cat termoplastik warna hitam, cat termoplastik warna hijau, dan cat termoplastik warna merah, cat ini digunakan bergantung pada bahagian-bahagian yang akan ditentukan oleh pihak yang bertanggungjawab. [8]

Manik kaca (*glass beads)* pada cat termoplastik digunakan bagi menambahkan lagi mutu pencahayaan campuran cat tersebut. Namun begitu disebabkan faktor ketidaklekitan manik kaca (*glass beads)* pada campuran cat termoplastik menyebabkan tempoh jangka hayat garisan jalan tidak bertahan lebih lama.

Disebabkan keadaan ini, pelbagai usaha telah dilakukan oleh pihak terlibat seperti JKR serta kontraktor bagi memastikan cat yang digunakan dapat bertahan lebih [1]. Dalam kajian ini, *glow powder* telah digunakan sebagai bahan tambah dalam campuran cat termoplastik. Kandungan g*low powder* dalam campuran ini bukan sahaja dapat memberikan pencahayaan ketika waktu gelap, malah ia dapat membantu mengurangkan penggunaan sistem pencahayaan jalan seperti *cat eyes* dan lampu jalan.

2.0 Penyata Masalah

Pembinaan garisan jalan adalah salah satu langkah bagi mengurangkan kadar kemalangan jalan raya sekaligus meningkatkan faktor keselamatan pengguna di jalan raya. Oleh itu, kualiti cat yang digunakan perlulah sentiasa dipertingkatkan bagi memastikan garisan jalan yang dibuat mampu bertahan untuk jangka masa yang panjang, memberi kesan pencahayaan yang cukup dan mengurangkan kerja-kerja penyelenggaraan yang boleh menyumbang kepada peningkatan kos. Antara kaedah yang digunakan untuk memastikan cat termoplastik dapat memantulkan cahaya yang cukup terutama ketika waktu malam dan cuaca buruk, manik kaca (*glass beads)* telah ditaburkan di atas cat termoplastik yang dihamparkan pada permukaan jalan. Namun begitu masih terdapat beberapa masalah yang berlaku, antaranya lekitan yang tidak berpanjangan di antara manik kaca dan cat termoplastik. Oleh yang demikian, dalam kajian ini bahan yang dikenali sebagai *glow powder* telah digunakan sebagai bahan tambah dalam campuran cat termoplastik. Ini kerana, secara teorinya *glow powder* ini dapat meningkatkan lagi kadar pantulan cahaya garisan jalan terutama di waktu malam dan juga ketika cuaca buruk.

3.0 Objektif Kajian

Dalam menjalankan kajian ini, secara umumnya beberapa objektif telah ditetapkan seperti berikut:

i. Menjalankan ujikaji bagi menentukan kesesuaian penggunaan *glow powder* sebagai bahan tambah dalam campuran cat termoplastik pada garisan jalan raya.
ii. Membuat perbandingan keputusan ujikaji antara penggunaan *Glass Beads* dan penggunaan *glow powder* pada garisan jalan raya.
iii. Mengurangkan penggunaan sistem pencahayaan jalan raya seperti *cat eyes* dan lampu jalan

4.0 Metodologi Kajian

4.1 Penyediaan Sampel

i. Sampel 1 (Cat termoplastik dibancuh bersama *glow powder*)

a) Cat termoplastik sebanyak 800 gram dipanaskan terlebih dahulu di dalam bekas dengan suhu 220^0C - 230^0C.
b) *Glow powder* sebanyak 80 gram dicampurkan ke dalam bancuhan cat termoplastik yang telah dipanaskan.
c) Garisan jalan ditandakan di atas permukaan jalan raya mengikut spesifikasi garisan jalan iaitu sebanyak 1 m panjang dan 100 mm lebar.

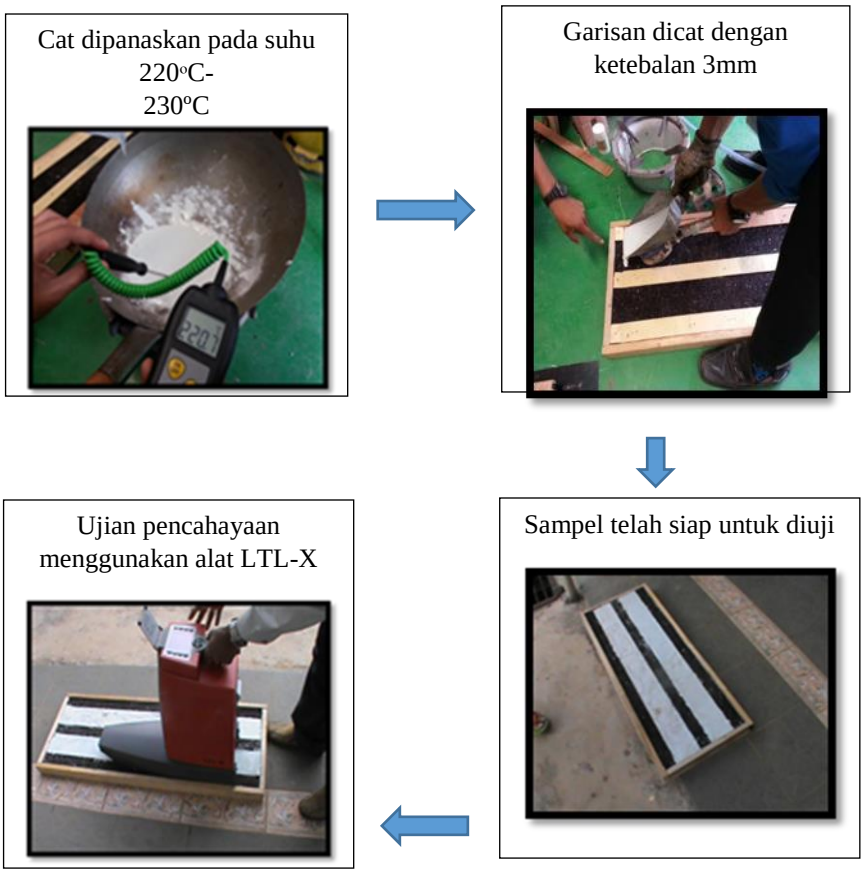
ii. Sampel 2 (Cat termoplastik dibancuh bersama *glow powder* dan ditabur *glass beads*)

a) Ulangi langkah 1-3 sama seperti penyediaan sampel 1.
b) Kemudian, *Glass beads* sebanyak 200 gram ditabur di atas permukaan jalan yang telah dihamparkan.

4.2 Ujian Pencahayaan

Ujian pencahayaan adalah bertujuan untuk memastikan campuran bahan *Glass beads* yang digunakan pada cat termoplastik akan memantulkan cahaya bagi menepati piawai yang telah ditetapkan oleh pihak JKR, iaitu 300 mcd bagi keadaan waktu kering dan 75 mcd pada waktu keadaan basah.

Langkah kerja:



5.0 Keputusan dan Perbincangan

Beberapa keputusan tahap pencahayaan daripada ujikaji yang telah dijalankan diperolehi melalui penggunaan *glow powder* pada garisan jalan adalah seperti yang dinyatakan:

5.1 Tahap Pencahayaan

Tahap pencahayaan bagi sampel 1 (sampel piawai) iaitu penggunaan cat termoplastik berserta taburan *glass beads.*

Jadual 1: Keputusan Analisis Sampel 1 (Sampel Piawai)

Ujian pencahayaan	Sampel 1 (sampel piawai)	Spesifikasi JKR	Keputusan
Keadaan kering	581 mcd	300 mcd	Lulus
Keadaan basah	91 mcd	75 mcd	Lulus

Keputusan tahap pencahayaan bagi sampel piawai adalah sebanyak 581 mcd bagi keadaan kering dan bagi keadaan basah adalah sebanyak 91 mcd. Keputusan tersebut menunjukkan sampel tersebut melepasi tahap minimum yang telah ditetapkan oleh spesifikasi JKR.

Tahap pencahayaan bagi sampel 2 (sampel terubahsuai) iaitu penggunaan cat termoplastik dibancuh bersama *glow powder*.

Jadual 2: Keputusan Analisis Sampel 2 (Terubahsuai)

Ujian pencahayaan	Sampel 2 (sampel terubahsuai)	Spesifikasi JKR	Keputusan
Keadaan kering	91 mcd	300 mcd	Gagal
Keadaan basah	-	75 mcd	-

Keputusan bagi sampel 2 menunjukkan ujian pada keadaan kering adalah sebanyak 91 mcd, manakala ujian pada keadaan basah tidak mencatatkan sebarang keputusan kerana ujian tersebut tidak perlu dilakukan disebabkan tiada penggunaan *glass beads* dalam sampel 2 ini. Setelah di analisis melalui ujikaji pencahayaan terhadap penyediaan sampel mendapati keputusan tidak melepasi spesifikasi yang telah ditetapkan oleh pihak JKR dan tidak sesuai digunakan untuk membuat garisan jalan.

Tahap pencahayaan bagi sampel 3 iaitu pengunaan cat termoplastik dibancuh bersama *glow powder* serta taburan *glass beads*.

Jadual 3: Keputusan Analisis Sampel 3 (Terubahsuai)

Ujian pencahayaan	Sampel 3 (sampel terubahsuai)	Spesifikasi JKR	Keputusan
Keadaan kering	1026 mcd	300 mcd	Lulus
Keadaan basah	561 mcd	75 mcd	Lulus

Setelah penyediaan sampel dilakukan dan dianalisis tahap pencahayaan bagi sampel 3 mendapati pencahayaan pada keadaan kering adalah sebanyak 1026 mcd manakala pada keadaan basah adalah sebanyak 561 mcd. Keputusan pencahayaan bagi sampel 3 ini menunjukkan ia bukan sahaja melepasi tahap minimum pencahayaan yang telah ditetapkan oleh spesifikasi JKR, malah ia mencatatkan keputusan yang sangat tinggi.

Jadual 4: Perbandingan Keputusan Ujian Pencahayaan

Ujian pencahayaan	Sampel 1 (sample piawai)	Sampel 2 (sampel terubahsuai)	Sampel 3 (Sampel terubahsuai)	Spesifikasi JKR
Keadaan kering	581 mcd	91 mcd	1026 mcd	300 mcd
Keadaan basah	91 mcd	-	561 mcd	75 mcd

Hasil daripada keputusan yang ditunjukkan pada Jadual 4, didapati hanya sampel 1 dan sampel 3 yang melepasi spefisikasi JKR bagi kedua-dua keadaan cuaca iaitu ketika keadaan kering dan basah. Manakala sampel 2 langsung tidak melepasi spesifikasi JKR bagi semua keadaan cuaca. Ini jelas menunjukkan sampel 2 adalah tidak sesuai untuk digunakan sebagai garisan jalan. Hal ini mungkin disebabkan sampel 2 tidak menggunakan *glass beads*. Perbandingan keputusan ujian pencahayaan bagi sampel 1 dan sampel 3 pula menunjukkan sampel 3 mencatatkan tahap pencahayaan yang lebih tinggi. Hal ini membuktikan penggunaan *glow powder* sebagai bahan tambah telah berjaya membantu meningkatkan tahap pencahayaan garisan jalan tersebut. Keputusan ujian pencahayaan bagi sampel 3 juga telah menunjukkan sampel 3 boleh digunakan untuk menggantikan campuran garisan jalan yang sedia ada iaitu sampel 1.

6.0 Kesimpulan

Kesimpulannya, *glow powder* sesuai untuk dijadikan sebagai bahan tambah dalam cat termoplastik. Ini terbukti apabila keputusan ujian pencahayaan terhadap sampel yang mengandungi *glow powder* dan *glass beads* mempunyai tahap pencahayaan yang lebih tinggi berbanding sampel yang hanya mengandungi *glass beads*. Penggunaan *glow powder* sebagai bahan tambah juga sedikit sebanyak dapat mengurangkan penggunaan *glass beads*. Hal ini secara tidak langsung dapat mengatasi masalah kekurangan bekalan *glass beads* dan monopoli harga oleh pihak-pihak tertentu. Selain itu *glow powder* juga sesuai digunakan sebagai bahan tambah kerana nilai tahap pencahayaan yang tinggi hasil daripada penggunaan *glow powder* dapat membantu untuk mengurangkan kos pemasangan sistem pencahayaan jalan raya seperti *cat eyes* dan lampu jalan sekaligus mengurangkan kos penggunaan elektrik.

7.0 Rujukan

[1] Road Marking Dileanation, Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/1988-S6

[2] Guide to Pavement Markings, Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/2008-S4

[3] Guidelines for Road Marking 2009, Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/1992

[4] K. Shimizu “Telemedicine by mobile Communication,” IEEE Engineering in Medicine and Biology, July/August 1999

[5] V.P.Rau (2005) “The Simulation Investigation of ZigBee / IEEE802.15.4”, Master Thesis, Dresden University of Technology.

