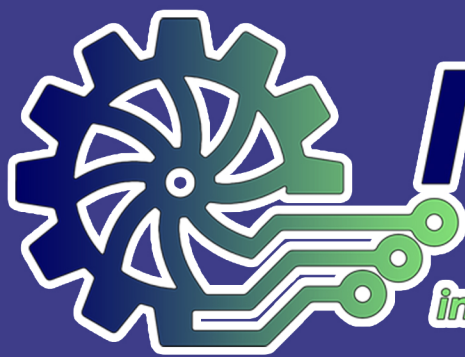




ICAME
International
Conference on Advances
in Mechanical Engineering

9th
edition

Programme Book

**Engineering Without Borders:
Towards a Sustainable Future**

13th-15th September 2026

Kuala Lumpur



Co-Hosts



UNIVERSITI
TEKNOLOGI
MARA

Institut
Pengajian Siswazah



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EDITORS

Dr Siti Rabizah Makhsin
Dr Nik Roselina Binti Nik Roseley
Dr Eli Nadia Binti Abdul Latip
Dr Roshakimah Binti Mohd Isa
Dr Farah Adilah Binti Mohd. Kasran

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Tel: 03-5543 5052

Website: <https://www.icame-uitm.com/>
E-mail: icamefkm@uitm.edu.my

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Welcoming Address from Dean

Assalamualaikum Warahmatullahi Wabarakatuh and Warm Greetings,

It is my great honour and privilege to extend a warm and cordial welcome to all distinguished participants of the 9th International Conference on Advances in Mechanical Engineering (ICAME2026).

Guided by the theme “Engineering Without Borders: Towards a Sustainable Future,” ICAME2026 reflects our collective commitment to advancing engineering excellence, strengthening international collaboration, and harnessing innovation to address the complex challenges confronting our world. The conference provides a distinguished platform for researchers, academic, engineering, industry professionals, and emerging scholars to exchange knowledge, share perspectives, and showcase pioneering developments across the broad spectrum of mechanical engineering.

In an era characterised by rapid technological transformation, environmental challenges, and evolving societal needs, the role of engineering extends far beyond the development of technologies and systems. Engineering must increasingly serve as a catalyst for sustainable development, resilience, and societal advancement. Emerging fields such as advanced materials, intelligent manufacturing, robotics, artificial intelligence, computational engineering, renewable energy, and sustainable technologies are reshaping the engineering landscape and creating new opportunities for impactful innovation.

Against this backdrop, ICAME2026 provides an important forum for the exchange of ideas and the advancement of knowledge across disciplinary and geographical boundaries. I encourage all participants to engage actively in the technical sessions, scholarly discussions, and networking opportunities throughout the conference. In particular, I hope that the research presented will not only contribute to scientific and technological advancement, but also demonstrate clear potential for addressing real-world challenges and supporting the aspirations of a more sustainable society.

I am confident that the interactions and intellectual exchanges fostered through ICAME2026 will strengthen existing partnerships while creating new opportunities for interdisciplinary research, academia—industry collaboration, and international engagement. More importantly, I hope that the conference will inspire innovative thinking and translate knowledge into meaningful solutions that create lasting value for industry and society.

I would like to express my sincere appreciation to the organising committee, technical committee, reviewers, keynote and invited speakers, sponsors, industry partners, collaborating institutions, and all contributors whose commitment, expertise, and dedication have made ICAME2026 possible. Your collective efforts are fundamental to the success and continued growth of this conference.

To our international and local participants, I hope that your engagement in ICAME2026 will be both intellectually enriching and professionally rewarding. I also trust that your time in Kuala Lumpur will provide an opportunity to experience the warmth, hospitality, and cultural diversity of Malaysia.

Once again, on behalf of the Faculty of Mechanical Engineering, UiTM Shah Alam, I warmly welcome you to ICAME2026. May this conference foster enduring collaborations, inspire transformative ideas, and generate impactful innovations that transcend disciplinary and geographical boundaries. May ICAME2026 be a meaningful platform for advancing engineering knowledge and shaping a more innovative, resilient, and sustainable future.

Thank you, and I wish you a productive, inspiring, and successful conference.

Prof. Ir. Dr. Azli Abd Razak
Dean
Faculty of Mechanical Engineering
Universiti Teknologi MARA (UiTM)
Shah Alam, Malaysia



Welcoming Address from Chairman General

*Bismillahirrahmanirrahim,
Assalamualaikum warahmatullahi wabarakatuh and warm greetings to all.*

On behalf of the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UITM), Shah Alam, it is my great pleasure and privilege to welcome you to the International Conference on Advances in Mechanical Engineering 2026 (ICAME2026).

Since its humble beginnings in 2009 as a national conference, ICAME has continued to grow in scope, participation and impact. Over the years, it has evolved into an international platform that brings together researchers, academicians, engineers, industry practitioners and emerging scholars to exchange knowledge, share innovative ideas and establish meaningful collaborations.

The theme of ICAME2026, “Engineering Without Borders: Towards a Sustainable Future,” captures the spirit of this year’s conference.

Through ICAME2026, we aspire to bring together a diverse global community of engineers and researchers who share a common vision: to transform knowledge and innovation into solutions that create meaningful and sustainable impact. ICAME2026 is therefore more than a platform for presenting research papers. It is a meeting of minds, a catalyst for innovation, and a gateway to global collaboration.

We are delighted to welcome participants to Kuala Lumpur, Malaysia, from 13 to 15 September 2026. As one of Southeast Asia’s most dynamic cities, Kuala Lumpur provides an inspiring setting for intellectual exchange, professional networking and cultural engagement. This year’s conference encompasses a broad spectrum of research areas, including advanced materials, thermal and fluid sciences, manufacturing and design, sustainable engineering, and emerging interdisciplinary technologies. These areas reflect the changing landscape of mechanical engineering and its growing contribution to addressing complex global challenges.

A distinctive feature of ICAME2026 is our special emphasis on engineering education and entrepreneurship. As technology continues to evolve at an unprecedented pace, engineering education must evolve with it. The engineers of the future must possess more than technical competence. They must be innovative, adaptable, resilient, ethically grounded and capable of transforming knowledge and ideas into solutions that generate value for industry and society.

In this regard, ICAME2026 seeks to strengthen the connection between knowledge and application, innovation and impact, and education and enterprise. Most importantly, let us use this conference to create connections that extend beyond these three days and to establish collaborations that will continue to generate knowledge, innovation and impact in the years ahead.

As we gather in Kuala Lumpur this September, let us celebrate not only the advances we have achieved, but also the opportunities that lie ahead. We look forward to welcoming you to TAMU Hotel & Suites, Kuala Lumpur, and to sharing an inspiring and memorable conference with all of you.

Thank you.

Wassalamualaikum warahmatullahi wabarakatuh.

Prof. Dr Salmiah Kasolang @ Kasalung

Chairman General
ICAME2026



Welcoming Address from Co-Chairman

Assalamualaikum Warahmatullahi Wabarakatuh and Warm Greetings,

It is my great pleasure, on behalf of the ICAME2026 Organising Committee, to welcome all distinguished speakers, researchers, academicians, engineers, and industry practitioners, postgraduate students, and participants to the 9th International Conference on Advances on Mechanical Engineering (ICAME2026).

ICAME is more than a platform for presenting research findings. It is a space for meaningful intellectual engagement—where ideas can be exchanged, perspectives challenged, knowledge expanded, and new possibilities explored. The true value of a conference lies not only in the quality of its technical contributions, but also in the conversions that take place beyond individual presentations. Through these interactions, we have the opportunity to develop new perspectives, identify common challenges, and establish collaborations that may extend well beyond this conference.

The engineering landscape is undergoing a profound transformation as emerging technologies reshape the way products, systems, and infrastructure are designed, manufactured, and operated. The convergence of digitalisation, intelligent systems, advanced materials, automation, and sustainable energy solutions is redefining the boundaries of mechanical engineering and expanding its role across diverse industries. As engineers and researchers, our responsibility is not simply to advance technology, but to ensure that innovation contributes meaningfully to a more sustainable, resilient, and inclusive future.

I encourage all participants to take full advantage of the technical presentations, keynote sessions, discussions, and networking opportunities throughout the conference. I particularly hope that the exchange of ideas will lead to new research directions, interdisciplinary initiatives, industry partnerships, and meaningful collaborations. The impact of ICAME2026 should ultimately extend beyond these conference sessions and contribute to the development of solutions that address real-world challenges.

It is our sincere hope that ICAME2026 will be a productive and engaging platform for knowledge sharing, professional networking, and the development of enduring collaborations. May the ideas exchanged here inspire new research, the connections established here lead to meaningful partnerships, and the knowledge shared here contribute to technological advancement and sustainable development.

I would also like to extend our appreciation to all authors and participants for sharing their research, knowledge, and experiences with the ICAME community. Your contributions are the foundation of this conference and are essential to creating an environment of meaningful academic and professional exchange. We hope you will find the conference intellectually stimulating, professionally rewarding, and personally memorable. May ICAME2026 inspire us to think beyond boundaries, collaborate across disciplines, and engineer solutions for a more sustainable future.

Thank you.

Assoc. Prof. Dr. Abdul Halim Abdullah
Co-Chairman
ICAME2026



Welcoming Address from Conference Chairman

Bismillahirrahmanirrahim.

Assalamualaikum Warahmatullahi Wabarakatuh, Salam Sejahtera, and a very warm welcome to everyone.

It is with great honor and pleasure that I welcome all distinguished speakers, esteemed researchers, industry representatives, academics, students, delegates, and honored guests to ICAME 2026, proudly organized by the Faculty of Mechanical Engineering at Universiti Teknologi MARA (UiTM), Malaysia.

On behalf of the ICAME 2026 Organizing Committee, I extend our sincere appreciation to all keynote and invited speakers, authors, presenters, reviewers, session chairs, co-hosts, collaborators, sponsors, supporting organizations, and participants. Your invaluable contributions, confidence, and continued support are central to the success and standing of ICAME.

I would also like to place on record my profound appreciation to the entire ICAME 2026 Organizing Committee. The successful organization of an international conference of this scale is the culmination of almost a year of careful planning, steadfast commitment, and close coordination.

Behind every element of the conference are dedicated teams managing paper submissions, reviews, and publications; secretariat, registration, and finance; promotion and outreach; sponsorship; stakeholder communication; technical sessions; event management; venue coordination; logistics; protocol; hospitality; and many other essential responsibilities. To every committee member, secretariat member, academic and administrative staff member, technical personnel, and volunteer, I offer my heartfelt gratitude for your dedication, perseverance, professionalism, and unwavering teamwork. Many hours of effort have taken place behind the scenes, often under demanding circumstances, and your collective commitment has made ICAME 2026 possible. It has been a true privilege to serve alongside such a dedicated team.

May ICAME 2026 inspire meaningful discourse, advance new research directions, strengthen existing collaborations, and cultivate enduring partnerships. Above all, may the knowledge and ideas shared during this conference contribute towards technological progress and sustainable engineering solutions for the betterment of society.

On behalf of the Organizing Committee, I warmly welcome you to ICAME 2026 and wish all participants a rewarding, enriching, and memorable conference.

Thank you.

Dr. Siti Rabizah Makhsin

Conference Chairman

ICAME2026



ABOUT ICAME2026

ICAME2026 is an international hybrid conference, which gather engineers, scientists, industry professionals, and researchers to present and discuss about topics related to synergy in engineering, science and technology. It provides a premier forum for researchers, developers and practitioners to present and discuss new problems, solutions, and latest technologies in the world. ICAME2026 welcomes researchers, engineers, scientists, and industry professionals to share technical knowledge and experience in this conference. ICAME2026 is an ideal platform for keeping up with advances and changes to a consistently morphing field. Leading researchers and industry experts from around the globe will be presenting the latest studies through papers and oral presentations.

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Bin Remeli

Ergonomics and workstation Assessment (EWA)

Ts Dr Helmi Bin Rashid

Structural Dynamics, Analysis & Validation (SDAV)

Assoc. Prof. Ir Dr. Mohd Azmi Bin Yunus

KEYNOTE SPEAKERS

01



IR. TS. DR. SHAMSUL KAMAR ABU SAMAH

Addressing Future National Aerospace Ecosystem through Strategic R&T Synergies
CEO
National Aerospace Industry Corporation (NAICO)
MALAYSIA

PROF. DR. NAOKI UCHIYAMA

Design and Applications of Feedforward Control Systems for Industrial Machinery
Toyohashi University of Technology
JAPAN

02



03



PROF. IR. TS DR. SHEIKH AHMAD ZAKI BIN SHAIKH SALIM

Beyond the Thermostat: Engineering Human-Centric Thermal Comfort for a Sustainable Tropical Future
Universiti Teknologi Malaysia (UTM)
MALAYSIA

PROF. DR. MOHAMMAD JAWAID

Green and Sustainable Biocomposites from Natural Fibres
College of Engineering,
United Arab Emirates University
UAE

04



TENTATIVE PROGRAMME

*Engineering Without Borders:
Towards a Sustainable Future*

Day 0: 13 Sept 2026 (Sunday)				
	Ball Room			
15:00 – 17:00	Registration			
Day 1: 14 Sept 2026 (Monday)				
	Ball Room			
08:00 – 08:30	Registration			
08:30 – 09:00	Opening Ceremony			
09:00 – 09:45	Ir. Ts. Dr. Shamsul Kamar Abu Samah Addressing Future National Aerospace Ecosystem through Strategic R&T Synergies CEO National Aerospace Industry Corporation (NAICO) MALAYSIA			
09:45 – 10:30	Prof. Dr. Naoki Uchiyama Design and Applications of Feedforward Control Systems for Industrial Machinery Toyohashi University of Technology, JAPAN			
10:30 – 10:45	Coffee Break & Poster Session			
	Breakout Session			
	Ball Room (Level 13)	Room 2 (Function Room 2, Level 13)	Room 3 (Podium 4, Level 2)	Room 4 (Podium 5, Level 2)
10:45 – 13:00	P1: Advanced Mechanical Design, Manufacturing & Simulation	P2: Advanced Materials for Sustainable Engineering	P3: Malaysia – Japan Joint Symposium On Biomechanics & Medical Engineering 2026	P4: Mechatronics, Control & Intelligent Systems
	Session chair: Dr. Mohd Khalid Mohd Nor (NAICO Malaysia) Invited speaker: Prof. Ashish K Rajak T1-O-B11 T1-O-A140 T1-O-A08 T1-O-A14 T1-O-A63 T1-O-A72	Session chair & invited speaker: Prof. Dr. Eng. Didik Nurhadiyanto T3-O-B20 T3-O-A93 T3-O-A67 T3-O-A20 T3-O-A02 T3-O-B19	Session chair: Assoc. Prof. Ts. Dr. Abdul Halim Abdullah Invited speaker: Assoc. Prof. Dr. Mitsugu Todo T8-O-B14 T8-O-B16 T8-O-B05 T8-O-B06 T8-O-B08 T8-O-B17	Session chair: Ir. Zainal Abidin Kamarul Baharin Invited speaker: Assoc. Prof. Dr. Wan Nurshazwani Wan Zakaria T7-O-A77 T7-O-B03 T7-O-B04 T7-O-A86 T8-O-B07 T7-O-A88
13:00 – 14:00	Lunch			

TENTATIVE PROGRAMME

	Ball Room (Level 13)	Room 2 (Function Room 2, Level 13)	Room 3 (Podium 4, Level 2)	Room 4 (Podium 5, Level 2)
14:00 – 15:45	P5: Advanced Mechanical Design, Manufacturing & Simulation	P6: Advanced Materials for Sustainable Engineering	P7: Malaysia – Japan Joint Symposium On Biomechanics & Medical Engineering 2026	P8: Mechatronics, Control & Intelligent Systems
	Session chair & invited speaker: Dr. Hussain Ali Alenezi T1-O-B15 T1-O-A85 T1-O-A29 T1-O-A32 T1-V-A31 (V) T1-O-A24 (V)	Session chair: Prof. Dr. Hj. Muhammad Izzat Nor Ma'arof Invited speaker: Prof. Dr. Aidah Jumahat T3-O-B24 T3-O-B21 T3-O-A04 T3-V-A39 T3-O-A111 T3-O-A50	Session chair & invited speaker: Dr. Eng. Azizah Intan Pangesty Invited speaker: Ts. Dr. Helmi Rashid T1-O-A134 T8-O-A124 T8-O-A135 T8-O-A105 T8-O-A125 T8-O-A23 (V)	Session chair & invited speaker: Dr. Sukarnur Che Abdullah T7-O-A91 T7-O-A83 T7-O-A100 T7-O-A37 T7-V-A75 (V) T7-V-A136 (V)
15:45 – 16:00	Coffee Break & Poster Evaluation Session T3-O-A113 T1-O-A102 T3-O-A119 T1-O-A131 T1-O-A137 T1-O-A145 T1-V-A42 T1-V-A107 T5-O-A40 T3-O-A57			
	Ball Room (Level 13)	Room 2 (Function Room 2, Level 13)	Room 3 (Podium 4, Level 2)	Room 4 (Podium 5, Level 2)
16:00 – 17:30	P9: Advanced Mechanical Design, Manufacturing & Simulation	P10: Automotive Engineering	P11: Advanced Materials for Sustainable Engineering	P12: Thermofluid & Sustainable Energy
	Session chair & invited speaker: Dr. Alias Mohd Saman T1-O-A130 T1-O-A33 T1-O-A106 T1-V-A99 (V) T1-V-A115 (V) T1-O-A27 (V)	Session chair & invited speaker: Assoc. Prof. Dr. Aman Mohd Ihsan Mamat T5-O-A41 T5-O-A62 T3-O-A108 T5-V-A54 (V) T5-V-A118 (V) T5-V-B22 (V)	Session chair & invited speaker: Assoc. Prof. Dr. Koay Mei Hyie T3-O-A81 T3-O-A10 T3-O-A13 T3-V-A43 (V) T3-O-A05 (V) T3-V-B23 (V)	Session chair & invited speaker: Assoc. Prof. Dr. Priyo Agus Setiawan T6-O-A35 T6-O-A126 T6-O-A21 T6-V-A98 (V) T6-V-A74 (V) T6-V-A47 (V)
17:30	Adjourned			

TENTATIVE PROGRAMME

Day 2: 15 Sept 2026 (Tuesday)				
	Ball Room			
08:00 – 08:30	Registration			
08:30 – 09:15	Prof. Ir. Ts Dr. Sheikh Ahmad Zaki Bin Shaikh Salim Beyond the Thermostat: Engineering Human-Centric Thermal Comfort for a Sustainable Tropical Future <i>Universiti Teknologi Malaysia</i>			
09:15 – 10:00	Prof. Dr. Mohammad Jawaid Green And Sustainable Biocomposites From Natural Fibres <i>College Of Engineering, United Arab Emirates University, UAE</i>			
10:00 – 10:30	Coffee Break & Poster Evaluation Session T5-O-A139 T3-O-A104 T5-O-A49 T3-O-A129 T5-O-A03 T6-V-A34 T6-O-A73 T3-O-A26 T1-V-A36 T-O-A122			
	Ball Room (Level 13)	Room 2 (Function Room 2, Level 13)	Room 3 (Podium 4, Level 2)	Room 4 (Podium 5, Level 2)
	P13: Thermofluid & Sustainable Energy	P14: Advanced Materials for Sustainable Engineering	P15: Aerospace/ Aviation Technology	P16: Engineering Education & Entrepreneurship
10:30 – 12:45	Session chair & invited speaker: Assoc. Prof. Ir. Dr Irnie Azlin Zakaria T6-O-A97 T6-O-A138 T6-O-A01 T6-O-A18 T6-O-A16 T6-V-A68 T6-O-A144	Session chair: Dr. Temitope Theophilus Dele-Afolabi Invited speaker: Ts. Dr. Nik Roselina Nik Roseley T3-V-B25 (V) T3-O-A87 T3-O-A92 T3-V-A80 (V) T3-V-A95 (V) T3-O-A48	Session chair & invited speaker: Assoc. Prof. Ts. Dr. Rizal Effendy Mohd Nasir T2-O-A78 T2-O-A79 T2-O-B01 T2-V-A127 T2-O-A38 T2-O-A94 T7-V-A55 (V)	Session chair & invited speaker: Prof. Ts. Dr. Salmiah Kasolang T9-O-A82 T9-O-A15 T9-O-A101 T9-O-A103 T9-O-A120 T9-V-A109 (V)
12:45 – 14:00	Lunch			

TENTATIVE PROGRAMME

	Ball Room (Level 13)	Room 2 (Function Room 2, Level 13)	Room 3 (Podium 4, Level 2)	Room 4 (Podium 5, Level 2)
14:00 – 16:00	P17: Thermofluid & Sustainable Energy	P18: Advanced Materials for Sustainable Engineering	P19: Structural Dynamics & Vibrations	P20: Advanced Mechanical Design, Manufacturing & Simulation
	Session chair & invited speaker: Assoc. Prof. Ir.Ts. Dr. Baljit Singh T6-O-A76 T6-O-A90 T6-O-A147 T3-O-A06 T6-V-A141 (V) T6-V-A28 (V) T6-V-B13 (V)	Session chair: Dr. Adel Mohammed Al-Dhahebi Invited speaker: Dr. Siti Rabizah Makhsin T3-O-A117 T3-O-A11 T3-O-A12 T3-O-A70 T3-O-A89 T1-O-A132	Session chair & invited speaker: Ir. Ts. Dr. Muhamad Sukri Bin Hadi T7-O-A52 T4-O-A84 T4-O-A61 T4-O-B09 T4-O-A45 T4-V-A56 (V) T4-V-A60 (V)	Session chair & invited speaker: Ir. Ts. Dr. Mohammad Azzeim Mat Jusoh T6-O-A66 T4-O-A46 T1-O-A110 T1-O-A112 T1-O-A123 (V) T1-V-A65 (V) T1-V-A69 (V)
16:00 – 16:30	Coffee break			
16:45	Adjourned			

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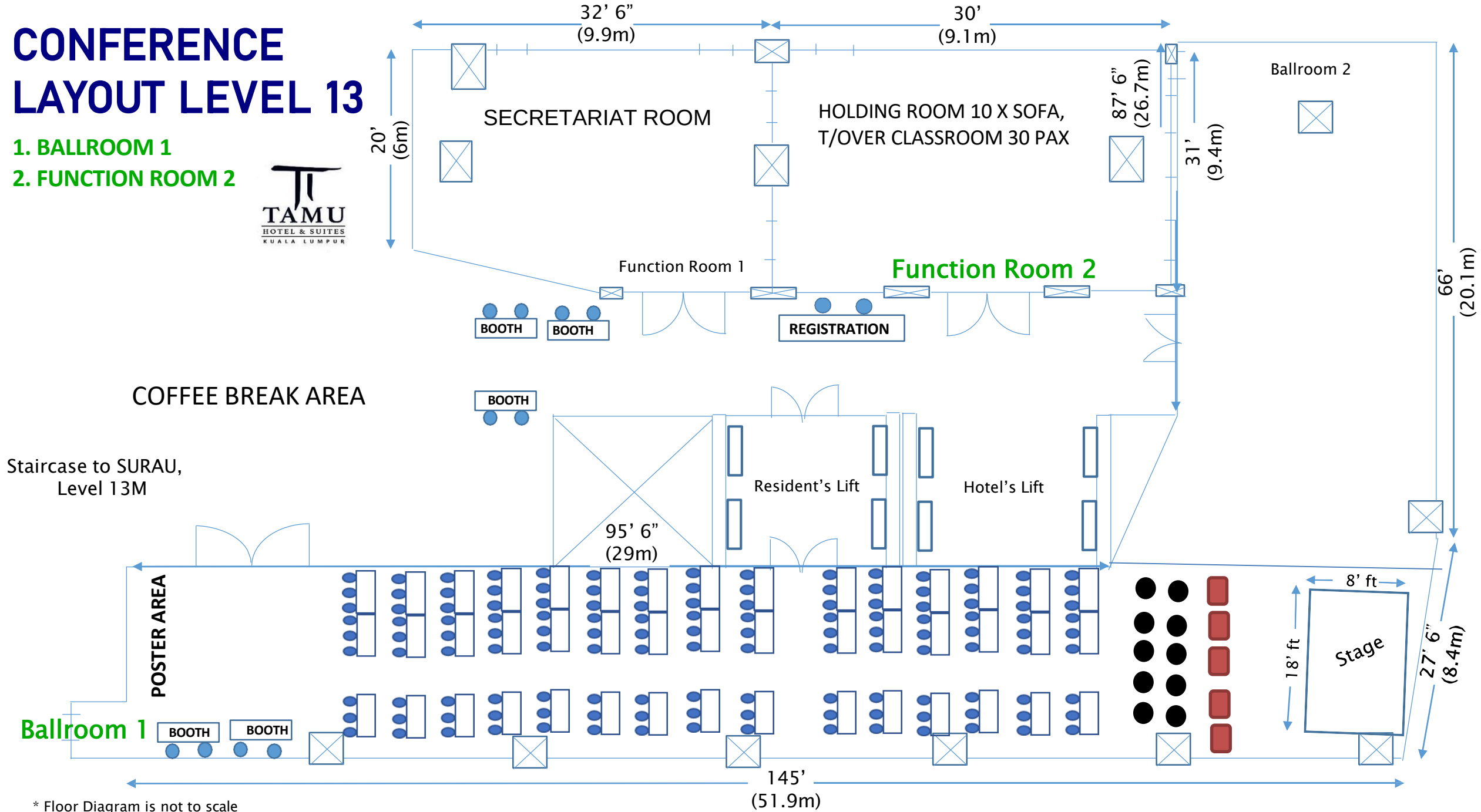


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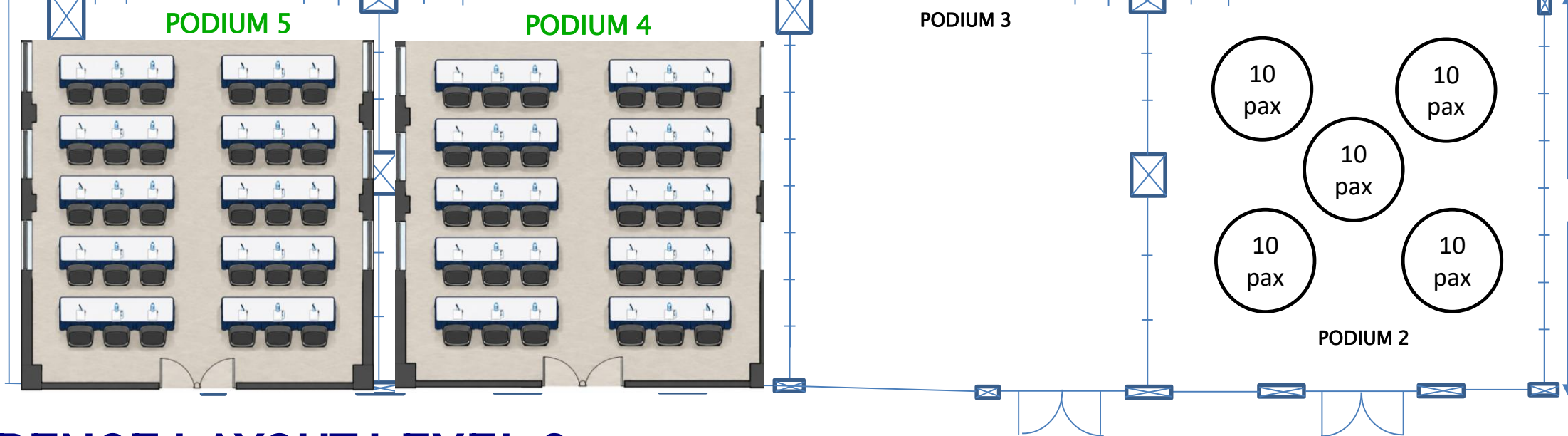
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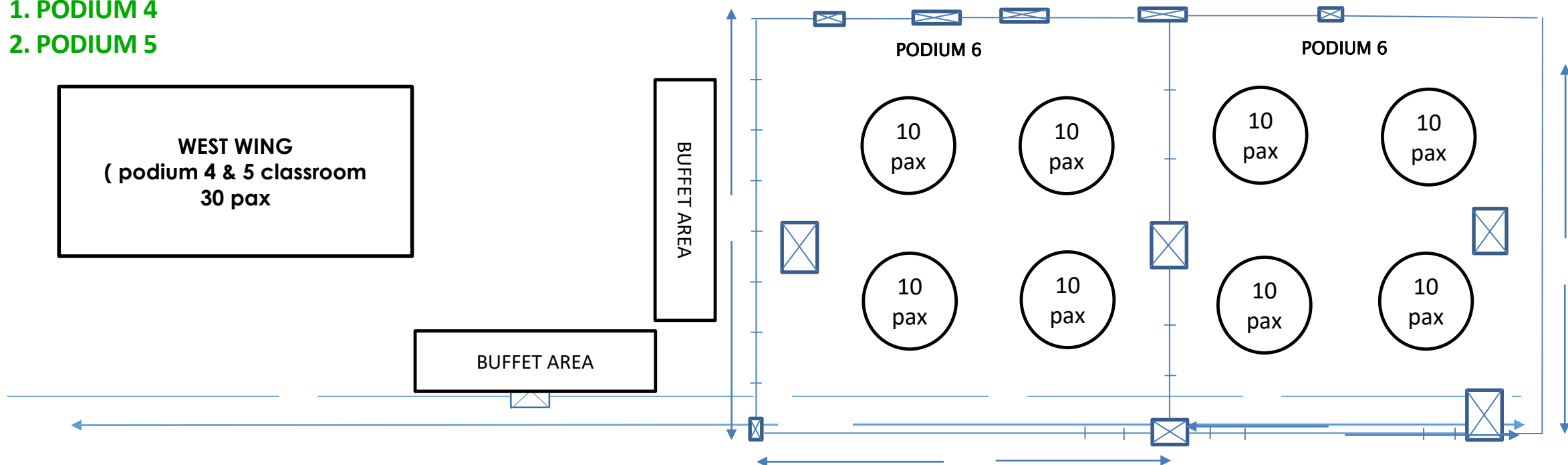


* Floor Diagram is not to scale



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1. PODIUM 4
2. PODIUM 5



ENGINEERING
WITHOUT BORDERS:
TOWARDS A
SUSTAINABLE
FUTURE

LIST OF PRESENTERS

Monday 14 Sept 2026

Parallel Session 1: Advanced Mechanical Design, Manufacturing and Simulation

Session chair	Dr. Mohd Khalid Mohd Nor NAICO Malaysia
Invited speaker T1-O-B11 10:45–11:05	Prof. Ashish K Rajak Indian Institute of Technology Indore, India <i>Joining of Aluminum-CFRP: A Force Fit Joint by High Speed Electromagnetic Process Evaluation of SS316L Thick-Wall Construction</i>
T1-O-A140 11:05–11:20	Sarah Najm Al-Challabi Universiti Teknologi PETRONAS <i>Influence of Mo Content on FCC Phase Formation and Design of FeNiCrMo High-Entropy Alloys: A CALPHAD-Based Computational Approach</i>
T1-O-A08 11:20–11:35	Nurlisa Binti Hamzan Universiti Teknologi MARA Shah Alam <i>Thermal Behaviour of Hybrid SiO₂: TiO₂ Nanolubricants in Biodegradable Oil Under Steady-State Conditions at the Tool-Workpiece Interface</i>
T1-O-A14 11:35–11:50	Afiq Durrani Bin Azli Universiti Teknologi MARA Shah Alam <i>Real-Time IoT-Integrated Andon System for Production Visibility and Automated Quality Control in Extrusion Manufacturing</i>
T1-O-A63 11:50–12:05	Ana Syahidah Binti Mohd Rodzi Universiti Teknologi MARA Cawangan Pulau Pinang <i>Optimization of Machining Parameters for Surface Roughness and Energy Consumption in Ball-End Milling of Hardened Stavax ESR</i>
T1-O-A72 12:05–12:20	Ana Syahidah Binti Mohd Rodzi Universiti Teknologi MARA Cawangan Pulau Pinang <i>Direct Optimization of Analytical Surface Roughness in Ball End Milling Using Particle Swarm Optimization</i>

Parallel Session 2: Advanced Materials for Sustainable Engineering

Session chair & invited speaker T3-O-B20 10:45–11:05	Prof. Dr. Eng. Didik Nurhadiyanto Universitas Negeri Yogyakarta Development of Composite Hybrid Ramie Fiber–Reinforced Epoxy– Tungsten Carbide and Silicon Carbide as Bulletproof Panel NIJ Standard
T3-O-A93 11:05–11:20	Muhammad Nur Hakimi Bin Yuzine Universiti Teknologi MARA Cawangan Terengganu <i>Comparative Evaluation of Ciprofloxacin Removal by Maghemite, ZnO, and Their Activated Carbon Nanocomposites in Batch Adsorption</i>
T3-O-A67 11:20–11:35	Intan Syafiqah Binti Isma Harisham Universiti Tun Hussein Onn Malaysia <i>A Review of Microwave-Assisted Soldering for Next-Generation Electronics: Interfacial Engineering, Reliability Enhancement, and Pathways to Industrial Sustainability</i>
T3-O-A20 11:35–11:50	Dr. Safyanu Bashir Danjuma Universiti Tun Hussein Onn Malaysia <i>Benchmarking Nigeria's Access to Clean Cooking Fuels and Fossil Fuel Consumption: An Environmental Kuznets Curve Analysis Relative to BRICS Countries</i>
T3-O-A02 11:50–12:05	Dr. Gan Shixi Universiti Teknologi MARA Shah Alam <i>Preliminary Process Window and Forming Quality of LPBF-Processed AA7075 Hybrid Composites Co-Reinforced with Ti and AlCoCrFeNi_{2.1} HEA</i>
T3-O-B19 12:05–12:20	Dr. Ir. Henny Pratiwi Universitas Negeri Yogyakarta <i>Effect of Alkali and Fumaric Acid Surface Treatments on the Mechanical Performance of Ramie Fiber-Reinforced Polyester Composites</i>

Parallel Session 3: Malaysia – Japan Joint Symposium on Biomechanics & Medical Engineering 2026

Session chair	Assoc. Prof. Ts. Dr. Abdul Halim Abdullah Universiti Teknologi MARA Shah Alam
Invited speaker T8-O-B14 10:45–11:05	Assoc. Prof. Dr. Mitsugu Todo Kyushu University <i>Development and Characterization of A 3D Tubular Bio-structure using iPS-Derived Cardiac Cell Sheets</i>
T8-O-B16 11:05–11:20	Prof. Ei Yamamoto Kindai University <i>Development of Elastin Materials to Mimic the Extensibility of Biological Soft Tissues</i>
T8-O-B05 11:20–11:35	Keita Takasu Okayama University of Science Development of a Hindlimb Rehabilitation Device for Small Animals
T8-O-B06 11:35–11:50	Yuki Tamura Okayama University of Science <i>Development and Experimental Evaluation of a Spring-shaped Low-Pressure Pneumatic Actuator for Wheelchair Transfer Assistance</i>
T8-O-B08 11:50–12:05	Takuma Habiro Okayama University of Science <i>Proposal of Attitude Control and Built-in Driving System of Spherical Flexible Pneumatic Actuator Using Serial Connected Vacuum Pumps</i>
T8-O-B17 12:05–12:20	Norain Binti Abdullah Kindai University <i>Assessment on new bone formation during early stage of defect healing under titanium implant plate</i>

Parallel Session 4: Mechatronics, Control & Intelligent Systems

Session chair	Ir. Zainal Abidin Kamarul Baharin MEC Engineering Resources
Invited speaker T7-O-A77 10:45–11:05	Assoc. Prof. Dr. Wan Nurshazwani Wan Zakaria Universiti Teknologi MARA Shah Alam <i>Visual SLAM-Based Navigation and Hybrid A* - Pure Pursuit Motion Planning for Agricultural Unmanned Ground Vehicle</i>
T7-O-B03 11:05–11:20	Kazuki Futawaka Okayama University of Science <i>Proposal of Miniaturized Outer Circumferential Hugging type Pipe Inspection Robot</i>
T7-O-B04 11:20–11:35	Takashi Matsumoto Okayama University of Science <i>Proposal of Lattice-Shaped Pipe Propulsion Mechanism Using Extension type Flexible Pneumatic Actuators</i>
T7-O-A86 11:35–11:50	Dr. Ernie Che Mid Universiti Malaysia Perlis <i>Fouling Detection in Heat Exchangers Using Multiparametric Programming</i>
T8-O-B07 11:50–12:05	Shunsuke Hirata Okayama University of Science <i>Development of a Feedback Control System for a Center-of-Gravity Estimation</i>
T7-O-A88 12:05–12:20	Ir. Zainal Abidin Kamarul Baharin MEC Engineering Resources <i>Obstacle Detection Utilising Ultrasonic Sensor and Haptic Feedback for the Visually Impaired</i>

Parallel Session 5: Advanced Mechanical Design, Manufacturing and Simulation

Session chair & invited speaker T1-O-B15 14:00–14:20	Dr. Hussain Ali Alenezi College of Technological Studies, Shuwaikh, Kuwait <i>Tailoring Cross-Sectional Architectures of Polymeric Nanofibers via a Novel Gyrospinning Vessel for Biomedical Applications</i>
T1-O-A85 14:20–14:35	Ir. Ts. Dr. Mohamed Asyraf Bin Mahboob Ali Universiti Teknologi MARA Shah Alam <i>Surface Roughness and Dimensional Accuracy during Machining of Nickel-Titanium Alloy</i>
T1-O-A29 14:35–14:50	Ts. Erwan bin Muhammed Ma'asus Universiti Tun Hussein Onn Malaysia <i>Effect of Increasing Wheel Flange Lubrication Coverage on the Wear Rate in MRT Kajang Line</i>
T1-O-A32 14:50–15:05	PM. Ir. Ts. Dr. Suhaimi Hassan Universiti Tun Hussein Onn Malaysia <i>A Study of Nut Feeder Mechanical Design to Improve Production Assembly in Aircraft Manufacturing</i>
T1-V-A31 (V) 15:05–15:20	Dr. Wan Emri Wan Abdul Rahaman Universiti Teknologi MARA Shah Alam <i>Experimental Investigation of Abrasive Water Jet Machining Parameters on Surface Roughness and Kerf Width of Brass</i>
T1-O-A24 (V) 15:20–15:35	Nor Ruzanna Abd Rahman Universiti Teknologi MARA Cawangan Pulau Pinang <i>A Critical Review of Energy-Efficient Wire Electrical Discharge Machining: Parameter Optimisation, Energy Modelling, and Sustainability Perspectives</i>

Parallel Session 6: Advanced Materials for Sustainable Engineering

Session chair	Prof. Dr. Hj. Muhammad Izzat Nor Ma'arof INTI International University
Invited speaker T3-O-B24 14:00–14:20	Prof. Dr. Aidah Jumahat Universiti Teknologi MARA Shah Alam <i>Impact Behaviour of Natural Fibres Reinforced Polymer Composites: Experiment & Simulation Analysis</i>
T3-O-B21 14:20–14:35	Dr. Bayu Rahmat Setiadi Universitas Negeri Yogyakarta <i>From Agricultural Residue to Regenerative Design: Exploring Coconut Shell–Natural Fiber Biomaterials for Sustainable Craft Innovation</i>
T3-O-A04 14:35–14:50	Basirah Binti Baharom Universiti Teknologi MARA Shah Alam <i>Effect of Zinc Doping on the Structural Integrity and Thermal Behavior of Chicken Bone-Derived Hydroxyapatite</i>
T3-V-A39 14:50–15:05	Jeffry Jamil Universiti Tun Hussein Onn Malaysia <i>Utilising Low-Frequency Phased Array Ultrasonic Testing Techniques for Defects Characterisation in Glass Fiber Reinforced Polymer</i>
T3-O-A111 15:05–15:20	Muhammad Zakwan Bin Ya'acob Universiti Teknologi MARA Shah Alam <i>Superhydrophobic Polyurethane/SiO₂ Coatings for Electrowetting-on-Dielectric Systems</i>
T3-O-A50 15:20–15:35	Muhammad Aiman bin Misri Universiti Teknologi MARA Shah Alam <i>Tailoring the Thermal and Mechanical Performance of Compression Moulded PA12 Through HA/ZnO Hybrid Reinforcement</i>

Parallel Session 7: Malaysia – Japan Joint Symposium on Biomechanics & Medical Engineering 2026

Session chair & invited speaker	Dr. Eng. Azizah Intan Pangesty Universitas Indonesia
Invited speaker T8-O-A134 14:00–14:20	Ts. Dr. Helmi Rashid Universiti Teknologi MARA <i>Design of a Novel Monolithic Electrocautery Rod for Pepper-Pot Tracheal Intervention in Excessive Dynamic Airway Collapse</i>
T8-O-A124 14:20–14:35	Choong Kah Hua Universiti Teknologi Malaysia <i>Cognitive Performance and Physiological Responses to Mild Oxygen Enrichment in Indoor Environments: An Exploratory Study</i>
T8-O-A135 14:35–14:50	Nursyazwani binti Zulkefli Universiti Tun Hussein Onn Malaysia <i>Application of Non-Destructive Testing Approaches in the Characterisation of Cockle Shell-Derived Hydroxyapatite/Polylactic Acid/Polycaprolactone Composite Scaffolds for Bone Tissue Engineering: A Review</i>
T8-O-A105 14:50–15:05	Dr. Shahrul Hisyam Bin Marwan Universiti Teknologi MARA <i>The Impact of Body Mass Index on Foot Pressure and Posture in Standing and Walking Conditions</i>
T8-O-A125 15:05–15:20	Dr. Abdul Halim Abdullah Universiti Teknologi MARA <i>Finite Element-Based Material Selection and Topology Optimization for the Development of a Lightweight Bed-Resting Ankle-Foot Orthosis</i>
T8-O-A23 (V) 15:20–15:35	Muhammad Naufal Bin Nazeri Universiti Teknologi MARA <i>Development of a Hybrid Basalt/Kenaf/Epoxy Locking Compression Plate: Experimental Characterisation and Design Optimisation via Finite Element Analysis</i>

Parallel Session 8: Mechatronics, Control & Intelligent Systems

Session chair & invited speaker T7-O-A91 14:00–14:20	Dr. Sukarnur Che Abdullah Universiti Teknologi MARA <i>Real-Time Embedded Mechatronic System for Haptic and Thermal Feedback: Hardware Validation and Response Delay</i>
T7-O-A83 14:20–14:35	Dr. Mat Hussin Ab Talib Universiti Teknologi Malaysia <i>Optimization and Application of Flower Pollination Algorithm in Dynamic Vibration of Magnetorheological Damper System</i>
T7-O-A100 14:35–14:50	Dr. Muhammad Zaiyad bin Muda Universiti Teknologi MARA <i>Data-Driven Fuzzy Inference System for Water Quality Classification via Fuzzy C-Means Clustering</i>
T7-O-A37 14:50–15:05	Muhammad Haziq Bin Noor Akashah Toyohashi University of Technology <i>Wide-Angle Camera Calibration for Net Quality Inspection Using K- Nearest Neighbors</i>
T7-V-A75 (V) 15:05–15:20	Catur Rakhmad Handoko Shipbuilding Institute of Polytechnic Surabaya (PPNS) <i>Batteryless PV-Diesel Hybrid System with VSG-Enabled Fuel Saver Inverter for Remote Island Waste Management: Performance Simulation and Analysis</i>
T7-V-A136 (V) 15:20–15:35	Iman Muhammad Akbar Rochester Institute of Technology <i>Development of an Integrated Autonomous System for Water Surface Waste Collection and Water Quality Monitoring</i>

Parallel Session 9: Advanced Mechanical Design, Manufacturing and Simulation

Session chair & invited speaker T1-O-A130 16:00–16:20	Dr. Alias Mohd Saman Universiti Teknologi MARA <i>Optimization of Flow Behaviour in Gating System using Computational Simulation</i>
T1-O-A33 16:20–16:35	Assoc. Prof. Ir. Ts. Dr. Suhaimi Bin Hassan Universiti Tun Hussein Onn Malaysia <i>Performance Evaluation of Laser Sensors in Signal Warning Detection (SWAD) Systems</i>
T1-O-A106 16:35–16:50	Thamil Selvan A/L S. Kumaresan Universiti Teknologi Malaysia <i>Mechanical Characterization of Elastomeric Materials for Single Use Test Plug Seal (TPS)</i>
T1-V-A99 (V) 16:50–17:05	Muhammad Adib bin Mohd Ali Universiti Teknologi MARA <i>Predictive Ergonomic Risk Assessment of Low Seating Workstations Using Digital Human Modelling and RULA</i>
T1-V-A115 (V) 17:05–17:20	Muhammad Nabil bin Abdul Ghani Universiti Teknologi MARA <i>Ergonomic Risk Prediction Models for Preventing Musculoskeletal Disorders in High Seating Workstations</i>
T1-O-A27 (V) 17:20–17:35	Dr. Mohd Rozaiman bin Aziz Universiti Teknologi MARA <i>Numerical and Experimental Evaluation of Lightweight Stab-Resistant Armour Configurations: National Institute of Justice-Compliant Design</i>

Parallel Session 10: Automotive Engineering

Session chair & invited speaker T5-O-A41 16:00–16:20	Assoc. Prof. Dr. Aman Mohd Ihsan Mamat Universiti Teknologi MARA <i>Computational Performance of Non-Radial Fibre Turbine at Steady State Condition</i>
T5-O-A62 16:20–16:35	Siti Aida Binti Ahmad Universiti Tun Hussein Onn Malaysia <i>Embedded Control and Retrofit Strategies for Automotive Dynamometer Modernization: A Review of Eddy-Current Retarder Control, Data Acquisition, and Industry 4.0 Integration</i>
T3-O-A108 16:35–16:50	Dr. Yusuf Olanrewaju Busari Universiti Teknologi MARA <i>Durian Husk-Derived Activated Carbon Hybridized with ZnO and MnO₂ for High-Performance Supercapacitor Electrodes</i>
T5-V-A54 (V) 16:50–17:05	Hazim bin Sharudin Universiti Teknologi MARA <i>Formulation, Characterization, and Properties Optimization of Refined Palm Oil Biofuel Blended with Hexanol for Compression Ignition Engines</i>
T5-V-A118 (V) 17:05–17:20	Firly Irhamni Ahsan Politeknik Perkapalan Negeri Surabaya <i>Thermodynamic Analysis of the Performance and Emissions of a Single-Cylinder Four-Stroke Diesel Engine Fueled with Ethanol–Diesel Blends</i>
T5-V-B22 (V) 17:20–17:35	Prof. Dr. Tiwan Universitas Negeri Yogyakarta <i>Effect of Varying Cerium Oxide (CeO₂) Additions on the Microstructure and Mechanical Properties of A356 Aluminum</i>

Parallel Session 11: Advanced Materials for Sustainable Engineering

Session chair & invited speaker T3-O-A81 16:00–16:20	Assoc. Prof. Dr Koay Mei Hyie Universiti Teknologi MARA Cawangan Pulau Pinang <i>Effect of Warm Compaction Parameters on the Electrical Resistivity and Transverse Rupture Strength of CNT-Reinforced PKS–Graphite–Copper Composites</i>
T3-O-A10 16:20–16:35	Amira Natasha Amir Rizal Universiti Teknologi MARA Shah Alam <i>Thermophysical and Tribological Characteristics of Hybrid SiO₂: TiO₂ Nanoparticles Dispersed in Coconut Oil for Minimum Quantity Lubrication</i>
T3-O-A13 16:35–16:50	Azib Roslan Universiti Teknologi MARA Shah Alam <i>Insights into the Role of Graphene Oxide Precursor Concentration in Reduced Graphene Oxide Formation for Enhanced Optical Properties in Fibre Optic Sensors</i>
T3-V-A43 (V) 16:50–17:05	Hazriel Faizal Pahroraji Universiti Teknologi MARA <i>Optimization of Eggshell as a Natural Corrosion Inhibitor for AISI 1020 Steel via Response Surface Methodology</i>
T3-O-A05 (V) 17:05–17:20	Nur Amelia Binti Ismailia Universiti Teknologi MARA Shah Alam <i>The Discolouring Efficiency on S-Type 29 of Activated Carbon</i>
T3-V-B23 (V) 17:20–17:35	Dr. Martinus Heru Palmiyanto Universitas Negeri Yogyakarta <i>Tribological Performance of Microcrystalline Cellulose-Filler Phenolic Composite Brake Shoes under Different Aqueous Environments</i>

