TECHNICAL SESSIONS

TUESDAY, 15 June 2010 • SESSION I (2.00 pm – 4.00 pm)

Track 1: Materials and Manufacturing (Venue: Room 4-06)
Chairperson: AP Dr Faiz Ahmad

12.00 MM 01 Material Selection Process in an Oil Production Unit in One of Iranian Onshore Project M. Reza Moghaddam

12.20 MM 02 Effect of T6 heat treatment on the mechanical properties of gravity die cast A356 aluminium alloy Lim Ying Pio

12.40 MM 03 Predicting Combined Effects of HAc and H₂S on CO₂ Corrosion Yuli Asmar

Track 2: IM – Inspection and Maintenance (Venue: Room 4-07)
Chairperson: Dr Syed Ihtsham Ul-Haq Gilani

12.00 IM 01 Effect of Age of Pipes on Performance of Natural Gas Transmission Pipeline Network System Abraham Woldeyohannes; Mohd Amin Abd Majid

12.20 IM 02 Stress Intensity Factor for Cracks Emanating from a Shaft Sze Wei Kho; Saravanam Karuppanan

12.40 IM 11 Organizational Structure and Performance of Plant Turnaround Maintenance in Large Process-Based Industries in Malaysia Zulkifli Ghazali

Track 3: EF – Energy and Fuel (Venue: Room 4-08)
Chairperson: Dr Zainal Ambri Abd Karim

12.00 EF 02 Numerical Simulation of Front Evolving Fiber Suspension Flow in Three-Dimensional Cavities Ahmed N. Oumer; Ahmed M. S. Ali; Othman Mamat

12.20 EF 03 Trade-off between NOx, Soot and EGR rates for an IDI diesel engine filled with JB5 Mohamed Gomaa; Ahmad Alimin; kamarul Azhar Kamarudin

12.40 EF 04 Models of Neural Network with Sigmoid and Radial Basis Functions for Velocity-field Reconstruction in Fluid-Structure Interaction Problem Mas Irfan Purbawanto Hidayat

Track 4: PE – Plant Equipment (Venue: Room 4-09)
Chairperson: Ir Dr Mohd Shiraz Aris

12.00 PE 03 Vibration Analysis of Flexible Gantry Crane System Subjected to Swinging Motion of Payload Edwar Yazid; Setyamartana Parmar; Khairul Fauad

12.20 PE 16 Generating Gas Turbine Component Maps Relying On Partially Known Overall System Characteristics Tamiru Alemu Lemma; Fakhruddin Mohd Hashim; Chaililullah Rangkuti

12.40 PE 01 Modeling of thermodynamic processes in the automatic welding of plates Yaroslav Tereshchenko

TUESDAY, 15 June 2010 • SESSION III (4.20 pm – 6.00 pm)

Track 1: MM - Materials and Manufacturing (Venue: Room 4-06)
Chairperson: AP Dr Puteri Sri Melor Megat Yusoff

4.20 MM 04 A Study of Bonding Mechanism of Expandable Graphite Based Intumescent Coating on Steel Substrate Sami Ullah; Faiz Ahmad, Puteri Sri Melor Megat Yusoff

4.40 MM 05 Development and Strengthening of 2219 Aluminum Alloy by Mechanical Work and Heat Treatment Muhammad Rafi Raza; Nazma Ikram; Rafiq Ahmad; Faiz Ahmad; Abdul Salam

5.00 MM 06 Effect of Machining Parameters on Surface Roughness During Wet and Dry-Wire EDM of Stainless Steel Sulaiman Abdul Kareem; Ahsan Khan; Zakaria Zain

5.20 MM 12 A Semi-elliptical Crack Modeling and Fracture Constraint on Failure Diagram Julendra B. Ariaedja; Othman Mamat; Khairul Fauad

5.40 MM 26 Reconfigurable Stewart Platform for Spiral Contours Sathcsh Gopal; Nagarajan T
TECHNICAL SESSIONS

Track 2: MM - Materials and Manufacturing (Venue: Room 4-07)
Chairperson: Dr Mokhtar Awang

4.20 MM 07 Production of MMC EDM Tools Using Powder Metallurgy Technique Noor Haslyena Hassan; Norhidayah Mohd Zain; Ibrahim Mustaffa; Md. Saidin Wahab

4.40 MM 10 Stress Analysis on Sialon/Ferritic Stainless Steel Joint Cik Suhana Hassan; Patthi Hussain; Mokhtar Awang

5.00 MM 14 Machining of Cemented Tungsten Carbide Using EDM Al Tidjani Mahamat; Ahmad Majdi Abdul Rani; Patthi Hussain

5.20 MM 11 Study on the Fibre Reinforced Epoxy-based Intumescent Coating Formulations and the Char Characteristics Norallin Amir; Faiz Ahmad; Puteri Sri Melor Megat Yusof

Track 3: EF - Energy and Fuel (Venue: Room 4-08)
Chairperson: Dr Azura Ken Japaer @ Jaafar

4.20 EF 05 Ocean wave energy along Terengganu coast of Malaysia Abdul Majed Muzathik; WB Wan Nik; MZ Ibrahim; KB Samo

4.40 EF 06 Flame Development study at Variable Swirl Level Flows in a Stratified CNG DI Combustion Engine Using Image Processing Technique Yohannes T Anbese; Zainal A Abdul Karim

5.00 EF 07 Performance Evaluation of Stratified TES using Sigmoid Dose Response Function Joko Wuluyo; Mohd Amin Ab Majid

5.20 EF 08 Smoldering Combustion of Biomass Particles Khaideh Madhusudan Chirag; Kadli Vijay; Vasudevan Raghavan; Ali Rangwala