[6] Dileanation Section 15 Raised Pavement Marked Jabatan Kerja Raya, Manual On Traffic Control Devices : Road Marking And Dileanation

[7] Road marking history 1918, Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/1981

[8] Road Marking Material Thermoplastic 1911, Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/2012-S6

[9] Jabatan kerja raya,Guidelines on Traffic Control and Management Devices, 2011

[10] Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/2011

[11] Jabatan Kerja Raya, Arahan Teknik Jalan 2D/85

[12] Jabatan Kerja Raya, Standard Specification for Road Work, JKR/SPJ/1993

KATEGORI TEKNOLOGI KEJURUTERAAN KOMPUTER / TEKNOLOGI MAKLUMAT

I4: Rural Wireless Communication & Network Using TV White Space Technology

Abdul Aliff b Abd Jalil
Industrial Training Institute Kuala Langat

abdul_aliff@jtm.gov.my

Abstract

The intention of this paper is to identify the perfect technology to be provided to the rural area network. The technology will be base on various wireless fidelity technology which in this case, usage of TV-White Space to catered the connectivity, development and securing the technology in order to successfully deploy it to the rural area. This paper is consider for TV-White Space as comprising the wireless networks that will connected to each designated area with the absence of any wired facilities that could not be setup or reach such as base station. It is also to identify any issues that will occur during the use of TV-White Space development for wireless fidelity for the rural area network. We will be expecting that this kind of technology still new to the rural area in Malaysia but with this paper, any findings and outcomes will be useful to better development of this technology. The initial finding is to state whether this technology is complying with the topology of the rural area itself. As for the design study, this paper will go through the development of this technology on the social impact, economical effects and environmental side to the intended rural area. As for meeting any complexity of completing the deployment process, this paper provides initial investigation, in a holistic manner, through the technology forecasting approach in order to understand the challenges brought about by the future deployment of TV-White Space to rural area networks.

Keywords – rural area networks, TV-White Space, technology forecast, technology development.

7.0 Introduction

The expansion and development of communication infrastructure has been identified as one of the National Key Economic Areas (NKEA) in Ecomonic Transformation Plan (ETP). The ETP is an initiative on the part of the Malaysian government to raise the country's Gross National Income (GNI) per capita to more than RM48, 000 by 2020, resulting in Malaysia becoming a high income nation by then. The NKEA is the enabler which would drive the Malaysian economy and is targeted to create an additional 75,000 jobs, particularly in rural areas.[1]. Looking at the statistics, it is vital not to leave those who lived in the rural area networks to have this kind of technology. The current state of technology could enhance the lifestyles of any communities to a better and proper organization.

The purpose of this network is firstly to provide high speed broadband access to rural communities which either have no or limited access to broadband services. Secondly the radios are designed as green low energy devices that do not require a connection to the electricity grid but can be solely powered by renewable energy sources and are mounted on an environmental friendly base station structure that does not require planning permission. Thirdly, the test bed serves as a framework for broadband access in the TV white space spectrum in order to measure and analyze the performance of a white space communications network implemented in real time[2]. Base on this purpose, the implementation of this technology in the rural area of Malaysia are need to be considered in term of geographical topologies since the rural area of Malaysia are divided as in peninsular and Borneo.

Most of the rural area from peninsular states is located among coast to coast and designated area by the government while at Borneo most of the rural area are located among high terrains and rivers. Even though broadband is widely used nowadays in the rural area but there some certain obstruction such as low signal or data throughput when it come to remote rural area that is far from any available base station. In this paper, we will look how TV-White Space could be implementing for the mentioned topology in giving the best services to the residents in the rural area. Before that, analysis of TV-white space capability and performances will present in the next chapter.

2.0 Technical Aspects of TV-White Space

TV-White Space has received many attentions throughout the decades especially after the breakthrough of internet usage for common daily tasks. It is believed that this technology could be the savior of wireless fidelity networks mainly on broadband which is nearly reaching the barrier of distributing appropriated data throughput. For this paper, it is the right time to develop and research this technology for the deployment of white spaces radios that can be used to provide Community Network services and Internet access. The reason is that TV broadcasters never had an economic incentive to serve sparsely populate areas with several concurrent TV channels as is the case in urbaspethe UHF TV spectrum is mostly fallen in these regions and ready to be put to good use [3]. Most important point that needs to be considered is the permission from the governing body to emulate the given frequencies from 470 MHz to 690 V standard provided by the FCC (Federal Communication Commission) to be implemented in the rural area for greater benefits for the rural residents. This frequency served better propagation characteristic, therefore provide better coverage with limited base station and yet economical cost of implementation.

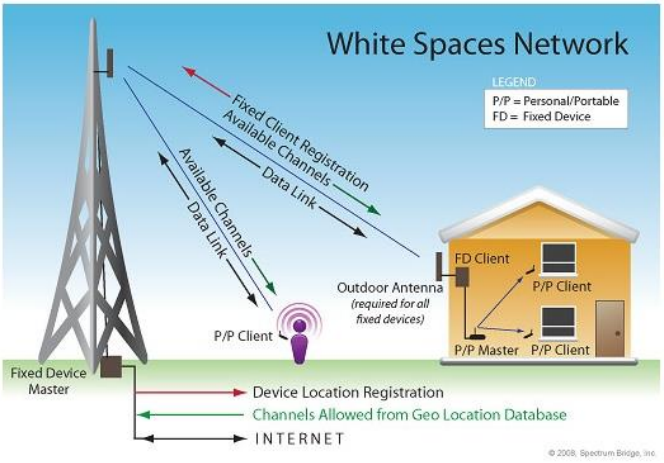


Figure 1 : How White Spaces work[4]

TV-White space work consists on connecting the access point to the database that registered for the propagation channel. The access point would then send the channel list request to the database where fixed device master that associated with the access point will use the request to distribute the data throughput to all devices that connected to the access point and have account in the database.

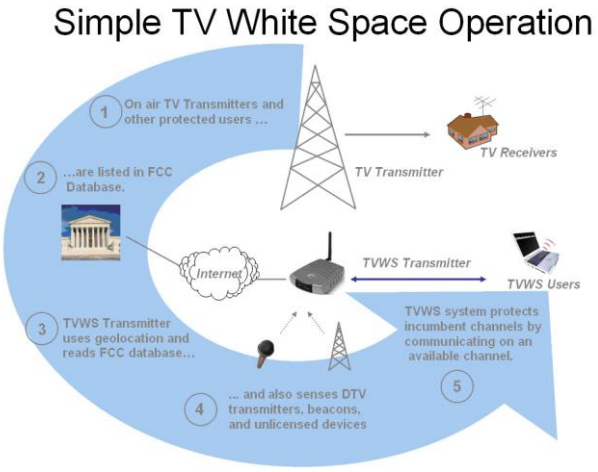


Figure 2: TV White Space using Geolocation

Typically, the deployment of wireless access networks is subject to coverage and capacity constraints for a given region. Coverage is defined with respect to the ability of clients to connect to access points within their service area. We use a coverage constraint ratio of 95% in this work for a target area[5]. The requirement of reliable network coverage at a very low operational and deployment cost especially in rural areas is particularly challenging for current technologies. Due to the above propagation characteristics, a new era of UHF white space communication has the potential to overcome the shortcomings by using low cost technology based on open standards. This results in a low infrastructure cost and greater coverage thus balancing the economics of low rate of return for commercial operators due to higher infrastructure cost in rural settings.[2].

The propagation will be evenly distributed to the designated area where as the most residents are likely to have an established connectivity for their usage. The usage of the services provided by the access point such as internet than will be monitored by the regulators or any incorporate body that entrusted to setup the facility.

The geo location is purposed to prevent any interference that will occur if any low specifications device nearby the TV white to protected any static events that are planned earlier.

The technique that would be required for this geo location is known as spectrum sensing. It is a method that will provide accuracy for the provider to setup the best geo location remote sensor for this TV white space. According to a research done by Motorola, stated that Spectrum sensing complements the geo location database to assist the network operator in finding the most noise-free channels to use. Spectrum Sensing provides the ability to sense RF signals or detect a beacon, thereby enhancing compatibility with incumbent operators and facilitating sharing among TV White Space devices. Sensing technology has been widely deployed in many outdoor RF applications for years, and is proven to provide information on the presence of signals and noise in individual bands within a selected spectrum of frequencies. Spectrum sensing reveals activity in frequency bands whether they are used by broadcast TV or other emitters. [6].

Thus, this kind of research acknowledged the ability of spectrum provided by the provider into its potential users such as state and local government that could perform faster data transfer, enterprises community that could enhanced their services to the maximum by performing an end to end services via network for the customers.

3.0 Standardization of TV-White Space Technology

The radio propagation characteristics in the white space spectrum range of around 700 MHz are considerably more benign than for WiFi systems in the 2GHz or 5GHz ranges, leading to larger coverage, better penetration of building structures, and easier access to rugged landscapes such as the Highlands and Islands, where a large number of transmissions nodes would be required, if coverage had to rely on line-of sight only. Thus the requirement of reliable network coverage at a very low operational and deployment cost especially in rural areas is particularly challenging for current technologies.

The new era of UHF white space communication has the potential to overcome these shortcomings by using low cost technology based on open standards.[7].

By using this technology, the rural area could boost their current activity base on social, business or administrative sides. It is shown that, wireless fidelity does play important roles in a community nowadays. The impact would be massive for the future generation of the community. Despite any setback that will be obtain such as unauthorized view of the internet, illegal downloading of any discreet material.

TV white space does have a governing issue as if to protect from any unauthorized usage of the spectrum. Hence, lead by the United States Federal Communication Commission (FCC) has set a standard that should be implemented by any regulatory bodies such as the United Kingdom Office of Communication (UK OFCOM), Japan Ministry of Internal Affairs and Communication (MIC) and Singapore Info Communication Development Authority (IDA). The standard requires that the new regulations offer opportunities for additional spectrum utilization. In response, industry and standardization initiatives have mobilized efforts to specify enabling technologies to effectively take advantage of these newly available spectra. These interest groups are allocating a significant amount of resources to ensure that the TV white spaces can be utilized to the maximum.[8]

	Fixed device	Personal/portable device		
		Mode I (slave)	Mode II (master)	Sensing only
Geolocation awareness	Required (±50 m)	Not required	Required (±50 m)	Not required
WSDB access	Required (once/day)	Not required	Required (once/minute)	Not required
Spectrum sensing	Not required			Required
Available TV channels	2–51 (except 3, 4, 37)	21–51 (except 37)		
Power (EIRP)	4 W		100 mW	50 mW

Figure 3: Summary of FCC Regulations.

From this regulation, the regulatory bodies will classify it through the IEEE standard in order to specify it accordingly. This is because most existing WLAN and WPAN systems occupy the 2.4 GHz and 5 GHz bands. Therefore, there is a need to modify legacy systems before adapting them to the VHF/UHF bands with substantially different channel properties. Besides, the system design has to also take into consideration various requirements imposed by governing rules in different regulatory domains. All these factors are essential for the wireless community to design a reliable and practical system.[8]

4.0 Conclusion

For the partial side of wireless technology, this TV white space sure does a lot of greater good. Even though the remarkable journey it has encountered still have a room of improvement. This technology could be the missing link that haunted the developer or the governing body on how to connect the rural area to the outside world without facing much hassle and trouble of its development. The main factor that should be considered before deployment of this technology is to provide the best equipments in setting up the facility. Our current technology (solely base on individual remark) is not enough to cater the technology.

The government should see this as an opportunity to educate the rural area communities towards the benefit of using this technology. It is also to mark the nation vision towards the information technology wise. This is also would be the stepping stone to any developer to enhancing their services to the rural area community. Further research's is most welcomed to seek a better understanding of this technology toward the rural area.

5.0 Acknowledgment

The author would like to thank to Dr Rudzidatul Akmar Binti Dziyauddin and Encik Saiful Adli b Ismail for spending times sharing the knowledge's of wireless technology. Friends for the never ending supports.

6.0 References

[1] K.-L. A. Yau, C. J. Perera, H. T. D. Chieng, K. H. Kwong, and A. Ting, "Exploring sustainability of the deployment of wireless broadband in Malaysia rural areas: Comprehensive insights," in *2011 IEEE Colloquium on Humanities, Science and Engineering (CHUSER)*, 2011, pp. 148–152.

[2] M. Brew, F. Darbari, C. McGuire, G. Bolton, S. Weiss, and R. W. Stewart, "A low cost and power efficient TV white space technology solution for future rural broadband access networks," presented at the GLOBECOM Workshops (GC Wkshps), 2011 IEEE, 2011, pp. 1024–1028.

[3] M. Zennaro, E. Pietrosemoli, J. Mlatho, M. Thodi, and C. Mikeka, "An assessment study on white spaces in Malawi using affordable tools," presented at the Global Humanitarian Technology Conference (GHTC), 2013 IEEE, 2013, pp. 265–269.

[4] *ws_4.jpg (JPEG Image, 531 × 375 pixels) - Scaled (0%)*. .

[5] P. Cui, H. Liu, D. Rajan, and J. Camp, "A measurement study of white spaces across diverse population densities," presented at the Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt), 2014 12th International Symposium on, 2014, pp. 30–36.

[6] "WB_TV White Space Position Paper_V2_11.08.pdf." [Online]. Available: http://www.motorolasolutions.com/web/Business/Product%20Lines/Motowi4/wi4%20Fixed/Point-to-Point%20Mulitpoint/Canopy/_ChannelDetails/_Documents/_Static%20files/WB_TV%20White%20Space%20Position%20Paper_V2_11.08.pdf?pLibItem=1. [Accessed: 20-Dec-2014].