Parallel Session 12: Thermofluid & Sustainable Energy

Session chair & invited speaker T6-O-A35 16:00–16:20	Assoc. Prof. Dr. Priyo Agus Setiawan Politeknik Perkapalan Negeri Surabaya, Indonesia <i>Effect of Blade Arc Length on the Performance of Myring-Profile Savonius Wind Turbine ($n = 1$)</i>
T6-O-A126 16:20–16:35	Farah Ain Binti Johar Universiti Teknologi MARA <i>Comparative Indoor Thermal Comfort Analysis of Roof Insulation and Air Velocity Enhancement in a Tropical Climate School Classroom</i>
T6-O-A21 16:35–16:50	Dr. Safyanu Bashir Danjuma Universiti Tun Hussein Onn Malaysia <i>Evaluation of Thermal Efficiency of Solar Distillation</i>
T6-V-A98 (V) 16:50–17:05	Vena Rizky Pusparani Politeknik Perkapalan Negeri Surabaya, Indonesia <i>Effect of Circular Cylinder on Returning Blade of Savonius Wind Turbine Performance: A Review</i>
T6-V-A74 (V) 17:05–17:20	Urip Mudjiono Politeknik Perkapalan Negeri Surabaya, Indonesia <i>Decentralized RDF Production from Marine Plastic Debris on a Small Indonesian Island: A Techno-Economic Feasibility Study</i>
T6-V-A47 (V) 17:20–17:35	Jivinesh A/L Muruges Universiti Malaysia Perlis <i>Design of Hybrid Active Cooling System for 2.10 kWp Floating Solar Photovoltaic System</i>

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Parallel Session 13: Thermofluid & Sustainable Energy

Session chair & invited speaker T6-O-A97 10:30–10:50	Assoc. Prof. Ir. Dr Irnie Azlin Zakaria Universiti Teknologi MARA Shah Alam <i>Tribological Properties of Graphene Quantum Dots (GQDs) Nanolubricant in MQL</i>
T6-O-A138 10:50–11:05	Assoc. Prof. Dr. Alhassan Salami Tijani Universiti Teknologi MARA <i>Thermal Analysis of On-Board Hydrogen Storage Tank of Light Duty Vehicles During Fast Refuelling Using a Diverging Nozzle</i>
T6-O-A01 11:05–11:20	Muhammad Syafiq Aiman bin Muhammad Bazlan Universiti Teknologi MARA Shah Alam <i>Dynamic Mesh Methodologies in OpenFOAM for Compression Ignition Engine CFD Simulation: A Review</i>
T6-O-A18 11:20–11:35	Nurul Izzatul Binti Azian Universiti Teknologi MARA Shah Alam <i>Effect of Titanium Dioxide (TiO₂) Nanoparticles On the Tribological Properties of Bio-Based Lubricants</i>
T6-O-A16 11:35–11:50	Amira Shahirah Binti Malek Amir Azmin Universiti Teknologi MARA Shah Alam <i>Industrial Waste Heat Recovery Potential Through Thermoelectric Generator in Steel Manufacturing</i>
T6-V-A68 11:50–12:05	Dr. Mohd Azan Bin Mohammed Sapardi International Islamic University Malaysia <i>Numerical Investigation on the Hydraulic Performance of an Inverted-Triangle Turbulence Promoter in a Tubular Channel</i>
T6-O-A144 12:05–12:20	Chua Kai Feng Universiti Teknologi Malaysia <i>A Review of Machine Learning Applications in Journal Bearing Optimization</i>

Parallel session 14: Advanced Materials for Sustainable Engineering

Session chair	Dr. Temitope Theophilus Dele-Afolabi Universiti Teknologi MARA Shah Alam
Invited speaker T3-V-B25 (V) 10:30–10:50	Ts. Dr. Nik Roselina Nik Roseley Universiti Teknologi MARA Shah Alam <i>Tailoring the Physical and Mechanical Properties of Ni–GO Composite Coatings through Pulse Frequency</i>
T3-O-A87 10:50–11:05	Ahmad Amir Akmal Bin Othman Universiti Teknologi MARA <i>Repurposing End-of-Life Al-Quran Paper Ash as a Partial Replacement for Silica Sand in Green Sand Aluminum Casting</i>
T3-O-A92 11:05–11:20	Teguh Budiyo Universitas Indonesia <i>Effect of Solution Treatment Temperature on Microstructures and Mechanical Properties of Al-4.7Zn-1.7Mg (wt. %) Alloy Produced by Squeeze Casting</i>
T3-V-A80 (V) 11:20–11:35	Dr. Nabilah Afiqah Mohd Radzuan University Kebangsaan Malaysia <i>Mechanical Performance of FDM-Printed PLA and TPU Lattices with BCC and Diamond Topologies Under Quasi-Static Compression</i>
T3-V-A95 (V) 11:35–11:50	Muhammad Irfan Rafee Bin Rohaizad Universiti Tenaga Nasional <i>Low-Temperature Synthesis of Activated Carbon from Keruing Wood Waste for Dual-Pollutant Adsorption</i>
T3-O-A48 11:50–12:05	Dr. Temitope Theophilus Dele-Afolabi Universiti Teknologi MARA Shah Alam <i>ANFIS Modelling of the Mechanical Reliability of CNT-Reinforced Sn-5Sb/Cu Solder Composite Joints</i>

Parallel Session 15: Aerospace/ Aviation Technology

Session chair & invited speaker T2-O-A78 10:30–10:50	Assoc. Prof. Ts. Dr. Rizal Effendy Mohd Nasir Universiti Teknologi MARA Shah Alam <i>Flight Performance and Stability of a Bird-Inspired Blended Wing-Body Planform in Laminar Incompressible Flow</i>
T2-O-A79 10:50–11:05	Dr. Zurriati Mohd Ali Universiti Teknologi MARA Shah Alam <i>Aerodynamic Study of Wing Sweep Angles in UiTM's Unconventional Wing Aircraft Using Computational Simulations</i>
T2-O-B01 11:05–11:20	Dr. Lawal Babatunde Abdulqadir Kwara State Polytechnic, Ilorin <i>Mechanical Influence of Build Orientation and Printing Parameters of PETG in FDM</i>
T2-V-A127 11:20–11:35	Dr. Ahmad Hussein Abdul Hamid Universiti Teknologi MARA Shah Alam <i>Design, Fabrication, and Testing of a Solid-Propellant Rocket Targeting a 3 km Apogee</i>
T2-O-A38 11:35–11:50	Muhammad Fikri Julianugerah Telkom University, Surabaya <i>Analysis of Work Efficiency Based on Comparison of Delays in the CN 235 Wing Production Process Using the Value Stream Mapping Method</i>
T2-O-A94 11:50–12:05	Dr. Hamid Bin Yusoff Universiti Teknologi MARA Pulau Pinang <i>Aerodynamic Performance of Swallow Birds Models for Bio-Inspired Fixed Wing Unmanned Aerial Vehicle Designs</i>
T7-V-A55 (V) 12:05–12:20	Abishai Asir A. Thederajan Universiti Tun Hussein Onn Malaysia <i>Collision-Aware Trajectory Planning for Passenger Boarding Bridges in Airport Apron</i>

Parallel Session 16: Engineering Education & Entrepreneurship

Session chair & invited speaker T9-O-A82 10:30–10:50	Prof. Ts. Dr. Salmiah Kasolang Universiti Teknologi MARA Shah Alam <i>Digital Operationalization of the Taqwa-Driven Business Model Canvas: A Practical Decision-Support Architecture for Ethical Entrepreneurship</i>
T9-O-A15 10:50–11:05	Nurul Faiqah Binti Zainal Abidin Universiti Teknologi MARA Shah Alam <i>Enhancing Engineering Learning Engagement Through Gamified Augmented Reality a Case Study of Karakuri and Material Handling Systems</i>
T9-O-A101 11:05–11:20	Dr. Noor Aniza Binti Norrdin Universiti Teknologi MARA Shah Alam <i>Development and Evaluation of an Interactive Augmented Reality System for Pneumatic Training in Technical Education</i>
T9-O-A103 11:20–11:35	Ts. Dr. Helmi Bin Rashid Universiti Teknologi MARA Shah Alam <i>Enhancing Motorcycle Control Understanding Through Early Counter-Steering Education Using a Riding Simulator</i>
T9-O-A120 11:35–11:50	Assoc. Prof. Dr. Saidatul Akmar Binti Ismail Universiti Teknologi MARA Shah Alam <i>Beyond Outcome-Based Education: Integrating Value-Based and Industry-Embedded Learning across Engineering and Engineering Technology Pathways</i>
T9-V-A109 (V) 11:50–12:05	Dr. Nik Roselina Binti Nik Roseley Universiti Teknologi MARA Shah Alam <i>Redefining Engineering Competencies in the AI Era: A Human-Centered AI Competency Model Based on the CDIO Syllabus</i>

Parallel Session 17: Thermofluid & Sustainable Energy

Session chair & invited speaker T6-O-A76 14:00–14:20	Assoc. Prof. Ir.Ts. Dr. Baljit Singh Universiti Teknologi MARA Shah Alam <i>PSO-Tuned LSTM with Genetic Algorithm Feature Selection for Short-Term Solar Irradiance Forecasting in Tropical Malaysia</i>
T6-O-A90 14:20–14:35	Firdaus bin Zawawi Universiti Teknologi MARA <i>Hazard-Population Interfaces in Urban Workplace Fire Disasters: Safety Lessons from Infrastructure and High-Rise Fires</i>
T6-O-A147 14:35–14:50	Assoc. Prof. Dr. Muhad Rozi Bin Mat Nawi Universiti Teknologi MARA Shah Alam <i>Influence of SiO₂ Nanoparticle Concentration on Bubble Growth Dynamics and Nucleate Pool Boiling Heat Transfer of HFE-7000-Based Nanorefrigerant</i>
T3-O-A06 14:50–15:05	Anis Farhana Binti Abu Bakar Universiti Tun Hussein Onn Malaysia <i>Energy Efficiency Mechanisms of Variable Speed Drives in Commercial Laundry Dryer Systems: A Review</i>
T6-V-A141 (V) 15:05–15:20	Puteri Nur Balqis Binti Ahmad Surri Universiti Malaysia Perlis <i>Experimental Assessment of Bird Dropping and Dust Soiling Effects on Electrical Performance and Acceptance Ratio of a Floating Photovoltaic System in Perlis, Malaysia</i>
T6-V-A28 (V) 15:20–15:35	Siti Norhazlinda Binti Roslan Universiti Teknologi MARA <i>Cooling Load Assessment and Passive Heat Gain Mitigation in a Tropical Commercial Office Building</i>
T6-V-B13 (V) 15:35–15:50	Nor Merlisa Ali Universiti Teknologi MARA Shah Alam <i>CFD Analysis of Ventilation Performance of Two-layered Enclosure with Internal Void</i>

Parallel Session 18: Advanced Materials for Sustainable Engineering

Session chair	Dr. Adel Mohammed Al-Dhahebi Universiti Teknologi MARA Shah Alam
Invited speaker T3-O-A117 14:00–14:20	Dr. Siti Rabizah Makhsin Universiti Teknologi MARA Shah Alam <i>Size-Dependent Plasmonic Enhancement of Gold Nanoparticles for Portable Fibre-Optic Cu²⁺ Sensing</i>
T3-O-A11 14:20–14:35	Imandeena Sofileeya Nor Azri Universiti Teknologi MARA Shah Alam <i>From Conventional to Green Synthesis of Graphene Quantum Dots: Biomass Precursors, Tunable Properties, and Future Perspectives</i>
T3-O-A12 14:35–14:50	Norjasween Abdul Malik Universiti Teknologi MARA <i>Graphene-Based Materials in Fiber Optic Sensors for Heavy Metal Ion Detection: A Review</i>
T3-O-A70 14:50–15:05	Dr. Saliza Azlina Osman Universiti Tun Hussein Onn Malaysia <i>Influence of Susceptor Material on Microstructure Evolution and Corrosion Resistance in Microwave Soldering</i>
T3-O-A89 15:05–15:20	Dr. Adel Mohammed Al-Dhahebi Universiti Teknologi MARA Shah Alam <i>MAX, MXene And MXene Polymer Composites: Design Fabrication and Characterizations</i>
T1-O-A132 15:20–15:35	Dr. Muhd Faiz Mat @ Muhammad Universiti Teknologi MARA Shah Alam <i>Wire-Arc Additive Manufacturing (WAAM) Mechanical Properties</i>

Parallel Session 19: Structural Dynamics & Vibrations

Session chair & invited speaker T7-O-A52 14:00–14:20	Ir. Ts. Dr. Muhamad Sukri Bin Hadi Universiti Teknologi MARA Shah Alam <i>Optimization of a PID Controller Using Cheetah Optimizer for Improved Vibration Suppression in Horizontal Flexible Plate Structure</i>
T4-O-A84 14:20–14:35	Dr. Intan Fatihah Ahmad Tunku Abdul Rahman University of Management and Technology <i>Dynamic Characterisation of Abaca Fibre-Reinforced Epoxy Structure Using Finite Element Model Updating Method</i>
T4-O-A61 14:35–14:50	Muhammad Syafiq Aiman Mohd Kahar Universiti Teknologi MARA Shah Alam <i>Comparative Assessment of Linear and Nonlinear Finite Element Analysis for Predicting the Dynamic Response of Bolted Structures</i>
T4-O-B09 14:50–15:05	Dr. Firoj Ali CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR) <i>Investigation on Physico-Mechanical Response and Micro-Fracture Development in Basaltic Rock under Explosion-Induced Dynamic Stress</i>
T4-O-A45 15:05–15:20	Abdulrahman Mubarak Salem Sawahli Universiti Teknologi MARA Shah Alam <i>Experimental and Numerical Modal Analysis of Fiber Cement Board with Elastic Supports</i>
T4-V-A56 (V) 15:20–15:35	Dr. Mohd Shahrir Mohd Sani Universiti Malaysia Pahang <i>Frequency-Based Finite Element Model Updating of a PALF/Epoxy Composite Plate Using Response Surface Methodology</i>
T4-V-A60 (V) 15:35–15:50	Dr. Mohd Shahrir Mohd Sani Universiti Malaysia Pahang <i>ANN–MFO Based Prediction and Optimization of Diesel Engine Vibration Using Waste Plastic Oil Biodiesel Blends</i>

Parallel session 20: Advanced Mechanical Design, Manufacturing and Simulation

Session chair & invited speaker T6-O-A66 14:00–14:20	Ir. Ts. Dr. Mohammad Azzeim Mat Jusoh Universiti Teknologi MARA Shah Alam <i>Development of a Mini Wind Turbine with Integrated Omni-Directional Guide Vanes (ODGV)</i>
T4-O-A46 14:20–14:35	Suhayl Azmin Bin Zulkipli Malaysian Space Agency (MYSA) <i>Finite Element Analysis and Structural Verification of MYCu-X1 CubeSat for JAXA Launch Compatibility</i>
T1-O-A110 14:35–14:50	Dr. Naja Aqilah Binti Hisham Universiti Teknologi Malaysia <i>Localized Micro-Airflow Dynamics and Cognitive Temperature Perception in a Tropical Air-Conditioned Space</i>
T1-O-A112 14:50–15:05	Maged Mustafa Mohammed Abdulatef Universiti Teknikal Malaysia Melaka <i>Impact of Tool Rotational Speed on Friction Stir Weld Strength Using Wavelet Signal Analysis</i>
T1-O-A123 (V) 15:05–15:20	Dr. Ramzyzan Ramly Universiti Teknologi MARA Shah Alam <i>Design and Repackaging of a Biohybrid Drive System for Integration into a Mountain Bike Mechanical Drive Package</i>
T1-V-A65 (V) 15:20–15:35	Dr. Azman bin Ahmad Bakir Universiti Teknologi MARA Cawangan Pulau Pinang <i>Development of a Vibration-Based Predictive Model for Surface Quality in Conventional Turning Using Artificial Neural Networks</i>
T1-V-A69 (V) 15:35–15:50	Jannis Louis Frederik Neth Universiti Tun Hussein Onn Malaysia <i>An Electrothermally Actuated 4D-Printed Multi-Joint Gripper Using Polylactic Acid (PLA) and Conductive PLA Bilayer Structures</i>

Poster presenters

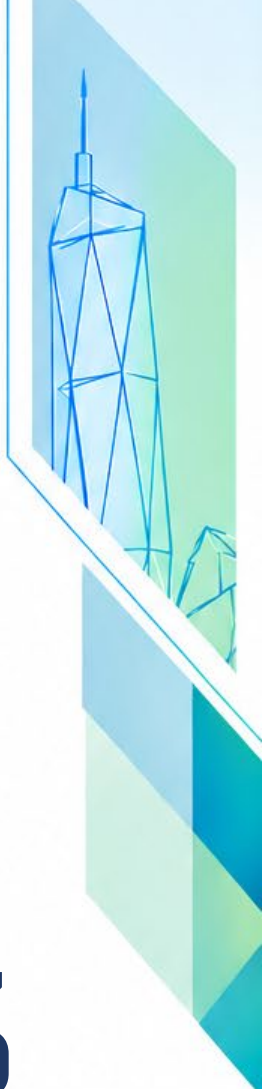
Paper ID	Title	Presenter	Affiliation
T3-O-A26	Durability of Jute/Epoxy Composites Under Acetic Acid Immersion	Ir. Ts. Dr. Abdul Hakim Abdullah	Universiti Teknologi MARA Shah Alam
T5-O-A03	Cross-Modal Feature Denoising for 4D Radar-Camera Fusion in Autonomous Vehicles Under Severe Fog	Li Zheng Qing	Universiti Teknologi MARA Shah Alam
T6-V-A34	An Entropy-Based Engineering Analysis of Thermoelectric Cooling Systems	Assoc. Prof. Dr. Ir. Muhammad Fairuz Remeli	Universiti Teknologi MARA Shah Alam
T1-V-A36	Optimization of Sintering Parameters via Response Surface Methodology for Ti-6Al-4V Fabricated Through Palm Stearin-Based Metal Injection	Assoc. Prof. Ts. Dr. Nor Hafiez Mohamad Nor	Universiti Teknologi MARA Shah Alam
T5-O-A40	Summary of Energy-Saving Control for New Energy Autonomous Vehicles	Dr. Amalina Amir	Universiti Teknologi MARA Shah Alam
T1-V-A42	Multiparametric Aerodynamic Analysis on Sedan Vehicle Rear End Design Using LHS Sampling	Ir. Ts. Dr. Kausalyah Venkatason	Universiti Teknologi MARA Shah Alam
T5-O-A49	Improving Stud Welding Quality in Automotive Manufacturing through 8D Problem Solving and Stud Gun Sleeve Redesign	Dr. Yusliza Binti Yusuf	Universiti Teknikal Malaysia Melaka
T3-O-A57	Tailoring Tensile Strength and Interfacial Adhesion of NR Latex/SIS Block Copolymer via Radiation-Curing in Vacuum Condition	Dr. Nurul Hakimah Binti Mohd Lazim	Universiti Teknologi MARA Shah Alam
T6-O-A122	Effects of Connection Configurations on the Hydraulic Filtration Efficiency of Self-Cleaning Rainwater Filters in Commercial Applications	Ts. Dr. Nur Atiqah Binti Ramlan	Universiti Teknologi MARA Shah Alam
T6-O-A73	Optimizing Indoor Air Quality Parameter in High Density Classroom Using Energy Recovery Ventilator	Ir. Hazran Husain	Universiti Teknologi MARA Shah Alam
T1-O-A137	Raspberry Pi-Based Driver Fatigue Monitoring Systems Using Eye Aspect Ratio (EAR): A Review of Recent	Ts. Dr. Nurul Ain Binti Maidin	Universiti Teknikal Malaysia Melaka

	Developments and Research Trends		
T1-O-A102	Comparative Analysis of Hot and Cold Runner Systems in Injection Molding for Minimizing Surface Defects in Polycarbonate QR Code Housings	Dr. Nurul Hayati Binti Abdul Halim	Universiti Teknologi MARA Shah Alam
T3-O-A104	Optimization of Sol-Gel Synthesis Parameters for Tailoring the Material Properties and Enhancing the Photocatalytic Performance of Nb ₂ O ₅ Nanoparticles	Assoc. Prof. Ts. Dr. Rozina Abdul Rani	Universiti Teknologi MARA Shah Alam
T3-O-A129	Sustainable Ambient Drying of Metallic Sludge: Experimental Investigation of Drying Kinetics and Phase Characterisation	Dr. Siti Mariam Binti Abdul Rahman	Universiti Teknologi MARA Shah Alam
T1-V-A107	Conceptual Design and Structural Feasibility Analysis of a Fully Electric Patrol Boat for Maritime Surveillance Application	Amirul Hafeiz Faizul	Universiti Teknologi MARA Shah Alam
T3-O-A113	Influence of Surface Treatment on Corrosion Resistance of Cobalt Alloy Coating	Dr. Nik Rozlin Nik Mohd Masdek	Universiti Teknologi MARA Shah Alam
T1-O-A131	Simulation-Based Optimization of Injection Molding Parameters and Feed System Design for Polycarbonate QR Code Housing	Dr. Izdihar Tharazi	Universiti Teknologi MARA Shah Alam
T3-O-A119	Recycled Polypropylene-Kenaf Composites with Waste Fire Extinguisher Powder as Flame-Retardant Filler	Dr. Ahsana Aqilah binti Ahmad	Universiti Teknologi MARA Shah Alam
T5-O-A139	Computer Vision-Based Assessment of Mirror-Checking Behaviour as a Proxy for Driver Situation Awareness During Automated Rapid Transit Operation	Ir. Ts. Dr. Ahmad Khushairy Bin Makhtar	Universiti Teknologi MARA Shah Alam
T1-O-A145	PLA/PA12 3D Printed Composite Fabrication	Dr. Farrahshaida Mohd Salleh	Universiti Teknologi MARA Shah Alam

ENGINEERING
WITHOUT BORDERS:
TOWARDS A
SUSTAINABLE
FUTURE

The page features decorative geometric patterns in the corners. The top-left corner has a cluster of blue and green wireframe cubes. The top-right corner shows a blue wireframe skyscraper against a green-to-blue gradient background. The bottom-left corner consists of overlapping blue and green triangles. The bottom-right corner features a blue wireframe grid pattern.

ABSTRACTS



ENGINEERING
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TRACK 1: ADVANCES MECHANICAL DESIGN, MANUFACTURING AND SIMULATION



T1-O-A27

Numerical and Experimental Evaluation of Lightweight Stab-Resistant Armour Configurations: National Institute of Justice-Compliant Design

Mohd Rozaiman Aziz^{1*} and Muhammad Shiddiq Sapparman¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang,
13500 Permatang Pauh, Pulau Pinang,

*man@uitm.edu.my

ABSTRACT

The development of lightweight stab-resistant body armour is essential to enhancing the mobility, comfort, and operational effectiveness of law enforcement and military personnel. Conventional soft armour systems often rely on heavy components, such as titanium O-rings, which restrict flexibility and reduce endurance. This study presents an optimized armour configuration that replaces titanium with ultra-high molecular weight polyethylene (UHMWPE) and high-density polyethylene (HDPE), complemented by Kevlar trauma liners and polycarbonate films arranged to minimize weight. Experimental evaluations were conducted using the Stab Apparatus and Measurement System (STAMS) at the Science and Technology Research Institute for Defence (STRIDE) Ballistic Laboratory, Batu Arang, Selangor, Malaysia, in accordance with the National Institute of Justice (NIJ) Standard 0115.00. Stab resistance testing employed P1 and S1 blades under impact energies of 33 J (E1) and 50 J (E2). Numerical simulations using ABAQUS were performed to validate experimental findings. The configuration consisting of HDPE type 2, Polycarbonate, HDPE type 2, Kevlar Trauma Liner, HDPE type 1 and HDPE type 2 demonstrated superior performance, achieving penetration depths of 6 mm (E1) and 10 mm (E2), both within NIJ Level II limits. Finite element analysis showed strong correlation with experimental results, with maximum errors was 10% and by average was 7.6%, confirming the reliability of the numerical model. In the newly developed body armour, the titanium ring weighing 580 g was removed. As a result, the proposed system achieves a notable reduction in weight compared to conventional titanium-based armour, while fully maintaining compliance with established protection standards. These findings establish a promising foundation for next-generation lightweight stab-resistant armour suitable for urban patrol and high-risk security operations.

Keywords: Stab-resistant armour; NIJ Standard 0115.00; ultra-high molecular weight polyethylene; high-density polyethylene; Kevlar trauma liners.

T1-O-A08

Thermal Behaviour of Hybrid SiO₂: TiO₂ Nanolubricants in Biodegradable Oil Under Steady-State Conditions at the Tool-Workpiece Interface

Nurlisa Hamzan¹, Zainoor Hailmee Solihin¹, Nurul Hayati Abdul Halim¹, Ahsana Aqilah Ahmad¹, Afifah Zakriyyah Juri^{2,3} and Irmie Azlin Zakaria^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Department of Mechanical and Manufacturing Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, 43600, Malaysia

³School of Electrical and Mechanical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia.

*irnieazlin@uitm.edu.my

ABSTRACT

The environmental and economic drawbacks of traditional flood cooling, including the use of large volumes of fluid and the resulting ecological damage, have accelerated the trend towards sustainable machining. Minimum Quantity Lubrication (MQL) is an environmentally friendly alternative as it uses an atomization process to deliver very small quantities of biodegradable oils to the cutting zone. The MQL has a limited cooling capacity when machining hard to cut materials such as AISI 4340 steel. The high heat generated during machining may cause rapid tool wear and the deterioration of surface finish. To compensate for this deficiency, Nano-MQL (NMQL) uses the addition of nanoparticles to biodegradable base oils to improve the thermal conductivity and tribological performance of the lubricant through the rolling effects, protective film formation and heat dissipation. The hybrid nanolubricants have been shown to be superior to single-particle systems in terms of tool wear and machining. Also, the thermophysical properties (thermal conductivity, dynamic viscosity, fluid density, specific heat capacity) of a SiO₂:TiO₂ nanolubricant were experimentally studied and used as input boundary conditions for the Computational Fluid Dynamics (CFD) simulation. The developed CFD model was validated by comparing the modeled heat dissipating spray of MQL with the experimentally observed heatdissipating spray during experimental runs. Further CFD analysis on temperature at tool-workpiece interface indicated that MQL and NMQL at a conventional delivery mode improved thermophysical properties, heat transfer and reduced tool temperature with increased concentration of nanoparticles in cutting fluid. In particular, the volume concentration of 0.1% exhibited the minimum peak temperature at the tool-workpiece interface compared to the base oil, confirming the better cooling and lubrication performance of NMQL. These results offer further insights into convective heat transfer and lubrication efficiency, paving the way towards optimized machining parameters and sustainable, high-precision manufacturing of hardened steels.

Keywords: Hybrid Nanolubricant; Heat transfer; CFD; Tool-workpiece; lubrication.

T1-O-A14

Real-Time IoT-Integrated Andon System for Production Visibility and Automated Quality Control in Extrusion Manufacturing

Afiq Durrani Azli¹, Noor Azlina Mohd Salleh^{2*}, Mohd Syazwan bin Sarudin¹, Falah Abu³, Joshua Goh⁴, Goh Wai Kah⁴ and Mah Lai Ching⁴

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Smart Manufacturing Research Institute Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

³Faculty of Applied Science, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

⁴School of Electrical and Mechanical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia

*noorazlinamohdsalleh@gmail.com

ABSTRACT

The adoption of Industry 4.0 technologies has increased the demand for intelligent manufacturing systems capable of real-time monitoring and automated quality control. This study presents the design and implementation of an integrated Production Status Detector System for a vacuum hose extrusion production line, combining an automated ABS-based pusher arm with an Internet of Things (IoT)-enabled andon monitoring system. The system integrates a NodeMCU controller, sensors, Node-RED middleware, and Telegram/email notifications to improve production visibility and defect response. A systematic engineering approach comprising process assessment, Pugh-based design selection, prototype development, system integration, and industrial validation was employed. Quantitative evaluation was conducted using production data collected over 22 consecutive operating days (approximately 1,000 products per day). The results showed that the average production cycle time decreased from 149.99 s to 31.50 s, representing a 79.0% improvement. Process variability was also substantially reduced, with the standard deviation decreasing from 2.88 s to 0.87 s (69.8% reduction) and the variance decreasing from 8.32 to 0.75 (91.0% reduction). These improvements demonstrate enhanced production consistency, operational stability, and repeatability. Furthermore, the IoT-enabled andon system provided immediate visual, auditory, and cloud-based notifications, enabling faster responses to abnormal production conditions and improving real-time production visibility. The findings confirm that the proposed system is a practical, low-cost, and scalable smart manufacturing solution capable of improving production efficiency and supporting Industry 4.0 implementation in extrusion manufacturing.

Keywords: Smart manufacturing; Industry 4.0; IoT monitoring; production automation; real-time quality control.

T1-O-A29

Effect of Increasing Wheel Flange Lubrication Coverage on the Wear Rate in MRT Kajang Line

Erwan Muhammed Ma'asus¹, Azrin Hani Abdul Rashid¹, Nik Normunira Mat Hassan^{2*}
and Zahin Iqmal Abd Rani³

¹Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

³Rapid Rail Sdn. Bhd., 47301 Petaling Jaya, Selangor, Malaysia

*normunira@uitm.edu.my

ABSTRACT

The MRT Kajang Line experiences premature wheel wear due to excessive flange-rail contact, reducing wheel service life from eight to four years and increasing maintenance costs. This study evaluates increasing the Low Coefficient of Friction (LCF) lubricant application from 25% to 50% coverage to mitigate wear rates. Utilizing real-time data from test trains, the research aims to optimize lubrication to reduce flange wear. Eight trains were selected for the test, with four equipped with an additional flange lubricator to achieve 50% lubrication coverage. These trains were assigned to the operational line as service trains simultaneously, and the wear rate was measured every 35,000 km of travel. Train inspections were conducted monthly to check the overall condition of the wheel flange lubricators and replenish the lubrication sticks. Data collection focused specifically on flange wear, the primary driver for wheel profiling on this line. By averaging wear rates across the test fleet and filtering outliers, this study provides a standardized performance metric to validate the effectiveness of different lubrication strategies in a real-world transit environment. The results show that increasing wheel flange lubrication coverage from 25% to 50% on the MRT Kajang Line reduces average wear rates by over 50%, with the 50% coverage rate achieving an average wear of 0.022 mm/kkm. The findings indicate that the original 25% coverage was insufficient, causing excessive wear. Implementing 50% lubrication coverage across the entire MRT Kajang Line fleet is recommended to significantly reduce wheel wear and achieve substantial cost savings, potentially extending wheel operational mileage by more than 50%.

Keywords: Wheel flange; Wear rate; Lubrication; Train; Flange thickness.

T1-O-A33

Performance Evaluation of Laser Sensors in Signal Warning Detection (SWAD) Systems

Hanin Auni Faizal¹, Suhaimi Hassan^{1}, Mohd Suhel Mohd Zahir¹, Muhammad Faisal Safri Mohd. Zulkeple¹, Hanis Zakaria¹, Mohd Azham Azmi¹, Mohd Sallehuddin Yusof¹, Maznan Ismon¹ and Mohamad Shah Ikhsan²*

*¹Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia,
86400 Parit Raja, Johor, Malaysia*

*²Center of Excellence, Projek Lebuhraya Usahasama Berhad, Menara Korporat, Persada PLUS,
47300 Petaling Jaya, Selangor, Malaysia*

**suhaimihas@uthm.edu.my*

ABSTRACT

Highway maintenance workers face high risks from moving traffic and limited warning systems. There are many incidents involving maintenance workers when working on the highway since there is a poor danger detection system in place to alert workers during the working process. This study integrates laser and radar sensors into a Signal Warning Detector (SWAD) for improved vehicle detection. The objective in this experimental study, which is to study the parameters effect of applying a both laser and radar sensor in finding the best safety vehicle detection at an emergency lane for the best installation at a road maintenance vehicle. Method to achieve the objective is completing the field testing on the object with selected vehicle based on the real situation for sensor implementation. Result from the field-testing show that the detection of sensor depends on the reflectivity of the vehicle with an optimum height for the sensor to detect the object. Experimental test was done at Padang Kawad, UTHM, showed optimal detection an approaching vehicle at a maximum distance of 90 m when the sensor was positioned at a height of 0.7 m. Results demonstrate that optimized sensor placement and robust design significantly enhance worker safety in highway work zones.

Keywords: *Signal Warning Detector (SWAD); Radar sensor; distance detection; heigh; laser sensor.*

T1-O-A110

Localized Micro-Airflow Dynamics and Cognitive Temperature Perception in a Tropical Air-Conditioned Space

Keshan Ravi Chandran¹, Sheikh Ahmad Zaki^{1}, Naja Aqilah¹ and Masaya Saito²*

¹Tropical Indoor Environmental Research Laboratory, Malaysia-Japan International Institutes of Technology, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia

²Laboratory of Built Environmental Design, School of Design, Sapporo City University, Geijutsu-no-mori, 1chome, Minami-ku, Sapporo 005-0864, Japan

**sheikh.kl@utm.my*

ABSTRACT

Conventional thermal assessments and standardized design frameworks are foundational to building performance evaluation. However, they possess several limitations due to their reliance on bulk-volume metrics and the assumption of perfectly well-mixed indoor air. In tropical climates, these macroscopic models may overlook complex, localized micro-airflow dynamics that significantly dictate human physiological heat transfer. This study investigates the localized micro-airflow characteristics and their psychophysical impact on thermal comfort in an air-conditioned space. Field measurements and subjective thermal comfort surveys were conducted with 32 respondents (n=32). High-resolution multi-height airflow data were processed using an adapted Decoupling Index (DI) and Fast Fourier Transform (FFT). While the mechanical system achieved a compliant 5.59 Air Exchange Rate (ACH), DI metrics revealed significant vertical airflow stratification ($p < 0.05$), where buoyancy-driven pressure differences caused mechanical supply air to pool at the floor. FFT analysis identified a critical aerodynamic threshold which is localized airflow rhythms exceeding 110 seconds significantly reduced convective cooling effectiveness. Occupants in stagnant zones reported their perceived room temperature to be up to 26 °C, despite a 24 °C ambient setpoint, revealing a measurable +2.1 °C cognitive temperature offset driven by localized airflow stagnation. This finding suggests that micro-airflow dynamics, rather than bulk ACH compliance, are critical determinants of perceived thermal discomfort in air-conditioned tropical spaces, underscoring the need to integrate localized micro-airflow metrics into conventional thermal comfort design frameworks.

T1-O-A137

Raspberry Pi-Based Driver Fatigue Monitoring Systems Using Eye Aspect Ratio (EAR): A Review of Recent Developments and Research Trends

Nurul Ain Maidin^{1*}, Mohd Salahuddin Mohd Basri², Mohd Hidayat Ab Rahman¹, Siti Nurul Akmal Yusof³ and Kiran Raj Manimaran¹

¹Faculty of Industrial & Manufacturing Technology & Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

²Department of Process and Food Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

³Faculty of Innovative Design and Technology, Universiti Sultan Zainal Abidin, Kampus Gong Badak, 21300, Kuala Nerus, Terengganu, Malaysia.

*nurulain.maidin@utem.edu.my

ABSTRACT

Driver fatigue and drowsiness are significant contributors to road traffic accidents, resulting in substantial human and economic losses worldwide. This paper reviews current driver fatigue detection approaches, with particular emphasis on computer vision-based methods that utilize the Eye Aspect Ratio (EAR) for drowsiness detection. Various techniques, including physiological signal-based, vehicle behavior-based, and facial feature-based approaches, are examined and compared in terms of detection accuracy, computational requirements, and practical applicability. Special attention is given to EAR-based methods due to their non-intrusive nature, computational efficiency, and suitability for real-time implementation on embedded platforms such as Raspberry Pi. The review highlights the effectiveness of facial landmark detection and eye movement analysis in identifying fatigue-related behaviors while discussing challenges such as illumination variations, head movements, and facial occlusions. Overall, the findings suggest that EAR-based systems offer a cost-effective and reliable solution for real-time driver monitoring, with strong potential for enhancing road safety and intelligent transportation systems.

Keywords: Driver Fatigue Detection; Drowsiness Monitoring; Eye Aspect Ratio (EAR); Computer Vision; Raspberry Pi.

T1-O-A24

A Critical Review of Energy-Efficient Wire Electrical Discharge Machining: Parameter Optimisation, Energy Modelling, and Sustainability Perspectives

Nor Ruzanna Abd Rahman¹, Abdul Rahman Hemdi^{2*}, Zulkilfi Mohamed³, Azmi Mohamed Yusof²,
Azman Ahmad Bakir² and Faiz Zubair²

¹Mechanical Engineering Department, Politeknik Sultan Abdul Halim Mu'adzam Shah, Bandar Darulaman, 06000, Jitra, Kedah, Malaysia

²Mechanical Engineering Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang, 13500 Permatang Pauh, Pulau Pinang, Malaysia.

³Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

*abdulrahman643@uitm.edu.my

ABSTRACT

Wire Electrical Discharge Machining (WEDM) is a cornerstone non-traditional manufacturing process, widely deployed in the aerospace, biomedical, and tool-and-die sectors for fabricating intricate geometries from difficult to-machine conductive materials. Despite its technological importance, a systematic quantitative analysis of its energy efficiency — particularly through the lens of Specific Energy Consumption (SEC) remains conspicuously absent from the literature. This Critical Review (CR) presents a comprehensive synthesis of 39 peer-reviewed studies published between 2012 and 2025, systematically analysing the relationship between primary machining parameters — Pulse-On Time (Ton), Pulse-Off Time (Toff), Peak Current (Ip), and Servo Voltage (SV) and key performance metrics, including Material Removal Rate (MRR), Surface Roughness (Ra), Kerf Width (KW), and energy consumption indicators. A critically important finding of this synthesis is that only 3 out of 39 studies (7.7%) explicitly measured Specific Energy Consumption (SEC), despite SEC being the most meaningful metric for capturing the true sustainability burden of WEDM, including the substantial energy drawn by auxiliary subsystems such as the chiller unit, dielectric pump, and CNC controller. This review further uncovers the counterintuitive SEC Paradox: operating at higher peak currents increases instantaneous power but reduces total SEC by shortening machine runtime, thereby diminishing the cumulative energy contribution of auxiliary systems an effect demonstrated by a 4.3-fold difference in SEC (0.19 vs. 0.81 Wh/mm³) between high and low current settings (Maurya et al., 2025). The review charts the methodological evolution from classical Taguchi/GRA frameworks to advanced AI-driven algorithms (ANN, PSO, NSGA-II, ANFIS-PSO) and identifies Pulse-On Time as the universally dominant parameter across 87% of surveyed studies. Critical research gaps identified include the near-total absence of SEC measurement, insufficient investigation of Wire Tension (WT) as a control parameter, a lack of real-time adaptive energy monitoring frameworks, and no integrated four-pillar optimisation models co-optimising quality, productivity, cost, and environmental impact simultaneously. These findings underscore the transformative potential of AI-augmented, sustainability-oriented process control in establishing a new paradigm for green WEDM operations, with direct relevance to UN Sustainable Development Goals 9 and 12.

Keywords: Wire Electrical Discharge Machining; Specific Energy Consumption; Sustainable Manufacturing; Multi-Objective Optimisation; Pulse-On Time.

T1-V-A65

Development of a Vibration-Based Predictive Model for Surface Quality in Conventional Turning Using Artificial Neural Networks

Muhammad Syahrul Iqfan Shazuan¹ and Azman Ahmad Bakir^{1*}

¹Universiti Teknologi MARA, Cawangan Pulau Pinang, 13500 Permatang Pauh, Pulau Pinang, Malaysia

*azmanbakir@uitm.edu.my

ABSTRACT

Surface quality in precision manufacturing is the ultimate factor for the functional performance, fatigue resistance, and lifetime of crucial components. Traditional quality assurance procedures in conventional machining are dependent on post-process, contact-based inspection, which produces severe throughput bottlenecks and contradicts the real-time requirements of Industry 4.0. In this study, an online surface roughness (Ra) estimation framework for mild steel conventional turning is investigated. The vibration signals were collected from the tool holder and transformed into Root Mean Square (RMS) acceleration features by means of a low-cost hardware architecture based on the ESP32 microcontroller and the ADXL345 MEMS accelerometer. These signals were used as the main input to an artificial neural network (ANN) with the Levenberg-Marquardt optimization algorithm. The work presents a thorough comparison examination of two modelling dataset approaches; Model 1 trained on a sparse data set of 17 runs and Model 2 trained on the complete data set of 490 trials. The key results reveal that the ANN is exclusively data dependent. Model 2 has a significant decrease in validation percentage error to 23.18% as opposed to the percentage error of 40.02% in Model 1. Moreover, Model 2 gave a positive coefficient of determination (R²) of 0.3231, while Model 1 failed to generalize with a negative R² of -0.374. The findings are a validation for the technological feasibility of using low-cost MEMS sensors for high-fidelity process monitoring. This work provides a strategic means for small-to-medium companies (SMEs) to integrate smart manufacturing capabilities without the prohibitive expense of industrial-grade dynamometers, thereby democratizing intelligent manufacturing technologies.

Keywords: Artificial Neural Network; Surface Roughness; Conventional Turning; Real-time Monitoring.

T1-V-A69

An Electrothermally Actuated 4D-Printed Multi-Joint Gripper Using Polylactic Acid (PLA) and Conductive PLA Bilayer Structures

Jannis Neth^{1,2}, Uwe Gleiter², Low Cheng Yee¹, Abishai Asir A. Thederajan¹ and Koh Ching Theng^{1*}

¹Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia,
Batu Pahat, Malaysia

²Faculty of Engineering, Hochschule Heilbronn, Heilbronn, Germany

*ctkoh@uthm.edu.my

ABSTRACT

Four-dimensional (4D) printing enables additively manufactured structures to change shape over time in response to external stimuli. While previous 4D-printed grippers have been demonstrated using continuous soft-curling structures activated by global heating methods, such approaches limit spatial control. Therefore, localised multi-joint actuation using integrated Joule heating remains an important research gap. This paper presents an electrothermally actuated 4D-printed multi-joint gripper using PLA/CPLA bilayer structures. The work evaluates how printing parameters influence thermally induced bending behaviour and assesses whether CPLA can be integrated as a functional resistive heating layer for electrically driven actuation. Rectangular strip specimens were fabricated by fused deposition modelling (FDM) using PLA, CPLA, and PLA/CPLA material configurations. The influence of printing speed, layer orientation, and layer thickness ratio on the bending angle was evaluated after thermal activation. In addition, three electrical contacting strategies were compared: crocodile clamps, melted-in wires, and wires embedded during the printing process. The results showed that the bending behaviour of PLA/CPLA bilayer specimens can be tuned through printing parameters. Using embedded wire contacts, Joule heating of a PLA/CPLA strip reached a maximum temperature of 87 °C and produced a bending angle of 24.58°. The selected actuator configuration was then transferred to a flat multi-joint gripper with four programmed bilayer joints. Under Joule heating, the gripper successfully closed and grasped a cube. The results demonstrate that 4D-printed PLA/CPLA bilayer joints can be tuned by FDM printing parameters and activated electrically by Joule heating. This makes the approach suitable for one-time deployable gripping structures with localised joint-based actuation. Reversibility, cyclic durability, gripping force, and object adaptability remain topics for future work.

Keywords: 4D printing; multi-joint gripper; PLA/CPLA Bilayer; FDM; Joule heating.

T1-O-A123

Design and Repackaging of a Biohybrid Drive System for Integration into a Mountain Bike Mechanical Drive Package

Ramzyzan Ramly^{1*} and Amir Radzi²

¹Flight Technology & Test Center (FTTC), Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

*ramzyramly@yahoo.com

ABSTRACT

This paper presents the design, repackaging, fabrication, and preliminary validation of a compact mechanical biohybrid drive package integrated into a foldable mountain bike (MTB). The work addresses the practical design gap associated with accommodating multiple mechanical transmission and energy-conversion components within the limited space of an existing bicycle frame while preserving the original MTB drivetrain. The novelty of the proposed system lies in its repackaged multi-chain transmission layout, which combines human pedalling, electric-motor assistance, and permanent-magnet charger operation through separate mechanical drive paths intended to reduce rider effort during long-distance cycling and uphill travel. The engineering contribution includes the systematic arrangement and three-dimensional modelling of the drive package in CATIA V5, the extension and modification of the mounting structure, and the integration of two 60-tooth sprockets, 16-tooth freewheels, a three-speed freewheel, an intermediate bottom bracket, three additional bicycle chains, and chain tensioners. The configuration was designed to minimise interference between the chain drives while providing adequate structural support for the motor, charger, and transmission components. Theoretical analysis showed that a 60T driving sprocket coupled to a 16T driven freewheel produced a speed-multiplication ratio of 3.75. At an input speed of 127.5 rpm, the predicted output speed was 478.1 rpm, whereas preliminary no-load tachometer testing recorded an average output speed of 493.7 rpm. These results confirm the basic functional operation of the fabricated chain-drive system under no-load conditions but do not yet represent performance under actual riding loads. The proposed design demonstrates the practical feasibility of retrofitting a compact biohybrid drive package onto an MTB platform and provides a basis for further structural refinement, load testing, efficiency evaluation, and full-system integration.

Keywords: Biohybrid drive system; Mountain bike; Mechanical drive package; Gear ratio; CATIA V5.

T1-O-A85

Surface Roughness and Dimensional Accuracy during Machining of Nickel-Titanium Alloy

Azreen Zainol¹, Mohamed Asyraf Mahboob Ali^{2*}, Dhiviyan Raj¹ and Azwan Iskandar Azmi¹

¹Faculty of Mechanical Engineering & Technology, Universiti Malaysia Perlis, Kampus Tetap Pauh Putra, 026000 Arau, Perlis, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

*mohamedasyraf@uitm.edu.my

ABSTRACT

Nickel-titanium alloy (NiTi), also known as a shape memory alloy, are widely gaining attention due to their unique mechanical and thermal properties. Unfortunately, NiTi faces difficulties during machining process, which are mainly caused by its low thermal conductivity, severe tool wear, generation of high cutting forces and strong strain-hardening tendencies during chip formation. Thus, this study investigates the effects of cutting parameters on surface roughness and dimensional accuracy during the milling process of a NiTi shape memory alloy. Utilizing a TiAlN-coated tungsten carbide end mill under semi-synthetic flood cooling, three feed rates (0.02, 0.04, and 0.06 mm/rev) and three cutting speeds (20, 30, and 40 m/min) were selected for the experimental process. An L9 orthogonal array Taguchi method was implemented as the experimental design. Experimental result shows surface roughness (R_a) ranged from 0.374 μm to 2.640 μm , with the finest finish achieved at 30 m/min and 0.02 mm/rev. Meanwhile, the slot dimensions varied between 7.973 mm and 8.338 mm relative to the 8.000 mm target baseline. The lowest dimensional deviation occurred at 40 m/min and 0.06 mm/rev, yielding a minimal error of 0.013%. Analysis of variance (ANOVA) confirmed that feed rate was the primary statistically significant parameter governing surface roughness ($p < 0.05$), whereas neither cutting speed nor feed rate was statistically significant for dimensional deviation ($p > 0.05$). This indicates that geometric errors in NiTi milling are driven by unmeasured physical factors, such as tool deflection, thermal expansion, and elastic recovery from phase transformations. Even though a Taguchi-ANOVA approach can identify the factors affecting surface roughness, it is still necessary to monitor secondary process dynamics, such as tool wear progression and cutting forces, to achieve dimensional conformity in NiTi.

Keywords: NiTi alloy; milling; Taguchi; ANOVA.