5.40 EF 09 Effect of the Moments of Probability Density Function for Non-Uniform Air Flow Distribution on the Hydraulic Performance of a Fin-Tube Heat Exchanger Wai Meng Chin; Vijay Raj Raghavan

Track 4: PE - Plant and Equipment (Venue: Room 4-09)
Chairperson: Prof Dr T. Nagarajan

4.20 PE 04 Design of a Vertical Self-balancing Autonomous Underwater Vehicle Kamarudin Bin Shehabudeen; Fakhruddin Hashim

4.40 PE 09 Analysis of the Temperature Distribution in GT Blade Cooled by Compressed Air Hussain Al-H. Al-Kayiem; Amir Hossein Ghanizadeh

5.00 PE 10 Modeling of the Waxing-Dewaxing Process in Scraped Surface Exchangers Nassir Mokhlif; Hussain Al-H. Al-Kayiem

5.20 PE 18 Two-Phase Flow Behaviour and Pattern in Vertical Pipes Mohamad Ardan Zubir

Wednesday, 16 June 2010 • SESSION IV (8.30 am – 10.30 pm)

Track 1: MM - Materials and Manufacturing (Venue: Room 4-06)
Chairperson: AP Dr Patthi Hussain

8.30 MM 08 Solid Freeform Fabrication of Prototypes Using Palm Oil Based Fly Ash Via 3D Printer Norhidayah Mohd Zain; Ibrahim Mustaffa; Md. Saidin Wahab; Noor Haslyena Hassan

8.50 MM 13 Feasibility of Electro-Discharge Machining of Aluminium Matrix Composite Alexs Mouang Nanimina, Ahmad Majdi Abdul Rani; Faiz Ahmad, Azman Zainuddin

9.10 MM 15 Binder Removal from Powder Injection Molded 316L Stainless Steel Muhammad Rafi Raza; Faiz Ahmad; Mohammad Omar

9.30 MM 44 The Study of Drilling Polyester Based Composite at Different Thickness on Damage Factor Mohd Azuwan Macinsor
TECHNICAL SESSIONS

Track 2: IN - Inspection and Maintenance (Venue: Room 4-07)
Chairperson: AP Dr Fakhruldin Mohd Hashim

8.30 IM 03 Fault Detection Relevant Modeling of an Industrial Gas Turbine based on Neuro-Fuzzy Approach Tamiru Alemu Lemma; Fakhruldin Mohd Hashim; Chalilullah Rangkuti

8.50 IM 04 Automated Calculations for Improvement of Tank Inventory at Fuel Terminals Shaharin Sulaiman; Sherrene Basil

9.10 IM 09 Problem Analysis at A Semiconductor Company: A Case Study on IC Packages Kamal Abidin; Keng Lee; Idris Ibrahim; Azman Zainuddin

9.30 IM 05 Performance Improvement through an Asset Maintenance Optimisation System Brian Cane

Track 3: EF – Energy and Fuel (Venue: Room 4-08)
Chairperson: Dr Setyamartana Parman

8.30 EF 10 Evaluation of heat and mass transfer coefficients for R134a/DMF bubble absorber Suresh Maniappan

8.50 EF 11 Artificial Intelligent System for Steam Boiler Diagnosis based on Superheater Monitoring Firas Basim Ismail Alnaimi; Hussain H. Al-Kayiem

9.10 EF 12 Transient Cooling Load Simulation of a Mechanical Workshop at UTP Using TRNSYS Petrus Tri Bhaskoro; Syed Ihtsham-ul-Haq Gilani

9.30 EF 31 Review on the Enhancement Techniques and a Novel Alternate of Solar Chimney Power Plant Ogboho Chikere Aja; Hussain H. Al-Kayiem; Zainal A Abdul Karim

9.50 EF 37 Droplet Size Measurement of Liquid Spray using Digital Image Analysis Abdelwahab Aroussi; Nectin Lad

Track 4: PE – Plant and Equipment (Venue: Room 4-09)
Chairperson: Ir Hj Idris Ibrahim

8.30 PE 06 The Development of Trash Diverter System For Tenom Pangi Hydro Power Station Intake, Sabah Hazza Abdul Hamid

8.50 PE 07 Open-Loop Responses of Flexible Gantry Crane System Edwar Yazid; Setyamartana Parman; Khairul Fudad

9.10 PE 13 Measurement Of Gas/Liquid Flow Velocities In A Rapidly Rotating Annulus Abdelwahab Aroussi

9.30 PE 05 A Study on the Use of Orifice Plates as Steam Traps Shaharin Anwar Sulaiman

Wednesday, 16 June 2010 • SESSION V (10.50 am -12.50 pm)

Track 1: MM – Materials and Manufacturing (Venue: Room 4-06)
Chairperson: AP Dr Othman Mamat

10.50 MM 09 Dynamic Mechanical and Thermal Analysis of Sugarcane Bagasse Filled Poly (Vinyl Chloride) Composites Riza Wirawan; Mohd Salit Sapuan

11.10 MM 22 Distributed Formation Planning and Navigation Framework for Wheeled Mobile Robots Kuppan Chetty Ramanathan; Singaperumal Makaram; Nagarajan T

11.30 MM 24 Cast Iron - An Old Name for a New Benchmark Material Adel Nofal

12.40 MM 28 Multiple Performance Optimization for the Best Metal Injection Molding (MIM) Green Compact Khairur Rijal Jamaludin; Mohd Yusof Md Daud

Track 2: MM – Materials and Manufacturing (Venue: Room 4-07)
Chairperson: Hj Kamal Arif Zainal Abidin

10.50 MM 27 Analysis of a Valveless Micropump Using Preliminary Characteristics from Fluid Flow Devarajan Ramasamy Devarajan; Zainal A Abdul Karim, S Mahendran, Nagarajan T
11.10 MM 34 Fabrication of Graphite/Carbon Nanotubes/Epoxy Nanocomposites: Electrical Conductivity and Flexural Strength  
Hendra Suherman; Jaffar Sahari