[7] M. Brew, F. Darbari, L. H. Crockett, M. B. Waddell, M. Fitch, S. Weiss, and R. W. Stewart, "UHF white space network for rural smart grid communications," presented at the Smart Grid Communications (SmartGridComm), 2011 IEEE International Conference on, 2011, pp. 138–142.

[8] C.-S. Sum, G. P. Villardi, M. A. Rahman, T. Baykas, H. N. Tran, Z. Lan, C. Sun, Y. Alemseged, J. Wang, C. Song, C. Pyo, S. Filin, and H. Harada, "Cognitive communication in TV white spaces: An overview of regulations, standards, and technology [Accepted From Open Call]," *Commun. Mag. IEEE*, vol. 51, no. 7, pp. 138–145, Jul. 2013.

I5: Internet Based Remote Fluid Ph Monitoring Using Iot Node

Siti Norhidayah Umar
Pusat Latihan Teknologi Tinggi (ADTEC) Melaka

siti_norhidayah@jtm.gov.my

Abstract

Internet based remote fluid pH monitoring using Internet of thing (IoT) node is a system that provides pH reading of fluids from the cloud or Internet and can be monitored from anywhere and everywhere using smartphone or web page. The pH data is transmitted to the IoT server using IoT node device that interpreted the analog pH sensor output to readable data. This system is designed to replace manual pH level monitoring operation that used human power to collect pH readings as implemented in chemical, automobile and fishery industries. The system consists of an IoT node device, a web page and an Android mobile application. The IoT node device is equipped with microcontroller and a Wi-Fi module. The microcontroller will process the sensor data and transmit the pH data to IoT server every 30s via Wi-Fi module. Every 30s the web page will update the pH data in forms of chart and table. The Android application is linked to the web page server so every update to web page will update the Android application too. This automated system can reduced human error and negligence that result in false and inconsistent reading. Furthermore, the web application is equipped with Microsoft Excel data export so all the data can be saved and viewed in local computer for private record. With this system, a consistent and automated worldwide-access remote pH monitoring is no longer impossible.

Keywords: *Internet of thing (IoT) , pH Monitoring*

1.0 Introduction

The idea of developing this project is due to the demand of the car assembly industry which is the car painting department. The car painting process involves a lot of liquid where one of them is DI water. DI water is basically a distill water with PH natural, 7. The Distill water is used to wash car body before the coating process begins. It is important to monitor the PH value of this water due to car body sensitivity. Car body which is made from metal cannot be exposed to the water that consists of unnatural element to avoid from corrosion and increase car body durability.

The Wireless PH measuring system for DI water will make the PH monitoring process become easier than ever because the system will replace the man power into automated system that will help monitor the PH and provide data collection. Therefore this system will help reduce cost by eliminating the man power and reduce paper consumption used by worker to record the PH reading before key in into the computer.

The wireless monitoring system that automatically updates pH level data in website and mobile application is much more suitable than manual pH monitoring using manpower. The fact that the pH data can be monitor anywhere and everywhere will make engineer life easier. The particular area only need to be attended when needed which will reduce time consumes and people can work efficiently.

2.0 Background

Internet Based Remote Fluid pH monitoring system using IoT node system function's with three basic parts which are Hardware Communication, Networking and Software. The hardware communication is used for sensing field purpose. The pH sensor will collect the pH data from the water tank and then the data will be sending to the WIDO board with microcontroller to process the data from the pH sensor to a readable form. The networking part is where the IoT node (client) device successfully sends pH sensor data to the IoT server which is Thingspeak.com. The communication begins by sending the data from IoT node to cloud via Wi-Fi connection. Then, the data will be transmitted to the IoT server using restful http get protocol. The data obtain in IoT server will then be use in webpage and android application software. The IoT server will send data in JSON format to those applications using restful http post protocol to allow data display in form of chart and table for the user.

3.0 Software and Hardware Development

Software development for this system will be website and android application development. These two applications will request data from the IoT server using restful http get protocol and will receive the data in form of JSON file. The tools used to develop the website are Html5, PHP, jQuery, notepad++ and Xampp. Meanwhile, for android application development, only one tool needed which is eclipse adt sdk. The architecture of the system is shown as follow:

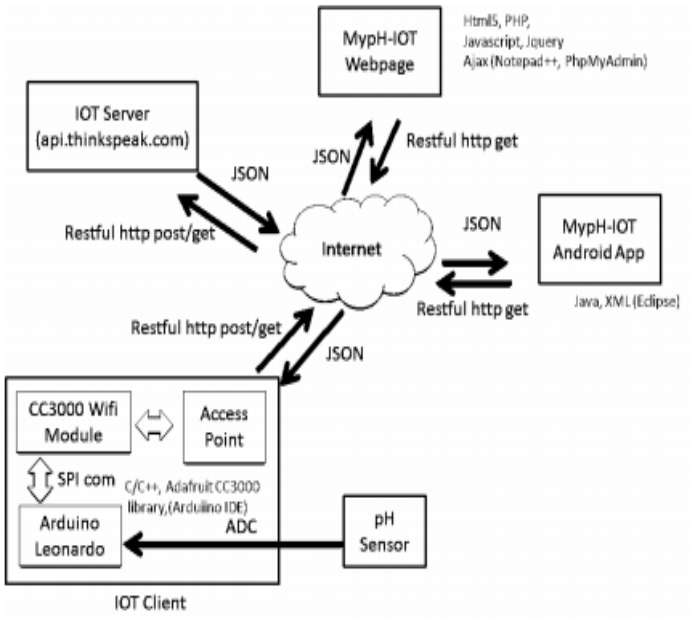


Figure 1: Internet Based Remote Fluid pH Monitoring Using IoT

Internet Based Remote Fluid pH monitoring system only has one part of hardware communication setup. Where, the communication is between the pH sensor and the IoT node. The reading from the pH sensor will be interpreted in form of digital value so that people will understand. The connection between the sensor and the IoT node are shown as follow:

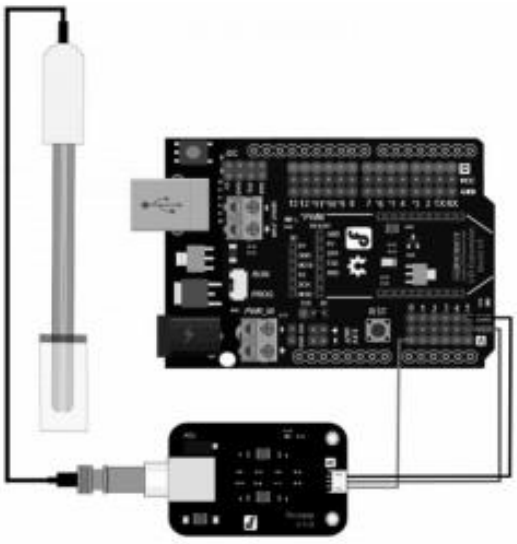


Figure 2 : pH sensor and IoT node connction

Figure 2 shows that only three wire connection required to communicate between pH circuit board (that come together with sensor) and IoT node device. The three connections are Power (5V), Ground and input (Analog1). In order to produce the reading of the pH sensor an Arduino IDE was used due to the presence of Arduino microcontroller in the IoT device (Arduino Leonardo).

Networking part of this project is to develop communication via Wi-Fi between the IoT node (WIDO board) and the IoT server (thingspeak.com).

The IoT node device (WIDO Board) consists of Arduino Leonardo and CC3000 Wi-Fi module. Therefore, three tools needed to setup these communications which are C/C++ language, Adafruit cc3000 library and Arduino IDE. C/C++ language used for writing the programming code in the Arduino IDE while Adafruit cc3000 library used to setup the Wi-Fi communication between the device and the internet. A ping test from the IoT node and the IoT server was done to start the communication setup. Once the ping test successful, random data was send to the IoT server using HTTP post.

Software development is important in this project for the man-machine interface purpose. The software will provide a pH value that can be understand by the human language. In addition, the system also provides the data in excel interface to make it easier for the user to take the pH reading and produce analysis graph from excel application. This software developed for this system is website and mobile application.

The website named MypH IOT developed using Xampp and Notepad++. Xampp act as local server for developing the website while Notepad++ was used to write programming for the website development. In order to design the website interface, the libraries used for programming in Xampp are Html5 (Web display), Css3 (GUI Style), jQuery v1.11.1 (GUI action), Bootstrap v3.3.2 (GUI design) and php (Data interfacing). Bootstrap v3.3.2 was choosing to design the website because it has the ability to produce a responsive website which is suitable for all type of device. Moreover, Bootstrap v3.3.2 also provides a lot of design to be chosen for website interface. The architecture of website development is as follow:

The client-side (web browser/pc) is where the interface of the website displays. The Graphical User Interface (GUI) and image on the website was design via Html5, CSS and jQuery. Where, the overall website interfaces that appear is in Html5 while jQuery is used to create GUI action such as button that is clickable for user to used. Meanwhile, CSS is used to color all the buttons and the entire web site to make it more interesting and attractive.

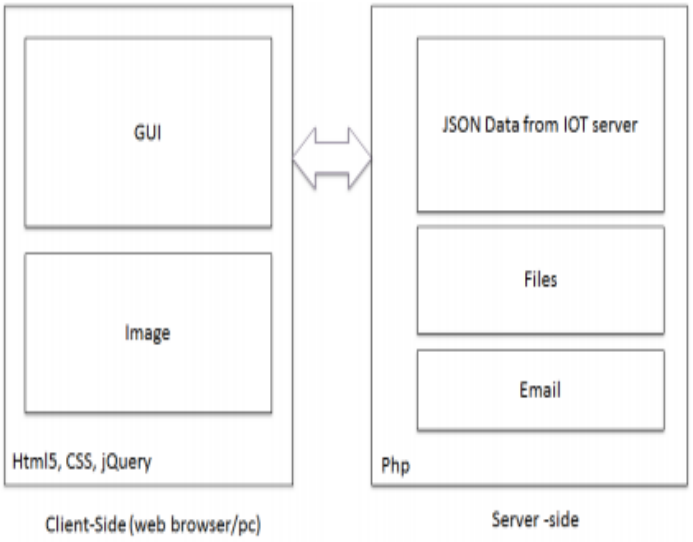


Figure 3 : Website Development Architecture

The server side is where the website development takes place. PHP, which is the most popular scripting language, is used in this website development. PHP was choosing because it is fast, flexible and pragmatic. Therefore, the programming write for the website development is saved as index.php in the notepad++ software. The pH data from the IoT server was request by the website to be display in table form. IoT server will sent bunch of data in form of JSON file.

Therefore, the JSON file must be decode in order to show the pH reading in table form on the website. PHP also have the ability to decode the JSON type file easily, hence become one of the reason why PHP is choose to develop this website. The codes used to decode JSON files obtain from the IoT server are as follows:

```
ini_get('allow_url_fopen');
        $json =
        file_get_contents('http://api.thingspeak.com/channels/34908/feeds        .json?results=1000');
        $obj = json_decode($json);
```

Finally after all the decoding and designing process successful, the website was equipped with Microsoft Excel data export for used to download and save as private documentation for easy pH level data analysis.

The software development continues by developing mobile application for Android user. The idea of having the mobile android application is because it is easier for user to open the monitoring system without having to search in the internet browser. Only with one press user can get access to the MypH IoT monitoring system.

This Android application was developed using Eclipse adt sdk software. The interface for this application is similar to the website. It was done by setting the web view as main page of the application. Then, the web view was linked to the webpage so that all the update form the website will be shown in the android application too. The tool for mobile Android application is as follow:

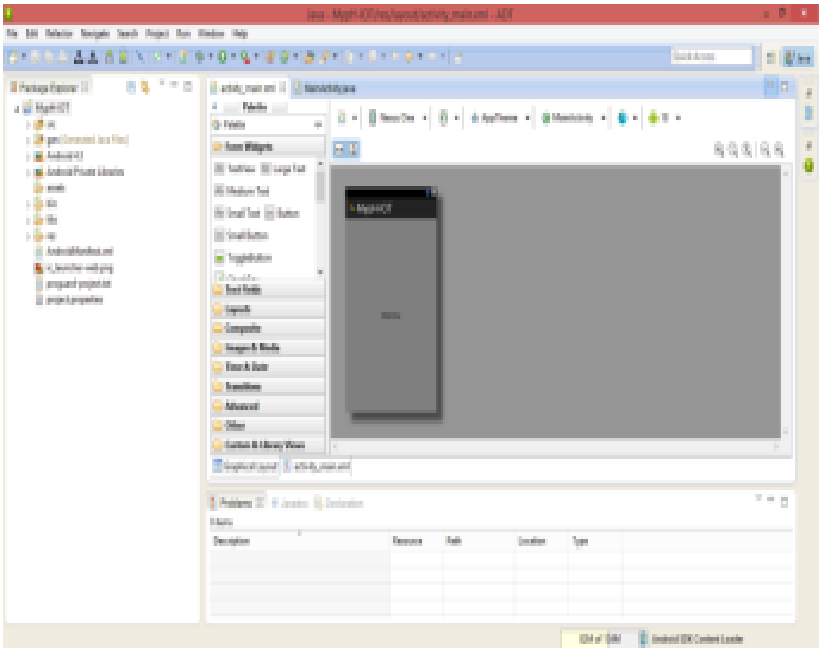


Figure 4: Mobile application developement tool

The code to link the webpage and the web view are as follows:

```
@Override
        protected void onCreate(Bundle savedInstanceState)
        {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);
                final WebView wv = WebView)findViewById(R.id.webView1);
        wv.getSettings().setJavaScriptEnabled(true);
        wv.setWebViewClient(new WebViewClient());
        wv.loadUrl("http://www.appslippers.com/myph-iot");
        }
```

4.0 Results and Discussions

IoT node device is the combination of sensing element and the WIDO board (combination of Arduino Leonardo and cc3000 Wi-Fi module). The sensing element for this system is pH sensor. The pH sensor used is analog pH meter which come together with pH sensor circuit board. The pH sensor and the circuit board were connected to the WIDO board using analog cable. Then, Arduino IDE was used to program the microcontroller in the WIDO board to display the analog data read by the pH sensor.