T1-O-A32

A Study of Nut Feeder Mechanical Design to Improve Production Assembly in Aircraft Manufacturing

Muhammad Faisal Safri Mohd. Zulkeple¹, Suhaimi Hassan^{1*}, Mohd Suhel Mohd Zahir¹,
Hanin Auni Faizal¹, Omar Mohd Faizan Marwah¹, Mohamad Farid Sies¹, Muhd Hafeez Zainulabidin¹,
Al Emran Ismail¹, Mohd Rasidi Ibrahim¹ and Ahmad Humaizi Ismail²

¹Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, Parit Raja,
86400 Batu Pahat, Johor, Malaysia

²Pusat CTRM AeroSystems Sdn.Bhd, Lapangan Terbang Sultan Abdul Aziz Shah,
47200 Subang, Selangor, Malaysia

*suhaimihas@uthm.edu.my

ABSTRACT

The mechanical design study of Nut Feeder Attachment to enhance the efficiency of the assembly process in aircraft manufacturing industry. It focuses on automating the fastening process using a gun-type nut runner and Hi-Lok fasteners in fastening operation of Bulkhead. This research aims to design a Portable Semi-Autonomous Nut Feeder and evaluate its performance through repeated time tests and torque test. The proposed attachment was developed to reduce manual nut handling while maintaining the required fastening torque. Experimental evaluation was conducted by comparing the proposed attachment with the conventional manual fastening method through 30 repeated cycle-time trials for each fastening condition, while 30 torque trials were performed to evaluate fastening performance. Time tests revealed a mean fastening time of 4.440 seconds for successful attempts with the attachment, compared to 7.447 seconds for manual installation, indicating a potential 40.39% reduction in cycle time. Torque analysis confirmed that the attachment consistently applies the correct torque within the acceptable range of 28.5 lb.ft to 31.5 lb.ft. A Portable Semi-Autonomous Nut Feeder Attachment was successfully developed according to the current assembly line requirements and lays the groundwork for future advancements in automated fastening systems.

Keywords: Nut-feeder; Fastening; Assembly Time; Automation; Aircraft manufacturing.

T1-O-A63

Optimization of Machining Parameters for Surface Roughness and Energy Consumption in Ball-End Milling of Hardened Stavax ESR

Ana Syahidah Mohd Rodzi¹, Ahmad Faiz Zubair^{1*}, Mohamad Irwan Yahaya¹ and Rizal Mohamed Noor¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Pulau Pinang, Malaysia.

*ahmadfaiz@uitm.edu.my

ABSTRACT

Stavax Electro-Slag Remelted (ESR) stainless steel widely used in precision mould manufacturing due to its excellent corrosion resistance, dimensional stability, and polishability. However, limited studies have investigated the simultaneous optimization of surface quality and machining energy consumption during ball-end milling of this material under practical machining conditions. This study examines the effects of spindle speed, feed rate, and depth of cut on the surface roughness and average milling power during ball-end milling of hardened Stavax ESR under dry cutting conditions. A Taguchi L9 orthogonal array was employed to design the experiments, while mean-response analysis, analysis of variance (ANOVA), response-surface analysis, and desirability-based multi-response optimization were used to evaluate machining performance and determine the optimal cutting conditions. Surface roughness was measured using a contact-stylus profilometer, while machine-level power was recorded using the CELOS Energy Analyzer integrated with the DMG MORI control system. Total machining energy, E_{total} , was subsequently calculated from the measured average milling power and machining time. The surface-roughness model was significant ($p = 0.0007$) and explained 98.47% of the observed variation, whereas the average-cutting-power model was significant ($p = 0.0004$) and explained 98.78% of the observed variation. Mean-response and regression analysis showed that feed rate was the strongest factor affecting average milling power. The total machining energy across the nine experimental conditions ranged from 54.70 to 104.35 kJ. The lowest total machining energy was obtained in Run 6 at 7000 rpm, 2000 mm/min, and 0.2 mm depth of cut, with $E_{total} = 54.70$ kJ. In contrast, the lowest surface roughness was obtained in Run 8 at 8000 rpm, 1500 mm/min, and 0.2 mm, producing $R_a = 0.093 \mu\text{m}$, an average milling power of 3853 W, and a total machining energy of 68.96 kJ. These findings demonstrate that a machining condition producing relatively low power or superior surface finish does not necessarily correspond to minimum total machining energy, because total energy also depends on machining duration. A separate desirability-based optimization, which minimized surface roughness and average milling power rather than total machining energy, identified approximately 7980 rpm, 1010 mm/min, and 0.203 mm as a compromise condition. Confirmation testing produced $R_a = 0.091 \mu\text{m}$ and an average milling power of 3782 W. These findings clarify the distinction between machine power demand and accumulated machining energy and provide a practical basis for balancing surface quality and energy-related performance during ball-end milling of hardened Stavax ESR.

Keywords: Stavax ESR; Ball-end milling; Surface roughness; Energy consumption; Machining parameters.

T1-O-A72

Direct Optimization of Analytical Surface Roughness in Ball End Milling Using Particle Swarm Optimization

Ana Syahidah Mohd Rodzi¹, Alif Daniel Mohammad Mokhtar¹, Ahmad Faiz Zubair^{1*}, Mohamad Irwan Yahaya¹ and Rizal Mohamed Noor¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Pulau Pinang, Malaysia.

*ahmadfaiz@uitm.edu.my

ABSTRACT

Ball end milling is widely used for finishing free-form and sculptured surfaces in die and mould, aerospace, and biomedical applications, where surface roughness is a critical quality indicator. Conventional optimization approaches such as the Taguchi method and Response Surface Methodology (RSM) rely on extensive experimental trials and empirical regression models that are valid only within the tested range, increasing machining cost, material consumption, and production time. This study proposes a simulation-based optimization framework that directly couples Particle Swarm Optimization (PSO) with an analytical geometry-based surface roughness model for ball nose milling, thereby eliminating the need for experimentally fitted regression models or training datasets. A custom PSO algorithm was developed in MATLAB to optimize the radial depth of cut (A_e) and tool radius (R) as simultaneous decision variables within practical machining constraints, using a roughness model first validated against published ball end milling behaviour. Three representative cases initialized with tool diameters of 8, 10, and 12 mm were investigated to assess the robustness of the framework. In all cases, the algorithm converged towards lower radial depths of cut and larger tool radii, substantially reducing the predicted surface roughness relative to the initial conditions while exhibiting rapid early improvement followed by stable convergence. The convergence behaviour was largely insensitive to the initial tool geometry, indicating reliable performance across different starting conditions. The results verify that PSO reproduces physically meaningful optimization behaviour when applied directly to a purely analytical model, providing a fast, low-cost basis for preliminary machining parameter selection and a foundation for future multi-objective machining optimization.

Keywords: Ball end milling; Surface roughness; Particle Swarm Optimization; Radial Depth of Cut; Tool Radius.

T1-O-A102

Comparative Analysis of Hot and Cold Runner Systems in Injection Molding for Minimizing Surface Defects in Polycarbonate QR Code Housings

Siti Mariam Abdul Rahman¹, Izdihar Tharazi¹, Muhammad Hazim Mohd Naziron¹, Nurul Hayati Abdul Halim^{1*}, Mohamad Firhan Morni¹, Norliana Abas¹, Farrahshaida Mohd Salleh¹, Muhammad Faizul Rizal Zainal Alam² and Afifah Zakyyah Juri^{3,4}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam,
40450 Shah Alam, Selangor, Malaysia

²Pintasan Eksklusif Sdn. Bhd., 35 & 35-1 South, Jalan Seri Rejang 5, Rampai Business Park,
53300 Kuala Lumpur, Malaysia

³Department of Mechanical and Manufacturing Engineering, Faculty of Engineering and Built Environment,
Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia

⁴School of Electrical and Mechanical Engineering, Adelaide University, Adelaide 5005, SA, Australia
*hayatihalim@uitm.edu.my

ABSTRACT

The injection molding process is a process for mass-producing plastic components with high production efficiency and low cost. However, for polycarbonate QR code housings, sink marks and warpage remain major quality issues that degrade surface appearance and cause misfit when assembled onto boat or vessel bodies. This study presents a comparative analysis of two-plate cold runner and hot runner systems for minimizing sink marks and warpage using Autodesk Moldflow Adviser integrated with Response Surface Methodology (RSM) under Box–Behnken Design (BBD). Process parameters: mold temperature, melt temperature, and end of fill pressure were controlled at three levels, and their effects on both responses were statistically analysed using ANOVA for both runner systems. Results showed that the cold runner produced sink marks of 0.2589–0.3968 mm and warpage of 0.8366–0.8800 mm, whereas the hot runner reduced the defects to 0.1804–0.3072 mm and 0.8009–0.8492 mm, respectively. ANOVA identified melt temperature as the dominant factor affecting both responses in both runner systems, followed by end of fill pressure and mold temperature, whereas interaction effects contributed less significantly. It was found that when melt temperature increases, sink mark depth and warpage also increase due to greater shrinkage and thermal deformation. For multi-objective optimization, RSM suggests mold temperature at 70 °C, melt temperature at 270 °C, and end of fill pressure of 80% as the optimum parameters for both runner systems. The validation was conducted through simulation work with validation errors below 2%. Overall, the hot runner system produced lower sink marks and warpage than the cold runner system, which demonstrates its superior surface quality and dimensional stability.

Keywords: Injection molding; Hot runner system; Cold runner system; Sink mark; Warpage, Moldflow.

T1-O-A131

Simulation-Based Optimization of Injection Molding Parameters and Feed System Design for Polycarbonate QR Code Housing

Izdiyar Tharazi^{1,2}, Muhammad Akmal Syahmi Sazaleigh¹, Nurul Hayati Abdul Halim¹*, Mohamad Firhan Morni¹, Siti Mariam Abdul Rahman¹, Norliana Abas^{1,2}, Farrahshaida Mohd Salleh^{1,2}, Bibi Intan Suraya Murat^{1,2}, Muhammad Faizul Rizal Zainal Alam³ and Afifah Zakiyyah Juri^{4,5}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam,
40450 Shah Alam, Selangor, Malaysia

²Industrial Metallurgy and Materials Processing (IMMaP), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

³Pintasan Eksklusif Sdn. Bhd., 35 & 35-1 South, Jalan Seri Rejang 5, Rampai Business Park,
53300 Kuala Lumpur, Malaysia

⁴Department of Mechanical and Manufacturing Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia

⁵School of Electrical and Mechanical Engineering, Adelaide University, Adelaide 5005, SA, Australia
*hayatih@uitm.edu.my

ABSTRACT

Plastic injection molding is widely used in manufacturing due to its productivity, dimensional accuracy and cost-effectiveness. However, surface defects such as weld lines, sink marks and warpage frequently occur and can adversely affect the appearance and quality of molded products. This study aims to analyze surface quality of Polycarbonate (PC) QR code housing components by optimizing the injection molding process parameters and subsequently evaluating gate location and runner design. Autodesk Moldflow Adviser 2026 was used to simulate the melt flow and predict defects. Mold temperature (70-90 °C), melt temperature (270-310 °C) and injection time (10-15 sec) were investigated using a Box Behnken Design (BBD) with 15 simulation runs. Warpage and sink mark were optimized using Response Surface Methodology (RSM) and Analysis of Variance (ANOVA), while weld lines were qualitatively evaluated during gate and runner analysis. Melt temperature was the most influential parameter on both warpage and sink mark. The optimum conditions were mold temperature of 75.119°C, melt temperature of 270.114°C, and injection time of 14.991 s with the predicted warpage and sink mark of 0.7151 mm and 0.057 mm, respectively. The central sprue gate with 4.5 mm runner diameter produced the lowest defect values. Experimental validation using a Coordinate Measuring Machine confirmed the optimized results, with measured warpage and sink mark values of 0.542 mm and 0.073 mm, respectively. The findings demonstrate that combining process parameters optimization with gate and runner evaluation can improve defect control and provide a more efficient approach to injection molded product development. Unlike conventional optimization studies, the integrated approach guides mold design and reduces reliance on repeated trial-and-error.

Keywords: Injection Molding; Polycarbonate; Gate Location; Runner Design; Response Surface Methodology.

T1-O-A145

PLA/PA12 3D Printed Composite Fabrication

Muhammad Hafiz Musyirif Adnan¹, Farrahshaida Mohd Salleh^{1*}, Izzah Atirah Ahmad Sirfan¹, Izdiyar Tharazi¹,
Nurul Hayati Abdul Halim¹ and Abdul Halim Abdullah¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam,
40450 Shah Alam, Selangor, Malaysia

*fshaida@uitm.edu.my

ABSTRACT

Polylactic Acid (PLA) is a biodegradable polymer known for its good strength and eco-friendly properties. Polyamide 12 (PA12) is a biocompatible material that offers excellent chemical and physical resilience, making it suitable for a wide range of applications due to its high strength and stiffness. However, PLA has some limitations, including brittleness, low toughness, poor thermal stability, and moisture sensitivity. Besides that, conventional manufacturing methods are becoming less relevant over time, highlighting the favourable shift toward newer technologies such as 3D printing and the development of composite filaments with high miscibility. Therefore, the aim of this study was to prepare a PLA/PA12 filament and fabricate a 3D composite to evaluate its mechanical and physical properties. A twin-screw extruder was used to mix and produce a 1.75 mm filament composed of 60 wt.% PLA and 40 wt.% PA12. The sample was designed using CATIA software, sliced with PrusaSlicer, and fabricated through Fused Deposition Modeling (FDM). Three sets of printing parameters were applied: minimum (190 °C, 60% infill density, 0.1 mm layer height), median (200 °C, 80% infill, 0.15 mm), and maximum (210 °C, 100% infill, 0.2 mm). The printed samples were evaluated using various tests, including density, compression, and hardness tests. The results showed that adding PA12 to PLA increased compressive strength relative to pure PLA, with improvements ranging from approximately 34.87% to 56.53%. Furthermore, the sample printed with 100% infill density achieved the highest strength among those printed at 60% and 80%, reaching 93.064 MPa. The combination of PLA and PA12 improved the overall properties of the printed composite and enhanced the efficiency of the production process.

Keywords: Polylactic acid; Polyamide 12; Composite filament; 3D printing.



T1-O-A132

Wire-Arc Additive Manufacturing (WAAM) Mechanical Properties Evaluation of SS316L Thick-Wall Construction

Noridzwan Nordin, Khairulnizam Kasim, Norasiah Muhammad¹, Azri Rahimi Abd Rahman¹, Muhd Faiz Mat^{1*},
Yupiter HP Manurung¹, Hui Leng Choo and Muhammad Taufiq Aiman Khairulnizam
¹Smart Manufacturing Research Institute (SMRI), Universiti Teknologi MARA (UiTM) Shah Alam,
40450 Shah Alam, Selangor, Malaysia
*muhdfaizmat@uitm.edu.my

ABSTRACT

A thick-walled austenitic stainless steel SS316L component was fabricated using directed energy deposition wire arc additive manufacturing (DED-WAAM). This study investigated the tensile strength, hardness and fatigue performance of the as-built WAAM structure. The component was produced using a robotic gas metal arc welding process with SS316L filler wire, a 4 mm substrate plate and 99.99% purity argon shielding gas. The fabricated structure consisted of three parallel passes and 10 layers which forming a multi-layered thick-walled component. Specimens were extracted from the upper section (US) and lower section (LS) of the structure to investigate the variation in mechanical properties across the build height. Tensile and hardness tests were conducted to evaluate the mechanical properties of the WAAM-fabricated SS316L. The results showed that the ultimate tensile strength was comparable to the AWS specification, while the yield strength was lower than the specified requirement. However, the hardness and tensile properties were generally within acceptable industrial requirements, indicating that the WAAM-fabricated SS316L component has suitable mechanical performance for engineering applications. Under fully reversed loading ($R=-1$), the fatigue lives of the upper and lower sections were 36,019 and 43,366 cycles at 85% σ_y respectively. Reducing the stress level to 70% σ_y increased the fatigue life to approximately 9.8×10^5 cycles, while both sections reached the predefined run-out criterion at 50% σ_y . Although the fatigue performance was better than welded SS316L specimens, it was lower than conventionally manufactured SS316L due to the layer-by-layer deposition process and the characteristics of the as-built WAAM structure. This study provides useful insight into the mechanical and fatigue performance of thick-walled SS316L components fabricated by DED-WAAM and supports the potential for industrial metal additive manufacturing applications.

Keywords: WAAM; DED; fatigue life; mechanical properties; SS316L.

T1-O-A106

Mechanical Characterization of Elastomeric Materials for Single Use Test Plug Seal (TPS)

Thamil Selvan S Kumaresan¹, Maslinda Kamarudin^{1*} and Mohd Nasir Tamin¹

¹Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM), 81310 UTM-JB, Johor, Malaysia

*maslinda.k@utm.my

ABSTRACT

Elastomeric test plug seals (TPS) are widely employed in hydrostatic pressure testing due to their ability to undergo large deformation while maintaining effective sealing under high-pressure conditions. Reliable hyperelastic material characterization is essential for accurate finite element simulation. However, the absence of a standardized characterization procedure and the challenges associated with conducting pure shear and equibiaxial tests can lead to incomplete material data and reduced simulation accuracy. The deformation behaviour of TPS is also influenced by contact conditions, particularly friction between the seal and surrounding surfaces. Therefore, consideration of friction is important for accurately predicting seal compression behaviour and selecting an appropriate seal for a given application. This study develops a practical characterization method that combines experimental testing with prediction techniques and identifies a suitable hyperelastic constitutive model. The proposed method aims to provide a simpler approach for obtaining the material data required for finite element modelling of elastomeric seals. NBR65 was selected as the case study material based on a comparative evaluation of several phenomenological models. Uniaxial tensile testing was conducted according to ISO 37, while the pure shear and equibiaxial responses were predicted using relationships reported in the literature. The uniaxial tensile test showed that NBR65 failed at 230% strain and 6.41 MPa stress. The combined datasets were used to determine the material parameters, which were subsequently verified through finite element simulations in Abaqus. Among the evaluated models, the Ogden N3 model provided the best representation of the elastomer, achieving the lowest fitting error. The predicted pure shear response exhibited a 1:1 relationship with the uniaxial curve, while the equibiaxial response was estimated using a constant ratio of 1.51. Compression simulations were performed using different coefficients of friction, showing that the gradient of the stress-strain curve increased with increasing coefficient of friction and when compared with experimental findings, CoF of 0.3 fits the closest to experimental result. The simulated responses showed good agreement with the corresponding experimental and predicted datasets for O-Ring test plug application. The proposed model and method can later be used to perform a parametric study on the sealing efficiency of various seal materials and test-plug seal sizes. a set of optimized parameters was established to improve cutting quality and address gaps in current research.

T1-O-A130

Optimization of Flow Behaviour in Gating System using Computational Simulation

Mohamad Alif Aiman Mohd Nazri¹ and Alias Mohd Saman^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam,
40450 Shah Alam, Selangor, Malaysia

*aliasms@gmail.com

ABSTRACT

Gating and risering system design is a critical stage in sand casting production. Inadequate design can lead to casting defects such as shrinkage porosity, air entrapment, and molten metal turbulence. Consequently, resulting in increased material waste, production cost, and energy consumption. This study aims to design and optimize the gating and risering system of a water pump impeller using computational simulation. The material of the component was Aluminium Bronze (C95400), while sand casting was used as the manufacturing process. CATIA V5R20 was used in developing 3D CAD models of the component, gating and risering system. The initial gating and risering system was established using conventional casting design equations before being evaluated and refined using Altair Inspire Cast. The casting performance was assessed based on three key simulation outputs, namely molten metal flow velocity, directional solidification, and total shrinkage volume. By modifying the gating ratio from 1:2:2 to 1:2:4, the average molten metal velocity at the ingates was reduced by 41.03%, subsequently creating smoother mould filling with velocities below the recommended critical limit of 0.5 m/s. Increasing the riser dimensions successfully established directional solidification for the casting. The riser becomes the last component to solidify and shrinkage defect was relocated from the impeller hub to the riser region. The findings demonstrate that integrating conventional casting design principles with computational simulation creates an effective method for optimizing gating and risering systems. Casting quality was improved and reduce dependency on traditional trial-and-error practice. The proposed methodology also has the potential to reduce material waste and remelting requirements by enabling design refinement before manufacturing.

Keywords: Sand casting; Gating and risering system; Aluminium Bronze; Computational simulation; Impeller.

T1-O-A140

Influence of Mo Content on FCC Phase Formation and Design of FeNiCrMo High-Entropy Alloys: A CALPHAD-Based Computational Approach

Sarah Najm Al-Challabi^{1*}, Ali Samer Muhsan¹, Thar Mohammed Badri², Mokhtar Che Ismail¹ and Yusuf Busari³

¹Mechanical Engineering Department, Universiti Teknologi Petronas, Perak, Malaysia

²Electromechanical Engineering Department, University of Technology, Baghdad, Iraq

³Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),

40450 Shah Alam, Selangor, Malaysia

*sarah_21001298@utp.edu.my

ABSTRACT

High-entropy alloys (HEAs) have emerged as promising candidates for additive manufacturing (AM) owing to their attractive combinations of mechanical properties and thermal stability. However, selecting alloy compositions that maintain phase stability while limiting detrimental secondary-phase formation remains challenging. In this study, the influence of Mo additions (3, 6, and 9 at. %) on the phase stability, non-equilibrium solidification behaviour, and thermophysical properties of Fe-Ni-Cr-Mo HEAs was systematically investigated using an integrated CALPHAD framework. Equilibrium calculations, Scheil-Gulliver solidification simulations, and Thermo-Calc property models were employed to evaluate phase evolution, elemental partitioning, and temperature-dependent engineering properties relevant to future AM and Directed Energy Deposition (DED) applications. The integrated assessment identified at 6% Mo as the preferred composition, providing an FCC-dominant phase constitution while limiting secondary-phase formation under the investigated equilibrium and non-equilibrium conditions. Increasing the Mo content to 9% enhanced elemental partitioning during non-equilibrium solidification and increased the predicted tendency for Mo-rich topologically close-packed phases. A temperature-dependent thermophysical dataset, including density, heat capacity, thermal conductivity, thermal diffusivity, electrical resistivity, viscosity, and surface tension, is provided in Supplementary Table S1 for implementation in finite-element thermal simulations. Compared with previous studies that primarily examined experimentally fabricated HEAs at fixed compositions, the present work establishes a computational framework for composition assessment prior to manufacturing, enabling quantitative evaluation of phase stability, solidification behaviour, and engineering properties. These findings provide practical guidance for CALPHAD-informed alloy design and support the future development of Fe-Ni-Cr-Mo HEAs for AM and DED applications.

Keywords: High-entropy alloy; CALPHAD; Fe-Ni-Cr-Mo; Molybdenum; Phase stability; Scheil-Gulliver; Thermophysical properties; Directed Energy Deposition.

T1-O-A112

Impact of Tool Rotational Speed on Friction Stir Weld Strength Using Wavelet Signal Analysis

Maged Mustafa Abdulatef¹, Mohammad Kamil Sued^{1*} and Wan Muhammad Ezkil Wan Hassan¹

¹Fakulti Teknologi dan Kejuruteraan Industri dan Pembuatan, Universiti Teknikal Malaysia Melaka,
76100 Durian Tunggal, Melaka, Malaysia;

*kamil@utem.edu.my

ABSTRACT

Process signal analysis has attracted considerable attention as a promising approach for real-time weld quality monitoring and defect characterization in friction stir welding (FSW). The weld quality and mechanical performance of FSW joints are significantly influenced by tool geometry, process parameters, and material flow behavior. This study investigates the influence of tool rotational speed on the mechanical properties and microstructure of FSW joints in AA6061 aluminum alloy. The rotational speeds of the thread taper pin with three flat faces were 1400, 1200, and 1000 rpm, and the traverse speed was fixed at 30 mm/min. The experimental results revealed that sound, defect-free joints could be achieved at a rotational speed of 1000 rpm in the microstructure test. Defects were located using features extracted from real-time power and vibration signals, with two wavelet transform methods (Discrete Wavelet Transform DWT and Continuous Wavelet Transform CWT). This study evaluates the performance of wavelet-based methods on both power and vibration signals and validates signal-based defect localization through microstructural and microhardness analyses. The signal results were collected from three butt-welded joints, and the data were classified as either "defect-free" or "defective" for developing an accurate weld defect detection approach. Mechanical testing was conducted to validate the signal-based observations. DWT-based defect localization achieved localization coefficients of up to 0.875 using the power signals. The investigation found that joints produced at 1000 rpm exhibited the highest microhardness of 71.14 HV compared with those welded at higher rotational speeds, due to improved material flow at low rotational speeds. The proposed methodology provides a reliable framework for process monitoring and defect identification in FSW and contributes to the development of intelligent welding systems for online weld quality assessment.

Keywords: Tool Parameter; Discrete Wavelet Transform (DWT); Continuous Wavelet Transform (CWT); Weld Quality; Vibration and Power Signal.

T1-O-A107

Conceptual Design and Structural Feasibility Analysis of a Fully Electric Patrol Boat for Maritime Surveillance Application

Amirul Hafeiz Bin Faizul¹, Shaharudin Ahmad¹, Mohd Azahari Johan², Hussain Ali Alenezi³ and Amalina Amir^{1}*

*¹Faculty of Mechanical Engineering, Universiti Teknologi MARA,
40450 Shah Alam, Selangor, Malaysia*

*²Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Terengganu, Kampus Bukit Besi,
23200 Bukit Besi, Dungun, Terengganu, Malaysia*

*³Department of Manufacturing Engineering Technology, College of Technological Studies, PAAET,
Shuwaikh Industrial, Kuwait
amalina.amir@utem.edu.my

ABSTRACT

This project aims to bridge the gap in the maritime industry's shift towards sustainable solutions by developing a comprehensive design framework for fully electric patrol boats suitable for surveillance. Current naval and marine patrol operations predominantly rely on fuel-based fleets, lacking efficient electric alternatives. The primary objectives are to evaluate hull design for enhanced stability and adaptability, analyse propulsion systems for seamless power transitions and optimal performance, and create a 3D model to ensure structural integrity through static analysis. The methodology unfolds in three systematic phases. Phase 1 involves an in-depth evaluation of hull and propulsion components to establish a strong foundation for the electric patrol boat's design. This phase emphasizes the identification of key design elements and electric propulsion approach. Phase 2 progresses to constructing a detailed 3D model using CAD software such as Solidworks, focusing on optimal weight distribution and layout. Phase 3 employs Finite Element Analysis (FEA) to perform static analysis, assessing structural strength and resilience under various conditions. The expected outcomes include the creation of a detailed 3D model that encapsulates the optimal design specifications for an electric patrol boat. This model will serve as a crucial tool, providing insights into weight distribution, hydrodynamics, and equipment placement. Alongside the model, a comprehensive proof of concept analysis will validate the theoretical design through simulated scenarios, addressing stability, resistance, and endurance. This project ultimately aims to demonstrate the feasibility and efficiency of the proposed electric patrol boat design, contributing to the advancement of sustainable maritime operations.

Keywords: Maximum FEA; Electric Boat; Maritime Surveillance.

T1-V-A36

Optimization of Sintering Parameters via Response Surface Methodology for Ti-6Al-4V Fabricated through Palm Stearin-Based Metal Injection

N. H. Mohamad Nor^{1*}, S. Shawal² and Zainal Abidin Kamarul Baharin³

¹Industrial Metallurgy & Materials Processing (IMMaP), Faculty of Mechanical Engineering,
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA,
40450 Shah Alam, Selangor, Malaysia

³MEC Engineering Resources, 6 Persiaran Multimedia, 40000 Shah Alam, Selangor, Malaysia

*norhafiez@uitm.edu.my

ABSTRACT

Titanium alloy or Ti-6Al-4V has been widely used in the metal injection moulding for research and industrial application. This titanium metal injection moulding is in need for an optimization for its strength because currently it is been a significant process to produce components that are now being used in the industrial and medical application such as for dental implants. Therefore, binding material used in this study is composed of 60wt% of palm stearin (PS) and 40wt% of polyethylene (PE) mixed with the Ti-6Al-4V powder. The powder loading that used in this study is 65%vol which is the powder loading that has been optimised during the injection moulding process. This study aims to optimize the parameters for sintering process which is one of the stages in the metal injection moulding to produce the highest strength of Ti-6Al-4V through the use of response surface methodology (RSM). For this RSM, the classes that been used is central composite design (CCD). The parameter that was focused in this study are sintering temperature, sintering time, heating rate and cooling rate. For this sintering process, the optimal parameters are a sintering temperature of 1208.75°C, a sintering time of 96.328 minutes, a heating rate of 4.591°C/min and a cooling rate of 9.38 °C/min. ANOVA analysis stated that the sintering temperature has the most influence and can be considered as the most significant parameter in the sintering process as the F value in the ANOVA analysis is the highest which is 253.29, followed by sintering time, heating rate and cooling with the value of 32.84, 6.40 and 2.44 respectively. Through SEM morphology, it can be seen that the presence of more β -phase compared α -phase, causing a decrease in the elongation of the sintered body while potentially increasing its strength.

Keywords: Ti-6Al-4V; Palm stearin; Strength; Metal injection moulding; RSM.

T1-O-B11

Joining of Aluminum-CFRP: A Force Fit Joint by High Speed Electromagnetic Process

Ashish Kumar Rajak^{1*}

¹Department of Mechanical Engineering, Indian Institute of Technology Indore, India

*a.rajak@iiti.ac.in

ABSTRACT

The demand for lightweight hybrid structures in automotive and aerospace industries necessitates reliable joining of aluminum alloys to carbon fiber-reinforced polymers (CFRP). However, adhesive bonding and mechanical fastening often face challenges such as surface preparation sensitivity, stress concentration, and galvanic corrosion. This study presents a novel force-fit joint between aluminum (AA6061) and CFRP, realized via a high-speed electromagnetic forming process. Unlike conventional methods, the proposed technique utilizes a pulsed magnetic field to drive an aluminum tube or sleeve into controlled plastic deformation, mechanically compressing it onto a CFRP insert without direct contact. The high strain rate enhances aluminum formability while avoiding thermal degradation of the polymer matrix. Experimental results demonstrate that the electromagnetic force-fit joint achieves consistent interference pressure. SEM analysis reveals uniform contact without fiber breakage or delamination. Furthermore, the process completes in milliseconds, requiring no surface pretreatment or additional fasteners. This approach offers a clean, rapid, and scalable solution for metal-composite joining, with potential for lightweight multi-material design. The findings highlight the viability of electromagnetic force-fit technology as a high-productivity alternative for dissimilar material assemblies.

Keywords: Electromagnetic forming; aluminum-CFRP joint; force-fit joint; high-speed forming; hybrid lightweight structures.

T1-O-B15

Tailoring Cross-Sectional Architectures of Polymeric Nanofibers via a Novel Gyrospinning Vessel for Biomedical Applications

Hussain Ali Alenezi^{1*} and Amalina Amir²

¹Manufacturing Engineering Technology Department, College of Technological Studies, PAAET, Shuwaikh 70654, Kuwait

²School of Mechanical Engineering, College of Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*ha.alenezi@paaet.edu.kw

ABSTRACT

Polymeric nanofibers are promising materials for drug delivery, wound healing, tissue engineering, regenerative membranes, and biomedical scaffolds. However, spinning approaches focus on diameter and material composition, while cross-sectional shape remains difficult to control. This limitation is important because nanofiber geometry influences drug loading, wetted surface area, diffusion length, degradation rate, polymer swelling, cell attachment, permeability, and mechanical response. This work aims to develop a novel gyrospinning vessel capable of producing polymeric nanofibers with tailored cross-sections, including elliptical, square, triangular, and circular structures, and to demonstrate how shape can be used as a design parameter for biomedical functionality. The gyrospinning vessel was designed with customized spinnerets containing engineered micro-orifice geometries. Polymeric solutions were processed under controlled rotational speeds and solution conditions to evaluate how spinneret design, polymer concentration, viscosity, solvent evaporation, and solidification time affect fiber formation and shape retention. Nanofibers were characterized by scanning electron microscopy (SEM) to assess morphology and fidelity to the designed cross-sectional geometry. The proposed vessel enabled production of shape-engineered polymeric nanofibers while maintaining fiber continuity. Elliptical and angular nanofibers are expected to increase exposed surface area and promote faster or staged drug release, whereas circular geometries may support slower release. Square and triangular profiles may enhance interfacial contact, mechanical interlocking, fluid penetration, and scaffold-cell interactions. However, jet stretching, surface tension, and centrifugal forces can distort designed shapes toward circular profiles. The gyrospinning vessel offers a scalable route for producing biomedical polymeric nanofibers whose performance can be engineered through material composition and cross-sectional shape.

Keywords: Shape-engineered polymeric nanofibers; Gyrospinning vessel; Nanofiber-based drug delivery.

T1-V-A31

Experimental Investigation of Abrasive Water Jet Machining Parameters on Surface Roughness and Kerf Width of Brass

Izdihar Tharazi¹, Wan Emri Wan Abdul Rahaman^{2} and Engku Aisyah Nuha
Engku Muhammad Faiz¹*

¹*Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

²*Smart Manufacturing Research Institute, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

**wanemri@uitm.edu.my*

ABSTRACT

Abrasive Water Jet Machining (AWJM) is a well-known non-conventional cutting process used to machine hard-to-cut and thermally sensitive materials. However, despite its widespread application, limited research has focused on optimizing AWJM process parameters for H62 brass, particularly regarding their combined effects on cutting quality and microstructural integrity. This lack of comprehensive understanding hinders the selection of optimal machining conditions for achieving high-quality cuts. This study investigates the effects of AWJM cutting parameters on 5 mm-thick H62 brass plates. The selected process variables are abrasive flow rate, traverse speed, stand-off distance and their effects on cutting responses such as kerf width and surface roughness are analyzed. A Central Composite Design (CCD) with 17 experimental runs was used to model and analyze process performance. Kerf width was measured with a vernier caliper and surface roughness was evaluated using the Alicona 3D surface profilometer. Three specimens with the highest, lowest, and median parameter conditions were further examined using a Scanning Electron Microscope (SEM) to assess microstructure and elemental composition. ANOVA revealed that traverse speed was the most influential factor affecting both kerf width and surface roughness ($p < 0.05$), followed by abrasive flow rate and stand-off distance. Verification experiments under optimal conditions yielded low errors of 4.2% for kerf width and less than 1.4% for surface roughness, confirming the reliability of the optimization. SEM analysis showed minimal thermal deformation and consistent elemental composition in the cut zones, indicating good material integrity. Overall, the study offers new insights into the machinability and microstructural features of H62 brass using AWJM. Additionally, a set of optimized parameters was established to improve cutting quality and address gaps in current research.

T1-V-A99

Predictive Ergonomic Risk Assessment of Low Seating Workstations Using Digital Human Modelling and RULA

Muhammad Adib bin Mohd Ali¹, Kausalyah Venkatasen^{1},
Muhhamad Fahim bin Mazelan¹ and Shasthri Sivaguru²*

*¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia*

*²School of Engineering and Physical Sciences, Heriot Watt University Malaysia, Jalan Venna P5/2,
Precinct 5, Putrajaya, 62200 Wilayah Persekutuan, Malaysia*

**kausalyah@uitm.edu.my*

ABSTRACT

Foldable floor tables are commonly used for homework and work because they are portable, affordable and save space. Long use of this type of workstation can cause awkward positions to be assumed particularly at the upper arm, wrist, neck and trunk areas. The aim of this study was to assess the ergonomic risk of a low sit position workstation using a simulation based multiparametric approach. Based on the selected body segment angles and table height, a total of 110 posture configurations were generated using Latin Hypercube Sampling method. The configurations were added to a digital manikin in CATIA V5, with the manikin in a floor seated position, legs extended. The Final RULA Score, Neck Score, Trunk Score, Upper Arm Score and Wrist Score were then obtained using Rapid Upper Limb Assessment. The results were analyzed using MATLAB Model Based Calibration in order to create prediction models based on angles. The angle-based model is chosen for the final analysis as it gave better model performance than the LHS coded values. The predictions proved to be valid with an R^2 value between 0.807 and 0.853 and an RMSE of 0.049 and 0.466. The results indicated that body segment angles played an important role on predictive ergonomic risk assessment when using the workstation at a low seating position. By systematically analyzing the relationship between postural parameters and ergonomic risk, this research provides evidence-based design guidelines for optimizing low seating workstation configurations.

Keywords: *Predictive Ergonomics Risk Assessment; Low seating workstation; Latin Hypercube Sampling (LHS); Digital Human Modelling (DHM); RULA.*

T1-V-A115

Ergonomic Risk Prediction Models for Preventing Musculoskeletal Disorders in High Seating Workstations

Muhammad Nabil bin Abdul Ghani¹, Kausalyah Venkatason^{1*} and Shasthri Sivaguru²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia

²School of Engineering and Physical Sciences, Heriot Watt University Malaysia, Jalan Venna P5/2,
Precinct 5, Putrajaya, 62200 Wilayah Persekutuan, Malaysia

*kausalyah@uitm.edu.my

ABSTRACT

High seating workstations are frequently used in industrial or laboratory environments but may be uncomfortable to use and can be a factor in the development of musculoskeletal disorders (MSDs), particularly if human stature variations are not taken into consideration. The influence of posture-related and workstation-related parameters on the ergonomic risk in a high seating workstation situation was examined. The aim was to identify the most relevant parameters for postural discomfort and for MSD risk and to develop prediction models for the ergonomic assessment of this. This was achieved via a simulation-based approach and imposing a Latin Hypercube Sampling (LHS) in MATLAB using twelve ergonomic parameters: lumbar flexion, lumbar twist, head flexion, head rotation, clavicular flexion or extension, arm abduction, forearm pronation, thoracic flexion or extension, line of sight, thigh abduction or adduction, chair height and table height with 120 posture configurations generated. The created configurations were then imported into a digital human manikin in software CATIA V5 and analysed using the methodology of Rapid Upper Limb Assessment (RULA) in the Human Activity Analysis module. This discovery suggests that head flexion, lumbar flexion, arm abduction, chair height and table height are some of the significant factors that affect ergonomic risk. Also, the relation of posture to the parameters of the work situation is important, which indicates that several parameters of the work situation are involved in the control of ergonomic risk. The developed predictive models show a good agreement between the actual and predicted responses ranging from R^2 0.874 to 0.937 and RMSE 0.200 to 0.401. The results provide valuable insight into the ergonomic risk in high seating workstations and provide practical suggestions for creating safer, more comfortable and ergonomically designed high seating workstations.

Keywords: Musculoskeletal Disorders (MSDs); Digital Human Modelling; Rapid Upper Limb Assessment; Latin Hypercube Sampling; Postural Risk Assessment.

T1-V-A42

Multiparametric Aerodynamic Analysis on Sedan Vehicle Rear End Design Using LHS Sampling

Mohamad Syamir Rafiq¹, Kausalyah Venkatason^{1} and Shasthri Sivaguru²*

*¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia*

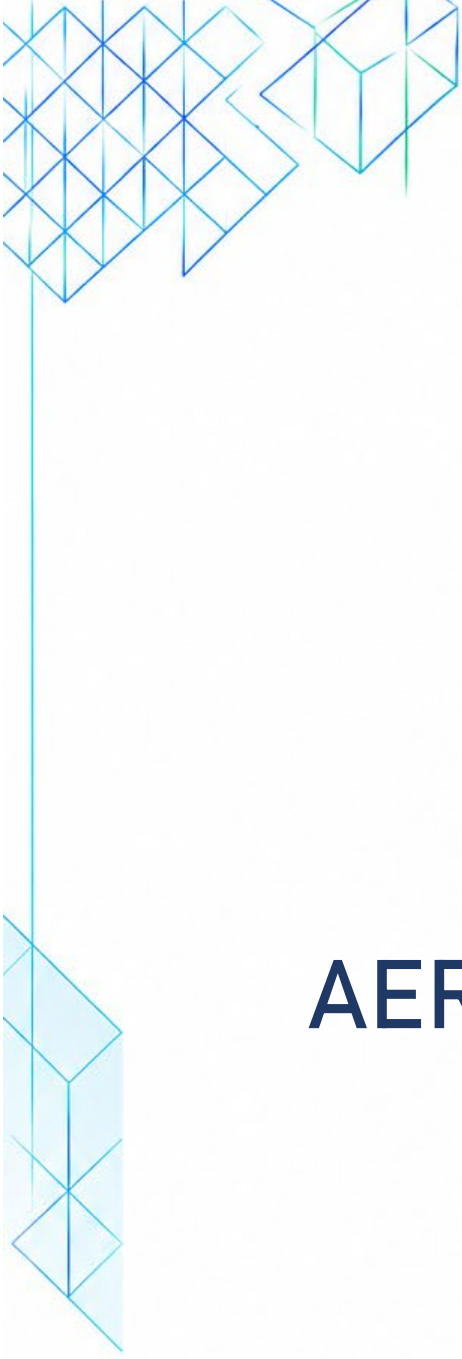
*²School of Engineering and Physical Sciences, Heriot Watt University Malaysia, Jalan Venna P5/2,
Precinct 5, Putrajaya, 62200 Wilayah Persekutuan, Malaysia*

**kausalyah@uitm.edu.my*

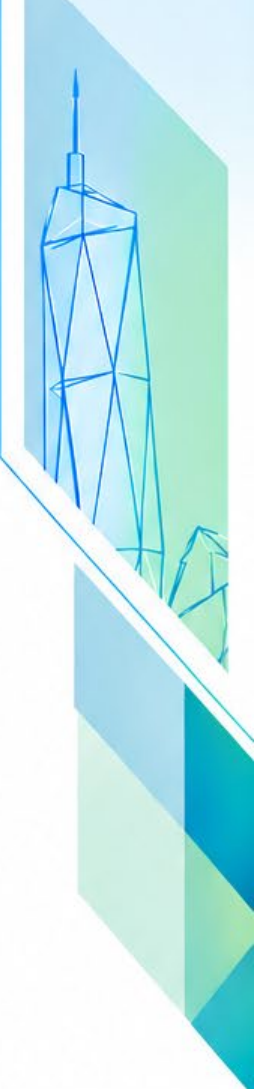
ABSTRACT

Aerodynamic drag in sedans is important for fuel consumption and stability, accounting for a significant proportion of energy loss while in motion. Although previous research has aimed to reduce aerodynamic drag through rear-end design modifications, most focused on only one or two parameters or relied on traditional sampling techniques such as Central Composite Design (CCD), which require more simulations and design iterations. Moreover, limited research has been conducted to systematically analyse the interrelationships among rear-end geometric parameters without the influence of external add-ons. This study addresses these gaps by applying the Latin Hypercube Sampling (LHS) method to explore a wide, multiparametric design space involving seven key rear-end features namely windshield angle, trunk angle, trunk length, bumper height, and ground clearance. A total of 40 unique sedan configurations were generated using LHS in MATLAB, modelled in CATIA, and analysed via CFD simulations in ANSYS Fluent to determine their drag coefficients (C_d). This data was then used to build a predictive model using Polynomial Response Surface Method (PRSM) in the MATLAB MBC toolbox. The PRSM model was highly accurate with an $R^2 = 0.9804$ and RMSE of 0.0055, compared to reference CCD model with 100 samples ($R^2 = 0.926$, RMSE = 0.006986). The best configuration achieved a minimum C_d of 0.2010, while the worst configuration achieved a minimum C_d of 0.3166, indicating that modifying rear-end geometry by itself can make a substantial difference to the aerodynamic characteristics of a vehicle. Sensitivity and interaction analysis revealed that windshield angle was the most influential parameter, especially when interacting with trunk angle and bumper height. The results validate LHS sampling method as a resource-efficient and statistically powerful method for aerodynamic optimization, offering precise modelling of complex interactions with fewer simulations. The findings support the development of drag-reducing vehicle designs without relying on external aerodynamic add-ons.

Keywords: Sedan aerodynamics; Drag coefficient (C_d); Rear-end design; Latin Hypercube Sampling (LHS), Computational Fluid Dynamics (CFD).



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TRACK 2: AEROSPACE/AVIATION TECHNOLOGY



T2-O-A38

Analysis of Work Efficiency Based on Comparison of Delays in the CN 235 Wing Production Process Using the Value Stream Mapping Method

Muhammad Fikri Julianugerah¹, Silvi Istiqomah^{1*} and Benazir Imam Arif Muttaqin¹

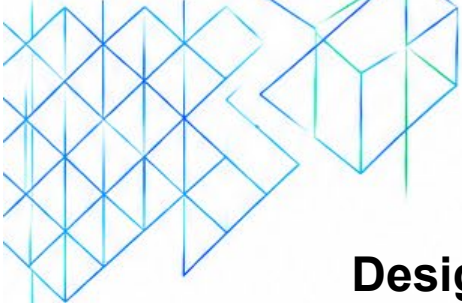
¹Telkom University, Kabupaten Bandung, Jawa Barat 40257, Indonesia

*silviistiqomah@telkomuniversity.ac.id

ABSTRACT

Air transportation plays a vital role in connecting people and goods across long distances while also supporting national defense activities. Recent air transportation data indicate a substantial increase in aviation activity, rising from 52,783,838 flights in 2022 to 62,838,931 flights in 2023. This rapid growth in demand, combined with the Indonesian government's procurement of 81 CN-235 aircraft, has required Indonesian Aerospace to enhance production effectiveness and ensure aircraft are delivered on schedule. However, production delays remain a critical challenge, particularly in the wing manufacturing process. Production records revealed that delays in wing manufacturing accumulated 10,588 hours, significantly higher than delays in the door manufacturing process (7,850 hours) and tail unit manufacturing process (8,033 hours). These delays negatively affected production flow and overall manufacturing efficiency. Subsequently, in a comprehensive comparison of delays in the wing manufacturing process, the largest production delay stemmed from Sub Assy Wing. The Sub Assy Wing revealed 2,221 hours of production delays, the largest delays contributor through the the wing manufacturing process. This study applies the Lean Manufacturing (LM) approach, specifically the Value Stream Mapping (VSM) and 7 waste method. This study identified waiting as the dominant waste through the Sub Assy Wing production process. Based on VSM and 7 waste analysis, the proposed improvement eliminated the Pick Up Rivet from Storage activity as an NVA category and integrated it into the Part Preparation Process to minimize waiting waste due to waiting for rivet material. The implementation of the proposed improvements successfully increased Process Cycle Efficiency by 11.81%, reduced lead time by 294.955 hours, and reduced waiting waste through the production process. The proposed improvement reduced waiting waste by eliminating the Pick Up Rivet from Storage activity and integrating it into the Part Preparation process. Consequently, production time and lead time were reduced without affecting the product output. The findings demonstrate that the Value Stream Mapping approach effectively enhances production efficiency, minimizes waste, and improves the overall production flow in the aircraft manufacturing process.

Keywords: Lean manufacturing, value stream mapping, process cycle efficiency, aerospace technology.



T2-V-A127

Design, Fabrication, and Testing of a Solid-Propellant Rocket Targeting a 3 km Apogee

Muhamad Hafiz Nazmi Abdul Razak¹, Zuraidah Salleh¹, Ahmad Hussein Abdul Hamid^{1*}, Fikri Abdul Rasih² and Muhammad Izzamir Firdaus Idris²

¹High Energy Material Research Laboratory (HEMREL), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Science & Technology Research Institute & Defence (STRIDE), Batu Arang, Selangor, MALAYSIA

*hussein@uitm.edu.my

ABSTRACT

An incremental design, internal ballistics scaling, and experimental validation approach for solid-propellant research sounding rocket designed for high apogee mission profiles is explored. Theoretical internal ballistics modelling and equations for the flight trajectory at high altitudes are very sensitive to the initial design parameters. Unexpected over-pressurization of the combustion chamber can cause significant performance degradation or catastrophic structural failure of the casing due to minor computational errors in the non-linear aerodynamic drag, manufacturing variations in the grains or combustion characteristics in the combustion chamber. To address these design risks and improve the predictive accuracy systematically, a multi-stage engineering development framework is presented, which involves conducting subscale experiments prior to scaling up to full scale for execution of scaling routines. The governing equations for the solid motor are introduced in the introductory sections and the general technical problems of scaling up the solid motor parameters are discussed. To address operational safety, an evaluation of alternative structural insulation techniques and thermal barrier strategies are presented to show how to isolate extreme internal heat transfer and protect the outer vehicle assembly. The research also describes the instrumentation architecture, parameters, and structural constraints used in ground-based static firing tests to collect real-time performance data and test combustion stability under controlled conditions. The last part of this work is dedicated to the use of captured empirical parameters in flight dynamic simulation environments to optimize the overall airframe and aerodynamic stabilizer surfaces of the vehicle. This investigation is used to detail a reference path for investigating the correlation between subscale validation data and full-scale predictive flight modelling.