11.30 MM 37 The Influence of Aramid Fibre Content on the Tribological Behaviour of Non-asbestos Brake Liners  
Vinitha Ranganathan; Gopinath Konechady; Shankar Krishnapillai

Track 3: EF - Energy and Fuel (Venue: Room 4-08)  
Chairperson: AP Dr Mohd Amin Abd Majid

10.50 EF13 A Short Review on the Analytical Methods in Fluid Dynamics Research: The Importance of Exact Solutions  
Gunawan Nugroho; Ahmed M. S. Ali; Zainal A. Abdul Karim

11.10 EF14 A Simulation Study of Downdraft Gasification of Oil-Palm Fronds, Using ASPEN PLUS  
Samson Mekhib Atanaw; Shaharin Anwar Sulaiman; Suzana Yusup

11.30 EF16 Effect of Exhaust Gas Recirculation on the Combustion of Gasoline and CNG by Compression Ignition  
Naveen Chandran Panchatcharam

11.50 EF15 Exergy based Performance Analysis of a Gas Turbine at Part Load Conditions  
Aklila Baheta; Syed Thsham-ul-Haq Gilani

12.10 EF12 Performance and Emission Characteristics of Supercharged Product Gas-Diesel Dual Fuel Engine from Biomass Gasification  
Suhaimi Hassan; Zainal Alimuddin Zainal Alauddin; Miskam M.A.; Mohd Faizairy Mohd Nazri

Track 4: EF - Energy and Fuel (Venue: Room 4-09)  
Chairperson: M Faizairy M Nor

10.50 EF15 Spray Characteristic Comparisons of Compressed Natural Gas and Hydrogen fuel Using Digital Imaging  
Salah Eldin Elfikiki

11.10 EF16 An experimental study of different effects of varying EGR rates on the nitric oxide (NO) emissions of the direct injection compressed natural gas engine at various excess air ratios  
Saheed Wasu

11.30 EF17 A Preliminary Study on Synthesis Gas Produced by Gasification of Oil Palm Fronds  
Mohamad Nazmi Zaidi Moni; Shaharin Anwar Sulaiman

11.50 EF18 Measurement of Near Wall Fluid Interaction With an Atomised Spray  
Abdelwahhab Aroussi; Neetin Ladi; David Adebayo

12.10 EF17 Studying the Operation of Free Piston Linear Generator Engine Using MOSFET and IGBT Drivers  
Abdulwahhab Adem Ibrahim; Ezran Zharif B. Zainal Abidin; A. Rashid A. Aziz; Saiful Azrin bin Mohd Zakilifi

Wednesday, 16 June 2010 • SESSION VII (4.20 pm – 5.00 pm)

Track 1: MM - Materials and Manufacturing (Venue: Room 4-06)  
Chairperson: AP Dr Puteri Sri Melor Megat Yusoff

4.20 MM 17 The Influence of Applied Load on Wear Characteristics of Rail Material  
Windarta; Mustafar Sudin; Khairul Fuad

4.40 MM 18 Experience on Friction Stir Welding (FSW) and Friction Stir Spot Welding (FSSW) at Universiti Teknologi Petronas  
Ifatun Ahmad; Mokhtar Awang; Patthi Hussain

5.00 MM 36 Investigation of Worn Surface Characteristics of Steel Influenced by Jatropha Oil as Lubricant and Eco-friendly Lubricant Substituent  
Abdul Munir Hidayat Syah Lubis; Mustafar Sudin; Bambang Ariwahjoedi

5.20 MM 42 Experimental Analysis Of Energy Absorption On Pultruded Composite Tube Under Oblique Loading  
Sulong Abu Bakar

5.40 MM 29 Interface layer of the Diffusion Bonded Sialon and High-Chromium Steel  
Hudsono Firmanto; Patthi Hussain; Othman Mamat
### TECHNICAL SESSIONS

#### Track 2: IR – Integrity & Reliability (Venue: Room 4-07)
**Chairperson:** Dr. Brian Cane

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<td>IR 01 PICA: Pipeline Integrated Corrosion Assessment Tool for Structure Integrity</td>
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<td>4.40</td>
<td>IR 02 Methodology for Soil-Corrosion Study of Underground Pipeline</td>
<td>Norhazilan Md Noor; Siti Rabe'ah Othman; Lim Kar Sing; Nordin Yahaya</td>
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<td>IR 03 Study on the Effect of Surface Finish on Corrosion of Carbon Steel in CO2 Environment</td>
<td>Yuli Asmaea</td>
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<td>IR 07 Advancement in Cathodic Protection Monitoring</td>
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#### Track 3: Energy and Fuel (Venue: Room 4-08)
**Chairperson:** Dr. Mohd Shiraz Aris

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<td>Sreejaya. k. V.Kv; Hussain H. Al-Kayiem</td>
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<td>EF 18 Experimental Studies on a Swirling Fluidized Bed with Annular Distributor</td>
<td>Mohd Faizal; Vijay Raj Raghavan</td>
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<td>EF 27 Analytical Models for Energy Audit of Cogeneration Plant</td>
<td>Zainal A Abdul Karim; Philip Yonggo</td>
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<td>EF 39 Study the Dynamic Behaviour of Micro Bubbles in Distilled and Polluted Water</td>
<td>Syed Ithsham-ul-Haq Gilani; Felixtianus Eko Wismoro Winarto</td>
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<td>EF 01 Three Dimensional Aerodynamic Design System for Turbomachines</td>
<td>Arkan Al Yasari Al Tai; Hairham Al Waked</td>
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#### Track 4: IR – Integrity & Reliability (Venue: Room 4-09)
**Chairperson:** Dr. Shaharin Anwar Sulaiman