The result of how the end product of the website design for this system is shown in this part of this report. The website is a responsive website which automatically fit any size of device screen.

Figure 5 and 6 shows the website interface using internet browser in laptop or personal computer. The header of this website which is in blue color with website logo on it will stay in place even if the page is scroll down. This is also one of the special features of this website.

Figure 7 shows the view of MypH-IOT website if it is open in web browser via smart phone. It can be see that the website is responsive to the size of device used to open it. The website orientation will automatically change so that it will be easier for user to view.

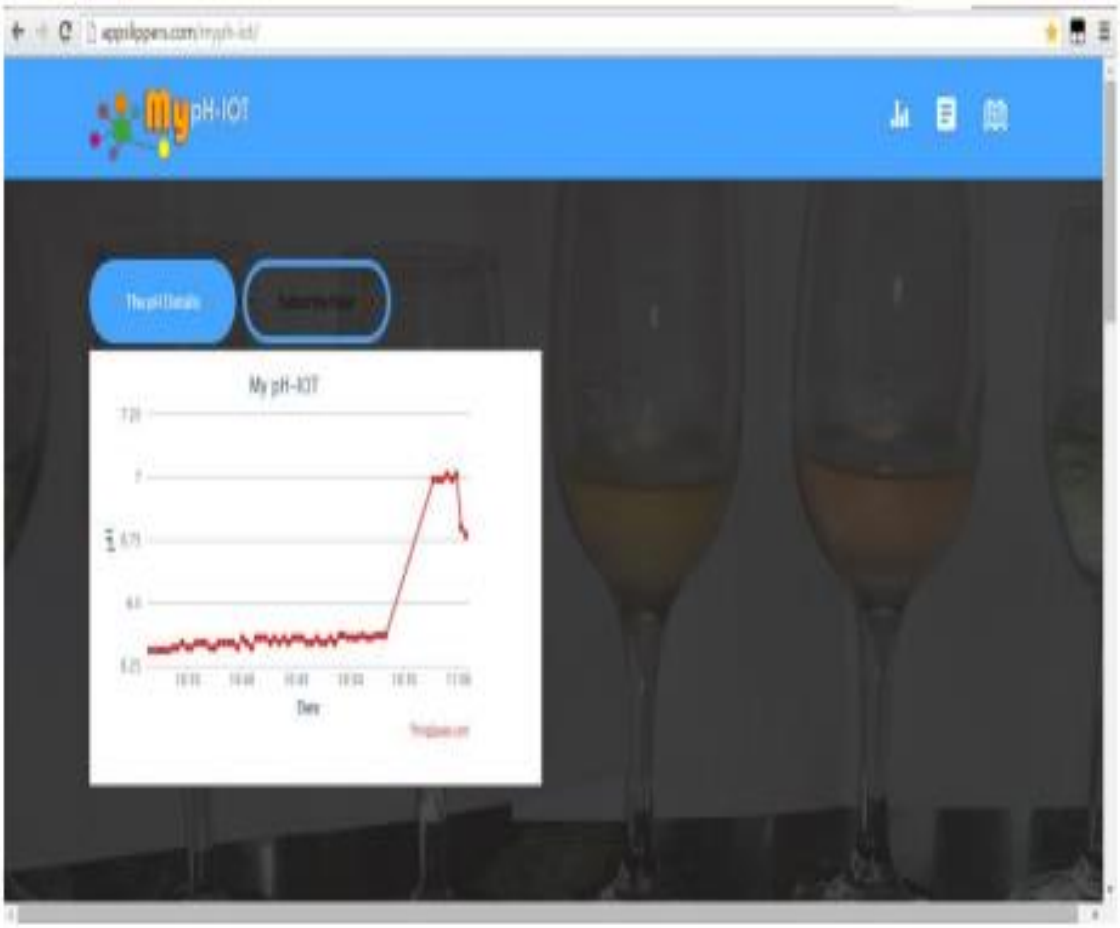


Figure 5 : MyPH-IOT interface via web browser- Part 1

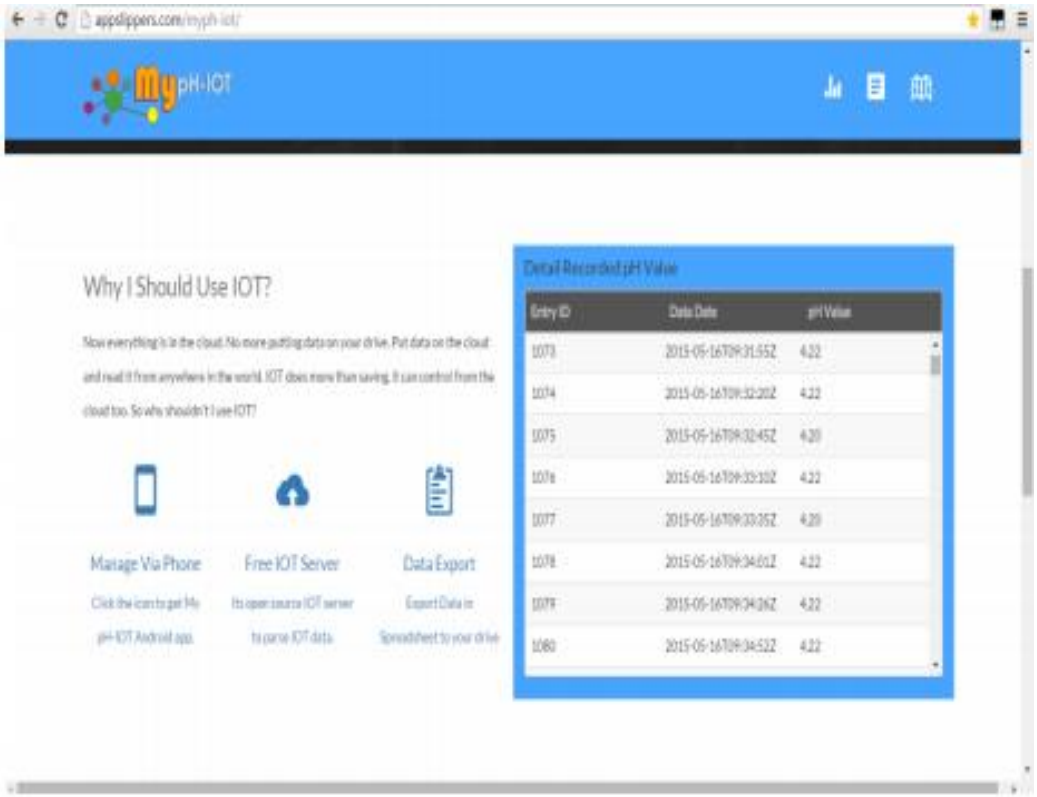


Figure 6 : MyPH-IOT interface via web browser- Part 2

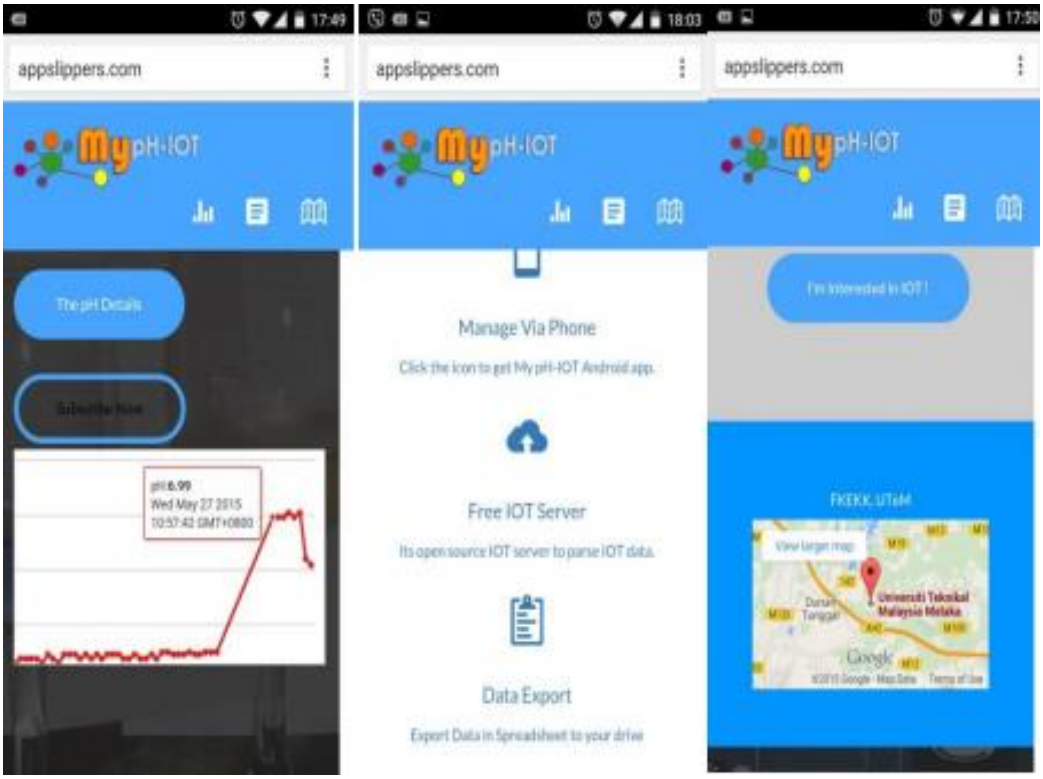


Figure 7 : MyPH-IOT interface via smartphones - Part

Data export to Microsoft Excel is one of the special features added in the website so that the data of pH level can be stored in local computer for private documentation. Having data in Excel make it easier for user to make analysis for the pH level as Microsoft Excel have a lot of feature such as graph and chart maker

Figure 8 shows how the downloading process of the Excel file from the website happen. Only one easy step need to be done by user to obtain the excel data which is by clicking the file icon in the green box shows in figure 23. Then, excel file contain with all pH level data will be downloaded as shown in the red box.

Figure 9 shows the result of pH data that have been successfully exported in Microsoft Excel software. The first column show the entry ID, the second column shows the entry date and the third column show the pH level value. The entire data in the excel file can be used for data analysis or etc.