T2-O-A94

Aerodynamic Performance of Swallow Birds Models for Bio-Inspired Fixed Wing Unmanned Aerial Vehicle Designs

Shafiq Suhaimi¹, Hamid Yusoff^{2*}, Aliff Farhan Moh Yamin², Halim Ghafar², Husnir Raziqin Md Rafie² and Wan Mazlina Wan Mohamed³

¹Department of Mechanical Engineering, Kuliyyah of Engineering, International Islamic University Malaysia (IIUM), 50728, Kuala Lumpur, Malaysia

²Pusat Pengajian Mekanikal, Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang Kampus Permatang Pauh, 13500, Permatang Pauh, Pulau Pinang, Malaysia

³Fakulti Kejuruteraan Mekanikal, Universiti Teknologi MARA (UiTM), Kampus Shah Alam, 40450 Shah Alam, Selangor, Malaysia

*hamidyusoff@uitm.edu.my

ABSTRACT

One of challenges of an Unmanned Aerial Vehicle (UAV), design lies in the aerodynamic performance where the vehicle needed to be efficient enough that allows for better endurance and low power requirement but still be able to be manoeuvrable and agile. One solution for need is to look at some of nature's best flyers and find if observing from them can help to produce a high performing UAV design. The objective of this study is to investigate the aerodynamic performance of a barn, bank, and cliff swallow models in order to design a swallow inspired UAV. This was done by performing a Computational Fluid Dynamic (CFD) simulation of the three swallow models that were generated using Computer Aided Design (CAD). The models were tested for their coefficient of lift (C_L), coefficient of drag (C_D) and lift over drag (C_L/C_D) at 19m/s airspeed and different angles of attack (-30° , -20° , -10° , 0° , 10° , 20° , 30°). From the simulation analysis, the results shown that the barn swallow's ability to resist airflow separation and its ability to generate a larger Leading-Edge Vortex. It is performance that made the barn swallow a leading candidate for a future UAV design.

Keywords: Bio-inspired; biomimicry; Bird wings; UA.

T2-O-A79

Aerodynamic Study of Wing Sweep Angles in UiTM's Unconventional Wing Aircraft Using Computational Simulations

Zurriati Mohd Ali^{1*}, Iskandar Shah Ishak², Noor Iswadi Ismail³, Mohd Irwan Yahya³
and Ahmad Naufal Danish Zulkarnain¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Sha Alam,
40450 Shah Alam, Selangor, Malaysia

²UTM Aerolab, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

³Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Pulau Pinang Campus, 13500,
Permatang Pauh, Pulau Pinang, Malaysia
*zurriatimohdali@uitm.edu.my

ABSTRACT

This study evaluates the aerodynamic performance of the UiTM "Hawkeye" Unmanned Aerial Vehicle (UAV), which utilizes a forward-swept wing (FSW) configuration. While FSW designs offer distinct advantages in manoeuvrability and construction, they suffer from unsteady aerodynamic behaviour at high angles of attack (α), risking compromised controllability. Because baseline aerodynamic data for this aircraft were previously unavailable, this research quantifies its lift coefficient (CL), drag coefficient (CD), and lift-to-drag ratio (L/D). Using ANSYS Fluent, Computational Fluid Dynamics (CFD) simulations were conducted at a Reynolds number of $Re = 2.4 \times 10^6$ (Mach 0.1, 35 m/s). The aerodynamic characteristics were analyzed across three forward-sweep angles ($\Lambda = -25^\circ, -30^\circ$, and -35°) at angles of attack ranging from 0° to stall (α_{stall}) in 2° increments. Turbulence was modeled using the Spalart-Allmaras one-equation model, which is well-suited for aerodynamic flows with mild separation. The simulation results revealed that all three wing configurations followed highly similar lift and drag trajectories. However, the most aggressively swept configuration ($\Lambda = -35^\circ$) exhibited slightly higher lift and drag coefficients at high angles of attack compared to the -25° and -30° variations. Ultimately, the performance differences were small within the numerical accuracy of the present CFD simulations. These findings establish a crucial aerodynamic baseline for the Hawkeye UAV, though further optimization studies are recommended to fully exploit the unique advantages of forward-swept wing configurations in unmanned aircraft design.

Keywords: UAV; Forward-Swept Wing; Aerodynamics; CFD; Unconventional Aircraft.

T2-O-A78

Flight Performance and Stability of a Bird-Inspired Blended Wing-Body Planform in Laminar Incompressible Flow

Rizal E. M. Nasir^{1*}, Zurriati Mohd Ali¹, Firdaus Mohamad¹, Iskandar Shah Ishak² and Zamri Omar³

¹Flight Tech. & Test RG, Faculty of Mechanical Engineering, Universiti Teknologi Mara,
40450 Shah Alam, Selangor, Malaysia

²AEROLAB UTM, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia,
81310 UTM Skudai, Johor, Malaysia

³Zamri Omar, Dept. of Aeronautics, Universiti Tun Hussein Onn, 86400, Batu Pahat, Johor, Malaysia

*rizal524@uitm.edu.my

ABSTRACT

Blended Wing-Body aircraft offer significant aerodynamic efficiency advantages over conventional tube-and-wing configurations, but their tailless design introduces critical longitudinal stability and trim challenges that have historically limited practical adoption. This study numerically investigates the flight performance and longitudinal static stability of the Baseline-11, a novel bird-inspired BWB planform designed to address these challenges through biomimetic geometric tailoring rather than active stabilizing surfaces. Computational analysis was performed using the OpenVSP and VSPAero vortex-lattice method solver under laminar, incompressible flow conditions across an angle-of-attack range of -5° to 15° . The aerodynamic characterization reveals that the Baseline-11 achieves a peak lift-to-drag ratio of approximately 36 at $\alpha \approx 3^\circ$ – 4° , representing a 12.5% efficiency improvement relative to the previously studied Baseline-V configuration, which attained a maximum L/D of 32. The drag polar exhibits a well-defined parabolic profile with a minimum drag coefficient of 0.0085 occurring at a positive lift coefficient of approximately 0.268, demonstrating that the configuration is most aerodynamically efficient while already producing meaningful lift — an advantageous property for sustained cruise performance. Longitudinal stability analysis confirms inherent passive stability, with a robust static margin of 27.01% and a negative pitching moment slope of -0.0242 per degree. The planform naturally trims at $\alpha \approx 2.56^\circ$, an angle that closely coincides with the optimum aerodynamic efficiency regime, thereby minimizing the requirement for continuous control surface deflection during cruise. For the proposed aircraft mass of 0.5 kg and wing area of 0.25 m² — yielding a low wing loading of 2 kg/m² — the Baseline-11 predicts an optimal cruise speed of 8.0 m/s with a minimum power requirement of approximately 1.09 W, underscoring its strong potential for low-speed, high-efficiency subsonic UAV applications. These findings validate bird-inspired planform geometry as an effective passive solution to the inherent longitudinal stability challenges of tailless BWB aircraft.

Keywords: Blended Wing-Body; Bird-Inspired Design; Longitudinal Static Stability; Lift-to-Drag Ratio; Vortex-Lattice Method.

T2-O-B01

Mechanical Influence of Build Orientation and Printing Parameters of PETG in FDM

Lawal Babatunde Abdulqadir^{1*}, Sadiq Ibrahim Issah², Yusuf Lanre Shuaib-Babata³

¹Department of Mechanical Engineering, Kwara State Polytechnic, Ilorin, Nigeria

²Department of Mechanical Engineering, Qassim University, Saudi Arabia

³Department of Materials and Metallurgical Engineering, University of Ilorin, Ilorin, Nigeria

*labbdulqadir@gmail.com

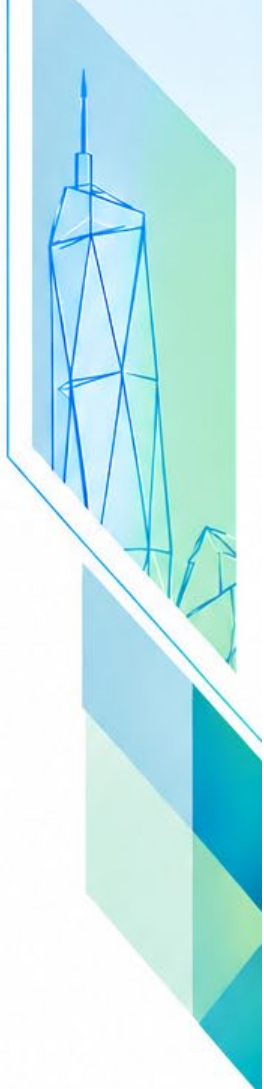
ABSTRACT

The advancement of additive manufacturing technologies, particularly Fused Deposition Modelling (FDM) has enabled the rapid production of functional components using a variety of thermoplastics. Among these, Polyethylene Terephthalate Glycol (PETG) has emerged as a favourable material due to its superior toughness, chemical resistance, and printability. However, the mechanical performance of PETG parts is highly sensitive to printing parameters and build orientation, and limited research exists in this area. This study proposes an experimental investigation aimed at identifying optimal FDM printing parameters and build orientations to enhance the tensile strength and mechanical reliability of PETG-printed parts. The tensile specimens will be fabricated based on ASTM D638 Type IV under varied orientations (flat, on edge, upright) and print angles (0°, 45°, 90°). Mechanical performance was assessed through uniaxial tensile testing and establish relationships between process settings and material behaviour. The Flat 0° specimen demonstrates the highest Young's modulus and ultimate tensile strength (UTS) with significant ductility, attributed to efficient load distribution along filament lines. In contrast, 45° specimens exhibit slightly lower UTS and elongation, yet perform better than the 90° specimens due to reduced interlayer bonding as the raster angle deviates from the loading direction. The 45° specimen achieves the highest UTS at ~32 MPa, while the 90° specimen shows early fracture and low ductility. On-edge configurations yield moderate performance, resulting in longer build times compared to flat orientations, whereas upright samples show the lowest tensile strength despite the highest build times. The findings offer valuable guidelines for the efficient and reliable use of PETG in functional applications, addressing current gaps in additive manufacturing research and supporting the broader adoption of PETG in many applications.

Keywords: Fused Deposition Modelling (FDM); PETG; tensile strength; build orientation.



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TRACK 3: ADVANCED MATERIALS FOR SUSTAINABLE ENGINEERING



T3-O-A113

Influence of Surface Treatment on Corrosion Resistance of Cobalt Alloy Coating

Nik Rozlin Nik Mohd Masde¹, Noor Leha Abdul Rahman^{1*} and Saiful Adham Sharil¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Sha Alam,
40450 Shah Alam, Selangor, Malaysia

*noorleha@uitm.edu.my

ABSTRACT

The effect of chemical pickling pre-treatment on the surface integrity and performance of electrodeposited cobalt-nickel-iron (CoNiFe) alloy coatings on mild steel substrates was investigated. The main objective was to determine the best pickling duration for improving the surface adhesion, mechanical and corrosion properties of the deposited CoNiFe coating. The mild steel substrates were prepared by an automated precision grinding process prior to the electrodeposition and subsequently pickled with different pickling times (0, 40, 50 and 60 seconds) in 12 vol.% sulphuric acid at room temperature. The CoNiFe coating was characterized in terms of microhardness, surface roughness, adhesion and corrosion resistance. It was found that 50 s pickling treatment produced the optimum overall coating performance with highest microhardness of 371.5 HV and lowest mass loss of only 0.022 g after 192 h of immersion in 3.5 wt.% NaCl solution, indicating superior corrosion resistance. The surface morphology observations also indicate that 50 s treatment promoted the formation of a uniform, dense and defect-free CoNiFe coating. In addition, the 50 s specimen had the highest adhesion performance as per ASTM D3359 standard. In conclusion, 50 s pickling time was the best pretreatment condition to produce improved coating performance indicating the importance of pickling duration in achieving superior coating integrity.

Keywords: Cobalt alloy coatings; Surface Pretreatment; Electrochemical Deposition; Adhesion Performance; Corrosion Resistance.

T3-O-B24

Impact Behaviour of Natural Fibres Reinforced Polymer Composites: Experiment & Simulation Analysis

Aidah Jumahat^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*aidahjumahat@uitm.edu.my

ABSTRACT

Natural fibre-reinforced polymer (FRP) composites are attractive alternative materials that could replace synthetic fibres such as glass and carbon, thereby reducing dependency on petroleum-based by-products. This research aims to analyse the low- and high-velocity impact behaviour of FRP composites using experimental and ANSYS Workbench simulation techniques. Three types of natural-based fibres, i.e. basalt, Arenga pinnata, and bamboo, were used to fabricate the FRP composite samples via the vacuum bagging method. Low-velocity drop-weight impact tests were conducted at three different impact energies (10 J, 30 J, and 50 J) on eight lamination systems, i.e. Unidirectional (UD) basalt FRP (UDBFRP), UD glass FRP (UDGFRP), UD hybrid glass-basalt FRP (UDGBFRP), UD Arenga pinnata FRP (UDAFRP), Woven basalt FRP (WBFRP), Woven glass FRP (WGFRP), Woven hybrid glass-basalt FRP (WGBFRP), and Woven Arenga pinnata FRP (WAFRP). The effects of fibre orientation, fibre type, and hybridisation on impact resistance and damage mechanisms were evaluated in accordance with ASTM D7136. Results indicated that FRP composites with a $\pm 45^\circ$ laminate orientation exhibited higher energy absorption and impact strength than those with UD and standard woven orientations. Furthermore, BFRP and GFRP demonstrated comparable impact properties, whereas APFRP absorbed less energy than both. To complement the experimental data, finite element analysis (FEA) was conducted via ANSYS Workbench to comprehensively evaluate the low- and high-velocity impact behaviour of BFRP, GFRP, BGFRP, bamboo FRP (BMFRP), and bamboo-glass FRP (BMGFRP). Simulations revealed that high-velocity impacts shortened the fibre deformation time to 0.2 s, resulting in a maximum Z-deformation of 0.9287 mm and a maximum stress of 78.955 MPa. In contrast, low-velocity impacts extended the deformation time to 0.55 s, yielding a Z-deformation of 0.9717 mm and a maximum stress of 2.647 MPa. Additionally, fibre hybridisation was shown to reduce deformation and energy absorption by up to 10% and 25%, respectively.

T3-O-A87

Repurposing End-of-Life Al-Quran Paper Ash as a Partial Replacement for Silica Sand in Green Sand Aluminum Casting

Ahmad Amir Akmal¹, Muhammad Faiz Mohd Mazelan², Omar Falyouna³, Bulan Abdullah⁴, Muhammad Hussain Ismail⁴ and Mohd Faizul Idham^{5}*

¹*Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

²*Faculty of Mechanical Engineering, UiTM Terengganu branch, 23200, Bukit Besi, Terengganu, Malaysia*

³*Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro-Ku, Tokyo, 153-8505 Japan*

⁴*Industrial Metallurgy and Materials Processing (IMMaP), Faculty of Mechanical Engineering, UiTM Shah Alam, 40450, Shah Alam, Selangor, Malaysia*

⁵*Industrial Metallurgy and Materials Processing (IMMaP), Faculty of Mechanical Engineering, UiTM Terengganu branch, 23200, Bukit Besi, Terengganu, Malaysia*

**faizulidham@uitm.edu.my*

ABSTRACT

The metal casting industry is highly dependent on virgin silica sand, resulting in increased raw material costs and the depletion of environmental resources. Concurrently, the incineration of end-of-life Al-Quran texts generates Al-Quran paper ash (AQPA), which is often discarded in marine environments, creating ecological risks and additional disposal costs. This study investigates a circular-economy approach by repurposing AQPA as a partial replacement for silica sand in green-sand molds for aluminum casting. Virgin silica sand was substituted with AQPA at weight percentages from 0% to 20%, while all other green sand components were held constant. The physical, morphological, thermal stability, and mechanical properties of the modified molds were evaluated, along with the microstructural, hardness, and tensile characteristics of the resulting cast aluminum. Results demonstrate that AQPA can safely replace up to 15 wt% of silica sand without compromising mold structural integrity. Morphological analysis confirms that at a 5 wt% substitution, AQPA acts as a micro-filler, increasing green compression strength to 0.0810 MPa. The pre-calcined nature of AQPA significantly improves the mold's dimensional stability under thermal stress. At 700°C, the 5% AQPA mold exhibited minimal volumetric shrinkage and lower mass loss (13.50%) than the standard silica sand control (17.56%). Furthermore, incorporating AQPA into the mold matrix increases density, promoting more efficient heat extraction and accelerating the cooling rate of the molten aluminum. This cooling behavior is evidenced by microstructural grain refinement, a 7% increase in Vickers hardness (97.16 HV), and a preserved ultimate tensile strength of 108.90 MPa, with no casting defects. The use of AQPA provides a zero-cost additive strategy that reduces raw material procurement costs and diverts regulated municipal byproduct from standard disposal procedures and marine environments, thereby supporting sustainable manufacturing practices in the foundry sector and directly aligning with UN SDG 12 (Responsible Consumption and Production).

T3-O-A20

Benchmarking Nigeria's Access to Clean Cooking Fuels and Fossil Fuel Consumption: An Environmental Kuznets Curve Analysis Relative to BRICS Countries

Mohammed H. Rad¹, Abubakar Kazeem², Safyanu Bashir Danjuma^{2,3*}, Emeka Joseph³
and Valentina U. Thompson-Adewole³

¹University of Wasit, Iraq

²Universiti Tun Hussein Onn Malaysia, Malaysia

³National Centre for Technology Management, Nigeria

*safyanu@uthm.edu.my

ABSTRACT

Nigeria is blessed with a diversity of over 53 minerals, an enormous amount of crude oil reserves, and several untapped natural resources. Yet, a large number of Nigerians depend on traditional biomass, such as firewood and charcoal for cooking and heating. Previous studies do not address key indicators such as the access of rural dwellers to clean fuels, and fossil fuel consumption in Nigeria in comparison to the BRICS countries. The current paper is an effort to expand the understanding on the application of parameters extracted from the Environmental Kuznets Curve. This was accomplished by comparing Nigeria's performance against the BRICS countries using Pearson correlation (PR) analysis. Remarkably, while the standard deviation (SD) was 3.1444 with a mean value (MV) of 2.45% for Nigeria, Brazil recorded 70.20% with an SD of 9.1732 in rural access to clean fuels and technologies (RACF). India (23.49%, SD = 17.3269), South Africa (54.41%, SD = 13.3044), China (41.45%, SD = 18.5406), and Russia (99.29%, SD = 0.3260). The Analysis of Variance (ANOVA) agrees with the statistical significance of the regression model ($F(1, 21) = 85.82, p < 0.001$). This indicates that the mean value for BRICS is a statistically significant forecast of rural access to modern energy sources in Nigeria. The EKC theory also readily agrees with the "Grow Now, Clean Later" paradigm. Hypothesis testing shows a strong positive correlation with the BRICS average, resulting in the adoption of the substitute hypothesis; showing that Nigeria's utilization of fossil fuel energy is remarkably higher than the mean uptake in BRICS nations. Key recommendations and policy directions were initiated with the aim to support evidence-based decision making of both the public and private sectors.

Keywords: Modern Energy Sources; Environmental Kuznets Curve (EKC); Grow Now; Clean Later; Nigeria and BRICS.

T3-O-A11

From Conventional to Green Synthesis of Graphene Quantum Dots: Biomass Precursors, Tunable Properties, and Future Perspectives

Imandeena Sofileeya Nor Azri¹, Faiz Haikal Johari¹, Nur Haziqah Izzati Roslan¹, Rozina Abdul Rani¹,
Khairunisak Abdul Razak², Muhammad Haziq Noor Akashah³ and Siti Rabizah Makhsin^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²School of Materials and Mineral Resources Engineering, Engineering Campus, Universiti Sains Malaysia,
14300 Nibong Tebal, Pulau Pinang, Malaysia.

³Department of Mechanical Engineering, Toyohashi University of Technology, Toyohashi, Japan.

*sitirabizah@uitm.edu.my

ABSTRACT

Graphene is a unique two-dimensional material owing to its exceptional electrical, optical, mechanical, and structural properties. Quantum confinement occurs when graphene is reduced to a few nanometres, producing graphene quantum dots (GQDs). These materials possess distinctive photoluminescence (PL) properties that are highly regarded for the fabrication of rapid-detection sensing platforms across various applications. Furthermore, their versatile surface chemistry enables facile functionalization, making GQDs particularly suitable for highly selective and sensitive applications, including heavy metal ion detection and early disease diagnosis. This review presents an overview of the various GQDs synthesis methods, their advantages and limitations, green alternatives to conventional approaches, and the utilization of biomass waste as carbon-based precursors, along with their respective properties. The transition from conventional synthesis routes to green-assisted and bio-derived approaches is primarily driven by the environmental and health concerns associated with traditional methods, particularly chemical oxidation processes that require concentrated acid, as well as growing demand for safer, more sustainable, and energy-efficient production of high-quality GQDs. The abundance of agricultural and food waste provides a renewable and environmentally friendly source of carbon for GQD synthesis, offering a sustainable alternative with minimal environmental impact. The top-down approach is particularly promising for large-scale production due to its scalability, whereas the bottom-up approach offers superior control over the size, morphology, and structure of GQDs, enabling the tailoring of their properties for specific applications. Finally, recent advances and prospects of GQDs in optical sensing are discussed, highlighting their significant potential for next-generation sensing technologies.

Keywords: Carbon nanomaterials; graphene quantum dots; bio-derived precursors; biomass; green synthesis.

T3-O-A12

Graphene-Based Materials in Fiber Optic Sensors for Heavy Metal Ion Detection: A Review

Norjasween Abdul Malik¹, Siti Rabizah Maksin^{2*}, Rozina Abdul Rani², Wan Fahmin Faiz Wan Ali³, Muhammad Haziq Noor Akashah⁴, Mohd Rafal Sahudin⁵ and Khairunnisa Auni Hazri²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 81750 Masai, Johor, Malaysia.

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

³Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

⁴Department of Mechanical Engineering, Toyohashi University of Technology, Toyohashi, Japan.

⁵Mechanical Engineering Branch, Jabatan Kerja Raya (JKR), 50480 Kuala Lumpur, Malaysia.

*sitirabizah@uitm.edu.my

ABSTRACT

Recent industrialization and urbanization have led to increasing contamination of water resources by heavy metal (HMs) ions such as copper (Cu^{2+}), lead (Pb^{2+}), cadmium (Cd^{2+}), and mercury (Hg^{2+}), posing serious risks to environmental sustainability and human health due to their toxicity, persistence, and bioaccumulation. Developing efficient, rapid, and sensitive detection methods for these ions is therefore critical. This paper presents a comparative review of graphene-based materials for fiber-optic sensors (FOS) in heavy metal ion detection, synthesizing 67 studies published between 2011 and 2026. Unlike existing reviews that address graphene-based metal-ion sensing across broader platforms such as electrochemical methods, or FOS without a graphene-specific focus, this review focuses on graphene-integrated fiber-optic configurations, offering a direct, quantitative comparison of Surface Plasmon Resonance (SPR), fluorescence-based, and Fiber Bragg Grating (FBG) sensing. Sensing mechanisms of graphene, graphene oxide (GO), reduced graphene oxide (rGO), and graphene quantum dots (GQDs) are discussed in detail. Among the reviewed configurations, graphene-based SPR sensors delivered the strongest overall performance: dual-mode plasmonic-electrochemical designs achieved detection limits as low as 10–14 M, while graphene/gold-nanoparticle-coated fibers reached sensitivities of 0.21 nm/ppm and detection limits of 0.48 ppm for Pb^{2+} , and tapered graphene-antimonene sensors showed up to 26% sensitivity gains over untapered fibers for Hg^{2+} . Fluorescence-based graphene quantum dot sensors achieved sub-micromolar detection limits (0.226 μM for Cu^{2+}) with fast real-time response but comparatively lower long-term stability. Overall, graphene integration addresses a key gap in FOS by combining high surface area, rich functional groups, and strong optical interaction to deliver sensitive, selective, label-free, and real-time HMs detection. Remaining challenges include robust anti-fouling surfaces, long-term stability in complex matrices, and low-cost fabrication for field deployment. Future trends are expected to focus on hybrid or trihybrid nanocomposites and advanced fabrication methods such as nanostructured coatings.

Keywords: Graphene-based; Optical sensing; Fiber optic sensors; Heavy metal ions; Heavy metal detection.

T3-O-A89

MAX, MXene And MXene Polymer Composites: Design Fabrication and Characterizations

Adel Mohammed Al-Dhahebi^{1*}, Sami-Alalimi¹, Yusuf Olanrewaju Busari² and Nor Fazli Adull Manan¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia.

²Smart Manufacturing Research Institute (SMRI), Universiti Teknologi MARA, 40450 Shah Alam, Malaysia.

*adelaldhahebi@uitm.edu.my

ABSTRACT

MXenes are fascinating 2D materials of carbides and nitrides that are derived from their parent MAX phases via chemical etching. Their unique layered structures, transition metal's ordering and compositions, atomic sublattice compositions and rich surface functional groups render them with remarkable features and behaviours that suit and enable desired advanced applications. Moreover, MXene surface functional groups enable effective interface with other functional nanomaterials and polymers which overcomes their oxidation degradation and restacking issues. In this paper, the synthesis of MXene via the minimally intensive delamination method (MILD) has been carried out followed by comprehensive morphological, elemental, functional, and topography characterizations and comparison with MAX phases. Finally, MXene with 0 % and 1% were also integrated with polyvinylidene fluoride via direct mixing followed by electrospinning technique to investigate the impact of MXene fillers on the morphologies, topography, functionality, crystallinity, thermal, mechanical, and electrochemical properties of PVDF nanofibers. The results indicate that the integration of MXene with polymeric matrix at 1% improved fiber diameter, crystallinity (β -phase), tensile strength, elongation, thermal properties and electrons transfer kinetics (R^2 of 0.999).

Keywords: Composition engineering; MXenes 2D materials; electrospun nanofibers; electrochemical characterization.

T3-O-A13

Insights into the Role of Graphene Oxide Precursor Concentration in Reduced Graphene Oxide Formation for Enhanced Optical Properties in Fibre Optic Sensors

Azib Haiman Roslan¹, Rozina Abdul Rani¹, Khairunnisak Abdul Razak², Beenish Siddique³
and Siti Rabizah Makhsin^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia.

²School of Materials and Mineral Resources Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia.

³AEH Innovative Hydrogel Ltd, The Cube, Coe Street, Bolton, England, BL3 6BU, United Kingdom.

*sitirabizah@uitm.edu.my

ABSTRACT

Reduced graphene oxide (rGO) has attracted considerable interest as a coating material for fibre-optic sensors due to its excellent optical properties and high surface area. However, green synthesis methods that simultaneously optimize the optical characteristics of rGO for fibre-optic sensing remain limited. This study reports the green synthesis of rGO via chemical reduction of graphene oxide (GO) using L-ascorbic acid as the reducing agent, replacing the toxic hydrazine hydrate conventionally used in rGO production. The effect of GO precursor loading on the structural, optical, and morphological properties of rGO was systematically investigated to identify the optimum synthesis condition for enhancing fibre-optic sensor performance. The synthesized rGO samples were characterized using UV-Vis spectroscopy, zeta potential analysis, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, and Raman spectroscopy. The rGO samples were subsequently coated onto a silica single-mode optical fibre and evaluated using SEM, EDX, and optical signal measurements. The optimum sample (rGO Sample B), synthesized from 400 mg of GO, exhibited characteristic UV-Vis absorption peaks at 241 and 308 nm, confirming successful reduction, together with good colloidal stability (zeta potential = -35.3 mV). Structural characterization revealed crumpled graphene sheets with partial restoration of the sp² carbon network, a C/O ratio of 1.03, and an ID/IG ratio of 1.069. When applied as a fibre-optic coating, rGO Sample B achieved a maximum light intensity of 2867 a.u., corresponding to signal enhancements of 106% and 86% compared with uncladded and GO-coated fibres, respectively. These results demonstrate that the optimized green-synthesized rGO effectively enhances light-material interaction and provides an improved sensing interface, highlighting its potential as a sustainable coating material for high-performance fibre-optic biosensors.

Keywords: Reduced graphene oxide; L-ascorbic acid; Fibre-optic sensor; Optical sensor.

T3-O-A48

ANFIS Modelling of the Mechanical Reliability of CNT-Reinforced Sn-5Sb/Cu Solder Composite Joints

T.T. Dele-Afolabi^{1,2} and M.A. Azmah Hanim^{3,4}*

¹Engineered Materials and Structures Research Group, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia.

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia

³Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang Selangor, Malaysia.

⁴Advance Engineering Materials and Composites Research Center, (AEMC), Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang Selangor, Malaysia.

**deleafolabitemitope@uitm.edu.my*

ABSTRACT

The use of a neuro-fuzzy system to predict the shear strength of carbon nanotubes-reinforced Sn-5Sb/Cu solder is presented in this study. In order to achieve highly efficient model, the study employed experimental database obtained by conducting shear test on composite solder joints using a single-lap joint configuration. As input parameters to the adaptive neuro-fuzzy inference system (ANFIS), a number of significant factors that impact the joints' shear strength performance were taken into consideration, such as the CNTs content, aging temperature, aging period, and IMC layer thickness. A total of 40 experimental data points were used to develop the ANFIS model. The result of the ANFIS model was compared with both the experimental results and the results obtained using the conventional multiple linear regression (MLR) model. The coefficient of determination (R^2) was used to evaluate the model's accuracy. According to the findings, the ANFIS model significantly outperformed the MLR model, which produced a R^2 value of 0.7506, with a R^2 value of 0.9799. This corresponds to a 30.6% increase in the coefficient of determination over the MLR model, demonstrating the ANFIS approach's better predictive power. Overall, the performance comparison showcases the superiority of artificial intelligence modelling model over the conventional statistical modelling such as the MLR model and can be successfully deployed to predict the shear strength of lead-free solder joints.

Keywords: *Composite solders; Carbon nanotubes; IMC layer; Shear strength; Adaptive neuro-fuzzy inference system.*

T3-O-A67

Microwave-Assisted Soldering in Electronic Packaging: A Critical Review of Microstructure Evolution, Mechanical Reliability, Corrosion Performance, and Future Perspectives

Intan Syafiqah Isma Harisham¹, Shahrul Azmir Osman¹ and Saliza Azlina Osman^{1*}

¹Fakulti Kejuruteraan Mekanikal dan Pembuatan, Universiti Tun Hussein Onn Malaysia,
86400 Batu Pahat, Johor

*salizaz@uthm.edu.my

ABSTRACT

Microwave-assisted soldering has emerged as a promising joining technique for next-generation electronic packaging because it offers rapid volumetric heating, microstructural control, and energy savings compared with conventional reflow processes. This critical review evaluates microwave parameters, susceptor configuration, alloying and nano-reinforcement strategies, surface finishes, and reliability-testing approaches that govern interfacial microstructure, intermetallic compound (IMC) evolution, mechanical integrity, corrosion behaviour, and industrial readiness of lead-free solder joints. Emphasis is placed not only on reported benefits, such as strength improvements up to 45% and energy reductions of 20-30%, but also on contradictory outcomes caused by excessive exposure, non-uniform heating, inappropriate susceptor loading, alloy chemistry, and cooling-rate variation. The review further assesses the role of electroless nickel immersion gold (ENIG), electroless nickel electroless palladium immersion gold (ENEPIG), and immersion coatings in interfacial stability and degradation resistance. Key gaps are identified in electromagnetic-thermal-diffusion coupling, quantitative IMC growth modelling, coupled corrosion-fatigue-electromigration reliability assessment, process standardisation, technology readiness, and life-cycle sustainability. Future perspectives highlight in-situ diagnostics, advanced characterisation, data-driven optimisation, artificial intelligence-assisted process control, and industrial adoption pathways to move microwave soldering from laboratory-scale development toward scalable, reliable, and sustainable electronic manufacturing.

Keywords: Microwave soldering; Lead-free solder; Intermetallic compounds; Corrosion resistance; Sustainable electronics.

T3-O-A70

Influence of Susceptor Material on Microstructure Evolution and Corrosion Resistance in Microwave Soldering

Syazlina Shabudin¹, Intan Syafiqah Isma Harisham¹ and Saliza Azlina Osman^{1*}

¹Fakulti Kejuruteraan Mekanikal dan Pembuatan, Universiti Tun Hussein Onn Malaysia,

86400 Batu Pahat, Johor

*salizaz@uthm.edu.my

ABSTRACT

This study examines the influence of susceptor material selection on the microstructural development and corrosion resistance of microwave-soldered lead-free bismuth-based solder joints. Two lead-free solder compositions, Sn-35Bi-0.3Ag and Sn-35Bi-1.0Ag, were investigated using three distinct susceptor materials: silicon carbide (SiC), graphite, and iron, applied to electroless nickel/immersion gold (ENIG) coated substrates. The microwave soldering process was carried out at 230°C for 3 minutes, followed by detailed characterisation using optical microscopy (OM), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDX). The corrosion behaviour was evaluated by potentiodynamic polarisation testing in 6 M potassium hydroxide (KOH) solution. The results indicate that silicon carbide susceptors yield superior joint quality, characterised by the most uniform formation of intermetallic compounds (IMCs) and a controlled thickness of 6.318-6.444 µm. Conversely, iron susceptors resulted in significantly thicker IMC layers, ranging from 9.59 to 11.83 µm, indicating excessive interfacial reactivity. The solder with higher silver content (Sn-35Bi-1.0Ag) consistently outperformed its lower-silver counterpart across all susceptor types, exhibiting enhanced microstructural organisation and improved corrosion resistance. Corrosion testing revealed that the combination of Sn-35Bi-1.0Ag with SiC susceptors achieved outstanding performance, yielding the lowest corrosion rate of 0.03275 mm/year and a current (I_{corr}) of 5.6375×10^{-8} A, reflecting a 75-93% improvement over other material combinations. These findings offer clear guidelines for optimising microwave soldering processes, emphasising that carefully selecting susceptor materials is essential for developing reliable, environmentally sustainable electronic assemblies that meet industry performance standards.

Keywords: Microwave soldering, corrosion behaviour, susceptor, lead-free soldering, intermetallic compounds.

T3-O-A81

Effect of Warm Compaction Parameters on the Electrical Resistivity and Transverse Rupture Strength of CNT-Reinforced PKS–Graphite–Copper Composites

Koay Mei Hyi^{1*}, Muhammad Akmal Mohd Zakaria¹, Normariah Che Maideen¹, Nor Azirah Mohd Fohimi¹,
Nor Suhada Abdullah² and Fazira Suriani Mohamed Fadzil³

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh Campus, 13500, Permatang Pauh, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam Selangor, Malaysia

³Advanced Materials Research Centre (AMREC), Lot 34, Jalan Hi-Tech 2/3, Kulim Park, 09000 Kulim, Kedah, Malaysia

*koay@uitm.edu.my

ABSTRACT

Carbon nanotube (CNT)-reinforced palm kernel shell (PKS)–graphite–copper composites were fabricated using a warm compaction method. The performance of the composite used in pantograph slide application must harmonize two main properties: minimum electrical resistivity and maximum transverse rupture strength (TRS). Both properties are strongly influenced by the warm compaction processing parameters. This study investigated the effects of three warm compaction settings, namely temperature, holding time, and compaction pressure, that govern this trade-off for the given application. A Taguchi L9 orthogonal array was employed to evaluate temperatures of 150, 200, and 250 °C; holding times of 2.5, 5, and 10 minutes; and compaction pressures of 40, 50, and 60 tonnes on electrical resistivity and TRS. Analysis of variance (ANOVA) was used to determine the statistical significance of these three factors. The results found that compaction pressure emerged as the dominant variable. Optimal values for both properties were achieved simultaneously at temperature of 200 °C, compaction time of 5 minutes, and pressure of 50 tonnes. At this optimum condition, a confirmation experiment was conducted and produced the highest TRS value of 45.64 ± 1.18 MPa and the lowest resistivity value of $14.2 \pm 0.3 \mu\Omega\cdot m$. The optimum conditions produced composite with denser, less porosity, and more graphitic carbon network, directly correlating with its superior conductivity and strength. This study highlights the interaction between warm compaction temperature, time, and pressure to tailor the balance between mechanical and electrical properties of graphite–copper composites for pantograph slide applications.

T3-O-A92

Effect of Solution Treatment Temperature on Microstructures and Mechanical Properties of Al-4.7Zn-1.7Mg (wt. %) Alloy Produced by Squeeze Casting

Teguh Budiyanto¹, Nuzulian Akbar Arandana¹ and Bondan Tiara Sofyan^{1*}

¹Metallurgy and Materials Department, Universitas Indonesia Kampus UI Depok, 16424, Indonesia

*bondan@eng.ui.ac.id

ABSTRACT

Aluminium alloys are widely used in aerospace, automotive, and transportation industries owing to their low density and high specific strength. Among aluminium alloy systems, Al–Zn–Mg alloys exhibit high mechanical strength, which can be further improved by Cr addition and precipitation strengthening. This research investigated the effects of Cr addition and solution treatment temperature on the properties of Al-4.7Zn-1.7Mg-0.37Cr (wt. %) alloy. The alloy was fabricated by squeeze casting, homogenized at 400 °C for 4 h, solutionized at 220, 420, and 490 °C for 1 h, water quenched, and aged at 130 °C for 48 h. Characterization included optical microscopy (OM), scanning electron microscopy–energy dispersive spectroscopy (SEM-EDS), hardness testing (HRB and HB), X-ray diffraction (XRD), and simultaneous thermal analysis (STA). Increasing the solution treatment temperature enhanced interdendritic phase dissolution into the Al matrix, indicated by the decrease in volume fraction from 6.67, 4.55, and 4.14 % at 220, 420, and 490 °C, respectively, compared with 6.9 % after homogenization. The 0.37 % Cr addition had no effect on interdendritic phase dissolution. However, Cr-containing intermetallics, including Al₁₈Cr₂Mg₃ and (Cr,Fe)Al₇, increased alloy hardness. After ageing, hardness reached 49.64, 52.54, and 70.52 HRB for samples solutionized at 220, 420, and 490 °C, respectively.

Keywords: Al-Zn-Mg, Cr, interdendritic phase, precipitation hardening, solution treatment.

T3-O-A93

Comparative Evaluation of Ciprofloxacin Removal by Maghemite, ZnO, and Their Activated Carbon Nanocomposites in Batch Adsorption

Muhammad Nur Hakimi¹, 'Azzah Nazihah Che Abdul Rahim², Ahmad Rozaimie Mustaffa³, Omar Falyouna⁴, Osama Eljamal⁵ and Mohd Faizul Idham^{6*}

¹Faculty of Mechanical Engineering, UiTM Bukit Besi branch, 23200, Bukit Besi, Terengganu, Malaysia

²Faculty of Chemical Engineering, UiTM Shah Alam branch, 40450, Shah Alam, Selangor, Malaysia

³Faculty of Chemical Engineering, UiTM Bukit Besi branch, 23200, Bukit Besi, Terengganu, Malaysia

⁴Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro-Ku, Tokyo, 153-8505 Japan

⁵Water and Environmental Engineering Laboratory, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University

⁶Industrial Metallurgy and Materials Processing (IMMaP), Faculty of Mechanical Engineering, UiTM Bukit Besi branch, 23200, Bukit Besi, Terengganu, Malaysia

*faizulidham@uitm.edu.my

ABSTRACT

The widespread occurrence of ciprofloxacin (CIP) in aquatic environments has become a major environmental concern because of its persistence, ecotoxicity, and contribution to the development of antibiotic-resistant microorganisms. Among the available treatment technologies, adsorption has emerged as one of the most promising approaches owing to its simplicity, high removal efficiency, low operating cost, and suitability for treating recalcitrant pharmaceutical contaminants. This study comparatively evaluated the adsorption performance of pristine maghemite (γ -Fe₂O₃), zinc oxide (ZnO), and their pineapple peel activated carbon (PPAC)-based nanocomposites for CIP removal from aqueous solution. PPAC was produced through potassium hydroxide activation followed by pyrolysis, while maghemite, ZnO, and their corresponding nanocomposites were synthesized via an in-situ co-precipitation method. Batch adsorption experiments were conducted at ambient pH and room temperature using an initial CIP concentration of 20 mg L⁻¹, an adsorbent dosage of 0.6 g L⁻¹, and contact times of 10, 30, and 60 min. Among all adsorbents investigated, the Maghemite-AC nanocomposite exhibited the highest adsorption performance, reducing the CIP concentration from 20.0 to approximately 9.2 mg L⁻¹ after 60 min, corresponding to an adsorption efficiency of approximately 54%. The adsorption performance based on removal efficiency followed the order: Maghemite-AC > pristine maghemite > ZnO-AC > ZnO > raw carbon > 1:1 KOH AC > 2:1 KOH AC. To elucidate the structural characteristics responsible for the superior adsorption behavior, detailed characterization was performed on pristine maghemite and the best-performing Maghemite-AC nanocomposite. SEM analysis revealed the development of a porous carbon framework with well-dispersed maghemite nanoparticles, FTIR confirmed the coexistence of oxygen-containing functional groups and Fe-O bonds, while XRD verified the successful incorporation of crystalline maghemite without disrupting the activated carbon structure. These structural features explain the enhanced adsorption performance of the Maghemite-AC nanocomposite, demonstrating its potential as a sustainable and efficient adsorbent for ciprofloxacin removal in future wastewater treatment applications.

Keywords: Ciprofloxacin; Batch adsorption; Maghemite; Zinc oxide; Activated carbon nanocomposites.

T3-O-A111

Superhydrophobic Polyurethane/SiO₂ Coatings for Electrowetting-on-Dielectric Systems

M. Z. Yaacob¹ and E. N. A. Latip^{1*}

¹Faculty of Chemical Engineering, UiTM Shah Alam, 40450, Shah Alam, Selangor, Malaysia

*elinadia@uitm.edu.my

ABSTRACT

Electrowetting-on-dielectric (EWOD) has become an important technology in digital microfluidics (DMF) due to its ability to manipulate liquid droplets with high precision at microscale. The performance of an EWOD device is strongly influenced by the characteristics of its actuating surface. This study investigates the feasibility of superhydrophobic polyurethane (SHPU) coatings with different hexadecyltrimethoxysilane (HDTMS) to silicon dioxide (SiO₂) ratios as actuating surfaces in EWOD applications. SHPU coatings containing HDTMS/SiO₂ (H/S) ratios of 2, 4, 6, and 8 mL g⁻¹ were fabricated by spin coating. The coatings morphology and elemental composition were characterised using scanning electron microscopy and energy dispersive X-ray spectroscopy, while contact angle hysteresis and electrowetting response were measured to evaluate their performance. The H/S ratios were found to significantly influence the surface morphology and electrowetting behaviour of the coatings. Increasing the H/S ratio lowered the surface roughness, whereas lower H/S ratios promoted particle agglomeration and reduced surface uniformity. Despite these differences in surface morphology, all four coatings exhibited static contact angles above 150°, demonstrating their ability to achieve superhydrophobicity. Among the coatings investigated, the H/S ratio of 4 mL g⁻¹ coating exhibited the best overall performance, producing contact angle hysteresis below 10° and a stable electrowetting response under the applied voltages. In comparison, the H/S ratios of 2 mL g⁻¹ and H/S of 8 mL g⁻¹ coatings exhibited higher contact angle hysteresis and electrowetting irreversibility at higher applied voltages. These findings demonstrate that the HDTMS/SiO₂ ratio influences the surface characteristics and electrowetting behaviour of SHPU coatings, highlighting their potential for use as actuating surfaces in EWOD devices.

Keywords: Superhydrophobic Polyurethane; SiO₂ Nanoparticles; Electrowetting-on-Dielectric, Contact Angle Hysteresis.

T3-O-A119

Recycled Polypropylene-Kenaf Composites with Waste Fire Extinguisher Powder as Flame-Retardant Filler

Zulfadli Ghazali¹, Nur Athirah Mohd. Ismail¹, Ahsana Aqilah Ahmad^{1,2*} and Izdihar Tharazi^{1,2}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²Industrial Metallurgy and Materials Processing (IMMaP), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor

*aqilah3739@uitm.edu.my

ABSTRACT

Recycled polypropylene-kenaf composites offer a lower environmental footprint than conventional polymer composites, though their flammability is a practical concern. This study tested whether waste fire extinguisher powder (FEWP), recovered from expired dry-chemical extinguishers, could serve as a flame-retardant filler in this system. Three formulations were prepared: a Control (60 wt% RPP / 40 wt% kenaf), Sample 1 (60/30/10 RPP-kenaf-FEWP), and Sample 2 (60/20/20 RPP-kenaf-FEWP). All were mixed in a sigma blade mixer at 170°C with sequential addition, then hot-press moulded. FTIR and XRD identified monoammonium phosphate and ammonium sulphate as the main FEWP components, pointing to a phosphorus-nitrogen flame-retardant mechanism. On tensile testing, Sample 1 reached 16.49 MPa an increase compared to 5.67 MPa for Control, a 191% increase. Sample 2 dropped to 11.28 MPa, likely due to particle agglomeration at the higher filler loading. The flexural strength also increased with the peak value at 28.86MPa for Sample 1 and then decreased to 19.31Mpa for Sample 2. Impact strength fell steadily from 14.27 to 9.84 J/m as filler content rose. All three formulations rated NR in the UL-94 vertical burning test and the horizontal burning rate was reduced by 24.4% and 2 out of 3 Sample 2 specimens self-extinguished after the initial flame, indicating a real improvement in fire resistance at 20 wt% loading.

Keywords: Flame retardant, Natural fibre, Thermoplastic Waste, filler, Circular economy.

T3-O-B19

Effect of Alkali and Fumaric Acid Surface Treatments on the Mechanical Performance of Ramie Fiber-Reinforced Polyester Composites

Henny Pratiwi^{1,2*}, Didik Nurhadiyanto^{1,2}, Aulia Majid^{1,2}, Mohd Yazid Yahya³, and Lin Feng Ng³

¹Department of Mechanical Engineering Education, Faculty of Engineering, Universitas Negeri Yogyakarta, Jl. Colombo No. 1, Yogyakarta 55281, Indonesia

²Center for Eco-Material Engineering and Manufacturing, Universitas Negeri Yogyakarta, Jl. Colombo No.1, Yogyakarta 55281, Indonesia

³Centre for Advanced Composite Materials (CACM), Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

*hennypratiwi@uny.ac.id

ABSTRACT

Natural fiber-reinforced polymer composites have emerged as promising sustainable materials for structural applications due to their low density, renewability, and favorable mechanical performance. However, the hydrophilic nature of natural fibers often results in weak interfacial adhesion with hydrophobic polymer matrices, thereby limiting composite performance. This study investigates the influence of alkali and fumaric acid surface treatments on the physical and mechanical properties of unidirectional ramie fiber-reinforced polyester composites. Five composite configurations were prepared using the vacuum infusion process, namely untreated fiber (UT), 3 wt.% alkali treatment (ALK3), 5 wt.% alkali treatment (ALK5), 1 wt.% fumaric acid treatment (FA1), and 2 wt.% fumaric acid treatment (FA2). The fabricated composites were characterized through density, tensile, flexural, and impact tests. The results demonstrated that chemical treatment significantly improved the composite performance compared with untreated fibers. The highest tensile strength was achieved by the FA1 specimen, representing an improvement of approximately 47.3% over the untreated composite. The FA1 specimen also exhibited the highest flexural strength (64.43 MPa) and impact strength (35.29 kJ/m²), corresponding to increases of 73.3% and 14.5%, respectively. Although ALK5 produced the highest density, its mechanical performance remained inferior to that of FA1. The superior performance of the FA1-treated composite is attributed to enhanced fiber-matrix interfacial bonding, which promotes more efficient stress transfer during mechanical loading. These findings indicate that a 1 wt.% fumaric acid treatment provides the most effective surface modification among the investigated conditions, offering a simple and environmentally friendly approach to improving the performance of ramie fiber-reinforced polyester composites for lightweight structural applications.

Keywords: Ramie fiber; Polyester composite; Fumaric acid; Alkali treatment; Mechanical properties.