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<td>PE 11 Numerical Analysis of Thermal and Elastic Stresses in Thick Pressure Vessels</td>
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<td>PE 08 Investigation on the Particle Settling Velocity in Non-Newtonian Fluids</td>
<td>Rawia Ehtibi; Hussain H. Al-Kayiem</td>
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<td>Sharafiz Abdul Rahim</td>
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<td>PE 14 Improvements To The 'Aroussi-Ishaq' Film Measurement Technique</td>
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<td>PE 15 Fouling Characteristic and Tendencies of Malaysian Crude Oils Processing</td>
<td>M Zamidah Ahmad</td>
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**Thursday, 17 June 2010 • SESSION IX (10.50 am – 12.50 pm)**

#### Track 1: MM – Materials and Manufacturing (Venue: Room 4-06)
**Chairperson:** Dr. Ahmad Majdi Abd Rani

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<td>MM 19 Predicting the Young's Modulus of Single-Walled Carbon Nanotubes (SWCNTs) using Finite Element Modeling</td>
<td>Ehsan Mohammadpour; Mokhtar Awang; Mohamad Zaki Abdullah</td>
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<td>MM 40 High Temperature Tribological Characteristics of Cast Iron</td>
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<td>MM 43 Injection Molding Parameter Optimization of Titanium Alloy Powder Mix with Palm Stearin and Polyethylene for Multiple Performance Using Grey Relational Analysis</td>
<td>Nor Hafiez Mohamad Nor; Nochamidi Muhumad; Ahmad Kamal Ariffin; Mohd Rusi; Khairur Kijal Jamainudin</td>
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<td>12.10</td>
<td>MM 45 Weld Corrosion in CO2 Environment</td>
<td>Anis Amilah</td>
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Track 2: MM – Materials and Manufacturing (Venue: Room 4-07)
Chairperson: Dr Khairul Fuad

10.50 MM 30 Finite Element Modelling of Static and Radial Ultrasonic Interface Friction in Compression Test
Mohd Yusof Md Daud; Khairur Rijal Jamaludin

11.10 MM 31 Wear Properties of Alumina Particles Reinforced Aluminium Alloy Matrix Composite
Muhammad Rafi Raza; Faiz Ahmad; Ahmad Majdi Abdul Rani; S. H. Lo

11.30 MM 35 Optimizing Injection Molding Processing Parameters for Enhanced Mechanical Performance of Oil Palm Empty Fruit Bunch High Density Polyethylene Composites
Puteri Sri Melor; M. R. Abdul Latif; Muhammad Shazwan Ramli

11.50 MM 38 SMA Actuator Technology Application in the Platform Construction
Victor Amirtham; Nagarajan T; Abdul Malik bin Sardi Roslan, Fakhruddin Mohd Hashim

12.10 MM 49 Review of Current Development of Pneumatic Artificial Muscle
Krishnan; Nagarajan T; Ahmad Majdi Abdul Rani

Track 3: EF – Energy and Fuel (Venue: Room 4-08)
Chairperson: AP Arkan Al Tai

10.50 EF 19 Analysis of Annual Cooling Energy Requirements for Glazed Academic Buildings
Shaharin Sulaiman, Ahmad Hadi Hassan

11.10 EF 20 A Preliminary Investigation into the Use of Solar PV Systems for Residential Application in Bandar Sri Iskandar, Malaysia
Dimas F Al Riza; Syed Ihtsham-ul-Haq Gilani; Mohd Aris

11.30 EF 26 Development of a Three Dimensional Large Eddy Simulation (LES) Code for Turbulent Flows
Timothy Ganesan

11.50 EF 33 Drag Reduction of Biopolymer Flows
Azraeen Jaar; Robert Poole

Track 4: EF – Energy and Fuel (Venue: Room 4-09)
Chairperson: AP Dr Hussain H. Al-Kayiem

10.50 EF 21 Comparison of HCCI and SI Characteristics on Low Load CNG-DI Combustion
Noraz

11.10 EF 24 Gas Flame Temperature Measurement Using Background Oriented Schlieren
Emishaw Iff; A. Rashid A. Aziz

11.30 EF 29 Steady State Simulation of a Double-effect Steam Absorption Chiller
Mojahid Ahmed; Syed Ihtsham-ul-Haq Gilani

Yusheila Md Yunus; Hussain H. Al-Kayiem; Khairul Ammar Kamarul Baharin

12.10 EF 35 Experimental Study on Micro Heat Pipe Configuration on Diesel Engine Performance
Idris Ibrahim; Kamal Abidin; Azman Zainuddin; T. N. Aiman Tuan Kamaruddin

Thursday, 17 June 2010 • SESSION X (2.00 PM – 4.00 PM)

Track 1: MM – Materials and Manufacturing (Venue: Room 4-06)
Chairperson: Mohd Ridzuan Abd Latiff

2.00 MM 21 Effect of Vermiculite Addition on Thermal Characteristic of Water-based Acrylic Fire Retardant Coating Formulation
Wan Aina Liza Wan Zaharuddin; Bambang Ariwahjoedhi, Patthi Hussain

2.20 MM 25 The Foundry Technology Department at CMRDI – An Overview of the Past and Outlook for the Future
Adel Nofal; Mohamed Waly

2.40 MM 32 A Comparative Investigation into the Two-way Training of Shape Memory Alloy Vortex Generators Manufactured in a Selective Laser Melting Process
Mohd Aris

3.00 MM 41 Investigation on Solidification behaviour of Cast Iron Using FEM Software
Sugrib Shaida

3.20 MM 47 In-line Inspection Robot System using Image Processing Technique
Ramachandran Ramakrishnan

2010 International Conference on Plant Equipment and Reliability a conference of World Engineering, Science & Technology Congress
**Track 2: IR – Integrity and Reliability (Venue: Room 4-07)**