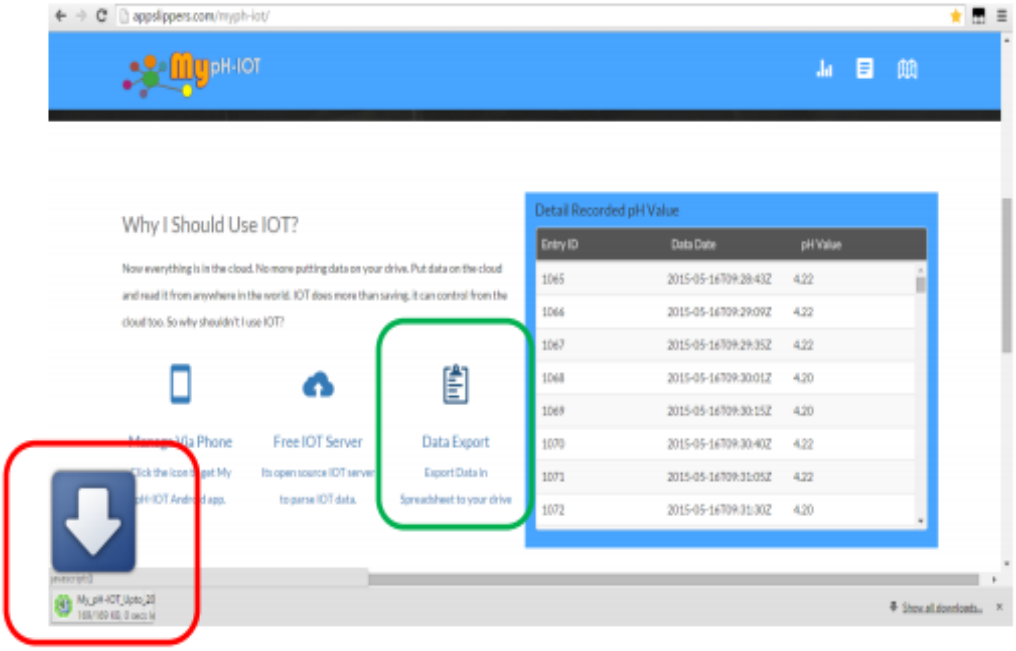


Figure 8 : Downloading Excel File data from website

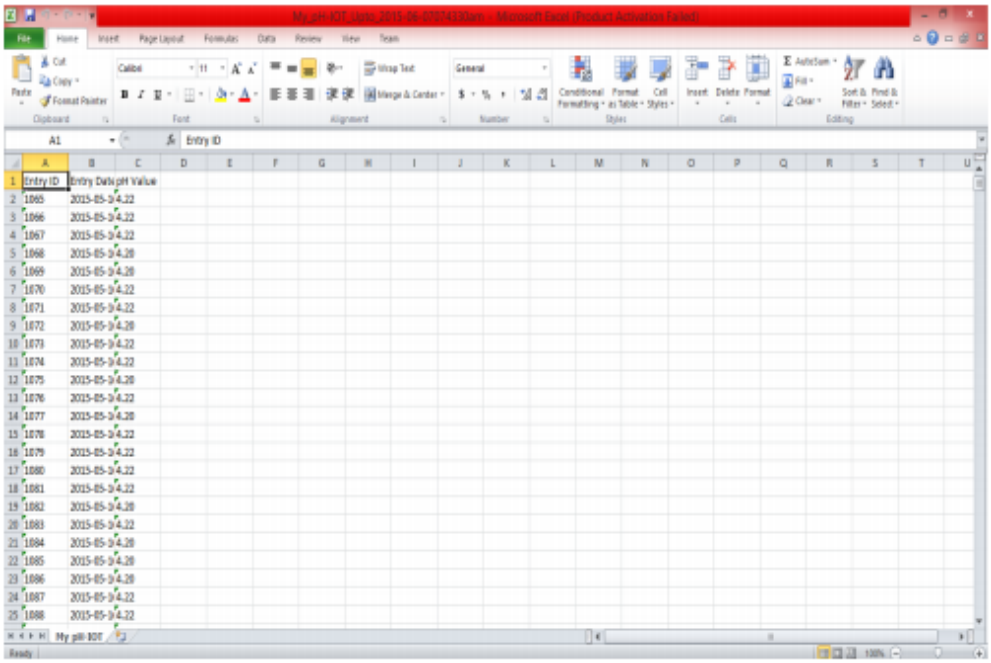


Figure 9 : pH level Data in Excel File

Having android application as one of system feature make it more easier for the user to monitor the pH level anywhere as mobile phone is much more closer to user compare to personal computer. Figure 10 show the MypH-IOT android application that is ready for user to download in their smart phones. When user installed MypH-IOT in their smart phone, they will have MypH-IOT shortcut icon. Then, with only one simple touch on the icon, user can monitor the pH level at anytime and anywhere they desire. The result of short cut icon for MypH-IOT android application is shown in figure 11.

Figure 10 : MypH-IOT in Play Store

Figure 11 : MypH-IOT android application Icon

The android application of this system has similar interface with the website. Therefore, the result for how the interface for the android application is shown in figure below and the interface is definitely similar to the website interface shown in figure before.

5.0 Conclusion

To conclude the overall program, it is safe to say that all the objective of the program is achieved throughout this project development. The output for the Remote pH Chemical System Using Internet of Thing (IoT) was successfully achieves using software (MypH-IOT website and android application) and the prototype make to show the function through hardware. It is proven that monitoring one point anywhere in the world (as long as there is internet connection) is possible.

6.0 References

[1] Zulhani Rasin and Mohd Rizal Abdullah. Water Quality Monitoring System Using Zigbee based Wireless Sensor Network: International Journal of Engineering & Technology Vol 09, No 10.

[2] Peng Jiang, Hongbo Xia, Zhiye He and Zhenning Wang. Design of a Water Environment Monitoring System Based on Wireless Sensor Networks: Sensors, 2009.

[3] Xiuhong Li, Xiao Cheng, Peng Gong and Ke Yan. Design and Implementation of a Wireless sensor Network-Based Remote Water-Level Monitoring System: Sensor, 2011.

[4] G.Sharma, N.Pradhan, B.chettri and D.Bhattacharjee. Development of Wireless PH measuring Device: International Journal of Advance Research in Electrical, Electronic and Instrumentation Engineering. Vol. 3, Issue A, April 2014.

[5] K.S.S Prasad, Nitesh Kumar, Nitish Kumar Sinha and Palash Kumar Saha, Water-Saving Irrigation System Based on Automatic Control by Using GSM Technology: IDOSI Publications, 2012

[6] Claudia Manjarres, David Grizado, Maria Calle, Cecilia Jimenez. Chemical Wireless Sensor Network for pH Remote Monitoring: Ibe, sensor, October 2012.

I6: Quadrant Directional Switching Equalization of Separated Plateau Limit Sub-Histograms for Local Content

Hoo Seng Chun[1], Haidi Ibrahim[2]
Japan-Malaysia Technical Institute, Pulau Pinang[1]
Universiti Sains Malaysia, Pulau Pinang[2]

hoo@jtm.gov.my, haidi@usm.edu.my

Abstract

Histogram equalization for digital image contrast enhancement is still useful in a variety of applications due to its simple implementation. However, most of the image contrast enhancement methods do not emphasize on local content. Thus, this paper proposes a local contrast enhancement method, referred to as Quadrant Directional Switching Equalization of Separated Plateau Limit Sub-Histograms for Local Content (QDSESPLS). The proposed method provides better brightness preservation in an image with the recursive mean separation point. Besides, plateau limit reduces the noise amplification in an image. Quadrant directional switching equalization is used to reduce the saturation effect. The proposed method is compared with several other histogram equalization methods. The results show that Quadrant Directional Switching Equalization of Separated Plateau Limit Sub-Histograms for Local Content provides desirable performance.

***Keyword** : Digital image processing, Histogram equalization, Local histogram equalization, Plateau limit, Histogram partitioning*

1.0 Introduction

Contrast enhancement is currently still one of the active research branches in digital image processing discipline. The main aim of this research branch is to improve the appearance of the acquired image [1]. Although both digital image enhancement and image restoration share the same aim, unlike image restoration, the results obtained from digital image enhancement mostly are evaluate subjectively, where the degree of image quality perceived might be different from person to person [2]. Yet, recent researches in digital image contrast enhancement also include some objective measures in order to evaluate the performance of the algorithms.

Histogram equalization (HE) is one of the popular digital image contrast enhancement methods [3]. This method is simple and easy to be implemented. HE enhances the given input image by using a monotonic mapping function, where this mapping function is derived from the intensity histogram of the input image. The mapping function also can be derived from the probability density function (pdf), which is basically the normalized version of the histogram [4]. In order to produce an overall contrast enhancement, HE stretches the dynamic range of the image's histogram.

In spite of its simple implementation and popularity, global HE (GHE), which is HE method that uses only one transfer function calculated from the whole pixels in the image, has several drawbacks. These drawbacks include intensity saturation artifacts and washed out appearance. Fortunately, Kim [5] has discovered that these undesired problems can be reduced by simply maintaining the average brightness level (i.e., average intensity level) of the input image into the corresponding output image. As a consequence from this important rule, many variations of GHE have been proposed.

Many of these GHE variations work by equalizing two sub-histograms independently in order to preserve the mean brightness. Within this framework, the method splits the input image's histogram into two sections, which is upper and lower sub-histograms, by using one splitting point. This splitting point has normally been calculated by using the input image's statistics, such as the average intensity value [5] or the median intensity value [6].

In order to further improve the performance of the contrast enhancement method in terms of the mean brightness preservation performance, several GHE based methods split the input image's histogram into more than two sections. This multiple separated histogram is obtained by using more than one splitting point. These separating points are typically calculated based on each section's average intensity values [7], median intensity values [8], and local minimum or local maximum values of histogram's bin [9].

Yet, several other GHE based contrast enhancement methods do not put any constrain on preserving the mean brightness. These methods avoid the appearance of unwanted artifacts in their output images by controlling the enhancement rate, which relates to the slope of the intensity mapping function, by modifying the shape of the input histogram. Such modifications are normally been carried out by clipping the histogram [4], applying a weighting function to the histogram's bins [10], or creating a complementary histogram [11].

However, GHE and its derivative methods process the image globally, which mean that these methods use only one monotonically increasing transformation function for each input image. As mentioned in [11], the calculation for this discrete transformation function is done by using discrete values. Therefore, the contrast enhancement is obtained by increasing the spaces between consecutive histogram bins. Yet, mostly the histogram bins with small values will be merged together, which lead to the deterioration of contrast for intensity levels with low probability values.

Local HE, also known as adaptive HE, is still not been fully explored. Unlike GHE based methods, local HE methods generally produce sharper images. As local HE is able to introduce new intensity levels into the output image, they may flatten the image histogram and thus increase the information content (i.e., which normally can be measured by using entropy value) [12]. One of the basic local HE methods is the block overlapped HE (BOHE). BOHE works by using a sliding window of size $W_{\mathrm{M}} \times W_{\mathrm{N}}$, which defines a local contextual region on the image [1]. This local region is treated as a subimage by BOHE, and thus a similar procedure to GHE is applied in order to determine the local intensity mapping function. However, for each windowing operation, only the center pixel of the contextual region is assigned the output value. As a consequence, for a given input image with dimensions $\mathrm{M} \times \mathrm{N}$ pixels, BOHE needs MN local intensity mapping functions, which leads to high computational time.

In this paper, a new method, which is called the quadrant directional switching equalization of separated plateau limit sub-histograms for local content (QDSESPLS), has been proposed. This paper is divided into four sections. After this introductory section, Section 2 will explain the methodology of QDSESPLS. The next section, which is Section 3, will present the experimental results and discussions. Finally, Section 4 will present the conclusion from this research work.

2.0 Methodology

The main objective of QDSESPLS is to increase the image contrast and sharpness, especially to images that suffer from uneven illumination. QDSESPLS also aims to preserve the mean brightness of the input image, so that intensity saturation problem can be avoided. The basic ideas of QDSESPLS are listed as follows.

(i) Reducing saturation artefact: QDSESPLS uses quadrant directional equalization, where the intensity mapping moves towards the local mean value.
(ii) Reducing noise amplification: QDSESPLS utilizes clipped sub-histograms in order to avoid abrupt intensity changes.
(iii) Reducing the processing time: switching approach has been used, so that instead of calculating transfer functions from four sub-histograms, QDSESPLS calculates one transfer function from one sub-histogram only.

The methodology for QDSESPLS is explained in the following subsections.

2.1 Define the Contextual Region

Similar to BOHE, the operation of QDSESPLS uses a sliding filter of size $W_M \times W_N$ pixels, where both W_M and W_N are odd integer numbers (i.e., $W_M = 2W_H + 1$ and $W_N = 2W_W + 1$). Here, W_H and W_W are integer values, presenting the distance from the center pixel of the sliding filter to the filter's border in vertical direction and horizontal direction, respectively.

This sliding filter is used to define the local image, or also known as the Contextual Region (CR), for local processing. Let assume (i, j) as the spatial coordinates of the pixel, and (y, x) represents the spatial coordinates for the center pixel of the current CR. Using the sliding filter, CR will only occupy the area with coordinates in the range of $y - W_H \le i \le y + W_H$ and $x - W_W \le j \le x + W_W$.

In the implementation of QDSESPLS, truncation of the sliding filter has been applied for the pixels located near the image border. For example, when coordinates (y, x) is at position (0, 0) the corresponding CR is truncated to the size of $(W_H + 1) \times (W_W + 1)$ pixels, instead of $W_M \times W_N$ pixels. At this position, the center pixel of CR is not located at the middle of CR, but is the pixel located at the top-left. By using truncation approach, the size of the original input image can be maintained and the padding operation (e.g., zero padding, padding with global average value, or padding with global median value) toward the input image is not needed. In this research, it is believed that the sampled intensity values from the truncation approach are more accurate than the padding approach, as the sample will not be contaminated by artificially added values.