T3-V-A43

Optimization of Eggshell as a Natural Corrosion Inhibitor for AISI 1020 Steel via Response Surface Methodology

Hazriel Faizal Pahraraji¹, Siti Khadijah Alias^{1*}, Haryana Mohd Hairi², Mohd Al-Fatihhi Mohd Szali Januddi³,
Bulan Abdullah⁴ and Masalina Md Ali⁵

¹Faculty of Mechanical Engineering, UiTM Johor Branch, Pasir Gudang Campus,
81750 Masai, Johor, Malaysia

²Faculty of Applied Sciences, UiTM Johor Branch, Pasir Gudang Campus, 81750 Masai, Johor, Malaysia

³Advanced Facilities Engineering Technology Research Cluster (AFET), Plant Engineering Technology
(PETech) Section, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur,
81750 Masai, Johor, Malaysia

⁴Faculty of Mechanical Engineering, UiTM Shah Alam, 40450 Selangor, Malaysia

⁵Universiti Kuala Lumpur, Malaysia Italy Design Institute, 56100, Kuala Lumpur, Malaysia

*khadijah_alias@uitm.edu.my

ABSTRACT

Corrosion inhibitors are one of the methods to minimize metal corrosion. However, many conventional inhibitors are expensive, toxic, and environmentally harmful. Therefore, there is a growing awareness of developing ecologically friendly inhibitors as sustainable alternatives for the industry. Eggshell (ES) extract with a high calcium carbonate (CaCO_3) content has the potential to serve as an environmentally friendly corrosion inhibitor. Therefore, this study aims to optimize eggshells as corrosion inhibitors for AISI 1020 steel in 1 M hydrochloric acid (HCl) using Response Surface Methodology (RSM), and the resulting models were analyzed using analysis of variance (ANOVA). The gravimetric approach was applied, and the results were used for statistical analysis. Results show that the statistical analysis revealed the developed quadratic model to be highly significant ($F = 117.41$, $p < 0.0001$) and to have excellent predictive capability ($R^2 = 0.9906$, Adj. $R^2 = 0.9822$, Pred. $R^2 = 0.8984$). Among the investigated parameters, concentration exerted the most significant influence on weight loss, followed by temperature and time. Optimization using RSM predicted the optimum operating conditions at 15 g ES, 42.7 °C temperature, and 6.66 days immersion time, resulting in a minimum predicted weight loss of 0.0185 g with a desirability value of 0.904. Under these conditions, the ES demonstrated excellent corrosion inhibition performance for AISI 1020 steel in acidic media. Thus, the optimization using RSM shows the optimum effectiveness of ES for AISI 1020 steel in acidic environments.

Keywords: Eggshell; AISI1020; Steel; Corrosion; RSM.

T3-V-A95

Low-Temperature Synthesis of Activated Carbon from Keruing Wood Waste for Dual-Pollutant Adsorption

Muhammad Irfan Rafae Rohaizad¹, Zaimah Hasan^{1,2*}, Mohd Zailani Daud³ and Irmie Azlin Zakaria⁴

¹Department of Mechanical Engineering, Universiti Tenaga Nasional, 43000, Kajang, Selangor, Malaysia

²Institute of Sustainable Energy, Universiti Tenaga Nasional, 43000, Kajang, Selangor, Malaysia

³Sensasi Tenaga Sdn. Bhd., Lot 809, Jalan Temerloh Batu 2, Kampung Sungai Dingin, 28400 Mentakab, Pahang, Malaysia

⁴Nanomaterials for Sensors and Heat Transfer (NaSH), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

*zaimah@uniten.edu.my

ABSTRACT

The escalating global demand for sustainable wastewater treatment necessitates environmentally friendly and high-performance adsorbent materials. Currently, conventional activated carbon (AC) production relies predominantly on high-energy physical activation techniques utilizing non-renewable precursors, incurring substantial environmental impacts and high energy requirements. To address this critical research gap, this study investigates the low-temperature chemical synthesis of AC to significantly reduce energy consumption and preserve carbon yield. The selected precursor is Keruing wood waste, an abundant Malaysian timber byproduct featuring a dense, lignin-rich composition and inherent structural channels uniquely conducive to targeted mesopore development. Raw Keruing precursors were carbonized and chemically activated using phosphoric acid (H₃PO₄) through an energy-efficient sealed crucible method. The acid to precursor impregnation ratio was systematically varied to determine the optimal processing conditions required for maximizing material yield and internal surface area. Subsequently, the synthesized AC was rigorously evaluated for dual pollutant adsorption performance utilizing Methylene blue (MB) dye and Cu(II) ions. Empirical results indicate that a 2:1 impregnation ratio provides the absolute optimal structural balance, achieving a relatively high carbon yield of 53.93% and a BET surface area of 347.93 m²/g. Furthermore, the optimized AC demonstrated maximum adsorption capacities of 95 mg/g for MB and 105 mg/g for Cu(II). Ultimately, this research demonstrates the potential of low-temperature H₃PO₄ activation as an alternative to conventional high energy activation methods for water treatment applications.

Keywords: Activated carbon; Biomass valorisation; Chemical activation; Wastewater treatment; Adsorption.

T3-V-B23

Tribological Performance of Microcrystalline Cellulose-Filler Phenolic Composite Brake Shoes under Different Aqueous Environments

Martinus Heru Palmiyanto^{1,2*}, Aulia Majid^{1,2}, Eko Surojo³, Fahmi Imanullah³

¹Department of Mechanical Engineering Education, Universitas Negeri Yogyakarta

²Center for Eco-material Engineering and Manufacturing, Universitas Negeri Yogyakarta, Indonesia

³Department of Mechanical Engineering, Universitas Sebelas Maret, Surakarta, Indonesia

*martinusherupalmiyanto@uny.ac.id

ABSTRACT

Automotive brake shoes are frequently exposed to rainwater, seawater, and acidic environments during service, which may adversely affect their tribological performance and material durability. This study investigates the effect of microcrystalline cellulose (MCC) addition and immersion environments on the friction coefficient, specific wear rate, and wear mechanisms of phenolic resin-based composite brake shoes. Composite specimens containing 0, 4, 8, and 12 vol.% MCC were fabricated and evaluated under dry conditions as well as after immersion in distilled water, seawater, and an acidic solution. Tribological performance was assessed using a pin-on-disc tribometer under a contact pressure of 1 MPa and a sliding velocity of 12 m/s, while worn surface morphologies were characterized using scanning electron microscopy (SEM). The results demonstrate that the incorporation of MCC effectively reduced the specific wear rate of the composites, with the 12 vol.% MCC specimens exhibiting the lowest wear rate and the MCC-free composite showing the highest wear. Immersion in aqueous environments decreased the friction coefficient because of the lubricating effect of absorbed water and the formation of a friction transfer layer. In contrast, the specific wear rate increased after immersion, particularly in the acidic medium. SEM observations revealed grooves, microcracks, particle pull-out, matrix degradation, and fiber debonding on the worn surfaces. The most severe damage occurred in specimens exposed to the acidic solution owing to the deterioration of the fiber-matrix interfacial bonding. Furthermore, MCC enhanced matrix adhesion, improved abrasive particle retention, and promoted the formation of stable primary and secondary plateaus, thereby contributing to improved wear resistance. These findings indicate that MCC is a promising sustainable reinforcement for enhancing the tribological performance and durability of composite automotive brake shoes, although prolonged exposure to aqueous environments, particularly acidic conditions, remains detrimental to their performance.

Keywords: automotive brake shoe; microcrystalline cellulose; friction coefficient; specific wear rate; tribology.

T3-O-A129

Sustainable Ambient Drying of Metallic Sludge: Experimental Investigation of Drying Kinetics and Phase Characterisation

Tengku Ammer Aizad Tengku Sulaiman¹, Siti Mariam Abdul Rahman^{1*}, Irmie Azlin Zakaria¹
and Salfarina Rozeman²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam,
Selangor, Malaysia

²PHN Industry Sdn Bhd, Kawasan Perindustrian HICOM, Seksyen 26, 40710 Shah Alam, Selangor, Malaysia.

*mariam4528@uitm.edu.my

ABSTRACT

Managing industrial metallic sludge remains challenging after mechanical dewatering due to its high residual moisture, which increases handling, transport, and storage requirements and costs. Additionally, understanding its drying kinetics under non-thermal conditions is still insufficient. This study characterised the sludge using X-ray diffraction (XRD) to analyse its components and examined an ambient forced-convection greenhouse as a low-energy pre-drying method. A transparent acrylic chamber, equipped with Arduino-based monitoring, was operated at a speed of 2.0 m/s and a temperature of approximately 31 °C for 140 minutes. The experiments utilised samples of 5, 10, and 15 grams, each with a consistent thickness of 5 mm. XRD scans were conducted from 20° to 90° at 10° min⁻¹ and 5° min⁻¹. XRD analysis tentatively identified CsFeO₂ and Ba₅LaTi₂Nb₃O₁₈ as the major crystalline phases based on the matching of the observed diffraction peaks with referenced databased patterns. However, these phase assignments should be considered preliminary and require further confirmation using complementary characterisation techniques. Drying occurred entirely in falling-rate periods after mechanical dewatering. Cracks appeared at 60, 80, and 110 min for 10, 15, and 5 g, respectively. Despite cracking last, the 5 g sample showed the greatest moisture reduction because its lower water inventory, greater edge-area-to-volume ratio, and shorter lateral moisture-migration distance reduced internal mass-transfer resistance; its more uniform shrinkage also delayed the critical tensile stress required for cracking. The 10 g sample cracked first, attributed to faster, non-uniform strain accumulation than in the more moisture-buffered 15 g sample. Overall, ambient forced convection provided controlled moisture reduction without heater energy and with a lower risk of heat-induced material changes, supporting its use as a sustainable industrial pre-drying step.

Keywords: Metallic sludge; Drying Kinetics; Acrylic Greenhouse Drying System; Ambient Forced Convection; X-ray Diffraction (XRD).

T3-O-A04

Effect of Zinc Doping on the Structural Integrity and Thermal Behavior of Chicken Bone-Derived Hydroxyapatite

Basirah Baharom¹, Mohamad Syafiq Mahmud¹, Mardziah Che Murad^{1,2*}, Natasha Ahmad Nawawi^{1,2} and Mohamed Kamal Abbas³

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Engineered Materials and Structures Research Group, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor Darul Ehsan, Malaysia

³Centre for Advanced Material (CAM), Qatar University, P.O. Box 2713, Doha, Qatar.

*mardziah31@uitm.edu.my

ABSTRACT

The conversion of biogenic waste into high value bioceramics has emerged as a critical strategy for environmental sustainability and the development of advanced biomaterials. Chicken bone waste, a significant byproduct of the poultry industry, serves as an abundant natural source of calcium for the synthesis of hydroxyapatite (HA). This study investigates the effect of zinc (Zn) incorporation on the structural, morphological, and thermal properties of HA derived from chicken bone (HA-cb). HA-cb was synthesized via thermal calcination at 1100°C, while zinc-substituted HA was subsequently prepared using a mechanochemical method with zinc oxide (ZnO) as the dopant precursor at concentrations of 3 wt% (Zn3HA-cb) and 5 wt% (Zn5HA-cb). The transformation from as-synthesized powders to sintered solid bodies was achieved through a sintering process at 1200°C. X-ray diffraction (XRD) analysis confirmed the preservation of the hexagonal apatite framework across all compositions, while peak broadening in the Zn-doped powders indicated that zinc acts as grain growth inhibitor, effectively reducing the crystallite size from 18.30 nm to 14.90 nm. The presence of β -tricalcium phosphate (β -TCP) highlights the natural biphasic characteristic inherent to the biogenic precursor. Fourier Transform Infrared (FTIR) spectroscopy verified the retention of fundamental phosphate (PO_4-3) and hydroxyl ($\text{OH}-$) vibrations, while the reduction in the carbonate (CO_3-2) band post-sintering suggested enhanced phase purity. Scanning Electron Microscopy (SEM) observations revealed a morphological transition from irregular powder agglomerates to distinct polygonal grain structures in the sintered solid, with Zn3HA-cb exhibiting superior densification compared to the Zn5HA-cb. The findings demonstrate that Zn3HA-cb substitution maintains optimal chemical integrity and thermal stability at 1200°C, offering a sustainable pathway for producing stable bone grafting materials from natural waste.

Keywords: Hydroxyapatite; Chicken bone waste; Sintering; Zinc doped; Thermal stability.

T3-O-A57

Tailoring Tensile Strength and Interfacial Adhesion of NR Latex/SIS Block Copolymer via Radiation-Curing in Vacuum Condition

Nurul Hakimah Lazim^{1*}, Siti Aisyah Shamsudin², and Nik Normunira Mat Hassan¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

²Department of Applied Physics, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

*hakimahlazim@uitm.edu.my

ABSTRACT

Developing high-performance elastomeric nanomaterials by blending natural rubber latex (NRL) and styrene-isoprene-styrene (SIS) block copolymers is frequently hindered by thermodynamic immiscibility, leading to macroscopic phase segregation and poor mechanical performance. However, while conventional chemical crosslinking is widely used to stabilize these blends, it often suffers from inhomogeneous vulcanization at the nanoscale level and leaves behind toxic chemical residues that restrict the usage of this polymer blend in advanced, eco-friendly engineering applications. This study presents a green, catalyst-free alternative by evaluating the effects of irradiation dose to improve mechanical and tune the interfacial nanostructure of NRL/SIS blends. The blend was prepared at a weight ratio of 70:30 (NRL: SIS) using a solution blending method, followed by exposure to gamma radiation at doses at 8 and 14 kGy. The condition of gamma radiation was set in a vacuum environment. Tensile and swelling experiments were conducted to evaluate the performance of both unirradiated and irradiated samples. Experimental results revealed that the tensile strength of the blend increased to 25.1 MPa and a maximum insoluble fraction of the blend (45%) with an exposure of 14 Gy irradiation dose. Field Emission Scanning Electron Microscopy provided definitive visual confirmation of this radiation-induced crosslinking. A Transmission Electron Microscopy revealed a nanostructure of SIS where self-assembled polystyrene nanodomains were uniformly dispersed and tightly anchored within the continuous amorphous rubber matrix. Ultimately, the improvement of tensile properties is attributed to improved radiation-induced crosslinking, positioning gamma irradiation as a viable processing method for high-performance elastomer blend for automotive, and rubber industries.

Keywords: Natural rubber latex; SIS block copolymer; Radiation crosslinking; Phase morphology; Tensile strength.

T3-O-A50

Tailoring the Thermal and Mechanical Performance of Compression Moulded PA 12 Through HA/ZnO Hybrid Reinforcement

Muhammad Aiman bin Misri¹, Abdul Manaf Abdullah^{1*}, Solehuddin Shuib¹, Abdul Halim Abdullah¹ and Aidah Jumahat¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

*abdulmanaf@uitm.edu.my

ABSTRACT

Polyamide 12 (PA 12) is widely used in engineering and biomedical applications because of its excellent chemical resistance, low moisture absorption, and balanced mechanical properties. However, its relatively limited stiffness, surface hardness, and thermal performance restrict its application in load-bearing biomedical implants, highlighting the need for reinforcement strategies that can simultaneously improve these properties without compromising processability. This study investigates the influence of hydroxyapatite (HA) and zinc oxide (ZnO) as reinforcing fillers on the thermal and mechanical properties of PA 12-based composites. The HA content was fixed at 10 wt.% while ZnO content was varied from 5-10 wt.%. The composites were fabricated using a twin-screw extrusion process to ensure homogeneous filler dispersion, followed by compression moulding to produce standardized flexural specimens. The thermal and mechanical behaviour of the composites was evaluated using Differential Scanning Calorimetry (DSC), Rockwell hardness testing, and three-point bending tests. DSC analysis demonstrated that the incorporation of HA and ZnO altered the crystallisation and melting behaviour of PA 12, increasing the crystallisation temperature by 0.73%, while reducing the degree of crystallinity by 57.47% compared to PA100. Rockwell hardness improved by 80.51%, whereas flexural testing revealed enhancements in mechanical performance, with flexural strength and flexural modulus increasing by 12.84% and 21.78%, respectively, relative to PA100. Overall, the results demonstrate that the synergistic reinforcement of HA and ZnO effectively enhances the thermal behaviour, surface hardness, and flexural performance of PA 12-based composites, highlighting their potential as high-performance materials for biomedical applications requiring improved mechanical reliability and thermal stability.

Keywords: Polyamide 12; Zinc Oxide; Hydroxyapatite; Hybrid Fillers; Compression Moulding.

T3-O-A104

Optimization of Sol-Gel Synthesis Parameters for Tailoring the Material Properties and Enhancing the Photocatalytic Performance of Nb₂O₅ Nanoparticles

Aida Zulaikha Abdul Aziz¹, Siti Rabizah Makhsin¹, Irmie Azlin Zakaria¹, Rosmalini Ab Kadir², Ahmad Sabirin Zoolfakar², Maizatul Zolkapli², Azrif Manut² and Rozina Abdul Rani^{1*}

¹Nanomaterials For Sensors and Heat Transfer, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²Faculty of Electrical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*rozina7370@uitm.edu.my

ABSTRACT

Niobium pentoxide (Nb₂O₅) is a promising photocatalyst for the treatment of wastewater. Conventional synthesis methods frequently utilise dangerous substances and necessitate meticulous regulation of processing conditions. This study synthesized Nb₂O₅ using a citric acid-assisted sol-gel approach that eliminates the necessity for N, N-dimethylformamide and hydrochloric acid. The effects of citric acid concentration, synthesis temperature, and annealing temperature on the material and photocatalytic properties of Nb₂O₅ were investigated to determine the optimum synthesis conditions. Different amounts of citric acid (0.01, 0.02, and 0.03 mol) were used to make the samples, which were then stirred on a magnetic mixer at different temperatures (25, 50, and 90 °C). The samples were annealed at four temperatures varying between 250 to 600 °C. The observations indicate that Nb₂O₅ sol-gel synthesized with varying molar concentrations of Citric Acid yielded nanoparticles in the form of nanospherical and nanocylindrical structures, with dimensions ranging from 90 to 350 nm. The annealed Nb₂O₅ samples exhibited an orthorhombic crystalline phase with band gap values ranging from 3.017 to 3.212 eV. The Nb₂O₅ sample synthesized with 0.01 mol of Citric Acid at a synthesis temperature of 90 °C and an annealing temperature of 250 °C, exhibits promising photocatalytic activity under UV light, achieving a 24.33% reduction of Methylene Blue after 180 minutes of exposure. The significant effective surface area for the Methylene Blue reaction, superior crystallinity, strong absorption, and narrow band gap properties demonstrated by the optimal Nb₂O₅ sol-gel sample are expected to produce outstanding photocatalytic performance.

Keywords: Nb₂O₅ sol-gel; Nanoparticles; photocatalysis; Methylene Blue degradation; Wastewater.

T3-V-A39

Low-Frequency Phased Array Ultrasonic Testing Techniques for Defects Evaluation in Glass Fibre Reinforced Polymer Structures

Jeffry Jamil¹, Tawhidul Islam Khan², Muhammad Nizam Zakaria³, Mohamad Nur Hidayat Mat⁴, Shahrul Azmir Osman¹ and Eliza M. Yusup^{1*}

*elizay@uthm.edu.my

ABSTRACT

Conventional Ultrasonic Testing (UT) techniques are severely constrained by high acoustic attenuation and structural wave scattering when evaluating heterogeneous, filament-wound Glass Fibre Reinforced Polymer (GFRP) components. This study presents a systematic comparative performance evaluation between low-frequency 1.0 MHz Phased-Array Ultrasonic Testing (PAUT) and conventional UT for quantitative defect characterisation in heavy-section GFRP composite. Manufactured via filament-winding with E-glass fibres and polyester resin at a 54° winding angle. Reference specimens were fabricated using Computerised Numerical Control (CNC) machining in accordance with NORSOK M-622 (2005) guidelines across three operational configurations: thickness profiling between 15.0 mm and 19.0 mm; Flat Bottom Hole (FBH) at diameters 16.0 mm to 20.0 mm, and bonded region integrity between 16.0 mm and 20.0 mm. The result demonstrates that while conventional UT yields restricted amplitude responses at 81% to 86% Full-Screen Height (FSH), low-frequency PAUT achieves superior, volumetric reconstruction with enhanced peak amplitudes ranging from 124% to 149% FSH for FBH evaluation. In high-damping bonded joints, characterisation by severe soundwave scattering and mode conversions reduced the signal amplitudes to 25%-70% of FSH. Spatial B-scan aggregation in PAUT successfully restores discontinuity visibility and cross-sectional depth profiling. However, deploying a 1.0 MHz transducer introduces an inherent compromise in resolution. Operating at an acoustic velocity of 3000 m/s generates a 3.0 mm wavelength (λ), physically restricting the resolution to a minimum detectable flaw size of approximately 3.0 mm, while leaving a near-surface dead zone of approximately 5.0 mm. Moreover, this work established a validated, empirically validated NDT diagnostic capability for heavy-section composite inspection; specialised delay lines and a stringent calibration procedure are essential to mitigate near-field effects and enhance resolution.

Keywords: Composites; GFRP; Ultrasonic Testing; PAUT.

T3-O-A26

Durability of Jute/Epoxy Composites under Acetic Acid Immersion

Abdul Hakim bin Abdullah^{1,2}, Nurul Izzah Mazelan¹, Nik Normunira Mat Hassan¹, Shafizal Mat³ and Nor Fazli Adull Manan^{1}*

¹*Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor*

²*Nanomaterials for Sensors and Heat Transfer (NaSH), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor*

³*Fakulti Teknologi dan Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia*

**norfazli@uitm.edu.my*

ABSTRACT

Natural fibre composites such as jute/epoxy composites are promising sustainable materials. However, their durability in weak organic acid environments remains insufficiently understood. The present study examined the effect of varying acetic acid concentrations of 3%, 6%, 9% (V/V) on the mechanical properties of jute/epoxy composites immersed for 45 days. Composite panels were fabricated by the hand lay-up method. The performance of the composites was evaluated through solvent absorption measurements and a series of mechanical tests (flexural, fracture toughness, Izod impact). Results indicate that increasing the acid concentration raises solvent uptake to 2.39%, suggesting enhanced diffusion and interaction of the acidic medium within the composites. Flexural strength and modulus decreased by 22-36% and 34-45%, respectively, indicating compromised fibre-matrix interfacial bonding. Fracture toughness dropped from 5.46 MPa·m^{1/2} to 2.64 MPa·m^{1/2} with higher acetic acid concentrations. Nevertheless, Izod impact strength improved by 68% to 168% at higher acid concentrations. The enhanced impact strength can be attributed to plasticization of the polymer matrix. The 9% acetic acid proved to be the most aggressive solution, causing substantial reductions in flexural and fracture properties. The findings imply that even mild acetic acids compromise the structural integrity of jute/epoxy composites, emphasizing the need for protective measures in long-term applications.

T3-O-A117

Size-Dependent Plasmonic Enhancement of Gold Nanoparticles for Portable Fibre-Optic Cu²⁺ Sensing

Siti Rabizah Makhsin^{1*}, Muhammad Ayman Ahmad Yani¹, Rozina Abdul Rani¹ and Beenish Siddique²
¹Nanomaterials for Sensors and Heat Transfer, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor
² AEH Innovative Hydrogel Ltd, The Cube, Coe Street, Bolton, England, BL3 6BU, United Kingdom
*sitirabizah@uitm.edu.my

ABSTRACT

Heavy metal contamination of water poses a substantial hazard to ecosystems and human health owing to its persistence, toxicity, and bioaccumulation. Amongst these contaminants, copper ions (Cu²⁺), although essential trace elements, can cause harmful health effects at higher concentrations, forcing rapid and reliable monitoring of drinking-water quality. This study presents a portable gold nanoparticles (AuNPs)-functionalized fibre-optic sensor for Cu²⁺ detection and systematically investigates the influence of AuNP size on sensing performance. AuNPs with average sizes of 15, 30, and 40 nm were synthesized using the citrate reduction method and characterized using Zeta sizer analysis, UV-Visible (UV-Vis) spectroscopy, and Fourier transform infrared (FTIR) spectroscopy. The morphology and elemental analysis of AuNPs-coated fibre optic probes were analyzed using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX). EDX analysis of the AuNP coating showed gold atomic compositions of 0.23, 0.49, and 1.07 at% for 15, 30, and 40 nm AuNPs, respectively, confirming effective nanoparticle immobilization on the fibre surface. Sensor performance was evaluated by monitoring changes in optical intensity using an Ocean Optics spectrometer. Compared with the uncoated probe, the AuNPs-functionalised sensors exhibited enhanced optical responses, demonstrating improved analyte interaction and sensing sensitivity. Among the investigated configurations, the 15 nm AuNPs-coated sensor achieved the highest sensitivity of 241.78 a.u. L mg⁻¹ with excellent linearity ($R^2 = 0.9391$) and a limit of detection (LOD) of 0.0302 mg/L. The enhanced performance is attributed to localized surface plasmon resonance (LSPR), which strengthens the interaction between the evanescent optical field and Cu²⁺ ions, thereby increasing refractive index modulation. These findings demonstrate that AuNP size plays a critical role in fibre-optic sensing performance and highlight the proposed sensor as a rapid, portable, cost-effective and simple sensing platform for real-time environmental monitoring of Cu²⁺ contamination.

Keywords: Gold nanoparticles; fiber-optic sensors; heavy metal detection; copper detection.

T3-O-A97

Tribological Properties of Graphene Quantum Dots (GQDs) Nanolubricant in MQL

Nurul Hayati Ab Halim¹, Muhamad Adib Hakimie Mohd Arifin¹, Siti Rabizah Makhsin¹, Zaimah Hasan², Anwar Ilmar Ramadhan³ and Irnie Azlin Zakaria^{1*}

¹Nanomaterials for Sensors and Heat Transfer, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

²Department of Mechanical Engineering, Universiti Tenaga Nasional, Malaysia

³Department of Mechanical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Jl. Cempaka Putih Tengah 27, 10510 Jakarta, Indonesia

*irnieazlin@uitm.edu.my

ABSTRACT

Machining hard-to-cut materials has always been challenging due to excessive heat generation, high tool wear, and expensive machining costs. Minimum Quantity Lubrication (MQL) provides an eco-friendly and lower-cost alternative to traditional flood cooling systems. However, the limited lubrication and cooling capacity of conventional MQL reduces its effectiveness under severe cutting conditions. Among the various nanomaterials, Graphene Quantum Dots (GQDs) have great potential as lubricant additives due to their ultra-small particle size, excellent dispersion stability, large surface area, tribofilm-forming ability, and low coefficient of friction. However, the effect of dialysis purification on the stability, thermophysical properties, and tribological performance of GQD nanolubricants has not been widely investigated. Therefore, this study investigated the effect of dialysis-purified GQDs on the tribological behaviour of GQD nanolubricants for MQL applications. Following purification, GQDs were dispersed in Unist Coolube® 2210XP at different concentrations and evaluated using UV-Vis spectroscopy, FTIR, zeta potential analysis, thermophysical calculations, and four-ball tribological testing. The dialysis-purified nanolubricant exhibited improved dispersion stability with a zeta potential of 40.4 mV, while the thermal conductivity and dynamic viscosity increased by 17.0% and 15.03%, respectively. The optimum 95% dialysis formulation also reduced the coefficient of friction and friction torque by 64.60% and 65.94%, respectively, compared with the base lubricant. These findings demonstrate that dialysis purification improves the stability and tribological performance of GQD nanolubricants, making them promising lubricant additives for sustainable MQL applications.

Keywords: Graphene Quantum Dots, Nanolubricant, Minimum Quantity Lubrication, Tribology, Dialysis Purification.

T3-V-A80

Mechanical Performance of FDM-Printed PLA and TPU Lattices with BCC and Diamond Topologies Under Quasi-Static Compression

Lipan Deng¹, Izzat bin Mat Samudin¹, Qianjin Ma² and Nabilah Afiqah Mohd Radzuan^{1*}

¹Department of Mechanical & Manufacturing Engineering, Faculty Engineering & Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

² Institute of Advanced Materials and Technology, Guangdong University of Technology, Guangzhou, 510006, China

*afiqah@ukm.edu.my

ABSTRACT

The work reported here compares the monotonic compressive response of FDM-printed PLA and TPU lattice specimens with two different architectures: strut-based Body-Centered Cubic (BCC) and sheet-based triply periodic minimal surface Diamond (TPMS-Diamond). PLA and TPU were chosen as deliberately contrasting polymer systems, one rigid and one elastomeric, so that the interaction between material behaviour and lattice architecture could be examined under the same nominal design envelope. All four groups were designed as 30 mm × 30 mm × 30 mm specimens at a nominal CAD relative density of 30% and were compressed to 50% engineering strain. Material selection was the dominant factor in the measured response, while the lattice architecture changed the deformation mode and the strain energy stored during monotonic compression. PLA-Diamond gave the highest measured values in this dataset, with an automatic compressive modulus of 225.74 ± 2.21 MPa, stress at 50% strain of 7.288 ± 0.199 MPa, and strain energy density to 50% strain of 3.014 ± 0.109 MJ/m³. TPU specimens carried much lower stress but retained more visible shape continuity after unloading. Since unloading curves and specimen masses were not available for all groups, the area under the monotonic curve is reported as strain energy density rather than as dissipated energy absorption or mass-normalised specific energy absorption. Tensile and shear tests were used to support the material-level interpretation, whereas single-run TGA and qualitative XRD were retained only as auxiliary material checks. The conclusions are therefore restricted to the present nominal- design comparison and do not rely on unmeasured density, SEA, cyclic recovery or statistical-significance claims.

Keywords: Fused deposition modelling; polymer lattice; PLA; TPU; strain energy density.

T3-O-A05

The Discolouring Efficiency on S-Type 29 of Activated Carbon

Nur Amelia Ismailia^{1*}, Bulan Abdullah¹, Nor Hayati Saad¹ and Siti Khadijah Alias²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA Kampus Pasir Gudang,
81750 Masai, Johor, Malaysia

*bulan_abd@uitm.edu.my

ABSTRACT

This study investigated the decolourization efficiency of activated carbon in the treatment of sugar liquor by evaluating the effect of contact time on colour removal. A volume of 100 mL carbonated liquor was treated with 1 g of S-29 type of activated carbon under controlled conditions at 70 °C. Colour measurements were conducted before and after treatment, and the percentage decolourization efficiency was calculated to assess adsorption performance. The highest decolourization efficiency of 13.8.% was achieved at an optimum contact time of 20 minutes, with a corresponding pH of 8.5 and Brix value of 61.8 °Bx. The results showed that decolourization efficiency varied with contact time, reaching its maximum average value at 20 minutes. Experimental variability also changed throughout the study, as indicated by the standard deviation error bars. Smaller error bars observed at 20 and 30 minutes suggested greater reproducibility and consistency of the decolourization process, whereas larger error bars at 10 and 40 minutes indicated higher trial-to-trial variation. Furthermore, the decolourization efficiencies obtained were consistent with values reported in previous studies, demonstrating the ability of activated carbon to adsorb colour-causing compounds such as melanoidins, caramelized substances, and phenolic compounds from sugar liquor. Overall, the study confirms the effectiveness of activated carbon as an adsorbent for sugar liquor decolourization and identifies 20 minutes as the optimum contact time under the investigated conditions.

Keywords: Activated carbon, Decolourization efficiency, Carbonated liquor, Adsorption, Contact time, Sugar refining.

T3-O-A02

Preliminary Process Window and Forming Quality of LPBF-Processed AA7075 Hybrid Composites Co-Reinforced with Ti and AlCoCrFeNi_{2.1} HEA

Shixi Gan^{1,3}, Mohd Shahrman Adenan¹ and Baljit Singh Bhathal Singh^{1,2*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia

²Solar Research Institute, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

³School of Mechanical and Electrical Engineering, Quanzhou University of Information Engineering,
Quanzhou 362000, China;

*baljit@uitm.edu.my

ABSTRACT

AA7075 remains difficult to process by laser powder bed fusion (LPBF) because its high Zn-Mg-Cu solute content promotes porosity, solidification cracking, and a narrow practical processing window. This study evaluates a hybrid modification strategy in which AA7075 is co-reinforced with 2 wt.% Ti and 5 wt.% AlCoCrFeNi_{2.1} high-entropy alloy (HEA) particles. A 3 × 5 LPBF parameter matrix was designed by combining three laser powers with five scan speeds, while layer thickness and hatch spacing were kept constant. The as-built cubic specimens were assessed through macroscopic inspection, low-magnification cross-sectional optical microscopy, Archimedes relative-density measurements, and Vickers microhardness testing. All fifteen parameter sets produced regular cubes without catastrophic build failure, confirming that the hybrid feedstock retained acceptable macroscopic formability within the investigated range. Cross-sectional observations indicate that the main quality variations were governed by pore population, pore size, and pore clustering rather than by pervasive through-thickness crack networks. Compared with monolithic AA7075, the hybrid composite exhibited a higher average relative density of 97.04 ± 0.72%, compared with 95.73 ± 0.62% for AA7075. A substantial hardness advantage was also obtained, with the hybrid system reaching 159.54 ± 11.03 HV0.5, compared with 95.95 ± 8.85 HV0.5 for the AA7075 baseline. Neither density nor hardness followed a strictly monotonic dependence on volumetric energy density. Instead, the constant-power analysis showed that the laser power-scan speed combination more clearly captured process sensitivity and defect evolution. These results establish a preliminary process-window basis for AA7075-Ti-HEA hybrid composites and identify representative conditions for subsequent phase, interface, and mechanical investigations.

Keywords: LPBF; AA7075; hybrid composite; process window; forming quality.

T3-O-A108

Durian Husk-Derived Activated Carbon Hybridized with ZnO and MnO₂ for High-Performance Supercapacitor Electrodes

Yusuf Olanrewaju Busari^{1,2*}, Siti Nurfatihah Adi Heirman¹, Abdallah Reghioua², Adel Mohammed Al-Dhahebi¹, Surajudeen Sikiru², Temitope T. Dele-Afolabi¹, Hassan Kobe Ibrahim³, Ajibike J. Farounbi⁴, Sarah Najm Al-Challabi⁵, Ibrahim Sadiq Issah⁶ and Lawal Babatunde Abdulqadi⁷

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, 40450, Malaysia

²School of Physics & Materials Studies & Sustainable Energy Materials Groups, Universiti Teknologi MARA, Shah Alam, 40450, Malaysia

³Mechanical Engineering Department, University of Ilorin, PMB 1515, Ilorin, Nigeria

⁴Department of Physics, Chemistry, and Mathematics, Alabama A&M University, Huntsville, AL 35811, USA

⁵Department of Mechanical Engineering, Universiti Teknologi PETRONAS, Seri Iskandar, Perak Darul Ridzuan 32610, Malaysia

⁶Department of Mechanical Engineering, Qassim University, 52571, Saudi Arabia

⁷Mechanical Engineering Department, Kwara State Polytechnic, P.M.B 1375, Ilorin, Nigeria

*yusufbusari@uitm.edu.my

ABSTRACT

Research of carbons derived from agricultural waste show good potential due to its natural porosity. However, electrodes composed of single materials usually exhibit moderate power capacity and electrical activity. The activated carbon (AC) derived from durian husks was synthesized followed by chemical treatment to create a porous structure. Afterward, metal oxides (zinc oxide (ZnO) and manganese oxide (MnO₂)) was introduced to form hybrid composite electrodes. The composite's structural, thermal and chemical properties were analysed by comparing ZnO and MnO₂ hybridisation on durian-husk activated carbon under identical conditions. XRD validated the synthesised electrode material's production. Cycle voltammetry (CV) and galvanostatic charge-discharge (GCD) studies assessed the synthesised electrode materials' charge storage and capacitive performance. XRD validated the synthesised electrode material's production. The AC electrode exhibited a characteristic graphitic diffraction peak at $2\theta = 44.11^\circ$, while the AC/ZnO composite showed distinct ZnO diffraction peaks at $2\theta = 56.68^\circ$ and 62.92° . Similarly, the AC/MnO₂ composite displayed characteristic MnO₂ reflections at $2\theta = 32.91^\circ$, 55.07° , and 65.68° , confirming the incorporation of the respective metal oxides into the carbon matrix. DSC revealed an endothermic peak at approximately 117°C , corresponding to the evaporation of physically adsorbed moisture. Electrochemical evaluation demonstrated that the activated carbon electrode exhibited the highest discharge specific capacitance of 229 F g^{-1} , with an energy density of 1.25 Wh kg^{-1} and a power density of 113 W kg^{-1} . The AC/ZnO composite achieved a discharge specific capacitance of 186 F g^{-1} , accompanied by the highest energy density of 4.13 Wh kg^{-1} at a power density of 24 W kg^{-1} , indicating enhanced energy storage capability resulting from ZnO incorporation. In contrast, the AC/MnO₂ composite exhibited a discharge specific capacitance of 189 F g^{-1} , an energy density of 2.06 Wh kg^{-1} , and a power density of 16.9 W kg^{-1} , demonstrating moderate electrochemical improvement. The incorporation of ZnO and MnO₂ modified the charge storage behaviour of the activated carbon through synergistic interactions between electric double-layer capacitance and pseudocapacitive mechanisms.

Keywords: Biomass carbon; Hybrid electrodes; Metal oxides; Energy storage; Electrochemical performance; Sustainable material.

T3-O-B20

Development of Composite Hybrid Ramie Fiber-Reinforced Epoxy-Tungsten Carbide and Silicon Carbide as Bulletproof Panel NIJ Standard

Didik Nurhadiyanto^{1*}, Mujiyonoa, Alaya Fadllu Hadi Mukhammad², Nur Kholis³ and Shukur bin Abu Hassan⁴

¹Center for Eco-Material Engineering and Manufacturing (CEEM), Universitas Negeri Yogyakarta, Yogyakarta 55281, Indonesia

²Department of Industrial Technology, Vocational School, Diponegoro University, Semarang, Indonesia

³Department of Mechanical Engineering, Wahid Hasyim University, Semarang 50275, Indonesia

⁴Centre for Advanced Composite Materials (CACM), Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

*didiknur@uny.ac.id

ABSTRACT

Multilayer armour system (MAS) becomes the best choice in reinforcing protection for military officers against projectile attack which has a high velocity of up to 7.62×51 mm NATO ball lead core (projectile level III NIJ standard) or AP 7.62×51 mm hard steel core (projectile level IV NIJ standard). The objective of the research is to develop the RFRE and to determine the effect of adding a strike face layer to ramie fiber epoxy composites as level III and IV bulletproof panels. The frontmost MAS uses tungsten carbide and is enveloped by a back layer of ramie fiber composites with epoxy resin reinforcing material as the matrix. Ballistic testing was carried out in this study using a long-barreled rifle to determine the resistance of the MAS to projectile impact. The speed meter in ballistic testing uses a velocity sensor type light screen B 471, and clay witness is used to measure back face signature (BFS). The results show that the Ramie Fiber Reinforced Epoxy (RFRE)-tungsten carbide composite had a thickness of 12 mm tungsten carbide and 10 mm RFRE, while the hybrid RFRE-silicon carbide composite had a thickness of 20 mm silicon carbide and 10 mm RFRE for non-perforation for NIJ standard level III. The RFRE-tungsten carbide composite had a thickness of 12 mm tungsten carbide and 10 mm RFRE, while the hybrid RFRE-silicon carbide composite had a thickness of 20 mm silicon carbide and 10 mm RFRE for non-perforation for NIJ standard level III.

T3-O-B21

From Agricultural Residue to Regenerative Design: Exploring Coconut Shell–Natural Fiber Biomaterials for Sustainable Craft Innovation

Bayu Rahmat Setiadi^{1,2*} and Anggi Tias Pratama^{2,3}

¹Department of Mechanical Engineering Education, Faculty of Engineering, Universitas Negeri Yogyakarta,
Yogyakarta 55281, Indonesia

²Center for Eco-Material Engineering and Manufacturing, Universitas Negeri Yogyakarta,
Yogyakarta 55281, Indonesia

³Department of Biology Education, Universitas Negeri Yogyakarta, Yogyakarta 55281, Indonesia
*bayursetiadi@uny.ac.id

ABSTRACT

The growing environmental impacts of resource extraction, fossil-based materials, and post-consumer waste require designers to reconsider materials not merely as production inputs but as integral components of ecological and socio-cultural systems. This paper examines the potential of coconut shell and natural fibers as biomaterial resources for sustainable craft and product design. Using a critical literature review of recent studies on bio-based materials, natural-fiber composites, circular design, and regenerative material practices, the paper discusses the relationship between material properties, manufacturing processes, environmental performance, cultural value, and end-of-life scenarios. Coconut shell is positioned not simply as an agricultural residue, but as a lignocellulosic material with distinctive structural, visual, and cultural characteristics. In solid, fragmented, or particulate forms, it can be combined with natural fibers such as coir, ramie, bamboo, or kenaf to produce hybrid composites for crafts, interior accessories, furniture components, and lifestyle products. However, the environmental advantages of such materials are not inherent. Their sustainability depends on resin selection, fiber–matrix compatibility, energy consumption, chemical treatment, durability, repairability, and material recovery after use. The study argues that biomaterial innovation should move beyond the symbolic use of “natural” materials toward measurable circular and regenerative design strategies. These include minimizing non-renewable binders, preserving material identity, enabling disassembly, extending product life, and integrating scientific material characterization with local craftsmanship. The paper concludes that coconut shell–natural fiber composites can become a strategic platform for sustainable design innovation, particularly in tropical regions, by connecting agricultural waste valorization, technological experimentation, local knowledge, and contemporary aesthetics. Such an approach repositions designers as mediators between material science, cultural practices, production systems, and ecological responsibility.

Keywords: biomaterials; coconut shell; natural fibers; sustainable craft; biocomposites; regenerative design; circular design.

T3-V-B25

Tailoring the Physical and Mechanical Properties of Ni–GO Composite Coatings through Pulse Frequency

Nik Roselina Nik Roseley^{1}*

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

**roselina_roseley@uitm.edu.my*

ABSTRACT

Coatings provide a protective layer that improves the wear resistance of a surface and reduces friction between contacting surfaces. Pulse electrodeposition method has gained significant attention owing to its capability to generate tailored fine-grained, dense and uniform coatings. This work explored the influence of pulse frequency on the physical and mechanical properties of fabricated nickel-graphene oxide (Ni-GO) composite coatings. The coatings were deposited on carbon steel with GO platelets concentration of 0.05 g/L through a 45-minute deposition at a temperature of 45 °C by pulse electrodeposition method. The pulse current frequency was varied from 200 Hz to 500 Hz. Surface morphology, surface roughness, coating thickness, microhardness, and phase structures were examined using Scanning Electron Microscope, Alicona InfiniteFocus, Micro-Vickers Hardness Testing Machine, and X-ray Diffractometer respectively. The highest coating hardness of 245.4 HV was obtained at the highest pulse frequency of 500 Hz. Surface roughness was drastically reduced to 0.3 µm as the pulse frequency increased to 500 Hz. The thickness of coatings increased with increasing pulse frequency, from 17.2 µm to 27.1 µm before decreasing to the lowest thickness of 14.0 µm at 500 Hz.

Keywords: *nickel, graphene oxide, composite, coating, pulse electrodeposition.*

T3-O-A10

Thermophysical and Tribological Characteristics of Hybrid SiO₂: TiO₂ Nanoparticles Dispersed in Coconut Oil for Minimum Quantity Lubrication

Amira Natasha Amir Rizal¹, Irmie Azlin Zakaria^{1*} and Siti Rabizah Makhsin

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

* irnieazlin@uitm.edu.my

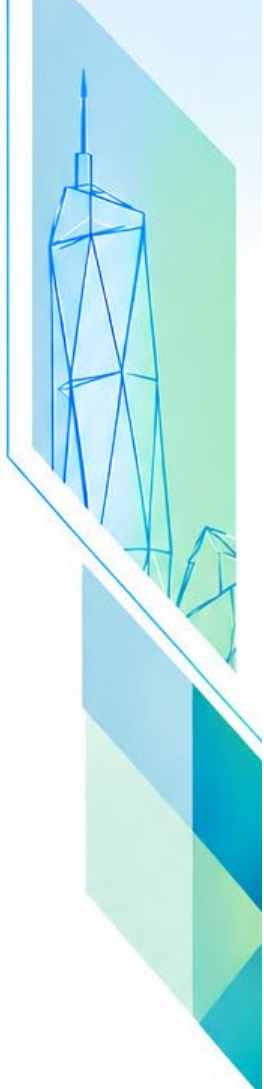
ABSTRACT

The increasing demand for sustainable manufacturing due to environmental concerns has driven industries to seek eco-friendly lubricants suitable for Minimum Quantity Lubrication (MQL) conditions. This research examines the overall performance of hybrid nano lubricants composed of SiO₂ and TiO₂ nanoparticles dispersed in biodegradable coconut oil, intending to address the limitations of conventional petroleum-based lubricants. Five varying concentrations (0.01%, 0.03%, 0.05%, 0.07%, and 0.1%) were prepared and compared against base coconut oil in terms of their stability, viscosity, and tribological behaviour. The stability was evaluated through visual sedimentation observation for 30 days, absorbance value with UV-Vis spectrophotometry, and zeta potential measurements. The UV-Vis and zeta potential tests showed the highest absorbance value at the wavelength of 295 nm and 57.1%, respectively. Thermophysical properties such as thermal conductivity and viscosity were evaluated, revealing that thermal conductivity increased by up to 28% at a 0.1% concentration, while viscosity rose with concentration but was inversely proportional to temperature. Tribological performance was measured using the ASTM D4172 Four-Ball test and Olympus Metallurgical Microscope. The 0.07% nano lubricant produced the lowest coefficient of friction and smallest wear scar diameter, indicating an optimal balance between particle dispersion and lubrication efficiency. Overall, the findings support and demonstrate the potential of SiO₂: TiO₂ hybrid nano lubricants in coconut oil as a sustainable and high-performance alternative to conventional lubricants for advanced machining applications, significantly improving tool life and machining performance while promoting environmentally sustainable industrial operations.

Keywords: Tribology; TiO₂; SiO₂ Nanoparticles; Coconut Oil; Viscosity.



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TRACK 4: STRUCTURAL DYNAMICS AND VIBRATIONS



T4-O-A61

Comparative Assessment of Linear and Nonlinear Finite Element Analysis for Predicting the Dynamic Response of Bolted Structures

Muhammad Syafiq Aiman Mohd Kahar¹, Muhamad Norhisham Abdul Rani¹, Mohd Azmi Yunus¹, Konstantinos Rousou^{2,3}, Andreas Kyprianou⁴ and Abdul Rahim Bahari^{1*}

¹Structural Dynamics Analysis & Validation (SDAV), Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia.

²Department of Mechanical Engineering, KU Leuven, Heverlee, Belgium.

³Flanders Make@KU Leuven

⁴Department of Mechanical and Manufacturing Engineering, School of Engineering, University of Cyprus, Nicosia, Cyprus

*abdurahimbahari@uitm.edu.my

ABSTRACT

Linear dynamic modelling is widely used to predict the dynamic response of bolted structures in aerospace and mechanical systems. However, under large excitation forces, the structural response becomes difficult to analyse due to the presence of nonlinear dynamic effects such as amplitude-dependent dynamic behaviour, including resonance frequency shift and resonance peak bending. This study presents a numerical framework for modelling the amplitude-dependent dynamic behaviour of bolted joint structures using finite element analysis. Linear and nonlinear dynamic analyses are performed under varying harmonic excitation forces from 0.20 N to 1.40 N to compare the predictive capabilities of both modelling approaches. The linear dynamic response is evaluated using the SOL108 frequency response solver, while nonlinear dynamic behaviour is modelled using a cubic stiffness representation incorporated within the SOL128 nonlinear frequency response solver. Resonance frequency variations are evaluated from the frequency responses to identify the presence of linear and nonlinear dynamic characteristics. The results obtained from the linear analysis demonstrate a constant resonance frequency of 19.20 Hz despite the increase in force magnitude from 0.20 N to 1.40 N, together with symmetric frequency responses throughout the excitation range, indicating amplitude-independent behaviour. In contrast, the nonlinear analysis successfully demonstrates a shift in resonance frequency from 19.20 Hz to 18.52 Hz, accompanied by a progressively pronounced softening response as the excitation level increases. These observations clearly demonstrate the amplitude-dependent dynamic characteristics induced by the bolted joints. Overall, the proposed numerical framework provides a highly representative simulation of amplitude-dependent dynamic behaviour of bolted structures subjected to varying excitation levels, thereby enhancing the predictive capability of engineering structures containing bolted joints.

Keywords: Linear Dynamic Analysis; Nonlinear Dynamic Analysis; Bolted Joint Nonlinearity, Frequency Response, Finite Element Modelling.