**Chairperson:** Hj Azman Zainuddin

- **2.00** IR 04 Modeling of Maintenance Downtime Distribution using Expert Opinion
  - Hilmi Hussin; Fakhruldin Hashim

- **2.20** IR 05 A Multi-State Reliability Model for a Gas Fueled Cogenerated Power Plant
  - Maceseret Reshid, Mohd Amin Abd Majid

- **2.40** IR 06 Burst Strength Analysis of Corroded Pipelines by Finite Element Method
  - Chanyalew Belachew; Mokhtar Che Ismail; Saravanan Karuppannan

- **3.00** IR 08 Reliability and availability evaluation for a multi-state system subject to minimal repair
  - Masdi Muhammad; Mohd Amin Abd Majid

**Track 3: IM – Inspection and Maintenace (Venue: Room 4-08)**

**Chairperson:** Hj Kamal Ariff Zainal Abidin

- **2.00** IM 07 RCM Analysis of Process Equipment: A Case Study on Heat Exchangers
  - Mohd Amin Abd Majid; Masdi Muhammad

- **2.20** IM 08 Switching System for Control of Stochastic Hybrid Multiple Models
  - Vu Minh; Fakhruldin

- **2.40** IM 10 Probabilistic Reliability Assessment of an Insulated Piping in the Presence of Corrosion Defects
  - Ainul Mokhtar

- **3.00** MM 33 Structural and Properties Development of Expanded Austenite Layers on AISI 316L after Low Temperature Thermochemical Treatments
  - Askar Triwiyanto, Mustafar Sudin, Esa Haruman, Shahjahan Mridha, Parthi Hussain

- **3.20** MM50 Design of Comparative Thermal Analysis of Circular and Profiled Looking Channels for Injection Mould Tools
  - Kurram Aitaf; Ahmad Majdi Abdul Rani; Vijay Raj Raghavan

**Track 4: EF – Energy and Fuel (Venue: Room 4-09)**

**Chairperson:** Dr Zainal Ambi Abd Karim

- **2.00** EF 22 The Tube Side Heat Transfer Coefficient for Enhanced Double Tube by Wilson Plot Analysis
  - Ramahlingam Tiruselvam; Vijay Raj Raghavan

- **2.20** EF 23 The Combustion Behavior Analysis of Dual Fuel HCCI Using the SHELL Model
  - Firmansyah

- **2.40** EF 25 A Computational Fluid Dynamics (CFD) Simulation of the Viscous Flow Encountered in the Mold-Filling Process
  - Suren Sinnadurai; Ahmed M. S. Ali

- **3.00** EF 40 Effect of Spray Cone Angle on Combustion of Compressed Natural Gas Direct Injection (CNG-DI) Engine Under Lean Stratified Conditions
  - Raja Shahzad Hassan Raja
ABSTRACTS

Effect of Spray Cone Angle on Combustion of Compressed Natural Gas Direct Injection (CNG-DI) Engine Under Lean Stratified Conditions

Raja Shahzad Hassan Raja

CNG as an alternative fuel has been applied in vehicles to reduce engine emissions with a trade off of engine performance. It has lower performance compared to gasoline due to lower volumetric efficiency, and longer combustion durations. However, high octane number of CNG is beneficial in increasing engine efficiency by employing high compression ratios. Direct injection application on CNG engine is expected to increase the volumetric efficiency of the engine, compared to conventional mixer technologies, to get improved engine performance while still maintaining low engine emissions. The following experimental study discusses the effect of injection cone angle on the combustion characteristics of CNG in a direct injection engine at lean stratified conditions. The experiments were carried out on a dedicated CNG-DI engine with a 14:1 compression ratio and central injection system. A stratified piston with a specially designed bowl in the crown was used. Injection was set to take place 12 degrees after the intake valve closure i.e. at 120 degrees BTDIC. Two different injectors having different spray cone angles were used. AFR was kept at about 36.5-37:1 and ignition timing was adjusted to obtain maximum brake torque (MBT). Engine load was kept constant while engine speed was varied from 2000-4000 RPM. The results obtained showed that wide cone angle injector
Study of Dynamic Behaviour of Micro Bubbles in Distilled and Polluted Water

Felixtianus Eko Wisno Winaeto, Syed Isham Ul-Haq Gilani, Department of Mechanical Engineering, University Technology PETRONAS, 31750 Tronoh, Perak, MALAYSIA. Email: felix.eko@yahoo.co.uk, Fax: 006053656461

Abstract—The zigzag upward movement of millimeter size spherical air bubble in a vertical column water purification system adds undesired turbulence effect and acts as a suspended particulate stainer. Size reduction of air bubbles is one of the solutions to minimize the turbulence effect. Lifting up of the suspended particle require minimum size-up of the air bubble.

An experimental setup is established to study the development of small size air bubbles in a vertical water column. Porous sintered glass with porosities of 1 to 40% are used to produce micro bubbles. Compressed air at a pressure of 27 kPa is forced through the diffuser to release bubbles at the bottom of the water column.

The strategies to control the bubble size in monodispersed and polydispersed cases are discussed. Microbubble technique was used to remove suspended particles in polluted water. Bubble horizontal velocity diminishes when maximum air pressure reaches 22 kPa. By using Glycerin in various volume fractions of 0.1% to 0.5% and CMC (Carboxy Methyl Cellulose) as water pollutant, the relationships between air pressures, vertical and horizontal velocities, as well as bubble size are established.

Index Terms: Micro bubble, water treatment technique, diffuser, polydispersed, polluted water.