2.2 Create Local Histogram

As mentioned in previous subsection, at every center pixel, (y, x), one CR is defined. If the input image, denoted as $\mathbf{X} = \{X(i, j)\}$, has the intensity levels within the range $[0, L-1]$ $(\text{i.e., } X(i, j) \in \{X_0, X_1, ..., X_{L-1}\})$, the sub-image defined by CR, $\mathbf{X_{CR(y,x)}} = \{X_{CR(y,x)}(i, j)\}$, also has the intensity levels $[0, L-1]$. Using this CR, a local intensity histogram $H_{CR(y,x)}$ is defined as:

$$H_{CR(y,x)}(X_k) = n_k, \quad \text{for } k = 0, 1, ..., L-1 \tag{1}$$

where X_k is the k-th intensity level and n_k is the number of pixels within CR with intensity level X_k

2.3 Separate Histogram into Four Sub-histograms

With the aim of maintaining the local mean brightness within CR, local mean-separation methodology has been used. The mean-separation methodology was first introduced by [5] in his method known as Brightness Preserving Bi-Histogram Equalization (BBHE). Unlike BBHE that uses global average intensity value as the splitting point, first, the middle local splitting point $\tilde{X}_{1CR(y,x)}$ in QDSESPLS, which is also the average intensity value from the samples within CR is computed. This local separating point is defined as:

$$\tilde{X}_{1CR(y,x)} = \left\lfloor \frac{\sum_{k=0}^{L-1} \left(X_k \times H_{CR(y,x)}(X_k) \right)}{W_M \times W_N} \right\rfloor \tag{2}$$

Next, both of the sub-histograms are split further into four sub-histograms. These recursive mean separation points are defined as:

$$\tilde{X}_{2CR(y,x)} = \left\lfloor \frac{\sum_{k=0}^{\tilde{X}_{1CR(y,x)}} \left(X_k \times H_{CR(y,x)}(X_k) \right)}{W_M \times W_N} \right\rfloor \tag{3}$$

And

$$\tilde{X}_{3CR(y,x)} = \left\lfloor \frac{\sum_{k=\tilde{X}_{1CR(y,x)}+1}^{L-1} \left(X_k \times H_{CR(y,x)}(X_k) \right)}{W_M \times W_N} \right\rfloor \tag{4}$$

where $\lfloor \cdot \rfloor$ is the floor function.

2.4 Clip the Corresponding Sub-Histogram

A special consideration is given in order to limit the amplification of speckle noise which may degrade the appearance of the resultant contrast enhanced image. In QDSESPLS, histogram clipping approach has been utilized. By clipping histogram bins which are exceeding certain threshold value, we can control the enhancement rate defined by the local intensity mapping function. Therefore, the enhanced pixel value at (y,x) will not deviate too much from its surrounding homogenous region. Adapted from Bi-Histogram Equalization with a Plateau Limit (BHEPL), the threshold value $T_{CR(y,x)}$ for the histogram clipping process is obtained by using the average value from sub-histogram [13]. However, unlike BHEPL, a switching approach has been used. The value for $T_{CR(y,x)}$ is defined as:

$$T_{CR} = \begin{cases} T_{L1}, & \text{if } X(y,x) \le \tilde{X}_{2CR(y,x)} \\ T_{L2}, & \text{if } \tilde{X}_{2CR(y,x)} + 1 < X(y,x) \le \tilde{X}_{1CR(y,x)} \\ T_{U1} & \text{if } \tilde{X}_{1CR(y,x)} + 1 < X(y,x) \le \tilde{X}_{3CR(y,x)} \\ T_{U2} & \text{otherwise} \end{cases} \tag{5}$$

where

$$T_{L1} = \left\lfloor \frac{\sum_{k=0}^{\tilde{X}_{2CR(y,x)}} H_{CR(y,x)}(X_k)}{\tilde{X}_{2CR(y,x)} + 1} \right\rfloor + 1 \tag{6}$$

,

$$T_{L2} = \left\lfloor \frac{\sum_{k=\tilde{X}_{2CR(y,x)}+1}^{\tilde{X}_{1CR(y,x)}} H_{CR(y,x)}(X_k)}{\tilde{X}_{1CR(y,x)} - \tilde{X}_{2CR(y,x)}} \right\rfloor + 1 \tag{7}$$

,

$$T_{U1} = \left\lfloor \frac{\sum_{k=\tilde{X}_{1CR(y,x)}+1}^{\tilde{X}_{3CR(y,x)}1} H_{CR(y,x)}(X_k)}{\tilde{X}_{3CR(y,x)} - \tilde{X}_{1CR(y,x)}} \right\rfloor + 1 \tag{8}$$

and

$$T_{U2} = \left\lfloor \frac{\sum_{k=\tilde{X}_{3CR(y,x)}+1}^{L-1} H_{CR(y,x)}(X_k)}{L - \tilde{X}_{3CR(y,x)} - 1} \right\rfloor + 1 \tag{9}$$

By using either one of this threshold value, QDSESPLS clips the histogram bins as follows:

$$H'(X_k) = \begin{cases} T_{CR}, & \text{if } H_{CR(y,x)}(X_k) \geq T_{CR} \\ H_{CR(y,x)}(X_k), & \text{otherwise} \end{cases} \tag{10}$$

Next, sub-histogram from the clipped histogram H' needs to be normalized, so that pdf of that histogram section can be obtained. In order to do this, the total number of pixels from the modified sub-histogram, n_T is calculated.

$$n_T = \begin{cases} \sum_{k=0}^{\tilde{X}_{2CR(y,x)}} H'(X_k), & \text{if } X(y,x) \leq \tilde{X}_{2CR(y,x)} \\ \sum_{k=\tilde{X}_{2CR(y,x)}+1}^{\tilde{X}_{1CR(y,x)}} H'(X_k), & \text{if } \tilde{X}_{2CR(y,x)} + 1 < X(y,x) \leq \tilde{X}_{1CR(y,x)} \\ \sum_{k=\tilde{X}_{1CR(y,x)}+1}^{\tilde{X}_{3CR(y,x)}} H'(X_k), & \text{if } \tilde{X}_{1CR(y,x)} + 1 < X(y,x) \leq \tilde{X}_{3CR(y,x)} \\ \sum_{k=\tilde{X}_{3CR(y,x)}+1}^{L-1} H'(X_k) & \text{otherwise} \end{cases} \tag{11}$$

2.5 Create the Quadrant Directional Intensity Switching Mapping Function

After the corresponding normalized clipped sub-histogram has been found, intensity mapping function f for the use in QDSESPLS is defined. Function f is defined as:

$$f(X_k) = \begin{cases} f_{L1}(X_k), & \text{if } X(y,x) \leq \tilde{X}_{2CR(y,x)} \\ f_{L2}(X_k), & \text{if } \tilde{X}_{2CR(y,x)} + 1 < X(y,x) \leq \tilde{X}_{1CR(y,x)} \\ f_{U1}(X_k), & \text{if } \tilde{X}_{1CR(y,x)} + 1 < X(y,x) \leq \tilde{X}_{3CR(y,x)} \\ f_{U2}(X_k) & \text{otherwise} \end{cases} \tag{12}$$

where

$$f_{L1}(X_k)=\left\lfloor \frac{\tilde{X}_{2CR(y,x)}}{n_T}\times\sum_{j=0}^{k}H'(X_j)\right\rfloor \tag{13}$$

,

$$f_{L2}(X_k)=\left\lfloor \frac{\tilde{X}_{1CR(y,x)}-\tilde{X}_{2CR(y,x)}-1}{n_T}\times\sum_{j=\tilde{X}_{2CR(y,x)}+1}^{k}H'(X_j)\right\rfloor \tag{14}$$

,

$$f_{U1}(X_k)=\left\lfloor \frac{\tilde{X}_{3CR(y,x)}-\tilde{X}_{1CR(y,x)}-1}{n_T}\times\left(n_T-\sum_{j=k}^{\tilde{X}_{3CR(y,x)}+11}H'(X_j)\right)\right\rfloor+\tilde{X}_{1CR(y,x)}+1 \tag{15}$$

And

$$f_{U2}(X_k)=\left\lfloor \frac{\left(L-\tilde{X}_{3CR(y,x)}-2\right)}{n_T}\times\left(n_T-\sum_{j=k}^{L-1}H'(X_j)\right)\right\rfloor+\tilde{X}_{3CR(y,x)}+1 \tag{16}$$

Switching approach has been used to choose the suitable mapping function. Instead of calculating the mapping functions from four sub-histograms, QDSESPLS calculates one transfer function from one sub-histogram only. As a result, the processing time is reduced. It is worth noting that the equalization process defined by equations (13) and (14) propagate from the left to the right side of the sub-histogram. On the other hand, equalization process given by equations (15) and (16) propagate in opposite direction.

By using quadrant directional switching equalization, the transformed intensities with high histogram values will be given values similar to one of the mean value ($\tilde{X}_{1CR(y,x)}$, $\tilde{X}_{2CR(y,x)}$ or $\tilde{X}_{3CR(y,x)}$) depends on which region the intensities are situated.

Another benefit that can be obtained from quadrant directional switching equalization is the prevention from intensity saturation artifact. In normal local histogram equalization based methods, equalization process is always propagates from the left side to the right side of the histogram.

Thus, if the center pixel, $X(y,x)$ has the highest intensity value within CR, the corresponding output pixel $Y(y,x)$ will be assigned the highest intensity level (i.e., intensity X_{L-1}) that normally corresponds to the whitest pixel. As a consequence, the output image might suffer from intensity saturation artifact.

However, this is not a problem to QDSESPLS as the equalization process by this method is moving towards its mean value ($\tilde{X}_{1CR(y,x)}$, $\tilde{X}_{2CR(y,x)}$ or $\tilde{X}_{3CR(y,x)}$) instead of X_0 or X_{L-1}.

2.6 Map the Center Pixel

Finally, the output intensity value corresponds to the center pixel, $Y(y,x)$ is given as:

$$Y(y,x) = f(X(y,x)) \tag{17}$$

After the value of $Y(y,x)$ is determined, the sliding filter slides to the next adjacent pixel and repeats the same procedure until all the pixels in output image $\mathbf{Y}$ get their corresponding contrast enhanced values. As compared with GHE based contrast enhancement methods, which use one monotonic intensity mapping function for each input image, QDSESPLS uses $\mathbb{M} \times \mathbb{N}$ intensity mapping functions. In QDSESPLS, each pixel has its own transformation function. As a consequence, QDSESPLS is able to introduce new intensity levels into the output image. Hence, the utilization of the dynamic range in QDSESPLS is more effective than GHE based method.

3.0 Results and Disscussions

Nine digital images of size 3264 × 2448 pixels (i.e., 7.99-megapixel images) are used in this experiment in order to evaluate the performance of QDSESPLS. All of these images are 24-bit-per-pixel color images and were acquired using the camera from the same smartphone. This images are shown in Figure 1. In order to process these color images, in this experiment, we treat each color channel (i.e., red (R), green (G), and blue (B) color channel) as an independent 8-bitper-pixel grayscale image. Therefore, in order to process one color image, QDSESPLS will be executed three times, where each execution corresponds to one color channel. Thus, in this experiment, the level of quantization L is set to $2^8 = 256$.

(a) *Monkey* (b) *Fruits* (c) *Fire*

(d) *Statue* (e) *Alley* (f) *Café*

(g) *Hill* (h) *Sunset* (i) *Sea*

Figure 1: Nine input color images used in QDSESPLS experiment

Then, in order to benchmark the performance of QDSESPLS, three other common HE based contrast enhancement methods have been implemented. These three methods are GHE [1], BOHE [12], and CLAHE [14]. In this implementation, the filter size for QDSESPLS, BOHE and CLAHE is set to 129 × 129pixels.

Two image quality measures have been used for the evaluation process. As the images are color images, in this research work, the measurements will be carried out on the luminance value of the image. The luminance value I of the pixel at position (y,x) is calculated by using the following equation [1]:

$$I(y,x)=\frac{1}{3}\big(R(y,x)+G(y,x)+B(y,x)\big) \tag{18}$$

where R is the red color component, G is the green color component, and B is the blue color component.

In this evaluation process, only two image quality measures are considered which are Mean Brightness Error, MBE [7] and Speckle Noise Strength, SNS. The reason is because both MBE and SNS do not require any reference image. This is in contrast with most of the existing image quality measures that require a perfect image with no distortion as a reference [15]. Since the nine input color images used in QDSESPLS are not distortion-free, MBE and SNS measures are very suitable as evaluation tools for quantitative analysis.

The first measure is the MBE that is widely used as a quality measure for histogram equalization based methods. MBE is defined as:

$$\text{MBE}=\frac{\tilde{I}_Y-\tilde{I}_X}{\mathbb{M}\times\mathbb{N}} \tag{19}$$

where $\mathbb{M}$ is the height of the image, $\mathbb{N}$ is the width of the image, $\tilde{I}_Y$ is the average luminance value of the enhanced image, and $\tilde{I}_X$ is the average luminance of the original input image. It is expected that a good contrast enhancement method can preserve the mean luminance, and therefore has small value of MBE. Besides, smaller MBE value produces less saturation effect in the enhanced image.

The second measure is the SNS, which is defined as follows:

$$\text{SNS}=\frac{\sum_{y=0}^{\mathbb{N}-1}\sum_{x=0}^{\mathbb{M}-1}\left|I(y,x)-\hat{I}(y,x)\right|}{(L-1)\times\mathbb{M}\times\mathbb{N}}\times 100\% \tag{20}$$

where $\hat{I}$ is the approximation to a clean, enhanced image. In this work, $\hat{I}$ is obtained from the version of I that has been filtered by a median filter of size 25 × 25 pixels. This filter size is still relatively small when compared with the size of the input image (i.e., $\mathbb{M}$ and $\mathbb{N}$), and work well even when the image has been corrupted by high density of impulsive noise. Good enhancement method is expected to give small value of SNS. Hence, smaller SNS value indicates less noise amplification.

Table 1 shows the measured MBE values for each of the HE based contrast enhancement methods. As shown by Table 1, the proposed method, which is QDSESPLS, has the second lowest average MBE value (difference by 0.17 compare to CLAHE). Its average MBE value is lower than others (i.e. GHE and BOHE). This outcome shows that QDSESPLS has the ability to maintain the mean brightness of the image.