T4-V-A56

Frequency-Based Finite Element Model Updating of a PALF/Epoxy Composite Plate Using Response Surface Methodology

M.S.M. Fouzi^{1,4}, M.S.M. Sani^{1,2,3*}, N.A.Z. Abdullah², J.M. Zikri³, M.N.A. Rani⁵, A.Z.F.A. Karim¹ and P. Gupta⁶

¹Faculty of Mechanical & Automotive Engineering Technology, Universiti Malaysia Pahang

Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

²Automotive Engineering Centre, Universiti Malaysia Pahang Al-Sultan Abdullah,
26600 Pekan, Pahang, Malaysia

³Academy for Advanced TVET, University Malaysia Pahang Al-Sultan Abdullah,
26600 Pekan, Pahang, Malaysia

⁴Jabatan Pendidikan Politeknik dan Kolej Komuniti, Aras 4-7, Galeria PJH, Jalan P4 W,
Persiaran Perdana, 62100 Putrajaya, Malaysia

⁵Structural Dynamic Analysis & Vibration (SDAV), Faculty of Mechanical Engineering,
Universiti Teknologi MARA, 40450 Shah Alam, Malaysia

⁶Mechanical Engineering Department, Madan Mohan Malaviya University of Technology,
Gorakhpur-273010, India

*mshahrir@umpsa.edu.my

ABSTRACT

Natural fibre-reinforced polymer composites have attracted increasing attention as sustainable lightweight materials for engineering structures. However, accurate finite element prediction of their dynamic behaviour remains challenging due to uncertainties in material properties, fabrication variability, thickness variation and simplified modelling assumptions. This study presents a frequency-based finite element model updating framework for a single-ply woven pineapple leaf fibre (PALF)/epoxy composite plate using Response Surface Methodology (RSM). A PALF/epoxy composite plate was fabricated using the hand lay-up method and experimentally evaluated through impact hammer modal testing. Four experimental natural frequencies were identified at 22, 60, 116 and 140 Hz and used as reference responses for model updating. An initial finite element model was developed and solved to obtain the corresponding numerical natural frequencies of 22.72, 63.13, 122.84 and 148.84 Hz. The initial EMA-FEA comparison produced frequency errors between 3.27% and 6.31%, with an overall RMS error of 5.30%. Eight updating parameters, namely E_{11} , E_{22} , ν_{12} , G_{12} , G_{23} , G_{13} , density and plate thickness, were varied using a face-centred central composite design. Quadratic RSM models were developed and assessed using ANOVA, predicted-versus-actual plots, perturbation analysis and response surface plots. The desirability-based optimization produced an RSM-predicted RMS error of 0.88% which was subsequently verified through direct FEA confirmation. After implementing the optimized parameters into the FE model, the confirmed updated FEA results reduced the RMS error to 1.43%. The findings demonstrate that RSM provides an efficient surrogate-based strategy for improving natural-frequency-based dynamic prediction of PALF/epoxy composite plates.

Keywords: PALF/epoxy composite; finite element model updating; response surface methodology; natural frequency; structural dynamics.

T4-V-A60

ANN–MFO Based Prediction and Optimization of Diesel Engine Vibration Using Waste Plastic Oil Biodiesel Blends

Muhammad Zikri Japri^{1,3}, Mohd Shahrir Mohd Sani^{1,2,3*}, Mohd Fadzil Faisae Abd Rashid², J.M. Zikri³, Mohd Azmi Yunus⁴ and Hasan Koten⁵

¹Academy for Advanced TVET, University Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

²Faculty of Mechanical & Automotive Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

³Automotive Engineering Centre, Universiti Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

³Academy for Advanced TVET, University Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

⁴Structural Dynamic Analysis & Vibration (SDAV), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia

⁵Istanbul Medeniyet University, Department of Mechanical Engineering, Kadıköy, 34720, İstanbul, Türkiye

*mshahrir@ump.edu.my

ABSTRACT

This study investigates the vibration characteristics and predictive optimization performance of waste plastic oil (WPO) biodiesel blends in a single-cylinder diesel engine using an Artificial Neural Network integrated with the Moth–Flame Optimization (ANN–MFO) approach. Waste plastic oil produced from polyethylene–polypropylene (PE–PP) pyrolysis was blended with pure diesel fuel at 10% and 20% by volume, namely WPO10 and WPO20, while pure diesel (D100) served as the reference fuel. Engine speeds and loads were varied across the low- to high-operating range. The experimental results showed that, under medium- and high-load conditions, the WPO blends generally produced lower vibration amplitudes than pure diesel fuel, indicating smoother combustion behavior and reduced mechanical excitation. Among the tested fuels, WPO20 exhibited superior vibration reduction under severe (high-load and high-speed) operating conditions, whereas WPO10 performed better under medium-load and high-speed conditions. For modeling, the ANN model demonstrated strong predictive performance, with an overall regression coefficient (R) of 0.96302, indicating excellent agreement between the predicted and experimental vibration responses. Subsequently, when integrated with the MFO algorithm, the model predicted that the optimum condition was achieved at approximately WPO11, operating at 1200 rpm under high-load conditions, resulting in a minimum RMS vibration amplitude of 0.438 mm/s. Experimental validation revealed only a 2.05% deviation between the predicted and measured values, confirming the reliability and robustness of the proposed optimization framework. In summary, the findings demonstrate that the ANN–MFO approach is an accurate and effective tool for predicting and optimizing the vibration characteristics of diesel engines fuelled by biodiesel blends of waste plastic oil. Furthermore, the results highlight the potential of WPO blends to improve engine vibroacoustic performance while simultaneously supporting sustainable fuel development and plastic waste valorization.

Keywords: PALF/epoxy composite; finite element model updating; response surface methodology; natural frequency; structural dynamics.

T4-O-A45

Experimental and Numerical Modal Analysis of Fiber Cement Board with Elastic Supports

Abdulrahman Mubarak Salem Sawahli¹, Adiza Jamadin¹, Mohamad Farid Misnan^{2,3},
Khairunisa Muthusamy⁴ and Sakhiyah Abdul Kudus^{1,5*}

¹Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²Faculty of Electrical Engineering, Universiti Teknologi MARA,
40450 Shah Alam, Selangor, Malaysia.

³Smart Manufacturing Research Institute (SMRI), Universiti Teknologi MARA,
40450 Shah Alam, Selangor, Malaysia.

⁴Faculty of Mechanical Engineering, Universiti Malaysia Pahang Al-Sultan Abdullah,
Persiaran Tun Khalil Yaakob, 26300, Kuantan, Pahang, Malaysia.

⁵Institute for Infrastructure Engineering and Sustainable Management (IIESM), Universiti
Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia.

*sakhiyah@uitm.edu.my

ABSTRACT

Fiber cement boards are widely used in modern construction due to their low density, durability, and suitability for lightweight and modular structural systems. However, accurate prediction of their dynamic behavior remains challenging, primarily due to uncertainties in boundary condition modelling. In many numerical analyses, supports are idealized as pinned, fixed, or roller restraints, which do not fully represent the actual flexible behavior of real support conditions. This study addresses this limitation by investigating the dynamic response of a fiber cement board with elastic boundary conditions. The proposed approach implements Experimental Modal Analysis (EMA), Finite Element Modelling (FEM), and Finite Element Model Updating (FEMU). Experimental modal analysis was conducted using two frequency response function estimators (H1 and H2) to ensure the reliability of the identified modal parameters. The experimental setup employed foam layers to simulate elastic support conditions, while the finite element model was developed using equivalent spring elements to represent the same boundary behavior. The initial model was subsequently updated through FEMU by refining the support stiffness parameters and elastic modulus of fiber cement board. The results demonstrate that introducing elastic support modelling significantly enhances the agreement between numerical and experimental modal properties. The natural frequency error was reduced from approximately 57% in the initial finite element model to about 6% after model updating, while the Modal Assurance Criterion (MAC) improved from 0.88 to 0.95. These findings highlight the importance of realistic boundary condition representation in lightweight structural systems and demonstrate the effectiveness of the proposed FEMU framework in improving model reliability.

Keywords: Experimental Modal Analysis; Finite Element Method; Model updating; Natural Frequency; Elastic Support.

T4-O-A46

Finite Element Analysis and Structural Verification of MYCu-X1 CubeSat for JAXA Launch Compatibility

Suhayl Azmin Zulkipli¹*, Nor'asnilawati Salleh¹, Syahrim Azhan Ibrahim¹, Ahmad Ammar Ahmad Termizi¹ and Fairul Azmin Zarain¹

¹Space Engineering and Technology Division, Malaysian Space Agency, Malaysia

*suhaylazmin@mysa.gov.com

ABSTRACT

In recent years, CubeSats have emerged as a cost-effective platform enabling rapid deployment of space missions due to their compact size and standardized architecture. However, many emerging programs remain dependent on commercial-of-the-shelf (COTS) structural frames, which limit design flexibility and hinder the development of local engineering capabilities. This study presents the structural design and verification of a locally developed 3U CubeSat by the Malaysian Space Agency (MYSA), aimed at reducing reliance on commercial structures while enhancing national space technology development. A high-fidelity 3D model of the CubeSat structure was developed using Siemens NX, followed by comprehensive finite element analysis (FEA) to evaluate structural integrity under launch conditions. The verification process included dimensional compliance, mass property verification, modal analysis, and static load assessment in accordance with international standards, including the CubeSat Design Specification (Cal Poly) and JAXA J-SSOD interface requirements. The simulation results demonstrate that the CubeSat structure satisfies all critical design constraints, with a total mass of 3.66 kg and center of gravity within the allowable tolerance limits. Modal analysis indicates a fundamental natural frequency of 551.91 Hz, significantly exceeding the minimum requirement of 30 Hz, thereby minimizing the risk of resonance during launch. Static structural analysis further confirms that the induced stresses remain well below the material yield strength of Aluminum 6061-T6, achieving a factor of safety greater than 1.5 under the applied compressive load of 46.6 N. These findings validate the structural integrity and launch compatibility of the MYCu-X1 CubeSat, establishing a reliable technical foundation for future locally developed nanosatellite missions. The study highlights the feasibility of adopting local structural design approaches to achieve cost-effective and high-performance space systems.

Keywords: CubeSats, Structural Design, Finite Element Analysis (FEA), Launch Survivability, Siemens NX.

T4-V-A84

Dynamic Characterisation of Abaca Fibre-Reinforced Epoxy Structure Using Finite Element Model Updating Method

Y. W. Wong¹, I. F. Ahmad^{2*}, C. Y. Teoh¹, M. A. S. Aziz Shah³, M. A. Yunus⁴ and A. R. A. Rahim⁵

¹Centre for Energy, Vibration and Acoustics Research (CEVA), Tunku Abdul Rahman University of Management and Technology (TAR UMT), 53300 Kuala Lumpur, Malaysia.

²Centre for Advanced Materials, Faculty of Engineering and Technology, Tunku Abdul Rahman University of Management and Technology (TAR UMT), 53300 Kuala Lumpur, Malaysia.

³Advanced Structural Integrity and Vibration Research Group (ASIVR), Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), 26600 Pekan, Pahang, Malaysia.

⁴Structural Dynamics Analysis & Validation (SDAV), Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia.

⁵Aerospace Engineering Service Centre (PUSPEKA), Royal Malaysian Air Force, 40000 Shah Alam, Selangor, Malaysia.

*intanfatihah@taru.edu.my

ABSTRACT

Abaca fibre-reinforced polymer (AbFRP) composite structures are increasingly considered for lightweight structural applications due to their sustainability and unique mechanical properties. This paper presents an integrated experimental and numerical investigation of the dynamic behaviour of AbFRP structure, focusing on the implementation of finite element model updating (FEMU) to enhance the accuracy of predicted natural frequencies and mode shapes under free-free boundary conditions. Experimental modal analysis (EMA) was conducted on a fabricated specimen of AbFRP to extract the composite modal parameters. A detailed finite element (FE) model was developed, incorporating orthotropic material properties and subsequently updated using the FEMU method to reduce discrepancies between initial FE predictions and experimental results. The FEMU process focused on optimising key material and structural parameters to improve correlation. The comparison before and after updating demonstrates a significant improvement in agreement, particularly in natural frequencies and mode shape consistency. The results confirm that the updated FE model provides a reliable representation of the dynamic behaviour of the AbFRP structure. This work contributes to the advancement of accurate predictive modelling techniques for natural fibre composites especially for AbFRP structure and supports their implementation in vibration-sensitive engineering applications.

Keywords: Natural fibre; abaca fibre reinforce polymer; finite element model updating; dynamic behaviour.

T4-O-B09

Investigation on Physico-Mechanical Response and Micro-Fracture Development in Basaltic Rock under Explosion-Induced Dynamic Stress

Firoj Ali¹*, Sunil Kumar Dhar¹ and Sivaji Lahiri¹

¹CSIR-Central Institute of Mining and Fuel Research, Dhanbad, India

*firojchem86@gmail.com

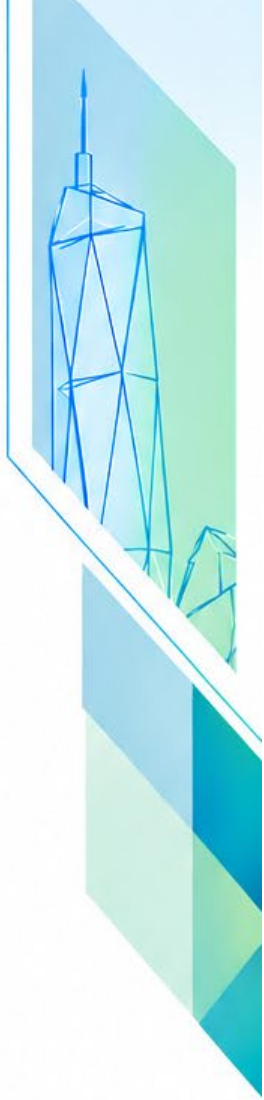
ABSTRACT

Rock mass stability is predominantly controlled by their inherent mechanical properties to determine their stability under various engineering application. However, blasting operation significantly affect the mechanical behaviour of rock masses by weakening structures, microstructural damage and fracture development. Therefore, understanding the geotechnical, properties and formation of blast-induced microstructure is essential for ground stability and safety workplace. Previous studies have examined mechanical behaviour and microcracks formation of basaltic rock under thermal, mechanical, and electromagnetic loading. However, studies on geotechnical parameter and the microfracture evolution under Explosion-Induced stress conditions remain limited in contemporary literature. Therefore, in this study, we analysed the in-depth mechanical characterization, evolution of microfracture and permeability of basaltic rock formation. Further, this study quantified the variation in fracture density, orientation, and connectivity under varying explosive charged conditions to assess the degree of microfracture development. Additionally, permeability analysis was carried out using the extracted microfracture networks to evaluate fluid percolation thresholds and flow behaviour through interconnected microcracks. Result confirmed that, higher explosive charge produces significantly greater microfracture density, connectivity (Maximum X- nodes), and fracture-length variability, indicating, a higher degree of internal structural disruption. Permeability was found to increase progressively with increasing microfracture density and network connectivity, demonstrating that blast-induced fracture development substantially enhances fluid migration pathways and increase the percolation threshold within the rock. This study provides a quantitative assessment of the mechanical properties, microfracture network evolution, and permeability response of blasted basalt, offering valuable insights for rock mass stability evaluation, fluid flow prediction, and blast design optimization.

Keywords: Mechanical response; Basaltic rock; Topological and spatial analysis; Permeability.



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TRACK 5: AUTOMOTIVE ENGINEERING



T5-O-A139

Computer Vision-Based Assessment of Mirror-Checking Behaviour as a Proxy for Driver Situation Awareness During Automated Rapid Transit Operation

Muhammad Fakhru Mohamad Sauti¹, Hazran Husain¹ and Ahmad Khushairy Makhtar^{1,2*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²Malaysia Institute of Transport (MITRANS), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

*ahmadkhushairy@uitm.edu.my

ABSTRACT

Automated Rapid Transit (ART) combines road-based operation with automated guidance and still requires human supervision. Maintaining awareness of surrounding traffic is therefore important when the driver's role shifts from direct control to supervisory monitoring. This study evaluated a computer vision-based method for quantifying mirror-checking behaviour as a proxy for Level 1 situation awareness during ART operation. Videos were obtained from four drivers: one professional and one locally trained driver in each operational condition. Manual operation was observed in Johor Bahru and semi-autonomous operation in Kuching, Sarawak. A total of 120 five-minute recordings, comprising 60 recordings per condition, were divided into 600 one-minute scoring intervals. OpenCV and MediaPipe Face Mesh were used to estimate head orientation from six facial landmarks. A transition beyond $\pm 2^\circ$ yaw and back to the forward region was counted as one mirror-checking event. Event frequency was converted into a five-level Situational Awareness Index (SAI). The mean SAI was higher in the manual/Johor Bahru condition ($M = 4.92$) than in the semi-autonomous/Kuching condition ($M = 3.19$), and the interval-level analysis indicated a significant condition difference, $F(1, 299) = 587.87$, $p < 0.001$, partial $\eta^2 = 0.663$. No significant session effect was reported within either condition. Automated scoring produced systematically higher values than manual observation, but this difference does not establish superior accuracy without event-level ground-truth validation. The findings provide preliminary evidence that computer vision-derived mirror-checking frequency can quantify visual environmental monitoring during ART operation. Because operational mode was confounded with location and minute-level observations were nested within drivers, further matched-condition and multilevel validation is required before operational application.

Keywords: Automated Rapid Transit; computer vision; driver monitoring; mirror-checking behaviour; situation awareness.

T5-V-A54

Formulation, Characterization, and Properties Optimization of Refined Palm Oil Biofuel Blended with Hexanol for Compression Ignition Engines

Hazim Sharudin^{1,3}, Sharzali Che Mat^{2}, Amirul Danish Yusri², Muhammad Arif Ab Hamid Pahmi², Azmi Husin², Faridzul Iqbal Muthar¹, Hasannuddin Abd Kadir¹ and Siti Nur Amalina Mohd Halidi²*

¹*Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Johor, Pasir Gudang Campus, 81750 Masai, Johor, Malaysia*

²*Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Pulau Pinang, Malaysia*

³*Nanomaterials for Sensors and Heat Transfer, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

**sharzali.chemat@uitm.edu.my*

ABSTRACT

Due to the increasing demand for diesel fuel, alternative biofuels are needed to reduce global reliance on fossil fuels. Straight Vegetable Oils (SVOs), such as Refined Palm Oil (RPO), are highly suitable biofuel sources due to their renewability and high production volume. However, using unblended SVO in internal combustion engines causes issues like incomplete combustion and carbon deposits due to its high viscosity. To overcome these problems, SVO can be blended with an alcohol like Hexanol (HEX) to significantly reduce its viscosity. This study focuses on formulating, optimizing, and characterizing binary blends of RPO and HEX. A statistical method was employed to analyze the relationship between RPO-Hexanol blend ratios and their effects on kinematic viscosity, calorific value, and density, utilizing the mixture design process in the Design of Experiment (DOE). Based on this analysis, five blend ratios—varying from 100% RPO to 100% HEX, with three repetition runs—were suggested for experimentation. Experimental data was then used to correlate and optimize the blend in accordance with ASTM D6751 and EN14214 biofuel standards. The results demonstrate that the density of RPO decreases linearly with the addition of hexanol. The reduction in the blends' viscosity increases volatility, thereby enhancing fuel spray characteristics, while a higher calorific value yields greater energy upon combustion, improving engine efficiency. Ultimately, the ratio of 22% RPO to 78% HEX was found to be the optimal blend, as it successfully met all targets set by the ASTM D6751 standard and proved suitable for use in Compression Ignition (CI) engines.

Keywords: *Straight Vegetable Oil; Refined Palm Oil; Hexanol; Mixture Design Method.*

T5-O-A62

Embedded Control and Retrofit Strategies for Automotive Dynamometer Modernization: A Review of Eddy-Current Retarder Control, Data Acquisition, and Industry 4.0 Integration

Mohd Mustaqim Tukiman¹, Aida Husna Ahmad¹, Mohd Firdaus Abas¹, Ahmad Hafizal Mohd Yamin¹, Mzahar Abd Jalal¹, Muhamad Khairul Ilman Sarwani² and Shahrul Azmir Osman^{1*}

¹Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia,
86400 Parit Raja, Batu Pahar, Johor, Malaysia

²G7 Aerospace Sdn. Bhd. (MELAKA), 16, Jalan PK 8B-1, Taman Perindustrian Krubong,
75260 Melaka, Malaysia

*shahrula@uthm.edu.my

ABSTRACT

Automotive dynamometers remain essential experimental platforms for vehicle performance evaluation, emissions assessment, powertrain calibration, and controller validation. However, many existing engine and chassis dynamometer facilities, particularly legacy systems, are constrained by outdated control hardware, limited data-acquisition capabilities, poor compatibility with modern communication protocols, and reduced flexibility for transient and automated testing. This review examines recent developments in embedded control systems and controller retrofitting for automotive dynamometers, with particular emphasis on eddy-current retarder control, real-time data acquisition architectures, Controller Area Network (CAN)-based communication, and Industry 4.0-enabled monitoring. The discussion synthesizes literature on dynamometer system architecture, retrofit strategies, embedded platforms, LabVIEW-based implementation, adaptive and intelligent control methods, thermal compensation, and cloud-connected DAQ systems. The review indicates that modern dynamometer performance is increasingly governed not only by the mechanical loading unit, but also by the effective integration of control algorithms, sensing systems, communication interfaces, safety logic, and data-management platforms. Persistent challenges remain in compensating for Eddy-Current Retarder (ECR) torque variation caused by thermal effects, correcting inertia during transient testing, synchronizing multi-channel Data Acquisition (DAQ) signals, satisfying real-time control constraints, and ensuring reliable safety integration. Future research should therefore focus on standardized retrofit frameworks, robust embedded control architectures, digital twin integration, predictive diagnostics, and scalable low-cost modernization strategies for legacy automotive test facilities. This review provides a structured technical foundation for researchers and practitioners seeking to upgrade automotive dynamometer systems toward more intelligent, connected, reliable, and cost-effective testing platforms.

Keywords: Automotive dynamometer; Eddy-current retarder (ECR); Embedded control systems; Controller retrofitting; Data acquisition (DAQ) systems; Industry 4.0.

T5-O-A41

Computational Performance of Non-Radial Fibre Turbine at Steady State Condition

S.N.S. Ridzuan¹, A.M. I. Mamat^{2*} and A. Abd Razak²

¹Johnson Pump (M) Sdn Bhd, Bukit Serdang Industrial Park, 43399 Seri Kembangan, Selangor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
*amanihsan@uitm.edu.my

ABSTRACT

The low-pressure turbine (LPT) in electric turbo compounding chokes at pressure ratios above 1.25 due to supersonic exit velocity and rapid density reduction. Conventional radial blade designs cannot adequately accommodate these aerodynamic changes, thereby limit swallow capacity and reduce exhaust energy recovery. This study examines the performance of non-radial fibre (NRF) turbine configurations with backward- and forward-swept exit blade angles to improve LPT aerothermodynamic behaviour. Single-passage computational fluid dynamics (CFD) simulations were performed in ANSYS CFX under steady-state conditions at 40,000 RPM, 50,000 RPM, and 60,000 RPM, with an inlet temperature of 1100 K, using the $k-\epsilon$ turbulence model, for mass flow rates, $\dot{m}$ ranging from 0.01 to 0.09 kg/s and all NRF configurations. The baseline rotor result was validated against experimental data, yielding a relative mean standard deviation (RMSD) of 0.37 for turbine efficiency. The forward-swept configuration achieved the best performance, increasing total-to-static efficiency by 2% to 0.780 and yielding a higher mass flow parameter at $PR = 1.25$ than the baseline and backwards-swept designs. Flow-field analysis showed choking at the blade midsection, while an improved downstream exit flow reduced the velocity curl and, subsequently, the static entropy at the trailing edge. The results indicate that the forward-swept NRF turbine offers a promising approach for improving efficiency and swallow capacity in electric turbo compounding applications.

Keywords: Low Pressure Turbine (LPT); Non-radial Fibre Turbine (NRF), Energy Recovery.

T5-O-A49

Improving Stud Welding Quality in Automotive Manufacturing through 8D Problem Solving and Stud Gun Sleeve Redesign

Yusliza binti Yusuf^{1}, Nur Aina Nasywa Noor Azly¹, Rohana binti Abdullah¹ and Reni Dwi Astuti²*

*¹Fakulti Teknologi dan Kejuruteraan Industri dan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang
Tuah Jaya, 76100, Durian Tunggal, Melaka, Malaysia*

*²Fakultas Teknologi Industri, Kampus 4, Universitas Ahmad Dahlan, Ring Road Selatan, Bantul,
DI Yogyakarta, Indonesia*

**yusliza@utem.edu.my*

ABSTRACT

Stud welding is a critical joining process in the automotive manufacturing industry because it directly influences structural integrity, production efficiency, and product reliability. However, recurring stud weld gap defects caused by unstable stud gun alignment remain a significant quality issue, leading to increased rework, production interruptions, and manufacturing costs. Although previous studies have mainly focused on welding parameter optimization, limited attention has been given to integrating engineering tooling redesign with structured quality improvement methodologies for permanent defect prevention. Therefore, this study aims to identify the root causes of recurring stud welding defects and develop an improved stud gun sleeve to enhance alignment stability and welding consistency. The study employed the Eight Disciplines (8D) problem-solving methodology, incorporating Pareto analysis, Fishbone (Ishikawa) diagrams, and Five-Why analysis for systematic root cause identification. Based on the findings, three stud gun sleeve concepts were developed, followed by prototype evaluation, alignment assessment, pull-out inspection, and production validation under actual manufacturing conditions. The results confirmed that unstable stud gun alignment was the primary cause of recurring stud weld gap defects. The redesigned stud gun sleeve improved alignment stability, positioning repeatability, and welding consistency, resulting in a substantial reduction in recurring stud weld gap defects during production validation. The findings demonstrate that integrating the 8D methodology with engineering tooling redesign provides a practical and sustainable approach for improving manufacturing quality and continuous quality improvement in automotive stud welding applications.

Keywords: *Stud welding; Automotive Manufacturing, 8D Problem solving, Root cause analysis, Welding defect Reduction.*

T5-O-A03

Cross-Modal Feature Denoising for 4D Radar-Camera Fusion in Autonomous Vehicles Under Severe Fog

Li Zhengqing^{1,2} and Baljit Singh^{1,3*}

¹Fakulty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam 40450, Selangor, Malaysia

²University of Sanya, Sanya 572022, China

³Solar research Institute (SRI), Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

*baljit@uitm.edu.my

ABSTRACT

Reliable environmental perception in low-visibility conditions remains a critical challenge hindering the safe and scalable deployment of autonomous vehicles, particularly in adverse weather scenarios like dense fog, heavy rain, and snow. Under such conditions, camera-centric Bird's-Eye-View (BEV) models suffer from significant visual degradation, including reduced contrast, color distortion, and partial feature occlusion, severely impairing semantic understanding and downstream tasks like detection and segmentation. Meanwhile, millimeter-wave radars experience increased point-cloud sparsity and background noise, leading to unreliable target localization and tracking. This paper specifically investigates sensor degradation under extreme fog and proposes a targeted cross-modal Feature Denoising Module (FADM) for 4D radar-camera fusion. Rather than focusing on a generic perception pipeline, this study deeply analyzes how weather-invariant spatial and Doppler motion cues from 4D radar can be leveraged to dynamically repair corrupted visual semantics. By introducing radar-guided cross-modal attention and residual enhancement, the proposed mechanism effectively suppresses noise in fog-occluded regions. Evaluated on the DualRadar dataset under varying synthetic fog densities, the analysis demonstrates that the FADM mechanism successfully restricts the semantic segmentation performance drop to merely 6.8%, significantly outperforming baseline fusion approaches. The qualitative and quantitative results provide critical insights into sensor degradation, offering a robust feature-level denoising solution for autonomous driving systems operating in adverse environments.

Keywords: Autonomous Vehicles; Cross-Modal Feature Denoising; 4D Radar-Camera Fusion; Sensor Degradation; Bird's-Eye-View (BEV) Perception.

T5-V-B22

Effect of Varying Cerium Oxide (CeO₂) Additions on the Microstructure and Mechanical Properties of A356 Aluminum

Tiwan^{1,2*}, Afrizal Rifqi H.¹, Arianto Leman Soemowidagdo^{1,2} and Beni Tri Sasongko^{1,2}

¹Department of Mechanical Engineering Education, Faculty of Engineering, Universitas Negeri Yogyakarta, Yogyakarta 55281, Indonesia

²Center for Eco-Material Engineering and Manufacturing, Universitas Negeri Yogyakarta, Yogyakarta 55281, Indonesia

*tiwan@uny.ac.id

ABSTRACT

Aluminum A356 is widely used in automotive components because of its light weight, good castability, and corrosion resistance, yet castings of this alloy are often limited by coarse grains and needle-like eutectic silicon that reduce ductility. This study examines the effect of adding 2, 4, and 6 wt.% cerium oxide (CeO₂) on the microstructure and mechanical properties of gravity die cast A356 aluminum. Melting was carried out at 750°C with a pouring temperature of 700°C and a mold preheating temperature of 250°C. Testing covered microstructure observation, tensile testing, charpy impact testing, and vickers hardness testing. The results show that CeO₂ addition transforms the coarse dendritic α -Al phase into a fine globular structure, with the most homogeneous condition achieved at 2 wt%. The highest impact toughness of 0.0551 J/mm² was obtained at 2 wt%, while the highest hardness of 90.38 HVN was reached at 4 wt%. In contrast, tensile strength and elongation decreased compared to the unmodified condition. At 6 wt%, most mechanical properties tended to decline due to a fading phenomenon that triggered agglomeration of the modifier particles. These findings indicate that the optimum CeO₂ content depends on which mechanical property is prioritized for aluminum casting applications.

Keywords: A356 aluminum; cerium oxide; microstructure; mechanical properties; metal casting.

T5-O-A40

Summary of Energy-Saving Control for New Energy Autonomous Vehicles

Huang Pengfei^{1,2*}, Amalina Amir¹ and Wang Jian^{1,2}

¹Universiti Teknologi Mara (UiTM), Faculty of Mechanical Engineering, 40450 Selangor

²Jiangxi College of Applied Technology, Faculty of Automotive Engineering, 341000 Ganzhou

*2022435838@student.uitm.edu.my

ABSTRACT

With the rapid advancement of autonomous driving, vehicle electrification, and intelligent transportation systems, energy-saving control for intelligent new energy vehicles (NEVs) has become an important research direction in sustainable mobility worldwide. This paper provides a systematic review of energy-efficient driving control technologies for intelligent NEVs, with particular attention to the interaction between electrified powertrains, autonomous driving functions, and connected vehicle environments. First, the basic principles of eco-driving are discussed from the perspective of vehicle energy flow, including energy transfer, power conversion, and motion optimization. The paper then reviews three major technical routes: optimal control methods for eco-driving, vehicle-network-assisted energy management, and V2X-enabled collaborative energy-saving control. Key technologies such as predictive cruise control, model predictive control, deep-learning-based driving behaviour optimization, powertrain coordinated control, multi-vehicle platooning, and spatiotemporal trajectory planning are examined in relation to their contributions to energy consumption reduction. The review shows that autonomous driving and connected vehicle technologies can expand the energy-saving potential of NEVs by enabling more accurate perception, prediction, and coordination among vehicles, roads, and cloud platforms. Compared with conventional single-vehicle energy management, collaborative control in intelligent networked environments offers broader opportunities for improving traffic efficiency, reducing unnecessary acceleration and braking, and optimizing overall system-level energy performance. However, challenges remain in real-time algorithm implementation, multi-source data integration, subsystem coordination, driver acceptance, and privacy-preserving use of vehicle operation data. This paper concludes that future research should further strengthen vehicle-road-cloud collaboration, develop adaptive and robust control frameworks, and promote the integration of intelligent energy-saving control with practical NEV applications.

Keywords: Intelligent New Energy Vehicles; Energy-Saving Control; Eco-Driving; V2X Collaborative Control.

T5-V-A118

Thermodynamic Analysis of the Performance and Emissions of a Single-Cylinder Four-Stroke Diesel Engine Fueled with Ethanol–Diesel Blends

Firly Irhamni Ahsan¹, Priyo Agus Setiawan^{1}, Edi Haryono, Lely Pramesti¹, Raden Dimas Endro Witjonarko¹, Abdul Gafur¹, Bambang Antoko¹, Budi Prasajo¹ and Vena Rizky Pusparani¹*
¹Marine Engineering Department, Politeknik Perkapalan Negeri Surabaya, Jalan Teknik Kimia Kampus ITS Keputih-Sukolilo, Surabaya, Indonesia
**priyo.as@ppns.ac.id*

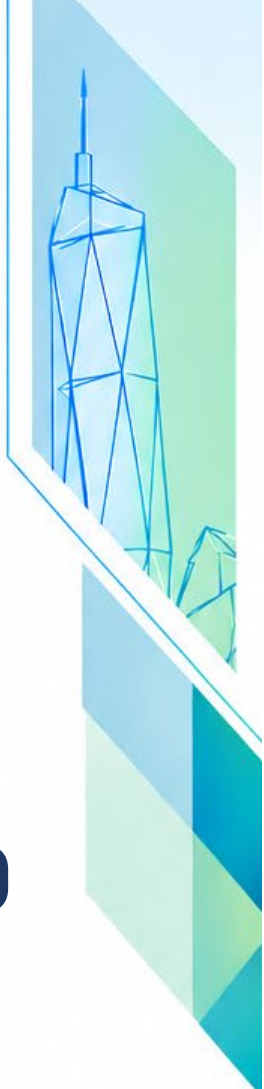
ABSTRACT

Single-cylinder mechanically injected diesel engines remain the primary propulsion system for small-scale fishing vessels in many developing maritime countries due to their simple construction, operational reliability, and ease of maintenance. However, these engines generally exhibit relatively low combustion efficiency and produce considerable particulate matter (PM) emissions. The application of oxygenated renewable fuels has emerged as a practical approach to improving combustion quality without requiring substantial engine modifications. This study investigates the thermodynamic performance and emission characteristics of a single-cylinder four-stroke diesel engine fueled with ethanol–diesel blends using a zero-dimensional combustion model. The investigated fuels consisted of neat diesel fuel (D100), D90E10, D85E15, and an extrapolated D80E20 blend. Engine performance was evaluated in terms of brake power (BP), brake-specific fuel consumption (BSFC), and brake mean effective pressure (BMEP), while exhaust emissions were assessed based on nitrogen oxides (NO_x) and particulate matter (PM). The simulation results indicate that increasing the ethanol fraction significantly reduces PM emissions owing to the oxygenated nature of ethanol, thereby promoting soot oxidation during combustion. Nevertheless, higher ethanol concentrations increase BSFC because of the lower heating value of ethanol and simultaneously increase NO_x emissions due to elevated combustion temperatures associated with enhanced premixed combustion. Among the investigated fuels, the D90E10 blend provides the most balanced compromise between engine performance, fuel economy, and emission reduction, making it the most suitable alternative fuel for small-scale marine diesel engines without requiring major hardware modifications.

Keywords: *ethanol–diesel blends; single-cylinder diesel engine; thermodynamic analysis; brake specific fuel consumption; brake mean effective pressure; nitrogen oxides; particulate matter.*



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TRACK 6: THERMOFLUID AND SUSTAINABLE ENERGY



T3-O-A06

Energy Efficiency Mechanisms of Variable Speed Drives in Commercial Laundry Dryer Systems: A Review

Anis Farhana Binti Abu Bakar^a, Mohd Mustaqim Tukiman¹, Amnur Akhyan² and Shahrul Azmir Osman^{1*}

¹Faculty of Mechanical and Manufacturing Engineering (FKMP), Universiti Tun Hussein
Onn Malaysia (UTHM) 86400 Parit Raja, Batu Pahat, Johor, Malaysia

²Politeknik Caltex Riau, Jl. Umban Sari No. 1, Rumbai, Pekanbaru 28265, Riau, Indonesia

*gd240082@student.uthm.edu.my

ABSTRACT

Commercial laundry systems used in hotels, hospitals, laundromats, and institutional facilities consume substantial thermal and electrical energy, with drying commonly recognised as the most energy-intensive process. In Malaysian commercial laundries, dryers have been reported to account for 59% of total energy consumption, indicating a strong need for improved dryer efficiency. This review evaluates the role of Variable Speed Drives (VSDs) in improving the energy performance of commercial laundry dryers by matching motor output with variable drying demand caused by textile moisture content, load mass, fabric characteristics, drum motion, and airflow resistance. The review synthesises literature on dryer load behaviour, VSD operating principles, including rectifier, DC-link, inverter, V/f control, and pulse-width modulation, as well as control strategies such as scalar control, vector control, sensorless control, and moisture-based closed-loop operation. The findings show that VSDs can reduce energy use by limiting unnecessary over-speed operation during low-demand drying stages, reducing airflow throttling losses, improving part-load motor performance, and enabling soft-start operation to reduce inrush current, vibration, torque shock, and mechanical wear. For blower-driven systems, affinity-law principles suggest that a 20% speed reduction can theoretically reduce power consumption to about 51% of full-speed operation. However, actual savings may be affected by converter losses, harmonics, motor insulation stress, reduced cooling at low speed, and control accuracy under fluctuating drying loads. Despite the technical potential of VSDs, direct validation in full-scale commercial dryers remains limited. Existing literature also provides weak comparison between blower-specific and drum-specific VSD control, limited integration of real-time moisture sensing, and insufficient techno-economic evidence. Therefore, future research should focus on experimentally validated, load-responsive, and economically justified VSD control strategies for commercial laundry dryer applications.

Keywords: Commercial laundry dryers; Variable Speed Drives (VSDs); energy efficiency; drying load; motor control.

T6-O-A122

Effects of Connection Configurations on the Hydraulic Filtration Efficiency of Self-Cleaning Rainwater Filters in Commercial Applications

Nur Atiqah Ramlan^{1*}, Khairul Anwar Ibrahim², Chee Chung Yee², Jan Maurer³ and Hayana Dullah⁴

¹Nanomaterials for Sensors and Heat Transfer Group, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Bacteria Free Water Engineering (M) Sdn. Bhd, No.7, Jalan SS13/3F, Subang Jaya Industrial Estate, 47500 Subang Jaya, Selangor, Malaysia

³WISY AG, Oberdorfstraße 26, 63699 Kefenrod-Hitzkirchen, Germany

⁴School of Engineering, Faculty of Engineering and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, 47500 Selangor, Malaysia

*atiqahramlan@uitm.edu.my

ABSTRACT

Rainwater harvesting systems are increasingly used in commercial buildings to reduce potable water demand and manage roof runoff. However, the hydraulic performance of self-cleaning rainwater filters may vary depending on the connection configuration used during installation, particularly under high-flow conditions. This study evaluates the hydraulic filtration efficiency of three 300 mm WISY Fine Filter models, namely WFF 300N, WFF 300PS, and WFF 300SH, under four connection configurations: Direct Connection, Y-Branch Duplex, Y-Branch Manifold 1, and Y-Branch Manifold 2. Laboratory testing was conducted using a closed-loop hydraulic setup, where incoming flow, velocity, outgoing filtered flow, discharge flow, and filtration efficiency were compared. The results show that Direct Connection achieved high efficiency under lower to moderate inflow but had limited hydraulic capacity. Y-Branch Duplex provided the most balanced performance between filtered-water recovery and flow capacity, particularly for WFF 300SH. The manifold configurations accommodated higher incoming flows but generally produced lower filtration efficiencies. Overall, the study demonstrates that connection layout is a critical design factor for self-cleaning rainwater filters in commercial applications and should be selected together with filter model capacity to ensure reliable hydraulic performance.

Keywords: Rainwater harvesting; Self-cleaning filter; Hydraulic efficiency; Connection configuration; WISY fine filter.

T6-O-A21

Evaluation of Thermal Efficiency of Solar Distillation

Safyanu Bashir Danjuma^{1*}, Taha Mohammed Ahmed Sadeq¹, Abubakar Kazeem², Mohammed Bashir Abdulrahman³, Abdulhafid M. A. Elfaghi⁴ and Abdoulhdi A. B. Omran⁵

¹ Faculty of Mechanical and Manufacturing Engineering (FKMP), Universiti Tun Hussein Onn Malaysia (UTHM) 86400 Parit Raja, Batu Pahat, Johor, Malaysia

² National Centre for Technology Management, Nigeria

³ Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

⁴ University of Zawia, Libya

⁵ Sohar University, Oman & Libyan Authority for Scientific Research, Tripoli, Libya

*safyanu@uthm.edu.my

ABSTRACT

Lack of access to clean freshwater in rural and off-grid communities has spurred interest in sustainable desalination technologies such as solar distillation. This study examines the impact of thermal efficiency on the basin water depth and distillate yield of a solar still under varying climatic conditions. The work provides a comprehensive performance evaluation of basin water depth in terms of thermal efficiency, basin temperature, distillate yield, and climatic parameters, with the aim of establishing a standard procedure for selecting the optimum water depth. Experiments were conducted at water depths of 20 mm, 40 mm, and 60 mm, and the system was evaluated based on average daily solar radiation, ambient temperature, wind speed, distillate yield, and thermal efficiency. Results show a strong dependence of system performance on basin depth, with the 20 mm depth achieving the highest daily distillate yield of 4.7 L/m²/day and thermal efficiency of 52.9% due to its lower thermal inertia and rapid temperature response to solar irradiance. At 40 mm, performance was moderately reduced to yield of 3.01 L/m²/day and thermal efficiency of 34.06 %, but exhibited greater thermal stability, while at 60 mm, yield of 2.33 L/m²/day and efficiency of 26.50 % were lowest as a significant portion of absorbed energy was retained as sensible heat rather than utilized for evaporation. Compared with the 60 mm depth, the 20 mm configuration increased freshwater production and improved thermal efficiency. Environmental parameters also played a secondary but notable role, with higher ambient temperature reducing convective losses and moderate wind speeds enhancing condensation efficiency. The findings confirm that shallow basin depths (20 mm) are optimal for maximizing productivity in solar stills, though practical considerations such as water replenishment frequency and operational stability must be addressed for large-scale applications. Overall, the study provides performance insights to optimize solar still operation and offers practical guidelines for enhancing freshwater production in rural and off-grid communities.

Keywords: Solar distillation; Thermal Efficiency; Basin water depth; Solar radiation and Basin water temperature.

T6-O-A01

Dynamic Mesh Methodologies in OpenFOAM for Compression Ignition Engine CFD Simulation: A Review

Muhammad Syafiq Aiman Muhammad Bazlan¹, Idris Saad^{1*} and Azli Abd Razak¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*edris_sd@uitm.edu.my

ABSTRACT

Compression ignition (CI) engines are vital for heavy-duty applications yet optimizing them for alternative fuels requires high-fidelity Computational Fluid Dynamics (CFD) to resolve complex in-cylinder processes. Accurate simulation is significantly challenged by the continuous reciprocating motion of the piston and valves, which fundamentally alters the computational domain throughout the cycle. This review evaluates dynamic mesh methodologies with a primary focus on implementation within the OpenFOAM framework, particularly the use of the lib-ICE and topoChangerFvMesh libraries to manage axial topological changes through dynamic layering. The study provides a unique contribution to the body of knowledge by synthesizing a standardized numerical roadmap which identifying optimal parameters for mesh quality (orthogonal quality > 0.79 , skewness < 0.36), temporal resolution (0.25° CA), and turbulence modelling (RNG $k-\epsilon$) to ensure solver stability under extreme state variations. Key limitations, including mesh distortion at high speeds and the high computational cost of detailed chemical kinetics for biodiesel, are critically analysed. Emerging trends such as adaptive mesh refinement (AMR) and machine learning (ML) integration are highlighted as potential solutions to enhance predictive accuracy and efficiency in open-source engine simulations.

Keywords: Compression ignition engine; dynamic mesh; CFD simulation; OpenFOAM.

T6-O-A16

Industrial Waste Heat Recovery Potential Through Thermoelectric Generator in Steel Manufacturing

Amira Shahirah Malek Amir Azmin^{1,2}, Danish Umair Mohamad Rizudin¹, Baljit Singh², Muhammad Fairuz Remeli², Shahrulnizar Mohamad Alias³, Anwar Ilmar Ramadhan⁴ and Irnie Azlin Zakaria^{1,2}*

¹Nanomaterials for Sensors and Heat Transfer (NaSH), Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia.

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia.

³Mycron Steel CRC Sdn Bhd, Shah Alam, Selangor, Malaysia.

⁴Department of Mechanical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Jakarta, Indonesia.

*irnieazlin@uitm.edu.my

ABSTRACT

Industrial waste heat recovery has become increasingly important for improving energy efficiency and reducing greenhouse gas emissions in energy-intensive manufacturing industries. This study evaluates the feasibility of integrating thermoelectric generators (TEGs) with the cooling radiator of a batch annealing furnace in a Cold Rolled Coil (CRC) manufacturing process. Radiator surface and surrounding air temperatures were measured over 30 min under natural and forced convection conditions at airflow velocities of 2.0, 3.0, and 3.6 m/s. The measured thermal conditions were used to calculate the available temperature difference, convective heat transfer rate, convective thermal resistance, open-circuit voltage, and maximum power output. The radiator surface temperature remained between 188 and 197 °C throughout the measurement period. At an airflow velocity of 3.6 m/s, the surrounding air temperature decreased to approximately 32–33 °C. Under this condition, the maximum temperature difference reached approximately 161 °C. The average convective heat transfer rate increased from 1.210 W under natural convection to 9.361 W at 3.6 m/s, while the convective thermal resistance decreased from 125 to 16.95 K/W. The highest theoretical open-circuit voltage reached approximately 8.05 V, while the theoretical maximum power output ranged from 0.84 to 0.97 W per module. Based on the available radiator area, approximately 620 TEG modules could be arranged on the radiator surface. Under ideal operating conditions, this configuration could provide a theoretical array power of approximately 521–601 W. These findings demonstrate the potential of TEG integration for recovering waste heat from batch annealing operations in steel manufacturing.

Keywords: Thermoelectric generators (TEGs); Waste heat recovery; Batch annealing surface; Thermal resistance modelling; Cold rolled coil industry.

T6-O-A18

Effect of Titanium Dioxide (TiO₂) Nanoparticles On the Tribological Properties of Bio-Based Lubricants

Nurul Izzatul Azian¹, M. Mazwan Mahat^{1*} and Salmiah Kasolang¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia.

*mazwan@uitm.edu.my

ABSTRACT

The increasing demand for environmentally friendly lubricants has encouraged the development of bio-based lubricants as sustainable alternatives to conventional mineral oils. However, their application under boundary lubrication conditions remains limited due to poor wear resistance and sensitivity to temperature changes. Titanium dioxide (TiO₂) nanoparticles have attracted considerable attention as lubricant additives because of their ability to enhance anti-wear properties, reduce friction, and promote the formation of protective tribofilms on contact surfaces. Nevertheless, their effectiveness is strongly influenced by operating conditions, particularly temperature. Previous studies mainly focused on limited temperature ranges, while the influence of temperature on nanoparticle behaviour and wear protection mechanisms remains insufficiently understood. Therefore, this study investigates the temperature-dependent tribological performance of TiO₂-enhanced bio-based lubricants formulated from castor oil using the Four-Ball wear test and Alicona 3D Surface Metrology System. The effects of TiO₂ concentration (0, 0.25, and 0.5 wt%), applied load (400, 500, and 600N), and operating temperature (25, 50, and 75°C) on the coefficient of friction (COF) and wear scar diameter (WSD) are analysed using a Box–Behnken experimental design. Overall, the findings provide a better understanding of the relationship between temperature and nanoparticle performance, contributing to the development of more efficient, reliable, and environmentally sustainable bio-based lubrication systems.

Keywords: Bio lubricant; Titanium Dioxide; Temperature; Coefficient of Friction; Wear Scar Diameter.