1. INTRODUCTION

Air bubbles flowing in aeration system have many purposes, i.e. air absorbing into water, stirring process, and suspended particle lift-up. Air absorbing is to supply oxygen or other gases into the water, therefore it can support microorganism's life. Stirring process is to transfer mass or heat into water hence forming a uniform solution. Suspended particle lift-up is to clean up water from impurities.

The above three processes can't be explicitly separated. In a bubble column, four different regions may be distinguished [1].

1. The region of primary bubbles (produced by the gas distributor).
2. The region of secondary bubbles (produced by break-up of the primary ones).
3. The region of dynamic equilibrium between coalescence and disruption of the bubbles.
4. The separation region, at the top of the liquid layer.

The other phenomenon is collision among bubbles vertically and/or horizontally that creates bigger bubbles [2]. This phenomenon prevents small bubbles production. However, some researcher found that small bubble could be produced by separation [3, 4]. For small bubbles less than 1.5 mm, they rise rectilinearly [5].

To generate a small bubble need a small hole diffuser. To create bubbles less than 100 microns size, minimally 10 micron pore material are required. A porous sintered glass has been used to create micron bubbles. The porosities used are 1 to 40 micron. For the milli hole size, the average bubble diameter was calculated using the following equation [1, 9].

\[ d_{b} = 0.289 \rho_{a}^{0.048} \mu_{a}^{0.038} \sigma^{0.112} U_{g}^{-0.34} \] \hspace{1cm} (1)

Or, in an approximation dimensionless form:

\[ Fr = \frac{0.5 \mu_{a}^{0.38} U_{g}^{1.5}}{\sigma} \] \hspace{1cm} (2)
Fr – Froude number \( Fr = \frac{U_d^2}{g d^2} \)

The above equation was derived for acetaldehyde, acetone, cyclohexane, n-heptane isopropanol, methanol and toluene. For distilled water the bubble diameter equation is function of gas velocity.

\[ d_b = \frac{(U_d)}{c} \] (3)

where:

\[ U_d = \frac{(P_d)}{c} \] (4)

The physicochemical characteristics of distilled water, \( \rho \) (density), \( \mu \) (viscosity), and \( \sigma \) (surface tension) are constants, \( \rho \approx 0.994 \text{ g/cm}^3 \), \( \mu \approx 0.4 \text{ g/m.s.} \) and \( \sigma \approx 71 \text{ mN/m.} \)

It's found that the bubble diameter and velocity is a function of air pressure and flow. The air bubble starts to emerge from diffuser and grows bigger and departs from diffuser when the departing force (buoyancy) is higher than the surface tension of water. The departing force depends upon the following factors:

1. Density difference of air and water (influence the buoyancy).
2. Velocity of air (depends upon air pressure).
3. Surface tension (depends upon hydrophilic or hydrophobic of diffuser surface material).

It has been reported in the literature [13] that pore size is not the only factor controlling the bubble size, rather another important parameter that affects the bubble size is ratio of surface energy of the diffuser material to the surface tension of the liquid. Generally the higher the ratio, the smaller the bubble would be.

The surface energy can be improved by using material that has a hydrophilic surface, and the surface tension can be decreased by adding surfactant into the liquid.

The number of forces is acting on the bubble before it detaches from the diffuser and they are shown in Fig. 1 and mathematically described in table1.[12].

Figure 1: The balance of all forces acting on a growing bubble [12]

Some porous diffuser has a rough surface, therefore a small part of the surface would be flat and the rest of the surface would be inclined (Fig.2). This condition will influence the surface energy, because the buoyancy will decrease bubble pull out force, eventually increasing the size of bubble (Fig.3).

Figure 2. The surface roughness of the porous sintered glass diffuser

Figure 3. Buoyancy force on a bubble at horizontal and inclined surfaces.

After departing from the diffuser hole, the bubble functions as a stirrer or lifting up suspended particles. Bigger bubble (milli bubble) has a lower surface tension that creates an unstable shape, and function as a stirrer process in water. Smaller bubble (micro bubble) has high surface tension that creates a stable shape. This bubble
will rise up smoothly and function as a lifting up of the suspended particles.

Table 1. The forces excises on a bubble detachment.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_B$</td>
<td>buoyancy force</td>
<td>$F_B = \frac{\pi}{6}d_b^3(\rho_l - \rho_g)g$</td>
</tr>
<tr>
<td>$F_M$</td>
<td>gas momentum force</td>
<td>$F_M = \frac{\pi}{4} D_b^2 \rho_g u_i^2$</td>
</tr>
<tr>
<td>$F_D$</td>
<td>Liquid drag force</td>
<td>$F_D = C_D \frac{\pi}{4}d_b^2 \rho_g u_i \frac{d u_i}{d t}$</td>
</tr>
<tr>
<td>$F_s$</td>
<td>Surface tension force</td>
<td>$F_s = \pi D_b \sigma \cos \gamma$</td>
</tr>
<tr>
<td>$F_{BA}$</td>
<td>Basset force</td>
<td>$F_{BA} = -\frac{3}{2} \frac{d}{dt} \int_0^t \int_{\Omega_b(t')} \rho_k \left( v - \frac{d x}{d t} \right) \mu_{ij} \left( \frac{d x}{d t} \right) \delta(x - x(t')) dx'(t')$</td>
</tr>
<tr>
<td>$F_{ix}$</td>
<td>bubble inertial force</td>
<td>$F_{ix} = -\frac{d}{dt} \left[ \rho_L \left( \frac{\pi}{6} d_b^3 \right) \nu_x \right]$</td>
</tr>
<tr>
<td>$F_C$</td>
<td>particle-bubble collision force</td>
<td>$F_C = -\frac{\pi}{4} \left( D_b^2 + \frac{d_b}{2} \right) \rho_i \rho_p \left( \frac{d x}{d t} \right)$</td>
</tr>
<tr>
<td>$F_{i_s}$</td>
<td>liquid-solid suspension inertial force</td>
<td>$F_{i_s} = -\frac{d}{dt} \left( \int_0^t \int_{\Omega_b(t')} \rho_k \left( v - \frac{d x}{d t} \right) \mu_{ij} \left( \frac{d x}{d t} \right) \delta(x - x(t')) dx'(t') \right) \frac{\pi}{4} \left( D_b^2 + \frac{d_b}{2} \right) \rho_i \rho_p \left( \frac{d x}{d t} \right)$</td>
</tr>
</tbody>
</table>