Table 2 shows the measured SNS values for each of the HE based contrast enhancement methods. As indicated in Table 2, all the contrast enhancement methods evaluated in this research increase the strength of the speckle noise. Yet, among these tested methods, QDSESPLS produces the lowest average SNS. Although CLAHE also uses clipping histogram approach similar to QDSESPLS, QDSESPLS has a better performance in SNS. This indicates that a better restriction for noise amplification can be obtained by combining the clipped histogram approach with quadrant directional equalization using sub-histograms.

Table 1: MBE values obtained from 9 input images

Methods / Image	GHE	BOHE	CLAHE	QDSESPLS
Monkey	23.3245	15.2141	10.5754	30.1937
Fruits	10.4738	13.5890	9.3127	20.7093
Fire	24.2728	38.7048	30.5922	23.4189
Statue	39.4145	45.6867	28.2706	15.3303
Alley	25.6025	28.3861	11.9334	15.4392
Cafe	52.9224	62.2760	42.9693	12.7964
Hill	11.3669	6.3181	7.0035	29.1706
Sunset	52.4181	80.1929	51.8291	20.3929
Sea	0.6324	6.0483	9.8283	36.3934
Average	26.7142	32.9351	22.4794	22.6494

Table 2: SNS values obtained from 9 input images

Methods / Image	GHE	BOHE	CLAHE	QDSESPLS
Monkey	10.4602	18.2116	12.6374	13.1788
Fruits	15.9535	23.8075	14.9450	10.3461
Fire	12.8723	21.9976	17.5813	7.9954
Statue	7.0348	19.8410	13.8103	9.6920
Alley	13.6009	22.8940	14.1334	12.6014
Cafe	20.8070	30.4298	20.1688	4.7768
Hill	7.7319	13.2477	9.5568	11.9953
Sunset	20.4854	44.9306	32.5611	6.6015
Sea	7.2053	20.6303	18.9394	12.6966
Average	12.9057	23.9989	17.1482	9.9760

Qualitative evaluation, by inspecting the appearance of the output images visually, has also been carried out in this research. Some of the output images are shown in Figure 2 to Figure 4. As shown by this figures, BOHE and CLAHE tend to enhance the edges too much, which make the resultant images lost their global contrast. On the other hand, images produced by QDSESPLS appear to be more natural. Furthermore, as also shown by these figures, QDSESPLS maintains the basic shape of the original histogram.

4.0 Conclusions

In this research work, a new contrast enhancement method has been proposed. This method is based on local HE method, where the method emphasizes on maintaining mean brightness, while improving contrast of small details on the image. As shown by the quantitative results, the proposed method has better performance in terms of preserving the mean brightness and avoiding significant noise amplification. Qualitative evaluation shows that the proposed method produces relatively more natural images. Therefore, it can be concluded that the proposed method shows the best overall performance.

5.0 References

[1] R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson Prentice Hall, Upper Saddle River, NJ, USA, 3rd edition, 2008.

[2] M. Petrou and P. Bosdogianni, Image Processing: The Fundamental, John Wiley & Sons, 2000.

[3] H. D. Cheng and H. Xu,"A novel fuzzy logic approach to contrast enhancement," Pattern Recognition, vol.33, no.5, pp. 809–819, 2000.

[4] S. Yang, J. H. Oh, and Y. Park, "Contrast enhancement using histogram equalization with bin underlow and bin overlow,"in Proceedings of the International Conference on Image Processing (ICIP '03), pp. 881–884, September 2003.

[5] Y.-T. Kim, "Contrast enhancement using brightness preserving bi-histogram equalization," IEEE Transactions on Consumer Electronics, vol.43, no.1, pp. 1–8, 1997.

[6] V. Magudeeswaran and C. G. Ravichandran, "Fuzzy logic-based histogram equalization for image contrast enhancement," Mathematical Problems in Engineering, vol. 2013, Article ID 891864, 10 pages, 2013.

[7] S.-D. Chen and A. R. Ramli, "Preserving brightness in histogram equalization based contrast enhancement techniques," Digital Signal Processing, vol. 14, no. 5, pp. 413–428, 2004.

[8] K. S. Sim, C. P. Tso and Y. Y. Tan, "Recursive sub-image histogram equalization applied to gray scale images," Pattern Recognition Letters, vol. 28, no. 10, pp. 1209–1221, 2007.

[9] K. Wongsritong, K. Kittayaruasiriwat, F. Cheevasuvit, K. Dejhan, and A. Somboonkaew, "Contrast enhancement using multi peak histogram equalization with brightness preserving," in Proceedings of the IEEE Asia-Paciic Conference on Circuits and Systems(IEEE APCCAS '98), pp. 455–458, November 1998.

[10] Q. Wang and R. K. Ward, "Fast image/video contrast enhancement based on weighted thresholded histogram equalization," IEEE Transactions on Consumer Electronics, vol. 53, no. 2, pp. 757–764, 2007.

[11] H. Ibrahim, N. S. P. Kong, C. H. Ooi, and D. C. J. Chieh, "Image enhancement with noise suppression ability using histogram manipulations," in Proceedings of the 1st International Conference on Information Science and Engineering (ICISE '09), pp. 579–582, December 2009.

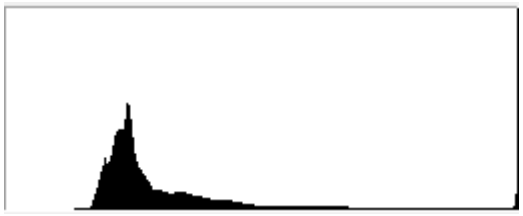
[12] N. S. P. Kong and H. Ibrahim, "Multiple layers block overlapped histogram equalization for local content emphasis," Computers and Electrical Engineering,vol. 37,no. 5, pp. 631–643, 2011.

[13] C. H. Ooi, N. P. Kong, and H. Ibrahim, "Bi-histogram equalization with a plateau limit for digital image enhancement," IEEE Transactions on Consumer Electronics,vol. 55, no. 4, pp. 2072–2080, 2009.

[14] S. M. Pizer, R. E. Johnston, J. P. Ericksen, B. C. Yankaskas, and K. E. Muller, "Contrast-limited adaptive histogram equalization: speed and effectiveness," in Proceedings of the 1st Conference on Visualization in Biomedical Computing, pp. 337-345, 1990.

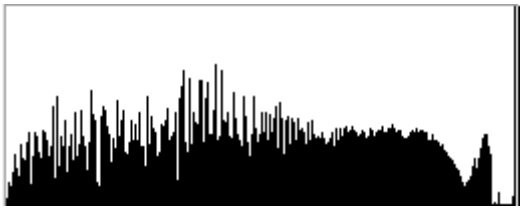
[15] Z. Wang, A. C. Bovik, H. R. Sheikh and E. P. Simoncelli, "Image Quality Assessment: From Error Visibility to Structural Similarity," IEEE Transactions on Image Processing. vol. 13, no. 4, pp. 600-612, 2004.

(a) Original input image



(b) Histogram of (a)

(c) GHE image



(d) Histogram of (c)

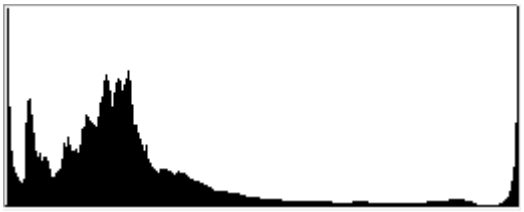
(e) BOHE image

(f) Histogram of (e)

(g) CLAHE image

(h) Histogram of (g)

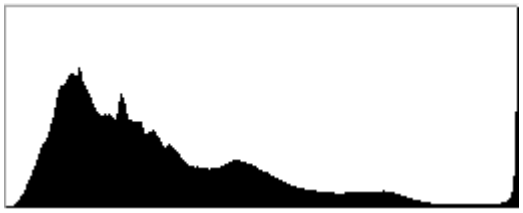
(i) QDSESPLS image



(j) Histogram of (i)

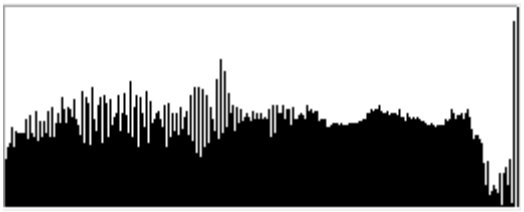
Figure 2: *Fire* and its enhanced version

(a) Original input image

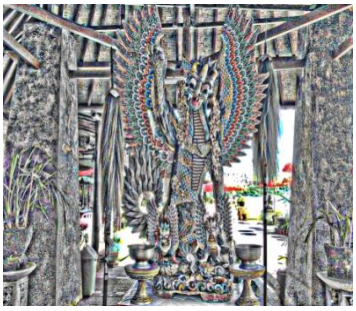


(b) Histogram of (a)

(c) GHE image



(d) Histogram of (c)



(e) BOHE image

(f) Histogram of (e)

(g) CLAHE image

(h) Histogram of (g)

(i) QDSESPLS image

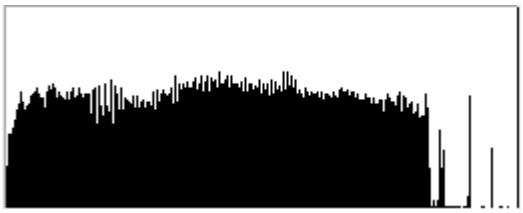
(j) Histogram of (i)

Figure 3: *Statue* and its enhanced version

(a) Original input image

(b) Histogram of (a)

(c) GHE image



(d) Histogram of (c)

(e) BOHE image

(f) Histogram of (e)

(g) CLAHE image

(h) Histogram of (g)

(i) QDSESPLS image

(j) Histogram of (i)

Figure 4: *Hill* and its enhanced version

I11: Remote AC Power Control Using Android

Mohamad Suhani Bin Hussin[1], Fauziah Bt Mohamad[2],
Rohani Bt Mat Ibrahim[3], Zuraini Bt Ghazali[4]
Institut Teknikal Jepun-Malaysia (JMTI), P.Pinang

suhani@jtm.gov.my, fauziah@jtm.gov.my, rohani@jtm.gov.my, zuraini@jtm.gov.my

Abstrak

Remote AC Power Controller Using Android direka dengan berkonsepkan sistem kawalan rumah berautomasi (selepas ini disebut Remote ACPC). Objektif utama ialah untuk mengawal lampu rumah dalam jarak tertentu dengan menjadikan telefon pintar mudah alih (smartphone) sebagai alat kawalan jauh. Ia menggunakan aplikasi android sebagai platform untuk memudahkan pengguna menggunakannya. Di samping itu projek ini juga boleh melaraskan kecerahan lampu untuk menjimatkan kos tenaga elektrik. Litar diuji secara simulasi untuk mengukur voltan dan keluaran cahaya dengan menggunakan Hukum Ohm. Keputusan yang diperolehi secara kiraan teori menunjukkan bahawa projek ini dapat menjimatkan penggunaan tenaga elektrik.

Keywords : *kawalan automasi, android, lampu*

1.0 Pengenalan

Projek ini direka untuk memudahkan pengguna menghidupkan dan mematikan lampu tanpa menggunakan suis. Aplikasi ini sesuai bagi golongan warga emas, orang kurang upaya, mereka yang memiliki kediaman dua tingkat, mereka yang terlupa untuk menutup lampu apabila keluar rumah dan lain-lain. Ia mempunyai dua fungsi iaitu menghidupkan dan mematikan lampu dan mengawal pencahayaan lampu dengan menggunakan aplikasi Android yang dimasukkan ke dalam telefon pintar.

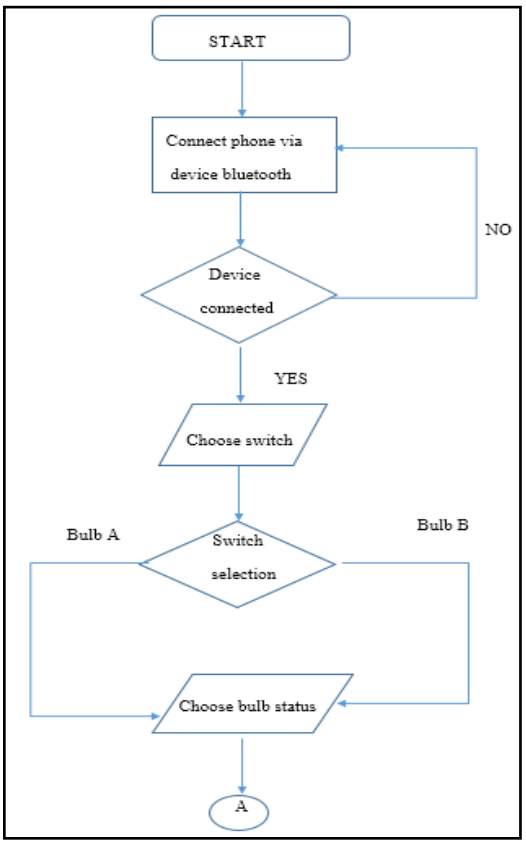
2.0 Latar Belakang

"AC Power Control Using Android" dihasilkan untuk memudahkan pengguna mengawal lampu dengan menggunakan aplikasi Android dengan GUI (*graphical user interface*) sebagai antaramuka. Untuk mencapai matlamat ini, aplikasi Android bertindak sebagai alat kawalan dengan menghantar arahan kepada peranti Bluetooth untuk menghidupkan (on) dan mematikan (off) kepada peranti penerima yang disambung kepada lampu beban [1]. Peranti Bluetooth digunakan untuk menghubungkan litar dengan Android menggunakan mikropengawal dari jenis Andruino UNO R3 untuk mengawal kecerahan lampu. Bekalan kuasa arus ulang-alik (AC) sebanyak 240 V digunakan yang disalurkan kepada lampu untuk menjana kuasa sebanyak 60 Watt. Kecerahan lampu dikawal dengan menggunakan aplikasi Android.