T6-O-A126

Comparative Indoor Thermal Comfort Analysis of Roof Insulation and Air Velocity Enhancement in a Tropical Climate School Classroom

Farah Ain, Sheikh Ahmad Zaki^{1*}, Naja Aqilah¹, Hom Bahadur Rijal² and Manoj Kumar Singh³

¹Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100, Kuala Lumpur, Malaysia

²Faculty of Environmental Studies, Tokyo City University, Yokohama 224-8551, Japan

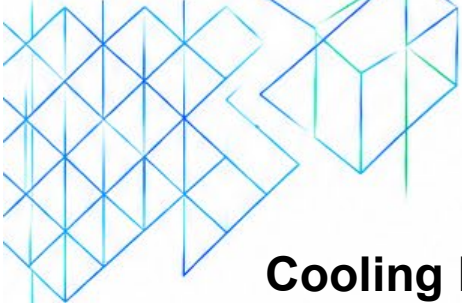
³Energy and Sustainable Built-Environment Design (ESBD) Laboratory, Department of Civil Engineering, Shiv Nadar Institution of Eminence, Greater Noida, Uttar Pradesh - 201314, India

*sheikh.kl@utm.my

ABSTRACT

Fan-assisted naturally ventilated classrooms in tropical regions frequently experience indoor overheating due to high solar radiation exposure, conventional roof insulation, and low-performance ceiling fan systems. Hence, passive cooling strategies, such as roof insulation and hybrid cooling strategies, such as airflow optimization through ceiling fans, have attracted attention as sustainable solutions to enhance thermal comfort in educational buildings. This study evaluated the effects of passive and hybrid cooling interventions on indoor thermal comfort in a fan-assisted, naturally ventilated classroom located within a tropical climate in Malaysia. Three experimental settings were assessed: baseline condition; rooftop insulation incorporating a radiant barrier and an anti-corrosion coating (ACC) weathering membrane (Case 1); and rooftop insulation combined with enhanced five-blade ceiling fans (Case 2). Indoor environmental parameters of ambient temperature, globe temperature, relative humidity, and air velocity were continuously measured using calibrated instruments during school hours. Meanwhile, a thermal comfort survey was conducted concurrently to assess students' thermal perceptions and comfort levels in the tropical-climate classroom. The findings demonstrated that Case 2 achieved the best thermal performance, with an operative temperature of 29.8 °C, compared to the baseline condition of 33 °C during peak noon hours (Session 3). Increasing the air velocity to 0.9 m/s improved air circulation and dispersion within the classroom. Furthermore, subjective comfort votes improved markedly as no students voted for "hot" and "very hot" sensations in Case 2. In short, incorporating a radiant barrier, an ACC membrane, and an upgraded five-blade ceiling fan offers a major opportunity for energy-efficient passive and hybrid cooling strategies in tropical educational buildings.

Keywords: Thermal Comfort; Roof Insulation; Air Velocity Enhancement; Tropical Classroom.



T6-V-A28

Cooling Load Assessment and Passive Heat Gain Mitigation in a Tropical Commercial Office Building

Siti Norhazlinda Roslan¹, Bulan Abdullah^{1*}, Nor Hayati Saad¹, and Khadijah Alias²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia.

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, Kampus Pasir Gudang,
81750 Masai, Johor, Malaysia.

*bulan_abd@uitm.edu.my

ABSTRACT

This study investigates excessive cooling demand and energy inefficiency in a tropical commercial office building. Despite continuous operation, the existing 3.5 HP non-inverter air-conditioning system failed to maintain the desired indoor temperature. The study aims to evaluate the cooling load, identify dominant heat gain contributors, assess the adequacy of the existing air-conditioning capacity, compare Passive Heat Gain Mitigation with a 6 HP upgrade, and evaluate the effect of thermostat settings on operating cost. A case study was conducted in a tropical commercial office building in Malaysia. The cooling load assessment considered conduction, solar heat gain, internal heat gain, ventilation, infiltration, and latent heat. The maximum calculated cooling load was 57,181 BTU/h (5.72 HP), indicating that the existing system was undersized. Solar heat gain from the glass wall, glass door, and staircase glazing contributed 29,966 BTU/h, representing the largest heat-load component. Using a conservative 73% Total Solar Energy Rejection (TSER), sputter-type Low-E film reduced the estimated solar heat gain by 21,875 BTU/h, reducing the cooling load to 35,306 BTU/h (3.53 HP). Estimated electricity consumption decreased from 594 to 366.8 kWh/month, with a corresponding carbon footprint of 271.43 kg CO₂e/month. A RM1,000 film investment achieved an estimated ROI of 120.23% and a 10-month payback, while internal installation at RM340 increased the ROI to 353.61% with a 3.4-month payback. In comparison, a 6 HP upgrade provides adequate cooling capacity but increases electricity consumption and operating cost without addressing the underlying solar heat gain. The findings demonstrate that sputter-type Low-E window film is a technically and economically favourable Passive Heat Gain Mitigation strategy for improving cooling and energy performance in tropical commercial office buildings.

Keywords: Cooling Load Assessment; Passive Heat Gain Mitigation; Solar Heat Gain; Energy Efficiency; Carbon Footprint.

T6-V-A47

Design of Hybrid Active Cooling System for 2.10 kWp Floating Solar Photovoltaic System

Jivinesh A/L Muruges¹, Mohd Sofwan Mohd Resali¹, Santoso², Reza Sarwo Widagdo², Ridzuwan Mohd Jais³*

¹Universiti Malaysia Perlis (UniMAP), 02600 Arau, Perlis, Malaysia

²Universitas 17 Agustus, 1945 Surabaya, Indonesia

³Decarbonisation and Renewable Energy Unit, TNB Research Sdn Bhd, 43000 Kajang, Selangor, Malaysia

**jivinesh@studentmail.unimap.edu.my*

ABSTRACT

The swift advancement in technology has led to the growth in electricity demand, and hence interest in renewable energy sources like floating solar photovoltaic (FPV) systems. FPV systems will have the potential of supporting the renewable energy goals of Malaysia. The entire exercise is based on the fact that PV efficiency is very much reliant on the operating conditions, hence this research is aimed at coming up with a hybrid active cooling method to improve the performance of the system. The study has three objectives; simulation of FPV systems with natural and hybrid active cooling in MATLAB Simulink, design and installation of a 2.10 kWp FPV system with cooling at Tasik Alumni UniMAP, Perlis, and to test efficiency of the systems in terms of simulation and experimental. The methodology will involve a literature review of other studies, the identification of a cost-effective cooling approach, simulations, and comparisons with the real world. The results of the simulation indicate that hybrid active cooling has better performance compared to natural cooling where the voltage growth, current growth, and power growth are 7.14 percent, 1.83 percent, and 9.08 percent, respectively. The field results show lower operating temperature which results in a 4.80 percent voltage gain and 0.83 percent power gain. Thermal regulation is enhanced, but there are only small increases in real-world power gains.

T6-V-A141

Experimental Assessment of Bird Dropping and Dust Soiling Effects on Electrical Performance and Acceptance Ratio of a Floating Photovoltaic System in Perlis, Malaysia

Puteri Nur Balqis Ahmad Surri^{1}, Mohd Sofwan Mohd Resali¹, Aris Heri Andriawan², Ridzuwan Mohd Jais³ and Puji Slamet²*

¹*Universiti Malaysia Perlis (UniMAP), 02600 Arau, Perlis, Malaysia*

²*Universitas 17 Agustus, 1945 Surabaya, Indonesia*

³*Decarbonisation and Renewable Energy Unit, TNB Research Sdn Bhd, 43000 Kajang, Selangor, Malaysia*

**puterinurbalqis@studentmail.unimap.edu.my*

ABSTRACT

Floating photovoltaic (FPV) systems are increasingly being adopted due to land scarcity, yet few studies have examined their performance under real-world soiling conditions, particularly in Malaysia. This study investigates the effects of bird droppings and dust accumulation on the electrical performance of an FPV system at Tasik Alumni, Universiti Malaysia Perlis (UniMAP) (6.45835° N, 100.34780° E), under Perlis weather conditions. The study quantifies the impact of soiling on current, voltage, power, efficiency, and acceptance ratio (AR). Bird droppings were tested under partial shading levels of 0%, 20%, 60%, and 100%, while dust accumulation was evaluated at the bottom edge of a 10° tilted panel under clean and soiled conditions. Irradiance and cell temperature were measured using a Seaward Solar Survey device, while electrical output was recorded using the Hoymiles monitoring application. Expected power was calculated using Sustainable Energy Development Authority (SEDA) Malaysia equations, and performance was assessed using AR. According to SEDA standards, an AR between 0.9 and 1.03 indicates acceptable operation; values below 0.9 reflect underperformance. Results show soiling significantly reduces performance primarily through current reduction. Bird dropping shading of 60%–100% caused power losses of approximately 30%, whereas dust soiling on day one resulted in a power loss of 101.28 W and increased cell temperatures to 47°C–49°C, reducing efficiency from 18.99% to 14.46%. Scientifically, these drops occur because shaded cells restrict current flow across series-connected string, inducing mismatch losses and thermal degradation from higher temperatures. Dust accumulation at the 10° edge resulted in minor degradation with acceptable AR values (0.98–1.00), which improved after rainfall.

T6-O-A90

Hazard-Population Interfaces in Urban Workplace Fire Disasters: Safety Lessons from Infrastructure and High-Rise Fires

Firdaus Zawawi^{1*}, Mazlina Zaira Mohammad¹, Nor Syamimi Samsudin², Azli Abd Razak³, Nurul Elma Kordi¹, Clara Cheung⁴ and Akilu Yunusa-Kaltungo⁵

¹Faculty of Civil Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia.

²Faculty of Built Environment, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia.

³Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

⁴Department of Civil Engineering and Management, School of Engineering, The University of Manchester M13 9PL Manchester, United Kingdom

⁵Department of Mechanical and Aerospace Engineering, School of Engineering, The University of Manchester M13 9PL Manchester, United Kingdom

*fdsatrix2@gmail.com

ABSTRACT

Workplace fire accidents in complex urban environments can rapidly escalate when occupational hazards intersect with densely populated communities and interconnected infrastructure systems. This paper examines two major urban fire incidents: the Putra Heights gas pipeline fire in Malaysia (1 April 2025) and the Wang Fuk Court high-rise residential fire in Hong Kong (26-28 November 2025), to explore how workplace fires propagate across hazard-population interfaces. Using a qualitative comparative case analysis informed by publicly available official communications, regulatory statements, and media chronologies, the study identifies six recurring failure themes: hazard-exposure coupling, changed conditions amplifying risk, barrier weaknesses revealed under stress, rapid escalation compressing early control windows, operational constraints shaping outcomes, and investigation friction. The Putra Heights incident demonstrated how unstable soil conditions contributed to pipeline fracture under cyclic tensile stress. In contrast, official operational observations identified external scaffolding as a fire-spread route at Wang Fuk Court, while the contribution of associated materials remained under examination by the ongoing inquiry. Despite their contrasting physical mechanisms, both cases reveal systemic governance challenges associated with managing hazardous occupational activities near residential populations. The comparative findings yield transferable lessons for strengthening workplace fire governance in urban environments, including risk-based land-use controls, robust change-management processes, performance-based barrier integrity assurance, pre-planned emergency triggers, and transparent multi-agency investigation frameworks.

Keywords: Workplace fire safety; Hazard-population interface; Urban fire governance; Infrastructure fire; High-rise building fire.

T6-O-A35

Effect of Blade Arc Length on the Performance of Myring-Profile Savonius Wind Turbine ($n = 1$)

Priyo Agus Setiawan¹, Denny Dermawan¹, Rachmad Tri Soelistijono², Aang Wahidin², Ruddianto², Vena Rizky Pusparani¹, Ratna Muningar¹ and Azli Abd Razak^{3*}

¹Marine Engineering Department, Politeknik Perkapalan Negeri Surabaya, Jalan Teknik Kimia Kampus ITS Keputih-Sukolilo, Surabaya, Indonesia

²Shipbuilding Engineering Department, Politeknik Perkapalan Negeri Surabaya, Jalan Teknik Kimia Kampus ITS Keputih-Sukolilo, Surabaya, Indonesia

³Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

*azlirazak@uitm.edu.my

ABSTRACT

The Savonius wind turbine, a vertical-axis drag-type rotor valued for its simple construction and self-starting capability at low wind speeds, has been extensively studied for geometric modifications. However, the effect of blade arc length on the turbine shape using the Myring equation ($n = 1$) remains insufficiently explored. This study investigates the aerodynamic performance of a Savonius wind turbine by systematically varying the blade arc length to evaluate the changes in the torque coefficient (C_m) and power coefficient (C_p). Experimental testing was conducted in a wind tunnel with a 30 cm $\times$ 30 cm cross-section at a constant wind speed of 5 m/s, using a turbine model of 40 cm in both height and diameter across three configurations: a conventional baseline, increased arc length (+40 mm), and decreased arc length (-40 mm). Complementary numerical simulations employing an unstructured quadrilateral mesh were performed to analyse the velocity contours and streamline flow patterns at blade rotation angles of 0°, 45°, 90°, and 135°. The results showed that reducing the arc length by 40 mm yielded a peak C_p of 0.1227, representing a 3.57% improvement over the conventional blade, whereas increasing the arc length decreased C_p by 8.88%, which was attributed to the reduced airflow directed towards the advancing blade. Flow visualisation further confirmed that the arc length reduction enhanced the attached flow and minimised the stagnation zones at key rotation angles. These findings demonstrate that fine geometric adjustments to the Myring blade profile constitute a viable strategy for the aerodynamic optimisation of vertical-axis wind turbines.

Keywords: Savonius turbine, Myring, Arc length, Torque coefficient, Power coefficient.

T6-V-A34

An Entropy-Based Engineering Analysis of Thermoelectric Cooling Systems

Shahira Elly Natasha¹, Muhammad Fairuz Remeli^{1*}, and Baljit Singh¹

¹Energy Conservation for Automotive, Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Malaysia

*fairuz1299@uitm.edu.my

ABSTRACT

Thermoelectric cooling (TEC) systems are a popular choice for low-carbon thermal management due to their compact structure, high reliability, and precise controllability. However, their widespread adoption remains constrained by a low coefficient of performance (COP). This study presents an experimental second-law thermodynamic evaluation of a laboratory-scale TEC enclosure, comparing the impacts of internal natural convection and active forced convection on system-level irreversibility. By combining empirical temperature data and electrical power metrics within a defined control volume, we quantified localized heat transfer rates, cooling capacities, and system entropy generation rates. The results demonstrate that transitioning from internal natural convection to forced convection reduce further the steady-state enclosure air temperature from 24.6°C to 18.1°C, while maintaining a similar electrical power input. This thermal optimization was achieved with a negligible electrical power penalty, requiring only 0.28 W under forced conditions compared to 0.26 W under natural convection. Furthermore, second-law analysis reveals that forced convection successfully stabilizes the system's entropy generation rate at a relatively stable value of approximately 9.2×10^{-4} W/K, whereas the natural convection system exhibits a decreasing entropy generation rate during the later stage of cooling. These findings empirically prove that active internal boundary-layer airflow management is a highly efficient thermodynamic lever to minimize exergy destruction and drive solid-state refrigeration closer to thermodynamic equilibrium.

T6-O-A66

Development of a Mini Wind Turbine with Integrated Omni-Directional Guide Vanes (ODGV)

Andi Farislee Andi Agus¹, Mohammad Azzeim Mat Jusoh^{1*} and Sukarnur Che Abdullah¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450, Shah Alam, Malaysia

*m_azzeim@uitm.edu.my

ABSTRACT

Running a conventional wind turbine are a challenge in low-wind regimes such as Malaysia, where the mean ambient wind speeds typically fall below 2 m/s. To address this operational constraint, this study evaluates a double-step Savonius vertical-axis wind turbine (VAWT), specifically optimized for low-velocity regimes. An Omni-Directional Guide Vane (ODGV) was integrated around the rotor assembly to capture multi-directional flow and concentrate air intake toward the turbine blades. The prototype was modelled using CATIA V5 and fabricated via additive manufacturing (3D printing). The experimental performance was evaluated across four configurations in a subsonic wind tunnel: a standalone rotor, and a rotor-ODGV assembly evaluated at three distinct flow incidence angles (0°, 15°, and 30°. The electrical output parameters (voltage and current) served as metrics for performance evaluation. The results show that the ODGV improved self-starting capabilities. During low speeds (below 2 m/s), the 30° angle gave the highest power output. Whereas during 4 m/s speed, the 15° angle worked best. Although the overall power generation for this scale remains modest, primarily suited for low-power applications such as micro-LED lighting, these findings confirm that integrating the ODGV enhances the feasibility of the Savonius turbines as a practical option for urban low-wind energy harvesting.

T6-O-A144

A Review of Machine Learning Applications in Journal Bearing Optimization

Kai Feng Chua^{1*}, Muhammad Noor Afiq Witri Muhammad Yazid¹, Zulhanafi Paiman¹,
and Syahrullail Samion¹

¹Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia.

*chuafeng@graduate.utm.my

ABSTRACT

The use of datasets derived from experimental tests or numerical simulations for journal bearing optimization is often limited by the considerable time and cost required to produce sufficient high-quality data. Recent advances in machine learning (ML) offer an efficient alternative by enabling rapid and extensive design space exploration through data-driven surrogate models. This review critically examines recent applications of ML in journal bearing optimization for both plain and textured journal bearings. The review emphasized ML-assisted optimization frameworks that integrate surrogate models with optimization algorithms. The review also evaluates dataset generation methods, data-partitioning strategies and testing procedures through reported performance metrics, with emphasis on the computational and methodological aspects of ML-based journal bearing optimization. Based on the reviewed studies, artificial neural network (ANN) is the most widely adopted model due to its ability to model complex and nonlinear relationships between input parameters and performance prediction involving multiple design parameters and operating conditions. In addition to accelerating optimization by reducing repeated computational fluid dynamics (CFD) or experimental evaluations, several studies reported strong predictive performance, including correlation of coefficients of up to 0.99 and relative errors below 3% in selected cases. Despite the advantages of applying ML to journal bearing optimization, several challenges and limitations have been identified and discussed in this review. This review provides a systematic guidance for selecting suitable ML model, datasets development, reliable validation strategies, and promising avenues for future improvements towards a robust and practically applicable ML-assisted optimization framework for journal bearing systems.

Keywords: Machine Learning; Journal Bearing; Optimization; Surface Texture.

T6-O-A73

Optimizing Indoor Air Quality Parameter in High Density Classroom Using Energy Recovery Ventilator

Hazran Husain^{1,2*}, Mohd Mazwan Mahat¹ and Mohamad Faiz Mohd Shahrul Munir¹

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Wind Engineering & Building Physics (WEBP), Faculty of Mechanical Engineering,
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*hazran@uitm.edu.my

ABSTRACT

The Indoor Air Quality (IAQ) is a key factor to the comfort, health, and productivity of the educational situation, especially in hot and humid climate. The most common challenges in classrooms are high levels of carbon dioxide (CO₂) and insufficient distribution of temperatures because of poor ventilation. This paper studies the performance of Energy Recovery Ventilators (ERVs) in combination with conventional HVAC systems in enhancing IAQ conditions in a classroom with high humidity. The main goals are to model various ERV ventilation airflow rates, examine their effects on indoor thermal conditions and air quality, and determine their effect on the CO₂ concentration and temperature. A classroom of size 31 occupants was simulated with Computational Fluid Dynamics (CFD) in ANSYS Fluent. The simulation included internal heat and CO₂ sources to reflect human occupancy, lighting, and solar gain, and ERV airflow was varied in several scenarios. The results show that an optimal ERV airflow can substantially decrease the indoor CO₂ concentration, and the temperature does not exceed the acceptable comfort range, although it rises slightly. One of the tested setups was an ERV flowrate of 240 cfm, which provided the most balanced results, with CO₂ concentrations of approximately 870 ppm and temperatures in the ASHRAE Standard 55 comfort zone. Increasing the airflow further decreased the CO₂ but also added more heat to the room, so 240cfm was the best setting both in regard to air quality and thermal comfort. In summary, there is a feasible and energy-saving approach to improving classroom indoor environments in tropical climates, which is the use of ERVs in the classroom ventilation system. The results give a good understanding of ERV sizing and operation to create healthier and more sustainable learning environments.

Keywords: Energy recovery ventilator; indoor air quality; classroom ventilation.

T6-O-A68

Numerical Investigation on the Hydraulic Performance of an Inverted-Triangle Turbulence Promoter in a Tubular Channel

Mohd Azan Bin Mohammed Sapardi¹*

¹Department of Mechanical Engineering, Kulliyah of Engineering, International Islamic University Malaysia,
Jalan Gombak, 53100 Kuala Lumpur, Malaysia

*azan@iium.edu.my

ABSTRACT

Microalgae are regarded as a promising renewable energy source and a potential candidate for next-generation biofuels. However, large-scale commercialization of microalgae-based biofuels remains constrained by high operational costs, largely attributed to excessive pumping energy demands resulting from inefficient hydrodynamic design. Furthermore, efficient hydrodynamic mixing is essential for optimizing the growth and productivity of photobioreactors (PBRs) used in microalgae cultivation, as poor mixing creates light and nutrient gradients that directly reduce photosynthetic efficiency. The present study investigates the influence of turbulence promoters on the flow structure and hydrodynamic performance in a tubular photobioreactor using a computational fluid dynamics (CFD) approach, with an inverted triangular (diverging nozzle) configuration to enhance flow recirculation and shear distribution. The study examines variations in the promoter contraction diameter ratio (b/a) and contraction length ratio (c/a), enabling systematic control of the geometric parameters. Dimensionless simulations are performed in OpenFOAM using varying Reynolds numbers ranging from 5,000 to 30,000. The influence of geometric parameters and Reynolds number on key hydrodynamic indicators, loss coefficient, skin-friction coefficient, and vorticity, is evaluated. The results provide insight into the role of contraction geometry in enhancing fluid flow circulation while limiting pressure and energy penalties. Higher b/a ratios demonstrate superior hydraulic performance across all Reynolds numbers tested but generate the weakest vorticity, revealing a trade-off between hydraulic efficiency and mixing intensity that must be weighed against the biological mixing requirements of the target PBR application.

T6-O-A76

PSO-Tuned LSTM with Genetic Algorithm Feature Selection for Short-Term Solar Irradiance Forecasting in Tropical Malaysia

Muhammad Syahrin Bin Suhaimi¹, Baljit Singh A/L Bhathal Singh^{1,3*}, Muhammad Fairuz Remeli¹ and Wandeep Kaur A/P Ratan Singh²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia

² Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia (UKM),
43600 Bangi, Selangor, Malaysia

³ Solar research Institute (SRI), Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia
*baljit@uitm.edu.my

ABSTRACT

Accurate short-term solar irradiance forecast is important for the operational efficiency of photovoltaic (PV) systems in equatorial regions such as Malaysia where the atmospheric variability is high. We propose a machine learning framework for one-step-ahead solar irradiance prediction through the integration of the Genetic Algorithm (GA) feature selection and a Particle Swarm Optimisation (PSO)-tuned Long Short-Term Memory (LSTM) network. Candidate variables were pre-processed and log-transformed by using hourly meteorological data from Open-Meteo (2024) for a Malaysian site (3.5°N, 101.5°E). The GA selected the optimal subset of the seven meteorological features, and PSO optimised some important hyperparameters of the LSTM, including recurrent layers, hidden units, learning rate, sequence length and batch size. Five structured experiments were designed to assess optimisation gains and sequence-length sensitivity. The PSO-tuned LSTM reached a root mean square error (RMSE) of 0.504, mean absolute error (MAE) of 0.282 and of 0.967 of log-transformed shortwave radiation, outperforming the manually tuned baseline (RMSE: 0.662, : 0.943). This results in 24% reduction in RMSE and 32% reduction in MAE. Analysis of sequence length showed that 24 hours captures most critical temporal context, with marginal gains at 48 hours.

Keywords: solar irradiance forecasting; LSTM; particle swarm optimisation; genetic algorithm; photovoltaic Systems.

T6-O-A147

Influence of SiO₂ Nanoparticle Concentration on Bubble Growth Dynamics and Nucleate Pool Boiling Heat Transfer of HFE-7000-Based Nanorefrigerant

M.F. Nabil¹, N.D. Syarifah^{1,3}, M.R.M. Nawil^{1*} and W.H. Azmi²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26000 Pekan, Pahang, Malaysia.

³Jabatan Kejuruteraan Mekanikal, Politeknik Banting Selangor, Persiaran Ilmu, Jalan Sultan Abdul Samad, 42700 Banting, Selangor, Malaysia.

*muhad@uitm.edu.my

ABSTRACT

Nanorefrigerants are a special type of refrigerant produced by dispersing nanoparticles in a base refrigerant and are used in various applications, such as refrigeration and air-conditioning systems. This combination has the potential to improve heat transfer performance compared with conventional refrigerants. Therefore, this study investigates the effect of SiO₂ nanoparticle concentration in HFE-7000 refrigerant during nucleate pool boiling. SiO₂/HFE-7000 nanorefrigerants were prepared using a two-step method at volume concentrations of 0.005%, 0.01%, and 0.02%. The experimental investigation of single-bubble dynamics was conducted using a high-speed camera operating at 1000 frames per second (fps) under atmospheric pressure and at wall superheats ranging from 3 K to 12 K. Experiments were conducted at various heat fluxes in the test section. The SiO₂/HFE-7000 nanorefrigerants exhibited higher heat fluxes than the base refrigerant. The heat transfer coefficient exhibited the highest enhancement of approximately 65% at a volume concentration of 0.02% compared with the base refrigerant at low wall superheats. At volume concentrations of 0.01% and 0.005%, the heat transfer coefficient enhancements were approximately 40% and 10%, respectively, at low wall superheats. The bubble waiting time decreased with increasing wall superheat and nanoparticle concentration. A similar trend was observed for bubble growth time.

Keywords: Nucleate Pool Boiling; Bubble Dynamics; SiO₂/HFE-7000 nanorefrigerant.

T6-V-B13

CFD Analysis of Ventilation Performance of Two-layered Enclosure with Internal Void

Nor Merlisa Ali^{1*}, Mohd Faizal Mohamad¹, Azli Abd Razak¹, Wei Wang¹, Chiyoko Hirose¹, Naoki Ikegaya¹
and Ryuichiro Yoshie¹

Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*merlisa@uitm.edu.my

ABSTRACT

Cross ventilation is one of the passive means to save energy and a sustainable approach to improve thermal comfort, remove bad smells and contaminants in an enclosure such as multi-layered building. This study investigates the internal airflow patterns, flow rate and ventilation performance in a two-layered enclosure with an internal void. The enclosure has an inlet at windward façade, and an outlet at leeward façade. The internal void is located at the mid-height floor that divides the enclosure into two different levels. Two different arrangements of inlet and outlet opening with variation of internal void positions are investigated. The steady Reynolds- Averaged Navier Stokes (RANS) turbulence model (Realizable k-Epsilon) is used to study the internal airflow distribution, dimensionless flow rate (DFR), age of air distribution, and air exchange efficiency (AEE). The computational fluid dynamics (CFD) simulations are also utilised to see the impact of incoming and internal jet through openings to the airflow patterns of the two-layered enclosure. The results indicate that different inlet-outlet openings configurations and internal void position alter the airflow patterns and affect the overall ventilation performance in the two-layered enclosure.

Keyword: CFD simulation; multi-layered enclosure; Ventilation performance.

T6-O-A138

Thermal Analysis of On-Board Hydrogen Storage Tank of Light Duty Vehicles During Fast Refuelling Using a Diverging Nozzle

Adil bin Ariff¹, Hafidzi Hamdan^{1,2}, Alhassan Salami Tijania^{1,3} and Sajith Thottathil Abdulrahman⁴*

*¹Faculty of Mechanical Engineering, Universiti Teknologi MARA,
40450 Shah Alam, Selangor Malaysia*

*²Flow Group, National Metrology Institute of Malaysia (NMIM), SIRIM Berhad,
43900 Sepang, Selangor, Malaysia*

*³Solar Research Institute, Universiti Teknologi MARA,
40450 Shah Alam, Selangor Malaysia*

⁴Department of Mechanical Engineering, KMEA Engineering College, 683560 Edathala P.O., Cochin, India

**alhassan@uitm.edu.my*

ABSTRACT

Hydrogen energy is an alternative fuel that can be used to substitute the use of petroleum in vehicles using a hydrogen fuel cell vehicle. In this study, the thermal effect of an on-board type IV hydrogen storage tank during fast refuelling has been investigated. A computational fluid dynamics (CFD) model available in ANSYS was used to simulate the hydrogen storage tank. The study investigates the effects of different geometric parameters on the temperature distribution in the tank during refuelling. Particularly, a diffuser nozzle with a varying length at the inlet of the tank was studied. Various turbulence models were evaluated to determine the most suitable one for the on-board hydrogen storage tank during fast refuelling. The results of this study show that towards the end of the tank, the gas temperature increases from 360 K to 387 K. This can be observed for any increase in the nozzle length, except for the tank with a nozzle length of $L=360$ m, where the temperature at the end of the tank drops significantly. An important observation is that as the tube length at the inlet gets longer, the temperature at the end of the tank reduces from 387K to about 376 K. It was also observed that when the gas inlet temperature is at 273K and 293K the maximum gas temperature in the cylinder is still below the SAEJ2601 safety standard of 358 K, except for an inlet temperature of 313 K, where the maximum gas temperature in the cylinder is observed to be above the SAEJ2601 standard, and this occurs when the filling time reaches 28 seconds. An important observation is that as the tube length at the inlet gets longer, the hot spot rejoins at the end of the tank. This means that the cold fluid that emerges at the end of the tube mixes rapidly with the hot gas at the end of the tank. The maximum temperature of hydrogen gas at 50 seconds still shows that it was below the safety standard by SAEJ2601, which ensures the safety of the tank during the fast-refuelling process.

Keywords: *Hydrogen on-board storage tank; Thermodynamics; Light-duty fuel cell vehicles; Different Inlet Angle.*

T6-V-A74

Decentralized RDF Production from Marine Plastic Debris on a Small Indonesian Island: A Techno-Economic Feasibility Study

Urip Mudjiono^{1,2*}, Sardono Sarwito², Kamarul Hawari Ghazali³, Deni Dermawan⁴,
Adi Kurniawan² and Catur Rakhmad Handoko¹

¹Department of Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya,
Surabaya, Indonesia

²Ocean Engineering Faculty, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia

³Faculty of Electrical and Electronics Engineering, Univesity Malaysia Pahang, Pekan-Pahang, Malaysia

⁴Department of Waste Treatment Engineering, Shipbuilding Institute of Polytechnic Surabaya,
Surabaya, Indonesia

*urip@ppns.ac.id

ABSTRACT

Marine plastic debris accumulation on small islands presents a dual environmental and energy challenge for densely populated coastal communities with limited waste management infrastructure. This study presents the first techno-economic feasibility assessment, to our knowledge, of a decentralized Refuse-Derived Fuel (RDF) production system utilizing coastal marine plastic debris as primary feedstock on Gili Ketapang Island, a 61-hectare marine protected area in Probolinggo Regency, East Java, Indonesia (population density: ~15,495 inhabitants/km²). Drawing on empirical waste characterization data and established waste generation benchmarks, we estimate a daily plastic feedstock potential of 916 kg/day, yielding 247.4 t/year of RDF pellets with a net calorific value (NCV) of 34.7 MJ/kg, substantially exceeding sub-bituminous coal (25 MJ/kg), consistent with calorific value ranges reported for plastic-dominant RDF. Two energy utilization scenarios are evaluated: (Scenario A) RDF export for cement kiln co-firing; (Scenario B) on-site electricity generation. When coastal debris collection costs (USD 14,516/year) are explicitly accounted for, Scenario A is not independently viable at 247 t/year (NPV: -USD 169,990); break-even analysis indicates viability at approximately 755 t/year. Scenario B demonstrates robust economic viability (NPV: +USD 170,659; IRR: 29.4%; payback: 3.3 years), supplying approximately ≥8.2% of the island's estimated electricity demand (~5,821 MWh/year). The system could avoid 1,191–1,611 t CO₂-eq/year vs. open-burning baseline, supporting Indonesia's NDC commitments. The framework is replicable across the Indonesian archipelago.

Keywords: Refuse-Derived Fuel; Marine plastic debris; Waste-to-Energy; Small island; Techno-economic analysis; Indonesia; Circular economy.

T6-V-A98

Effect of Circular Cylinder on Returning Blade of Savonius Wind Turbine Performance: A Review

Vena Rizky Pusparani¹, Priyo Agus Setiawan^{1}, Hildan Fahrizal Nur Faurizki², Savitri Ramadhani², M. Rizqi Mubarak¹, Yulia Ayu Nastiti¹, Lilik Khoiriyah³, Choirul Mufit⁴ and Firly Irhamni Ahsan¹*

¹Marine Engineering Department, Politeknik Perkapalan Negeri Surabaya, Jalan Teknik Kimia Kampus ITS Keputih-Sukolilo, Surabaya, Indonesia

²Department of Mechanical, Politeknik Negeri Semarang, Jalan Prof. H. Soedarto, S.H., Tembalang, Semarang, Jawa Tengah, Indonesia

³Naval Architecture Department, Politeknik Perkapalan Negeri Surabaya, Jalan Teknik Kimia Kampus ITS Keputih-Sukolilo, Surabaya, Indonesia

⁴Marine Electrical Engineering Department, Politeknik Perkapalan Negeri Surabaya, Jalan Teknik Kimia Kampus ITS Keputih-Sukolilo, Surabaya, Indonesia

**priyo.as@ppns.ac.id*

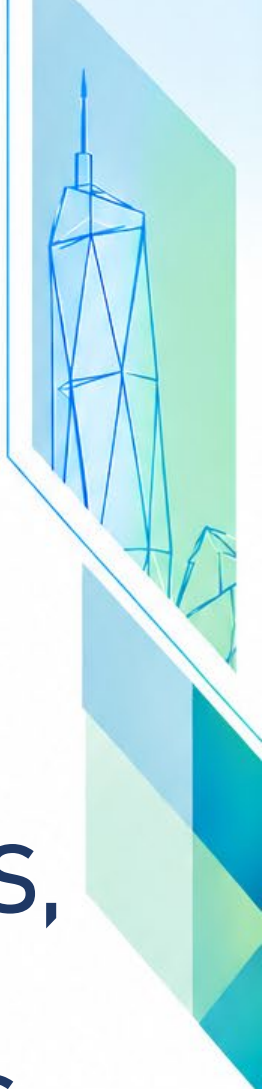
ABSTRACT

The Savonius turbine is a vertical-axis wind turbine (VAWT) characterized by a simple structure, relatively low manufacturing cost, good self-starting capability, and the ability to operate under multidirectional flow conditions. However, its performance is relatively low because of the negative torque generated by the returning blade. Various studies have therefore been conducted to improve the performance of Savonius turbines through geometric modifications and flow-control techniques. This review paper applies a thematic review approach by grouping previous studies according to four major themes: (1) the original or conventional Savonius turbine, (2) overlap ratio variation, (3) blade shape modification, and (4) circular cylinder addition as a passive flow-control device. The thematic grouping is used to compare research approaches, investigated parameters, methods, and their effects on turbine performance. The reviewed studies indicate that the conventional Savonius turbine provides the baseline for understanding torque and flow characteristics. Optimization of the overlap ratio shows that a ratio of approximately 0.10–0.15 has frequently been reported as a favorable configuration, although the optimum value may depend on operating and geometric conditions. Blade-shape modifications, particularly elliptical and combined blade configurations, have demonstrated improved performance compared with conventional blades. Furthermore, the addition of a circular cylinder around the advancing or returning blade can modify the flow structure, increase positive torque, and reduce the negative torque effect. Overall, the development of Savonius turbine research has progressed from basic geometric optimization toward passive flow control around the rotor.

Keywords: *Renewable energy; Savonius Wind Turbine; Circular Cylinder; Passive Flow Control; Power Coefficient.*



ENGINEERING
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TRACK 7: MECHATRONICS, CONTROL AND INTELLIGENT SYSTEMS



T7-O-A86

Fouling Detection in Heat Exchangers Using Multiparametric Programming

Ernie Che Mid^{1,2*} and Vivek Dua³

¹ Faculty of Electrical Engineering & Technology, Universiti Malaysia Perlis, Pauh Putra Campus, 02600 Arau, Perlis, Malaysia.

² Centre of Excellence for Renewable Energy, Universiti Malaysia Perlis, Kampus Pauh Putra, 02600 Arau, Perlis, Malaysia.

³ Department of Chemical Engineering, Centre of Process System Engineering (CPSE), University College London, London WC1E 7JE, United Kingdom

*ernie@unimap.edu.my

ABSTRACT

Fouling in heat exchangers is a major operational problem that reduces heat transfer performance, increases energy consumption, and raises maintenance costs. Early detection of fouling is therefore essential for condition monitoring and maintenance planning without interrupting plant operation. This paper presents an explicit parameter-estimation-based fouling detection method for a counter-flow tubular heat exchanger using multiparametric programming (MPP). A nonlinear heat exchanger model is discretised and reformulated as an optimisation-based parameter estimation problem, from which the overall heat transfer coefficient is derived as an explicit function of process measurements. The estimated heat transfer coefficient is then used to compute the fouling resistance, which serves as the diagnostic indicator for thermal degradation. The proposed method is evaluated under clean and fouling heat exchanger scenarios, with random measurement noise included to represent practical uncertainty. Under clean operating conditions, the estimated heat transfer coefficient remains close to its nominal value, and the fouling resistance remains below the threshold of $0.0001 \text{ m}^2 \text{ K/W}$. Under fouling conditions, the estimated heat transfer coefficient decreases progressively, while the fouling resistance exceeds the fouling threshold at 6.63 h and reaches the severe fouling region after 9.5 h. These findings demonstrate that the proposed method can distinguish between normal, fouling, and severe fouling conditions. Since the estimator is expressed explicitly, the method avoids repeated online optimisation and offers a computationally efficient framework for online fouling detection and maintenance decision support.

Keywords: Fouling; heat exchanger; multiparametric programming; parameter estimation; fault detection.

T7-O-A37

Wide-Angle Camera Calibration for Net Quality Inspection Using K-Nearest Neighbors

Muhammad Haziq Noor Akashah¹, Masako Yamamoto² and Naoki Uchiyama^{1}*

¹Department of Mechanical Engineering, Toyohashi University of Technology, Toyohashi 441-8580, Japan.

²AMITA, Toyohashi 441-8580, Japan.

**uchiyama@tut.jp*

ABSTRACT

Accurate image-based measurement is important for visual inspection, dimensional monitoring, robotic perception, and experimental analysis. However, wide-angle images can produce spatially inconsistent measurements because lens distortion and perspective effects cause physically identical segments to appear with different pixel lengths across the image. This paper presents a progressive measurement correction workflow for a printed net imitation: First, the error produced by direct wide-angle measurement is quantified; second, the improvement from camera calibration and image undistortion is evaluated; and third, K-nearest neighbors (KNN) regression is subsequently trained to predict this residual error. The printed net contained repeated knot-to-knot segments with a known real-world length of 30 mm. Ninety-six segments were manually traced in the original wide-angle image and another 96 segments were traced in the undistorted image. A centre-reference scale was used as the main evaluation strategy because it reveals how measurements vary spatially when scale is fixed from a central reference. Undistortion reduced the centre-scale mean absolute error from 5.80 mm to 1.39 mm, confirming that calibration improved measurement consistency. However, residual error remained even after the undistortion. A KNN model was therefore trained to predict residual error using pixel length, estimated distance, and line midpoint coordinates. On held-out test samples, KNN reduced the mean absolute error without undistortion from 6.96 mm to 0.48 mm and that with undistortion error from 1.34 mm to 0.11 mm. The results demonstrate that KNN can serve as an effective post-calibration residual correction layer for camera-based planar measurement.

T7-O-A52

Optimization of a PID Controller Using Cheetah Optimizer for Improved Vibration Suppression in Horizontal Flexible Plate Structure

Muhamad Sukri Hadi^{1*}, Khairullah Lukman¹, Mat Hussin Ab. Talib², Hanim Mohd Yatim²
and Intan Zaurah Mat Darus²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

msukrihadi@uitm.edu.my

ABSTRACT

In advanced technological applications, horizontal flexible plate structures offer several advantages including lightweight design, improved operational efficiency and reduced energy consumption. These characteristics make them highly attractive for use in fields such as automotive, aerospace, robotics and general engineering applications. However, despite these benefits, horizontal flexible plate structures are inherently prone to excessive vibrations, which may compromise system performance and potentially lead to structural instability or failure. To overcome this limitation, this study proposes a Proportional–Integral–Derivative (PID) controller tuned via the Cheetah Optimizer (CO) algorithm to achieve enhanced vibration suppression in horizontal flexible plate structures. The PID controller is first tuned using the Ziegler–Nichols (ZN) method to provide a baseline for performance comparison. Subsequently, an intelligent PID controller is formulated by employing the Cheetah Optimizer (CO) algorithm to achieve optimal parameter tuning for suppressing vibrations induced by a single sinusoidal excitation. The proposed control strategy is implemented and validated within the MATLAB/Simulink environment. Both controllers are further evaluated through robustness tests under multiple sinusoidal disturbances to validate their performance. The effectiveness of the proposed controllers is assessed based on the Mean Squared Error (MSE) with lower values indicating better control effectiveness. Additionally, vibration behaviour is analysed in both frequency and time domains, where first-mode vibration is assessed via frequency response, while oscillation amplitudes are examined in the time domain. The results indicate that the PID-ZN controller achieves a first-mode vibration attenuation of 38.08 dB, whereas the PID-CO controller attains a higher attenuation of 44.43 dB. Furthermore, the PID-CO controller demonstrates superior vibration suppression performance by achieving attenuation levels of 42.89 % and 37.86 % under single and multiple disturbance conditions, respectively. The PID-CO controller demonstrates superior performance by achieving lower MSE values of 0.0068 and 0.0258 for single and multiple disturbance cases, respectively. This improvement reflects enhanced control precision and reduced tracking error. These findings underscore the effectiveness of the PID-CO controller as a reliable approach for mitigating excessive vibrations in complex dynamic systems.

Keywords: Flexible Plate; Active Vibration Control; Cheetah Optimizer; Metaheuristic Algorithm; PID Controller.

T7-O-A88

Obstacle Detection Utilising Ultrasonic Sensor and Haptic Feedback for the Visually Impaired

Zainal Abidin Kamarul Baharin¹, Wan Mazlina Wan Mohamed^{2*}, Nor Hafiez Mohamad Nor³
and Mohd Syahar Mohd Shawal²

¹MEC Engineering Resources, W-08-03, 6 Persiaran Multimedia, 40000 Shah Alam, Selangor, Malaysia 2

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

³Industrial Metallurgy and Materials Processing (IMMaP), Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*wmazlina@uitm.edu.my

ABSTRACT

Independent spatial navigation presents a profound challenge for visually impaired individuals, as traditional mobility aids like the white cane offer limited detection ranges and cannot safely identify overhead or dynamic environmental hazards. While electronic travelling aids (ETAs) offer technical solutions, advanced commercial units remain economically inaccessible, and existing low-cost alternatives frequently trigger high false positive rates due to uncalibrated ultrasonic beam flaring in constrained indoor layouts. To address these critical limitations, this research presents the design, development, and laboratory validation of an affordable, highly adaptable ETA built from commercial off the shelf components. Rather than maximising raw hardware capacity, the core focus lies in a specialised geometric footprint optimisation and firmware constraint technique. Although laboratory evaluations confirmed a maximum raw sensor range of 395 cm, the operational boundary was algorithmically restricted to an optimal threshold of 150 cm. This constraint intentionally matches standard adult white cane dimensions to mitigate user cognitive data overloading. At this optimised 150 cm limit, the sensor maintains a precise 20-degree scanning envelope with a horizontal footprint of 53 cm. This calibrated configuration is designed to map restrictive environments, such as standard 90 cm doorways, substantially reducing false alarms from structural edges. Experimental indoor navigation trials verified that the multi-tiered proximity to tactile pulse frequency mapping architecture effectively replicates ergonomic sweeping motions. The dynamic haptic feedback profiles ranging from intermittent pulses to continuous vibration allowed users to systematically locate clear pathways and traverse narrow openings with minimised risk of physical contact or collision. Ultimately, this research provides a scalable, socio economically viable engineering framework for low resource demographics, demonstrating that precise geometric envelope calibration can achieve high fidelity spatial awareness using accessible hardware components.

Keywords: Obstacle detection; Ultrasonic sensor; Haptic feedback; Visually impaired; Blind.

T7-V-A75

Batteryless PV-Diesel Hybrid System with VSG-Enabled Fuel Saver Inverter for Remote Island Waste Management: Performance Simulation and Analysis

Catur Rakhmad Handoko^{1*}, Urip Mudjiono¹, Mohammad Basuki Rahmat¹, Sintia Megawati¹,
Sekar Wibowo² and Anisa Esti²

¹Marine Electrical Engineering Department, Shipbuilding Institute of Polytechnic Surabaya, Indonesia

²Waste Treatment Engineering Department, Shipbuilding Institute of Polytechnic Surabaya, Indonesia

*caturhan007@gmail.com

ABSTRACT

This paper evaluates a batteryless photovoltaic (PV)-diesel hybrid for a TPS3R waste-processing facility on Gili Ketapang, East Java, using a commercial fuel saver inverter with Virtual Synchronous Generator (VSG) capability. A Deye SUN-5K-SG04LP3 in generator (GEN) terminal mode couples a 7.2 kWp PV array to a 7.5 kVA diesel generator without storage. Three configurations are simulated using decoupled Python models: an hourly energy-dispatch model benchmarked against published methods and a 2 ms VSG transient model. Inputs include NASA POWER solar data and a characterised three-phase induction-motor load with VFD/soft-starter control per PUPR (2021). The proposed batteryless configuration (Config B) reaches a renewable fraction (RF) of 56.1%, cuts diesel uses by 24.1% (1,244 L/yr) and yields an LCOE of IDR 2,543/kWh with a 14.9-year simple payback (7.4 years at non-subsidised fuel prices). The battery benchmark (Config C) provides 73.4% fuel reduction and lower LCOE, but Config B suits sites where battery maintenance and replacement logistics are impractical. Across $H_{VSG} = 1.0\text{-}3.0$ s, VSG control reduces ROCOF by 31.9-58.4% and raises the frequency nadir from 47.859 Hz to 49.26-49.44 Hz. All disturbances comply with Permen ESDM No. 20/2020, although the severe +30% case does not meet IEC 60038 $\pm 1\%$.

Keywords: Batteryless hybrid; fuel saver inverter; virtual synchronous generator; PV-diesel; frequency stability; islanded microgrid.

T7-V-A136

Development of an Integrated Autonomous System for Water Surface Waste Collection and Water Quality Monitoring

Mahir Mohamed Ibrahim¹, Ranjini Hazra¹, Muhammad Khan², Iman Akbar³, Ismail Mohammed Habibi³, Ahmed Raza Sayyad², Jinane Mounsef^{2,3} and Umer Javed^{1*}

¹Department of Mechanical Engineering, Rochester Institute of Technology, Dubai, UAE

²Department of Electrical Engineering, Rochester Institute of Technology, Dubai, UAE

³Department of Computing, Rochester Institute of Technology, Dubai, UAE

*uxjcad@rit.edu

ABSTRACT

This paper presents the design and development of an integrated autonomous marine surface debris remediation platform comprising a Mobile Unmanned Surface Vehicle (USV) and a proposed Stationary Floating Dock for future persistent autonomous operation. The developed USV features a modular 3D-printed catamaran hull, a re-engineered conveyor-based debris collection mechanism, a marine-grade electrical power distribution architecture, and a ROS 2-based software framework for modular system integration. An onboard perception pipeline incorporating an OAK-D Lite camera and a YOLO11n-based object detection model was developed to enable real-time trash detection and support vision-assisted autonomous navigation. The platform further integrates embedded electronics, power management, telemetry, and hardware interfaces to support the future integration of water-quality sensors for pH, turbidity, electrical conductivity, and temperature monitoring. Preliminary fabrication, subsystem integration, and preliminary testing demonstrate the feasibility of the proposed mechanical, electrical, embedded, and perception architectures. The overall system design further incorporates a stationary floating dock, autonomous docking, renewable-energy-assisted charging, and onboard waste compaction as planned extensions toward a scalable, self-sustaining ecosystem for aquatic waste collection and environmental monitoring.

Keywords: Aquatic waste management; Vision-based marine navigation; Renewable energy microgrid; Ros2-based modular robotics; Modular robotics.