Fig. 4 shows the micro bubbles and suspended particles circulate along the water column. The circulation carried the water and the suspended particles flow-up. After reach the top surface the bubbles broken. It produced water surface waves push flowing particles close to the water column wall. Its move down and some of suspended particles precipitated at the bottom of water column. At the top water surface unsettle particles will form foam. The water has been cleaned up, even not all particles can be separated from the water, but the significant reduction of water turbidity shows the effectiveness of this system.

The bubble characteristics, such as bubble diameter, rise-up velocity, and horizontal velocity in relationship with air pressure and flow are investigated. The effect of suspended particles separating from water represented by water turbidity level is monitored.

**EXPERIMENTAL SET-UP**

Fig. 5 shows the experimental set-up to produce air bubbles through a submerged diffuser at the base of a water column. It shows various transducers to monitor different parameters at the time. A vertical water column of 100 mm W x 6100 mm L x 240 mm H was used. Porous sintered glass with porosities of 1 to 10, 10 to 16 μm, and 16 to 40 μm were used to produce micro size bubbles.

Compressed air at a pressure range of 5 to 33kPa was forced through the diffuser at the bottom of the water column. A pressure regulator was used to control air flow in the system with a range of 0.25 to 1.8 liter/minute.

Fig. 6 shows the set-up to monitor the size of the air bubble and horizontal/vertical velocities using Laser Doppler Anemometry (LDA). Four laser beams having a diameter of 1mm, were shot from a laser source. Two laser beams were
horizontal (blue, at the right and left position), and other two beams were vertical (green, at the top and the bottom). The light made a cross junction at a certain point. The refraction of light (when light met bubbles) was accepted by a receiver and detected as a burst shown on a monitor. Each burst was detected and noted as a sample. The number of samples was 1 up to 2000 and the sampling duration was 30 seconds.

The experiment was carried out to find the behaviors of air bubbles in distilled water, ordinary tap water, and polluted water. Vertical movement of air bubbles lifts up suspended particles, which will form scum on the upper layer of water and precipitation particles in the bottom. The effectiveness and efficiency of the lifting process represent the optimum energy spent by diffuser air pressure. The initial air pressure level before bubble commencement depends on the depth of the water column. The air pressure should also overcome the diffuser porosity resistance. Further increment of air pressure influences the bubble dimension and compressible effect of air bubbles.

A diffuser was mounted at the bottom side of the water column. Various porosities of sintered glass were used to produce air bubbles (1-10μm, 10-15μm and 15-20μm). Pressurized air was induced through the diffuser. Glycerin solution was used to manipulate the variations of bubble surface tension, density and viscosity. It was found that the waste water density is 0.003g/cm³ higher than the density of 0.2% glycerin by volume in distilled water. This reality is due to the presence of various contaminants in the waste water. The pollutant solutions in distilled water were CMC and Glycerin, where CMC imitate as a suspended particles and Glycerin as a colloid matter. The bubble diameter and rise-up velocity was measured using LDA/PDA. The two contaminants were creating the cloudiness water solution; mentioned as a turbidity number. The turbidity was measured by Hach turbidimeter and has an NTU unit (Nephelometric Turbidity Unit).

Figure 6. Laser Doppler Anemometry (LDA) used to measure the bubble size and velocity.

RESULTS AND DISCUSSION

Monodispersed bubble is a single bubble that is detected at the point of interference of laser beams. The 1-10 μm porosity sintered glass produced certain horizontal and vertical velocities bubble. Fig. 7 represent graph from micro bubbles in tap water, where monodispense bubble was found at an air pressure of 22 kPa. The lower pressure produces single bubble dimension and single rise up velocity (monodisperse). The higher air pressure produces various size bubbles (polydispersed), as shown in Fig. 8.

The solid graphs are measurement result: Fig. 7(a) represents 43 μm bubbles diameter, counts 1 is mean 2000 bubbles were detected. Fig. 7(b) represents 3.7 m/s bubbles horizontal velocity, counts 200 is mean 400000 horizontal velocities were detected. The number is bigger than present bubble detecting, cause of every bubble can create more than one horizontal velocity (vibrate condition). This situation should not happen in vertical velocity, because vertical velocity is always in one direction (up). Fig. 7(c) represents 0.3 m/s bubbles vertical velocity.

Fig. 8. shows that the LDA detects four different bubbles sizes. The LDA also measures those bubbles have different rise-up velocities. Therefore, the velocity of each bubble can not be easily determined in the polydisperser graph than monodispersed case. The horizontal velocities give divergence counting with the bubbles exist, caused every bubbles have possibility to move in two directions, left or right. Also the bubbles change their horizontal velocity eventually by compressible air bubbles characteristic.
The distilled water has surface tension of 73 mN/m, while the presence of glycerin decreased the surface tension to a minimum of 53 mN/m. The more added percentage of glycerin increases the surface tension, where this phenomena influence the bubble detachment from diffuser. It turn causes the bubble to merge easily. The result, bubbles production has added size. Mean while the viscosity decrease and the water became denser and even in the other side the density increasing brings the higher density different between air and water (and produce higher buoyancy force), but it create a higher friction force too between bubble and water. The horizontal velocity become exists because of this balance force. From these phenomena, the glycerin impurity not only reduces the linearity of bubble movement or creates new horizontal velocities, but also adds the variation of bubble size, due to the bubble dispersion. The highly divergent of bubble is due to the fact that the three liquid phase properties (density, viscosity, and surface tension) can not be manipulated independently. It is impossible to modify one property without changing the other two. Consequently, the realizable range of air pressure for achieve zero horizontal velocity is very limited.