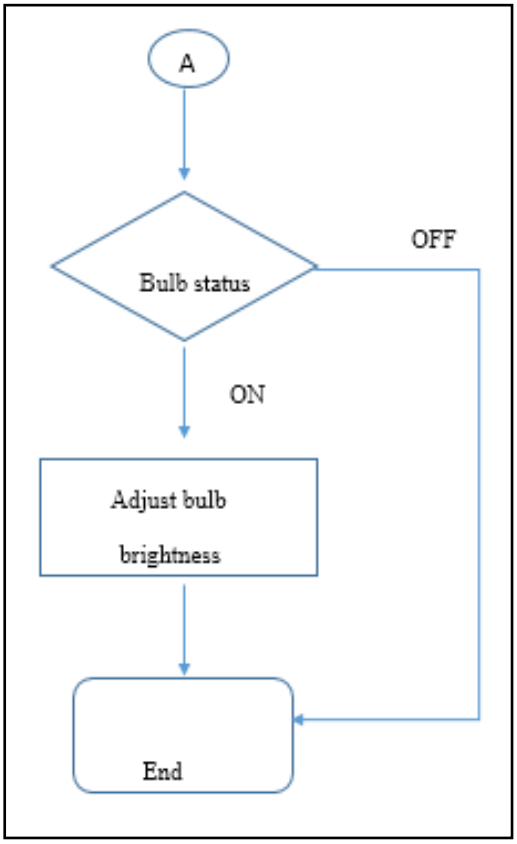
3.0 Metodologi

Sistem ini bermula apabila pengguna membuat sambungan Bluetooth menggunakan telefon pintar Android yang telah diprogramkan dengan mikropengawal Arduino untuk menerima isyarat tanpa wayar dan disambungkan kepada lampu. Apabila mikropengawal Arduino telah menerima isyarat Bluetooth dari Android, ia akan dihubungkan dengan lampu secara automatik untuk menghidupkan dan mematikan lampu tersebut. Android juga dibina aplikasi sesentuh dengan menggunakan GUI untuk mengawal kecerahan lampu pada masa yang sama apabila aplikasi buka dan tutup dijalankan.

3.1 Carta Alir Proses

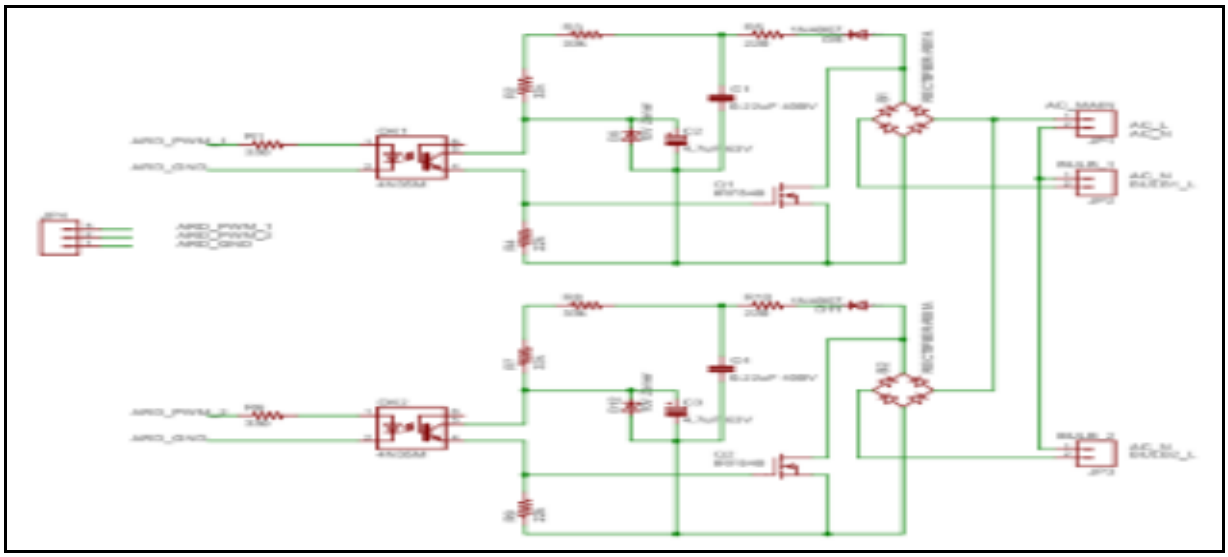


Rajah 1 : On/Off Lampu

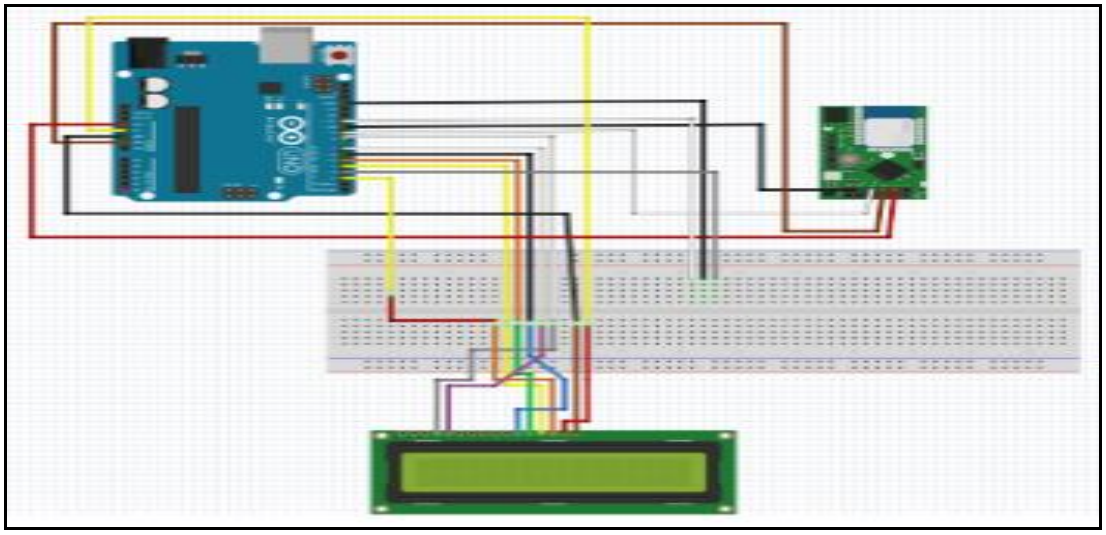


Rajah 2 : Mengawal Kecerahan Lampu

3.2 Gambarajah Litar



Rajah 3 : Gambarajah Litar Skematik

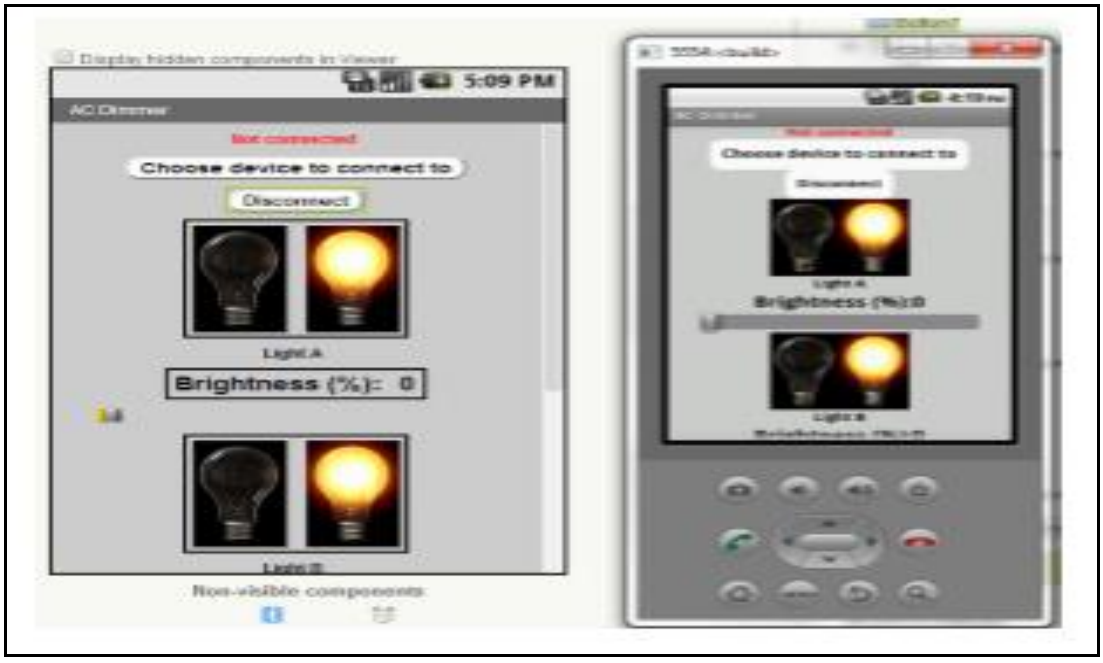


Rajah 4 : Gambarajah Litar 3D

3.3 Perisian dan Perkakasan Yang Digunakan

Projek ini menggunakan perisian *App Inventor* secara atas talian yang disokong oleh pelbagai sistem pengoperasian dan juga pelayar Internet untuk membina aplikasi antaramuka. Di samping itu, projek ini juga menggunakan aplikasi Arduino yang menggunakan Bahasa pengaturcaraan C dan perisian pembangunan *Java (Java Development Kt)* untuk aplikasi Android. Perkakasan yang digunakan adalah seperti *Arduino UNO R3*, *Bluetooth Module HC06*, lampu, *LCD Display* dan telefon pintar (*smartphone*).

3.4 Antaramuka Sistem



Rajah 5 : Antaramuka Telefon Pintar Yang DiBangunkan

4.0 Keputusan Analisa

Jadual 1: Analisa tenaga elektrik yang digunakan untuk satu hari.

Peratusan Penggunaan	Bulb (Watt)	Tempoh Guna (jam)	Kadar Bil (sehari)
100%	60	12	**RM** = (KWh*21.8) /100 = [(Watt*Jam Guna)/1000]/100 = (0.72*21.8)/100 **= 0.16**
75%	45	12	**RM** = (KWh*21.8) /100 = [(Watt*Jam Guna)/1000]/100 = (0.54*21.8)/100 **= 0.12**
50%	30	12	**RM** = (KWh*21.8) /100 = [(Watt*Jam Guna)/1000]/100 = (0.36*21.8)/100 **= 0.08**
25%	15	12	**RM** = (KWh*21.8) /100 = [(Watt*Jam Guna)/1000]/100 = (0.18*21.8)/100 **= 0.04**

Penggunaan tenaga elektrik adalah bermula dari pukul 7.00 malam hingga 7.00 pagi.
Pelarasan pada lampu dapat menjimatkan penggunaan tenaga elektrik serta kadar bil juga dapat dikurangkan.
Penggunaan lampu (Kecerahan) adalah bergantung kepada penggunaan pengguna.

5.0 Kesimpulan

Projek yang dibangunkan ini mempunyai fungsi untuk menghidup (on) dan mematikan (off) dan mengawal kecerahan lampu secara kawalan jauh. Ia boleh dikembangkan dengan menambah beberapa aplikasi lain seperti mengawal peralatan ketuhar gelombang mikro, kipas angin, penghawa dingin, tv dan sebagainya dengan peralatan-peralatan tersebut menggunakan suis manual untuk mematikan dan menghidupkannya. Projek ini juga boleh ditambah baik untuk mengawal peralatan secara serentak dengan paparan GUI Android yang lebih kompleks dengan pertambahan suis antaramuka bagi beberapa peralatan lain.

Aplikasi ini boleh digunakan oleh beberapa pengguna serentak apabila disambung dengan rangkaian tanpa wayar Bluetooth. Pada masa ini projek ini hanya memberi kebenaran pada seorang pengguna sahaja untuk menggunakannya. Di samping itu, jarak antara telefon pintar dengan mikropengawal boleh diluaskan sehingga beberapa meter bergantung kepada modul Bluetooth yang digunakan. Ia menjadi kemudahan kepada pengguna untuk menghidupkan dan mematikan suis lampu kerana pada hari ini aplikasi-aplikasi sistem banyak tertumpu kepada pembangunan Android kerana telefon pintar yang mempunyai pelbagai fungsi mampu dimiliki oleh semua orang kerana harga yang murah.

6.0 Rujukan

[1] IEEE 802.15.4, Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personnel Area Network (LR-WPANs), IEEE, October 1 2003.