The air bubbles diameter produced by the sintered glass depends mainly on the porosities and supplied air (pressure and flow). Smaller porosity produces smaller bubbles, and also gives uniform bubbles in a certain air pressure range. Higher porosity produces polydisperse bubbles that means varied of bubbles diameter, horizontal and vertical velocities be excited. The bubbles move-up have a zig-zag trajectory motion, finally create stirring effect in the water. Even in the micro bubbles case has smaller stirring effect compare to millimeter size bubbles, therefore applied higher air pressure added bubbles diameter production, and than stirring effect. By limiting air pressure the smaller bubbles can be produced and the linear bubble move-up can be achieved.

The second order polynomial curve fit has been provided and found that smaller porosity produce more linear curve than the bigger porosity, as shown in Fig. 10. The porosity of sintered glass has a pressure range where the bubble diameter can be controlled. It influence by the resistant of porosity and the diffuser material.
The supplied air can be controlled by air pressure and automatically follow by the air flow. The smaller porosity needs smaller air flow and the bigger porosity need higher air flow. The result in Fig. 11 shows that the smaller porosity create a linear relation between bubble diameter and air flow, therefore bigger porosity produce varied bubbles diameter that creates non linear relation between bubble diameter and air flow.

Figure 10: The effect of various inlet air pressures on the bubble size through different porosity as diffuser.

Figure 11: The effect of various inlet air flow on the bubble size through different porosity as diffuser.

Figure 12: Relationship between bubble diameters and vertical velocity in distilled water.

Figure 13: The relationship between bubble diameters and vertical velocity in glycine polluted water.

For 0.1% glycine in distilled water the equation is derived from Eq. 3. Where \( d_v = \frac{1}{(U_v)} \).

The equation becomes: \( d_v = C U_v^\alpha \) \hspace{1cm} (5)

The logarithm of Eq. \( y = 6.9212 x - 103.69 \) is \( \ln(d) = \ln(6.9212 + \delta \ln(U) \) \hspace{1cm} (6)

which is a linear equation.

Taking \( y = K + mx \) \hspace{1cm} (7)

with \( \mu = \ln(d), x = \ln(U) \), \( \delta = \ln(6.9212) \)

Putting back into the original equation, it becomes: \( d = 9.29 \times 10^{-5} U_0^{-0.53} \) \hspace{1cm} (8)

The smaller air flow produces smaller air bubble and gives the better performance of lifting-up suspended particle. Stirrer effect is limited by reducing the air flow and pressure (less energy distributed). The 0.4 and 0.6 L/min air flow maintain produced stirrer effect. 0.2 L/min air flow gives better turbidity decreasing result as shown in Fig. 14.
The minimum flow rate is 0.2 l/min for bubble generating. More than 0.6 l/min flow rate, some bubbles production is in milli size. Reaching 2 l/min most of the bubbles production is in milli size. The better result on suspended particle lift-up is using 1-10 micron porous diffuser and 0.2 l/min air flow. The rate of suspended particles lift-up direct proportional to flow rate inversely.

CONCLUSIONS

Air pressure at 22 kPa produced monodispersed air bubbles. The condition shows uniform bubble size and gives the bubble uniform vertical velocity. Increasing inlet pressure produce increased air bubble vertical velocity at detachment. Polydispersed creation of bubble is a function of increased inlet flow rate. This dynamic behavior shows that air pressure and flow are a significant factor in micro air bubble control. The micro bubbles have a horizontal velocity that creates a zigzag trajectory.

Pollution in water influences the bubble characteristics, i.e., bubble diameter, horizontal and vertical velocities. These impurities also change the liquid characteristic, i.e., viscosity, density, and surface tension. The vertical velocity maintained at the average of 0.3 m/s in distilled water, and 0.5 m/s in polluted water, and air bubbles diameter range 11 to 110μm. The relationship between bubble diameter and vertical velocity at 0.1% glycerin impurity is calculated as: $d = 9.29 \times 10^{-10} \rho_\text{H}_2 \text{O}^{0.97}$. The minimum turbidity level is 3.8 NTU in 5 hours aeration, achieved by 1-10μm porosity and 0.2 l/min air flow. The smaller bubbles give better result in Turbidity decreasing.

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LIST OF SYMBOLS

- $C_D$: drag coefficient
- $d_{b,i}$: diameter of bubble
- $D_0$: orifice diameter
- $d_{v}$: volume-equivalent bubble diameter
- $e$: restitution coefficient
- $f$: inertial force
- $\gamma$: contact angle
- $\delta$: thickness of liquid film
- $\phi_\text{s}$: solids holdup
- $\rho_g$: gas density
- $\rho_s$: liquid density (kg/m$^3$)
- $\rho_{ss}$: density of liquid-solid suspension
- $\rho_s$: solids density
- $\tau$: viscosity stress tensor
- $u_b$: bubble rise velocity relative to the liquid phase
- $U_s$: bubble expansion velocity
- $U_v$: superficial air velocity
- $U_{ss}$: superficial bubble velocity
- $U_{s,i}$: superficial gas velocity (m/s)
- $\mu$: liquid viscosity
- $\mu_s$: suspension viscosity
- $\nu_i$: superficial gas velocity through the orifice

REFERENCES