T7-O-A83

Optimization and Application of Flower Pollination Algorithm in Dynamic Vibration of Magnetorheological Damper System

Mat Hussin Ab Talib^{1*}, Muhammad Khalis Noor Hisham¹, Hanim Mohd Yatim¹, Mumahad Sukri Hadi²,
Muhammad Firdaus Isham¹, Wan Aliff Abdul Saad¹ and Muhammad Danial Abu Hasan¹

¹Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*mathussin@utm.my

ABSTRACT

This study explores the effectiveness of an intelligent optimization technique known as the flower pollination algorithm (FPA) in determining the parameters for a proportional-integral-derivative (PID) controller for semi-active suspension systems. The purpose of this work is also to provide a systematic comparison between the proposed FPA and other methods for optimizing the vibration control of MR damper system. The study assesses the performance of the PID controller with FPA tuning. It compares it to traditional and intelligent optimization methods, including a non-PID heuristic approach and particle swarm optimization (PSO). The comparative assessment was investigated based on the mean square error (MSE) against iteration, body displacement against time and body acceleration against time. To conduct these assessments, a MATLAB simulation environment was employed to create a comprehensive model of the semi-active suspension system, complete with all control components. The results of the study demonstrate a significant improvement, with the proposed PID-FPA controller reducing the amplitude of body acceleration and displacement responses by up to 70.4 % and 84.5 %, respectively, when compared to PID-HEURISTIC, PID-PSO, and passive systems. The FPA optimization integrated with the PID controller should be considered to achieve the optimum target in the MR damper control strategy for the suspension system.

Keywords: Suspension System; Magnetorheological Damper; Vibration Control; PID Controller; Flower Pollination Algorithm.

T7-V-A55

Collision-Aware Trajectory Planning for Passenger Boarding Bridges in Airport Apron

Abishai Asir A.Thederajan ¹, Cheng Yee Low ^{1*}, Jingye Yee ², Ramhuzaini Bin

Abd Rahman ¹, Koh Ching Theng ¹, Tobias Seidenberg ² and Laban Asmar ²

¹Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia,
Parit Raja, Johor, Malaysia

²Fraunhofer Institute for Mechatronic Systems Design IEM, Paderborn, Germany

*cylow@uthm.edu.my

ABSTRACT

Passenger Boarding Bridges (PBBs) are a critical component of modern airport ground operations, providing the primary physical interface between terminal buildings and commercial aircraft. Current semi-automated PBB systems rely on pre-programmed trajectory sequences designed for static environments and lack real-time obstacle awareness, making them unsuitable for the dynamic environment of airport aprons, where ground support vehicles, cargo equipment, and personnel continuously occupy the docking corridor. This study proposed and validated a collision-aware trajectory planning framework for autonomous PBB docking operations, implemented within the Robot Operating System 2 (ROS 2) and MoveIt 2. Rather than committing to a single fixed path, the framework used the MoveIt Task Constructor (MTC) to simultaneously evaluate multiple topologically distinct docking routes and autonomously select the safest and most time-efficient collision-free trajectory. The system architecture incorporates a multi-modal perception pipeline combining 3D Light Detection and Ranging (LiDAR) point cloud data and computer vision, with obstacle geometry registered as collision objects in the planning scene. The framework was validated within a simulation environment across unobstructed and obstructed scenarios. Benchmarking revealed that planner selection directly affects trajectory execution safety, with asymptotically optimal planning required for collision-free execution under the tested single-obstacle kinematic configuration, establishing a safety baseline for future multi-obstacle and dynamic-environment validation. The MTC fault-tolerance mechanism autonomously selected a collision-free fallback strategy when the primary route was obstructed. These findings establish a robust simulation-based foundation for collision-aware autonomous PBB docking and support the case for future physical deployment at operational airport facilities.

Keywords: PBB; autonomous docking; trajectory planning; ROS 2; MoveIt 2.

T7-O-A100

Data-Driven Fuzzy Inference System for Water Quality Classification via Fuzzy C-Means Clustering

Maxwell Sengiang Liban¹ and Muhammad Zaiyad Muda^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

*zaiyad@uitm.edu.my

ABSTRACT

Ensuring safe drinking water and protecting public health requires reliable, continuous water quality monitoring. However, conventional laboratory-based methods are generally costly and time-consuming, restricting their suitability for real-time water quality evaluation. To address these issues, we design a data-driven fuzzy inference system for intelligent water quality classification in a low-cost edge-monitoring system. The main objective of this research is to design and evaluate a data-driven fuzzy inference system that can classify water quality based on three basic input parameters: pH, turbidity and total dissolved solids (TDS). To achieve this, a fully integrated prototype consisting of low-cost sensors, an ESP32 microcontroller, and a Python-based fuzzy inference system was developed. In this data-driven environment, experimental data were collected from five different water sources: purified drinking water, bottled mineral water, tap water, lake water and drain water, to distinguish variability in sensor responses. Instead of relying on manually defined rules and membership functions, a data-driven modelling method was employed using the collected datasets. During the data collection stage, sensor readings were labelled based on water source categories: purified and mineral water as 'Good', tap water as 'Moderate', and lake and drain water as 'Poor'. This resulted in a fully labelled dataset that was used for system development and evaluation. The well-known Fuzzy C-Means (FCM) clustering algorithm was applied to compute the cluster centres to build the trapezoidal membership functions for all three input variables. The Mamdani inference mechanism and centroid defuzzification method were then applied to evaluate the fuzzy rules and classify water quality into three categories: Good, Moderate and Poor. In an expanded empirical evaluation with a reserved 20% test subset (30 samples), the prototype achieved an overall classification accuracy of 93.33%, achieving 100% accuracy in both 'Good' and 'Poor' water quality categories. These results demonstrate the effectiveness of this proposed data-driven fuzzy inference system in interpreting sensor data and hence the classification of water quality.

Keywords: Data-Driven System; Fuzzy Logic; Water Quality Monitoring; Fuzzy C-Means Clustering; ESP32.

T7-O-A77

Visual-inertial SLAM and Geometric Path Tracking for Tree-to-Tree Agricultural UGV Navigation

Zunnurain Zainor¹ and Wan Nurshazwani Wan Zakaria^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

*wshazwani@uitm.edu.my

ABSTRACT

Malaysia's palm oil industry faces a significant labour shortage due to its reliance on foreign workers, creating a demand for sustainable automation solution. Autonomous navigation in palm oil plantations is challenging because of uneven terrain, dense tree canopies, and Global Positioning System (GPS)-denied environments. This study proposes a motion planning framework for autonomous Unmanned Ground Vehicle (UGV) navigation using Visual Simultaneous Localization and Mapping (V-SLAM), A* global path planning, a local circling planner, and a Pure Pursuit path-tracking controller. The framework is implemented on an AgileX Mini Bunker UGV equipped with a stereo camera for environmental perception. Straight-line, A* path-following, and tree-circling experiments were conducted in both laboratory and outdoor environments to validate the proposed navigation framework. Subsequently, a complete tree-to-tree navigation experiment was performed in an outdoor palm plantation environment. The proposed system achieved a mean tracking error of less than 0.01 m in the validation experiments and less than 0.10 m during tree-to-tree navigation. The shortest tree-to-tree traversal was completed in 198 s over an actual travel distance of 30.43 m. These results demonstrate that the proposed framework enables reliable and accurate autonomous navigation for palm oil plantation operations.

Keywords: Visual SLAM; Agricultural UGV; A* Path Planning; Pure Pursuit Control; Autonomous Navigation.

T7-O-A91

Real-Time Embedded Mechatronic System for Haptic and Thermal Feedback: Hardware Validation and Response Delay

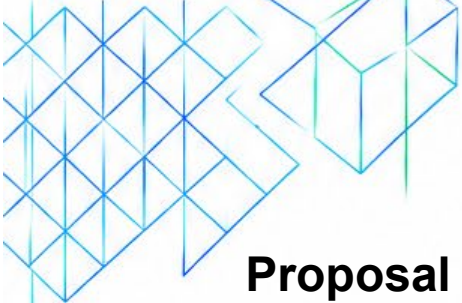
Zuhairi Zakwan Mohd Faizal¹, Sukarnur Che Abdullah^{1} and Mohd Azzeim Mat Jusoh¹*

*¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam,
Selangor, Malaysia*

**sukarnur.ca@gmail.com*

ABSTRACT

Traditional automotive instrumentation and visual dashboards introduce significant cognitive overhead, resulting in critical sensory propagation delays exceeding 100 ms during imminent collision events. This paper presents an ESP32-microcontroller-based, real-time embedded mechatronic system designed to transduce physical telemetry into immediate haptic and thermal feedback. The hardware architecture integrates a Time-of-Flight (ToF) laser-ranging sensor (VL53L0X) and a DHT11 temperature sensor with custom-configured tactile and thermal actuators. To safeguard the microcontroller from inductive spikes and back electromotive force (EMF) generated by inductive loads, electromagnetic relays are implemented to ensure rigorous galvanic isolation. System communication integrity was validated via I2C bus monitoring of the Serial Data (SDA) and Serial Clock (SCL) lines using an 8-channel logic analyzer sampling at 2 MHz, confirming error-free address decoding without bus loading. Real-time firmware execution and internal memory registers were verified using a Joint Test Action Group (JTAG) boundary-scan interface for on-chip debugging. Furthermore, the algorithmic state machine incorporates hysteresis logic to suppress relay chatter alongside a dynamic translation matrix that maps raw telemetry to proportional Pulse Width Modulation (PWM) frequencies. Empirical results demonstrate a highly responsive, deterministic mechatronic architecture capable of mitigating hazard response latency, offering a scalable foundation for advanced driver assistance systems (ADAS) and industrial automation.



T7-O-B03

Proposal of Miniaturized Outer Circumferential Hugging Type Pipe Inspection Robot

Kazuki Futawaka*, Tetsuya Akagi, Shujiro Dohta, Takashi Shinohara, Feifei Cho and Masashi Yokota
Information Science and Engineering, Okayama University of Science, Okayama, Japan
*r26smh7ah@ous.jp

ABSTRACT

A pneumatic drive flexible robot that moves along pipes to inspect the complex pipe in chemical plants have been developed for several years. However, as the robot was relatively large, impact increases in proportion to its mass when the robot falls. The goal of this research is to miniaturize and simplify the robot and reduce its impact force during falls. In this study, a downsizing simple holding mechanism using an Extension type Flexible Pneumatic Actuator (EFPA) that can be bent by fiber restraint when it is pressurized. The mechanism provides sufficient holding force to prevent slippage on vertical pipes. The small-sized outer circumferential hugging type pipe inspection robot that consists of two holding mechanisms set on both sides of an Extension / Bending Mechanism (E/BM) was also developed. The E/BM consists of parallel arranged three EFPAs with restraint plates. By integrating the robot and a wireless control system with small-sized on/off valves, a lighter and simpler pipe inspection robot was also proposed and tested. As a result of traveling test using the robot, the tested robot demonstrated that it could climb up-and-down on vertical pipe and rotational motion along pipes. As a result, it could be found that the robot could travel smoothly along vertical pipes and avoid obstacles.

Keywords: Extension type Flexible Pneumatic Actuator; Outer Circumferential Hugging Type Pipe Inspection Robot; Soft Actuator; Simplification of Holding Mechanism.

T7-O-B04

Proposal of Lattice-Shaped Pipe Propulsion Mechanism Using Extension type Flexible Pneumatic Actuators

Takashi Matsumoto*, Tetsuya Akagi, Shujiro Dohta, Takashi Shinohara, Feifei Cho and Masashi Yokota
Information Science and Engineering, Okayama University of Science, Okayama, Japan

*r26smh7ah@ous.jp

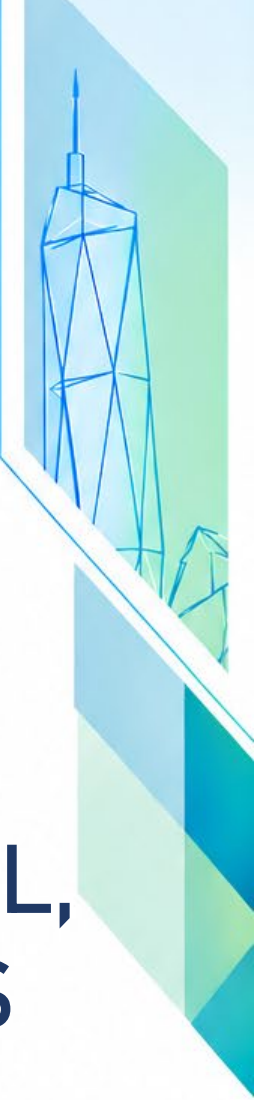
ABSTRACT

As increasing needs to inspect aging pipelines, development of reliable and versatile pipe-inspection robots has been required. In the previous study, a pipe-hugging inspection robot capable of moving along the outer surface of pipes was developed. However, a critical safety issue remained: the robot would lose its grasping and fall if electric or pneumatic power was lost. To address this problem, a novel Lattice-Shaped Pipe Propulsion Mechanism (LSPPM) was proposed and tested. The LSPPM features a unique safety mechanism that naturally wraps around the pipe even during a power failure, preventing accidental falls. The LSPPM is constructed using eight Extension type Flexible Pneumatic Actuators (EFPAs) combined with elastic rubber bands, arranged in lattice pattern. By sequentially controlling the pressurized EFPAs, the LSPPM achieves moving along the pipe by a caterpillar-like locomotion. The flexible and compliant structure allows the mechanism to move along various geometrical pipes. The driving tests demonstrated that the developed LSPPM can successfully travel not only straightforward vertical and horizontal pipes but also complex L-shaped pipes and pipelines with bulging joints. As a result, it was confirmed that the proposed LSPPM was lightweight, highly adaptable, and possessed an inherent fail-safe mechanism to maintain its holding on pipes without power. was confirmed. The LSPPM will offer a promising and secure solution for the automated inspection of irregular and aging pipeline infrastructure.

Keywords: Lattice-Shaped Soft Actuator; Extension type Flexible Pneumatic Actuator; Pipe Inspection Robot; Caterpillar Motion.



ENGINEERING
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TRACK 8: BIOMECHANICAL, CLINICAL AND SPORTS ENGINEERING



T1-O-A134

Design of a Novel Monolithic Electrocautery Rod for Pepper-Pot Tracheal Intervention in Excessive Dynamic Airway Collapse

Helmi Rashid¹, Masaany Mansor^{2*}, Norazila Abdul Rahim², Mardiana Abdul Aziz³, Hilwati Hashim⁴, Xin Wee Chen⁵, Anis Syafinas Dahri² and Nor Amizan Mohd Sabri²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Department of Otorhinolaryngology Head Neck Surgery, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor, Malaysia

²Department of Otorhinolaryngology Head and Neck Surgery, Hospital Al Sultan Abdullah, Universiti Teknologi MARA, Puncak Alam, Selangor, Malaysia

³Department of Pathology, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor, Malaysia

³Department of Clinical Diagnostic Laboratories, Hospital Al-Sultan Abdullah, Universiti Teknologi MARA, Puncak Alam, Selangor, Malaysia

⁴Department of Radiology, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor, Malaysia

⁵Department of Public Health Medicine, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor, Malaysia

*masaanymansor@uitm.edu.my

ABSTRACT

Excessive Dynamic Airway Collapse (EDAC) is characterized by excessive inward collapse of the posterior tracheal wall during respiration, which can significantly obstruct airflow and may require surgical intervention in severe cases. Existing treatment approaches, including open tracheobronchoplasty, laser-based procedures, and airway stenting, present limitations associated with invasiveness, specialized equipment requirements, and procedural complications. Although conventional electrocautery systems are widely available in hospitals, existing probes lack features for controlling penetration depth, potentially increasing the risk of unintended thermal injury to adjacent structures during endoscopic procedures. This study aimed to develop a specialized electrocautery rod incorporating a depth-guiding feature to facilitate controlled penetration and improve visual guidance during endoscopic airway intervention. The device was developed through a systematic engineering design process involving needs identification, concept development, material selection, Computer-Aided Design (CAD), fabrication, and structural evaluation using Finite Element Analysis (FEA). Stainless steel 316L was selected as the structural material, and the proposed design incorporated a depth-indicating feature while maintaining compatibility with conventional electrocautery systems. FEA was performed under applied loads of 2 N and 5 N to evaluate the structural response of the rod. The results showed maximum von Mises stresses of 79.8 MPa and 200 MPa, with corresponding maximum displacements of 1.46 mm and 3.65 mm, respectively. The resulting factors of safety were 2.56 and 1.03, with both stress values remaining below the assigned material yield strength of 205 MPa. However, the 5 N loading condition approached the material yield limit, indicating a substantially reduced safety margin at the higher load. Overall, the findings demonstrate the mechanical feasibility of the proposed electrocautery rod and provide an engineering basis for a depth-guided instrument that may improve penetration control during endoscopic airway procedures using conventional electrocautery systems.

T8-O-A124

Cognitive Performance and Physiological Responses to Mild Oxygen Enrichment in Indoor Environments: An Exploratory Study

Kah Hua Choong¹, Sheikh Ahmad Zaki^{1*}, Naja Aqilah Hisham¹, Muhammad Faiz Md Shakhiah², Siti Balqis Samdin², Hom Bahadur Rijal³ and Fitri Yakub¹

¹Tropical Indoor Environmental Research Laboratory, Malaysia-Japan International Institute of Technology (MJIT), Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia

²Universiti Teknologi Malaysia (UTM), 81310 81310 Johor Bahru, Johor, Malaysia

³Graduate School of Environmental and Information Studies, Tokyo City University, Yokohama, 224-8551, Japan

*sheikh.kl@utm.my

ABSTRACT

Smart ventilation systems typically regulate indoor air quality (IAQ) by controlling ventilation and air composition, including carbon dioxide concentration. However, oxygen concentration is generally treated as a relatively inert parameter despite its potential influence on cognitive performance and physiological regulation. This study examined the effects of mild oxygen enrichment ($21.05 \pm 0.1\% \text{ O}_2$) on cognitive performance and physiological responses in healthy adults under controlled indoor conditions. Using a repeated measure, within-subject design, 11 participants were exposed in a counterbalanced order to a control room and a mild oxygen-enriched room. The oxygen-enriched room was also cooler, more humid, and had a different air velocity profile than the control room, limiting attribution of the observed responses specifically to oxygen concentration. Cognitive performance was evaluated across attention, executive function, and visual-spatial reasoning domains, while physiological responses were assessed using heart rate variability (HRV), galvanic skin responses (GSR), and electroencephalography (EEG). Under the mild oxygen-enriched condition, Rotations performance was higher in unadjusted cognitive analysis but was not significant after false discovery rate correction. Skin conductance response peak count measures remained unchanged between conditions, while HRV analysis indicated a marginal increase in the root mean square of successive differences (RMSSD) before correction. EEG analysis revealed significantly higher relative alpha power under the mild oxygen-enriched condition before correction, whereas relative beta power, alertness index, and engagement index did not differ significantly. Although none of the cognitive or physiological outcomes remained statistically significant after correction, the directional patterns in Rotations performance, RMSSD and relative alpha power identify outcomes that warrant further investigation. These findings provide preliminary evidence to support continued evaluation of oxygen concentration as a complementary indoor air quality parameter under more tightly controlled environmental conditions.

Keywords: Oxygen-enriched; Heart rate variability; Physiological response; Cognitive enhancement; Indoor air quality.

T8-O-A23

Development of a Hybrid Basalt/Kenaf/Epoxy Locking Compression Plate: Experimental Characterisation and Design Optimisation via Finite Element Analysis

Muhammad Naufal bin Nazeri¹, Solehuddin Shuib^{1*}, Ahmad Zafir Romli² and Mohd Fairudz Mohd Miswan³

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam, 40450, Selangor, Malaysia

²Faculty of Applied Sciences, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

³Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor Branch, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia

*solehuddin2455@uitm.edu.my

ABSTRACT

Bone fractures are conventionally stabilised using Locking Compression Plates (LCPs), most often manufactured from stainless steel or titanium alloys. Whilst these metals provide the necessary mechanical strength, their stiffness greatly exceeds that of cortical bone, leading to stress shielding effects that hinder natural bone remodelling and prolong healing. To address this limitation, the present study investigates a modified LCP design and evaluates a sustainable basalt/kenaf/epoxy hybrid composite as an alternative implant material. Geometric variations of the plate were modelled in CATIA V5 and analysed in ANSYS 2023 R2 under a simulated axial load of 350 N. In parallel, tensile and flexural properties of the composite were experimentally characterised using a Shimadzu AG-X universal testing machine, with results validated through finite element analysis. Among the proposed geometries, Design 2 demonstrated superior biomechanical performance, recording the lowest Von Mises stress (272.93 MPa) and controlled deformation (0.375 mm), conditions favourable for callus formation. The treated composite containing 50 wt% kenaf fibre achieved tensile and flexural moduli of 8018.20 MPa and 13258.75 MPa, respectively, closely approximating cortical bone stiffness. SEM analysis confirmed improved fibre-matrix adhesion and reduced void content. When integrated into the LCP model, the 50KT composite reduced stress concentration to 221.32 MPa, representing an 18% decrease compared with conventional 316L stainless steel. Although the 50KT composite reduced stress-shielding indicators, its total fracture-site deformation of 3.206 mm exceeded the conventional 2 mm clinical limit; this defines an explicit requirement for geometric stiffening or additional laminate layers before clinical translation. These findings identify the basalt/kenaf hybrid composite as a promising, sustainable implant material while clearly delimiting its present structural constraint.

Keywords: Stress shielding; Locking Compression Plate (LCP); Finite Element Analysis (FEA); Von Mises stress; Composite.

T8-O-A135

Application of Non-Destructive Testing Approaches in the Characterisation of Cockle Shell-Derived Hydroxyapatite/Polylactic Acid/Polycaprolactone Composite Scaffolds for Bone Tissue Engineering: A Review

Nursyazwani Zulkefli¹, Mohamad Nur Hidayat Mat², Shahrul Azmir Osman¹ and Eliza M. Yusup^{1*}

¹Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia,
86400 Parit Raja, Johor, Malaysia

²Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang Al-Sultan
Abdullah, 26600, Pekan, Pahang, Malaysia

*elizay@uthm.edu.my

ABSTRACT

Bone defects caused by trauma, infection, or degenerative disease remain difficult to treat with autologous grafting alone, prompting interest in synthetic scaffold alternatives. Cockle shell waste, composed of roughly 97–99% calcium carbonate in aragonite form, has emerged as an unusually practical precursor for hydroxyapatite (HAp), offering chemical compatibility with bone mineral alongside a low-cost production route. Combined with the biodegradable polymers polylactic acid (PLA) and polycaprolactone (PCL), HAp composites reportedly achieve the physicochemical, mechanical, and biological profile required of bone tissue engineering scaffolds; PLA:PCL ratios of 70:30 to 85:15 with 10–35 wt% HAp have been shown to satisfy the porosity, compressive strength, and biocompatibility benchmarks set by trabecular bone. This review draws that literature together, and pairs it with a less-developed strand of research: the use of non-destructive testing (NDT) to characterise such scaffolds without destroying them. Building on established industrial composite NDT practice and an emerging set of studies applying non-destructive methods directly to biomaterials, it proposes a two-stage workflow, chemical and structural verification by XRD, FTIR, SEM-EDX, and TGA, followed by mechanical screening via ultrasonic testing, alongside a defect-typology framework linking known composite flaws such as pore heterogeneity, HAp-polymer debonding, and HAp agglomeration to their likely NDT signatures. Neither framework has yet been tested experimentally; both are offered as a structured starting point rather than a finished protocol. In bringing this fragmented literature together, the review aims to provide cockle shell-derived scaffold research with a clearer path toward systematic characterisation.

Keywords: Bone tissue engineering, cockle shell, hydroxyapatite, non-destructive testing, polymer-matrix composite.

T8-O-A105

The Impact of Body Mass Index on Foot Pressure and Posture in Standing and Walking Conditions

Shahrul Hisyam Marwan^{1*} and Abdul Halim Abdullah²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Cawangan Terengganu,
Kampus Bukit Besi, 23200 Dungun, Terengganu Darul Iman, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam 40450, Selangor, Malaysia
*shahrulhisyam@uitm.edu.my

ABSTRACT

Body Mass Index (BMI) is an important indicator of body weight that may influence plantar pressure and foot posture. This study investigates the effect of BMI on plantar stress distribution under static standing and dynamic walking conditions by integrating computational and experimental approaches. A three-dimensional Finite Element (FE) model of the human foot was developed using Computer-Aided Design (CAD) software, while experimental plantar pressure data were collected using an F-Scan system equipped with a 3000E sensor. The FE model was implemented to evaluate stress distribution under different loading and boundary conditions, and the results were compared with experimental measurements. The findings demonstrated that higher BMI was associated with increased plantar stress distribution in both computational and experimental analyses. Under static standing conditions for the obesity category, the computational analysis recorded peak stress values of 289.25 kPa (left foot) and 319.60 kPa (right foot), whereas the experimental analysis recorded 195 kPa and 213 kPa, respectively. During walking, the highest right-foot pressure at heel strike reached 319 kPa in the computational analysis compared with 124 kPa in the experimental analysis. These findings indicate that increased BMI contributes to greater plantar loading, which may alter foot posture and influence foot biomechanics during standing and walking, providing useful insights for biomechanical assessment and future clinical applications.

Keywords: BMI, F-Scan, Finite Element, Human Foot.

T8-O-A125

Finite Element-Based Material Selection and Topology Optimization for the Development of a Lightweight Bed-Resting Ankle-Foot Orthosis

Ahmad Haziq Darwisy Mukhainizam¹, Eka Noorul Amanina Darwin¹, Muhammad Hanif Ramlee², Azizah Intan Pangesty³, Muhammad Hazli Mazlan⁴ and Abdul Halim Abdullah^{1*}

¹Biomechanical & Clinical Engineering, Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Department of Biomedical Engineering & Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

³Department of Metallurgical and Material Engineering, Faculty of Engineering, Universitas Indonesia, Depok City, West Java 16424, Indonesia

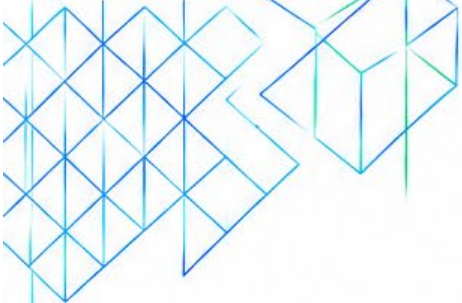
⁴Fakulti Kejuruteraan Elektrik dan Elektronik, BioMedical Engineering and Measurement System (BioMEMS), Universiti Tun Hussein Onn, Batu Pahat, Johor

*halim471@uitm.edu.my

ABSTRACT

Ankle Foot Orthosis (AFO) is designed to support the ankle and foot, providing stability, motion control, and compensating for weakness or deformity in the lower limbs. While commonly used in rehabilitation for conditions such as stroke and foot drop, this study focuses on developing an AFO specifically for bedridden patients to maintain muscle activity and prevent complications like muscle atrophy. Current AFO designs often lack sufficient structural analysis, leading to inconsistent performance and limited adaptability to individual biomechanical needs. This project aims to improve the design of a bed-resting AFO by evaluating structural performance through Finite Element Analysis (FEA) and optimizing the design using topology optimization techniques. The analysis includes five different materials: Polylactic Acid (PLA), Acrylonitrile Styrene (ABS), Nylon 6, Polypropylene, and Polyethylene. Weight reduction targets of 10%, 20%, and 30% are considered during topology optimization to enhance the device's efficiency without compromising strength and durability. The results reveal that the topology optimization process successfully achieved up to a 30% reduction in weight while maintaining the structural performance and functional integrity of the AFO. Among the materials analyzed, Nylon 6 demonstrated the best balance between strength and weight reduction, achieving superior performance at a 30% mass reduction. Polypropylene and Polyethylene also showed good performance but with slightly lower mechanical strength, while PLA and ABS were less suitable due to limited durability under load. These findings establish a robust framework for fabricating a lightweight, high-performance AFO tailored to bedridden patients, ensuring enhanced functionality, reliability, and adaptability.

Keywords: Ankle Foot Orthosis (AFO); Material Selection; Topology Optimization; Finite Element Analysis (FEA); 3D printing.



T8-O-B05

Development of a Hindlimb Rehabilitation Device for Small Animals

Keita Takasu^{1*}, Feifei Cho¹, Takamasa Itoi¹, Tetsuya Akagi¹ and Masumi Eto¹

¹Information Science and Engineering, Okayama University of Science, Okayama, Japan

*r26smh7ah@ous.jp

ABSTRACT

As in humans, severe spinal cord injuries caused by accidents or intervertebral disc disease in animals such as dogs and cats can lead to reduced hindlimb motor function and gait disorders. Currently, rehabilitation for small animals mainly depends on continuous treatment at veterinary hospitals, which places considerable temporal and financial burdens on pet owners. Therefore, this study developed a wearable gait support system for animals that enables rehabilitation during daily walking activities by attaching the device to hindlimb paraplegia dog. The proposed system integrates a wheelchair mechanism with a hindlimb rehabilitation device. In addition, a low-frequency electrical stimulation unit and a hindlimb rehabilitation mechanism were designed and constructed. The rehabilitation mechanism employs a link-arm mechanism composed of servo motors and hindlimb fixtures components to assist hindlimb motion. Furthermore, a synchronization system was developed using an accelerometer and a microcontroller to coordinate the driving speed of the device with the gait speed of the dog. To improve safety for biological tissues, a feedback control system based on position and motor current was also introduced.

Keywords: Small-animal rehabilitation; Hindlimb gait support; Wearable device; Feedback control system.

T8-O-B06

Development and Experimental Evaluation of a Spring-shaped Low-Pressure Pneumatic Actuator for Wheelchair Transfer Assistance

Yuki Tamura^{1*}, Feifei Cho¹, Tetsuya Akagi¹, Shujiro Dohta¹ and Takashi Shinohara¹

¹Information Science and Engineering, Okayama University of Science, Okayama, Japan

*r26smh7ah@ous.jp

ABSTRACT

In recent years, the number of young wheelchair users with acquired disabilities caused by illness or accidents has been increasing. Although many of these individuals seek physical and psychological independence, toileting-related difficulties often limit their ability to go out or travel alone. In particular, assistance with excretion remains a major challenge because transferring between a wheelchair and a toilet generally requires caregiver support, which is difficult to obtain in public environments. To address this issue, this study aims to develop a portable excretion-support system for wheelchair users to assist with independent outings. For this purpose, a compact and lightweight pneumatic actuation system capable of generating high output force under low-pressure conditions is required. In this study, a low-pressure driven high-power pneumatic actuator using an Eco-Flat hose made of EVA (ethylene-vinyl acetate copolymer) is proposed. The hose was formed into a spring-like structure to achieve large deformation and high output force while maintaining flexibility and safety for human interaction. The proposed actuator is intended to assist the standing support by applying force to the user's buttocks and back during transfer motions. To evaluate its feasibility for excretion support applications, several actuator structures were fabricated and experimentally compared. Basic performance characteristics, including generated force and displacement, were investigated to determine the most suitable structure for future integration into a wheelchair-based excretion assistance device.

Keywords: Low-pressure-driven; high-power pneumatic actuator; Excretion support; Assistive wheelchair.

T8-O-B07

Development of a Feedback Control System for a Center-of-Gravity Estimation

Shunsuke Hirata^{1*}, Feifei Cho¹, Tetsuya Akagi¹, Shujiro Dohta¹ and Takashi Shinohara¹

¹Information Science and Engineering, Okayama University of Science, Okayama, Japan

*r26smh7ah@ous.jp

ABSTRACT

Children with limited lower-body mobility due to illness or accidental injury often experience difficulties in walking and standing. Although various rehabilitation programs have been proposed, the continuous training at rehabilitation facilities places a considerable burden on both children and their caregivers due to transportation and time constraints. Therefore, there is a growing demand for a home-based rehabilitation system that enables an enjoyable and continuous training. In this study, we developed a rehabilitation support system that combines an 18-legged mobile robot for trunk training with a Virtual Reality (VR) environment to promote balance and postural control training while playing. The robot is driven by Tetrahedron-type Flexible pneumatic Actuators (TFAs), each composed of three Extension-type Flexible Pneumatic Actuators (EFPAs), enabling soft and human-friendly motion. This report focuses on the development of a feedback control system for posture stabilization and motion analysis. The proposed system uses OpenCV to detect the orientation of ArUco markers attached to the movable cushion section and estimates the user's center of gravity from the measured tilt angle, user's weight, and pneumatic supply pressure. When the estimated center-of-gravity position or tilt angle exceeds predefined thresholds, the system automatically adjusts the air supply and exhaust of the pneumatic actuators to maintain stability. In addition, a head movement measurement system using an overhead camera and markers was constructed to evaluate the displacement of the head during motion. The obtained data are expected to enable future comparative analysis between children with lower limb disabilities and healthy individuals.

Keywords: Children with lower limb disabilities; VR environment; 18-legged mobile robot; Home-based rehabilitation support device.

T8-O-B08

Proposal of Attitude Control and Built-in Driving System of Spherical Flexible Pneumatic Actuator Using Serial Connected Vacuum Pumps

Takuma Habiro^{1*}

¹Information Science and Engineering, Okayama University of Science, Okayama 700-0005, Japan

*r26smh7ah@ous.jp

ABSTRACT

A Spherical Flexible Pneumatic Actuator (SFPA) was developed for a healthcare support device that could providing passive exercises to wrist. The SFPA consists of six Extension type Flexible Pneumatic Actuators (EFPAs) arranged in parallel and restrained by PET sheets to form a rugby ball shape. The device can provide passive exercise simply by placing a hand on it. The attitude control system by feedback of the center axis length of SFAP using wire type potentiometer was also developed. It was confirmed that SFPA could be controlled so as to tack to bending angle in every bending direction in the previous study. In this study, a wire winding mechanism using a compact motor was proposed in order to stabilize the wire winding motion as an improvement of position sensor. Furthermore, a serial connected vacuum pumps was proposed and tested as built-in silent pneumatic source. The pneumatic driving system that can circulates and uses air inside SFPA without exhaust air was also proposed and tested. Driving test using SFPA and built-in air circular driving system was carried out. As a result, it could be confirmed that the tested built-in driving system could bend the SFPA up to approximately 45 degrees without large sound of exhaust. As a future work, the attitude control using the built-in attitude measuring and air circular driving system will be carried out.

Keywords: Spherical flexible pneumatic actuator; Healthcare supporting device; Air circular driving system using serial connected vacuum pumps; wire-type liner potentiometer with DC motor.

T8-O-B16

Development of Elastin Materials to Mimic the Extensibility of Biological Soft Tissues

Ei Yamamoto^{1*} and Yuki Kawamura²

¹Department of Biomedical Engineering, Faculty of Biology-Oriented Science and Technology,
Kindai University, Wakayama 649-6493, Japan

²Department of Medical Engineering, Faculty of Health Sciences, Morinomiya University of Medical Sciences,
Osaka 559-8611, Japan

*ei@waka.kindai.ac.jp

ABSTRACT

The mechanical properties of biological soft tissues such as skin are determined by the amount and organization of elastin fibers. Despite their essential role, elastin biomaterials for the repair or regeneration of damaged skin have not been widely developed. The purpose of the present study was to fabricate elastin-based biomimetic materials with mechanical properties comparable to those of native skin. Elastin was extracted from the bulbus arteriosus of fish and dissolved in dimethyl sulfoxide (DMSO). Hexamethylene diisocyanate (HMDI) was used as a crosslinking agent at a volume fraction of 15%. The elastin concentration in DMSO was set at 100 and 150 mg/ml. The fabricated elastin materials were approximately 3 mm thick. Dorsal skin samples were harvested from adult hairless rats. Dumbbell-shaped specimens were prepared from both the skin and the fabricated elastin materials (Fig. 1A). Tensile tests were performed using a universal testing machine. The elastin material prepared with the higher concentration exhibited the initial tangent modulus of stress-strain curves and the failure strain comparable to those of rat skin (Fig. 1B), indicating that the fabricated material possesses extensibility similar to that of native skin. A minimal mechanical mismatch between skin substitutes and native tissue is essential for successful tissue repair. Therefore, the mechanical properties of skin substitutes should be close to those of native tissue. The present study demonstrates that elastin-based materials can reproduce the extensibility of native skin and have the potential to serve as biomimetic scaffolds for skin repair and regenerative medicine.

Keywords: Biomechanics; Elastin; Skin; Tensile property; Tissue repair.

T8-O-B17

Assessment on New Bone Formation During Early Stage of Defect Healing Under Titanium Implant Plate

Norain Binti Abdullah^{1*}, Ei Yamamoto² and Masaaki Nakai^{3,1}

¹Bio-coke Research Institute, Kindai University, Osaka 577-8502, Japan

²Department of Biomedical Engineering, Faculty of Biology-Oriented Science and Technology, Kindai University, Wakayama 649-6493, Japan

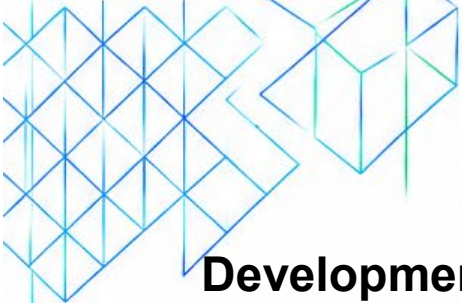
³Department of Metallic Biomaterials, Institute of Science Tokyo, Tokyo 101-0062, Japan

*norainabdullah95@gmail.com

ABSTRACT

Titanium alloy has been a promising metallic biomaterial because of its low elastic modulus. Compared to stainless steel (200 GPa) and cobalt chrome alloy (220 GPa), commonly used Ti-6Al-4V ELI (Ti-64) alloy has lower elastic modulus of 110 GPa that can avoid stress shielding effects for a long-term implantation. However, vanadium element in Ti-64 raises concerns as it is considered as toxic element. Hence, Ti-29Nb-13Ta-4.6Zr (TNTZ) is developed as compromising implant plate because it has much lower elastic modulus of 60 GPa. Implant plate with low elastic modulus is widely discussed on its relation with long-term implantation, but on the early stage of defect healing, it hasn't been addressed properly. Present study aimed to explore the effect of low elastic modulus implant plate fixation on new bone formation during early stage of defect healing. Ti-64 and TNTZ were used as implant plate with size of 25.0 mm x 5.0 mm and different thickness of 0.5 mm and 1.5 mm, which set as a variation of stiffness. The implant plate was fixed on defect made on rabbit femur for three weeks, and then the femur bone was extracted and evaluated (Figure 1). As a result, SEM micrograph shows that the new bone formation with porous structure (callus) on defect is similar in all fixation types but on the other region, larger area of callus is formed when using Ti-64 implant plate of 1.5 [mm] thickness, which has the highest stiffness in this case. This study reveals that stiffness plays an important role in promoting early stage of defect healing. Further results will be discussed.

Keywords: Bone formation; Defect healing; Elastic modulus; Titanium alloy.



T8-O-B14

Development and Characterization of A 3D Tubular Bio-structure using iPS-Derived Cardiac Cell Sheets

Mitsugu Todo^{1*} and Hiroko Kurita²

¹Research Institute for Applied Mechanics, Kyushu University, Japan

²Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, Japan

*todo@riam.kyushu-u.ac.jp

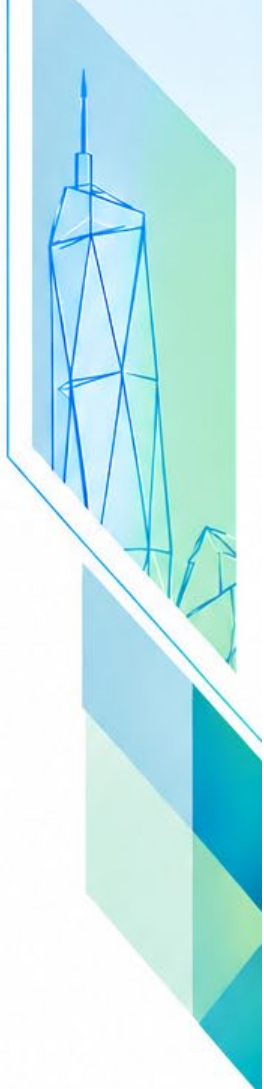
ABSTRACT

The culture condition has been established to derive cardiac cells from human iPS cells. Then, the iPS-derived cardiomyocytes (iPS-CMs) have been used to construct cardiac cell sheets using the cell sheet technology. Their clinical studies have been conducted in some hospitals to treat heart diseases. In the meantime, active research has been conducted to develop 3D-heart like structures using iPS-CMs; however, the basic technology has not been well established yet. In the present study, a 3D tubular biostructure was tried to be developed using a polymeric scaffold and cardiac cell sheets. The pulsation behaviors of the cell sheets and tubular structure were then characterized using a laser microscope system. The fluid dynamic behavior inside of the tubular structure was also investigated and it was found that the flow of culture medium was synchronized with the pulsation of the cardiac cell sheets.

Keywords: Tissue engineering, iPS cells, Cardiac cells, Cell sheet technology, Heart Pulsation.



ENGINEERING
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TRACK 9: ENGINEERING EDUCATION AND ENTREPRENEURSHIP



T9-O-A103

Enhancing Motorcycle Control Understanding Through Early Counter-Steering Education Using a Riding Simulator

Helmi Rashid¹, Abdul Rahman Omar², Lim Jin Wei³, Norshahida Shaadan⁴, Aaron Mitchell Ugi¹
and Nursalbiah Nasir^{1*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²UNITAR University College Kuala Lumpur, 50450 Kuala Lumpur, Malaysia

³Faculty of Engineering and Quantity Surveying, INTI International University, 71800 Nilai, Malaysia

⁴Faculty of Computer Science and Mathematics, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*nursalbiah@uitm.edu.my

ABSTRACT

Motorcycle stability and directional control fundamentally depend on counter-steering; however, many riders apply this technique unconsciously and lack an explicit understanding of the underlying steering dynamics. While conventional rider training focuses primarily on practical riding skills, limited attention has been given to developing learners' conceptual understanding of counter-steering during the early stages of rider education. This study investigated the effectiveness of simulator-based counter-steering education using the Counter-Steering Semi-Interface Motorcycle Simulator (CS-SiMS) in improving learners' understanding of motorcycle control dynamics. Of the 48 university students who completed the pre-intervention questionnaire, 41 completed the paired post-intervention assessment and were included in the statistical analysis. Participants aged 19–30 years, comprising licensed riders and non-licensed riders, performed simulated riding tasks at speeds between 80 and 120 km/h that required deliberate counter-steering inputs for directional control and hazard avoidance. Prior to the intervention, only 14 participants (34.1%) demonstrated an understanding of counter-steering, whereas after the simulator session, 40 participants (97.6%) reported understanding and being able to apply the concept. A McNemar test confirmed a statistically significant improvement in participants' understanding following the intervention ($\chi^2(1) = 24.04, p < .001$). Qualitative observations further revealed that non-licensed riders adapted more readily to the instructed steering technique than experienced riders, who initially struggled to reconcile their habitual steering behaviour with the explicit counter-steering strategy but demonstrated progressive improvement through repeated practice. The findings indicate a disconnect between implicit riding experience and explicit conceptual understanding of motorcycle steering dynamics, which may influence riders' initial adaptation to structured counter-steering instruction. These results demonstrate the educational value of simulator-based counter-steering training in developing accurate mental models of motorcycle control and support its integration into early rider education programmes to enhance hazard avoidance preparedness. Future studies should evaluate the transfer of learning to real-world riding performance and safety outcomes.

T9-O-A15

Enhancing Engineering Learning Engagement Through Gamified Augmented Reality a Case Study of Karakuri and Material Handling Systems

Nurul Faiqah Zainal Abidin¹, Noor Azlina Mohd Salleh^{2*}, Mohamad Aiman Najib Rahim¹ and Falah Abu³

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450, Shah Alam, Selangor, Malaysia

²Manufacturing Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia

³Faculty of Applied Sciences, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia
*noorazlinamohdsalleh@uitm.edu.my

ABSTRACT

This study presents the development of an interactive learning and augmented reality (AR)-based platform for the Karakuri System and Material Handling Unit System (MHUS) to support engineering education and Industrial Revolution 4.0 (IR4.0) applications. Conventional learning approaches for Karakuri and MHUS are often limited to theoretical explanations and practical observations, resulting in lower engagement and understanding among learners. Therefore, this study integrates gamification, interactive learning, and AR technology to improve visualisation, operational understanding, and learning experiences related to lean manufacturing systems. The study also reviews concepts related to Karakuri mechanisms, MHUS, Manufacturing Execution Systems (MES), AR technology, interactive learning, and IR4.0 applications. The platform was developed using Blender software for 3D modelling and animation, Unity Hub and Vuforia for AR integration, Active Presenter for interactive learning content, and Android SDK for mobile application development. The developed platform includes learning modules, quizzes, animations, AR visualisation, and self-assessment activities related to Karakuri and MHUS operations. The findings indicate that the platform successfully improves user engagement, operational understanding, and interactive learning experiences through immersive AR technology and gamification features. The developed application also demonstrates potential applications in engineering education, manufacturing training, and digital learning environments aligned with IR4.0 initiatives.

Keywords: Karakuri system, Augmented Reality (AR), interactive learning system, Material Handling Unit (MHU), Digital Operating Reporting.

T9-O-A101

Development and Evaluation of an Interactive Augmented Reality System for Pneumatic Training in Technical Education

Mohd Izzat Mohd Fazli¹, Nur Kamarliah Kamardin¹, Nurul Syuhadah Khusaini²,
Norheliena Aziz² and Noor Aniza Norrdin^{2*}

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang, Kampus Permatang Pauh, Pulau Pinang, Malaysia

²Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

*nooraniza@uitm.edu.my

ABSTRACT

This paper presents the development and evaluation of an interactive Augmented Reality (AR)-based training system for pneumatic education in technical and vocational institutions. Conventional approaches to teaching pneumatic systems primarily rely on static two-dimensional (2D) diagrams, textbook explanations and limited laboratory sessions, which often hinder students' understanding of dynamic pneumatic operations and circuit behaviour. To address these challenges, a marker-based AR mobile application was developed using Unity and the Vuforia Software Development Kit (SDK). The application integrates a three-dimensional (3D) animated model of a double-acting pneumatic cylinder with six FluidSIM-generated pneumatic circuit simulations aligned with the diploma-level pneumatics syllabus. The application enables students to visualise component movements, airflow sequences and circuit operations interactively through Android mobile devices. The effectiveness of the proposed application was evaluated using a pre-experimental one-group pre-exposure and post-exposure design involving 30 diploma-level Mechanical Engineering students from three academic groups. Students' perceptions of learning and usability were measured using paired five-point Likert-scale questionnaires. Statistical analysis showed significant improvements in post-exposure ratings across all groups ($p < 0.001$), with large effect sizes (Cohen's $d=1.41-2.37$) and moderate-to-high normalized gains (Hake's $g = 0.606-0.760$). The greatest improvements were observed in simulation usefulness, understanding of pneumatic components, and learning efficiency. These findings demonstrate that the proposed AR application effectively enhances students' perceived learning experience and provides a practical, accessible, and cost-effective supplement to conventional pneumatic instruction. The study contributes to engineering education by demonstrating the potential of curriculum-aligned mobile AR technology to support practical learning in technical and vocational education.

Keywords: Augmented Reality; Pneumatic Systems; Technical Education; Mobile Learning; Simulation-Based Learning.

T9-O-A120

Beyond Outcome-Based Education: Integrating Value-Based and Industry-Embedded Learning across Engineering and Engineering Technology Pathways

Saidatul Akmar Ismail^{1,2}, Nor Hayati Saad^{2*}, Shahrin Sahib²

¹Faculty of Information Science, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

²Office of the Vice-Chancellor, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

*norhayatisaad@uitm.edu.my

ABSTRACT

Outcome-Based Education (OBE) remains the principal accreditation foundation for engineering education, yet its strong emphasis on measurable learning outcomes may not sufficiently address the ethical judgement, adaptability, professional values, and sustained industry preparedness increasingly required in the Industry 5.0 era. This conceptual study proposes that engineering and engineering technology education should move beyond an outcome-only orientation by integrating Value-Based Education (VBE) and Industry-Embedded Learning (IEL) while retaining OBE as the accountability backbone of accredited programmes. The study adopts a qualitative conceptual design combining contemporary Scopus- and Web of Science-indexed literature, national and international policy and industry reports, established industry-integration practices within Malaysian higher education, and reflective benchmarking observations from a reciprocal academic engagement with Quanzhou University of Technology (QVTU), China. A thematic synthesis was undertaken to identify areas of convergence across outcome attainment, engineering technology pathways, industry immersion, industry leadership, societal engagement, value formation, employability, and Industry 5.0 competencies. The analysis culminates in the Value-Based Industry-Embedded Engineering Education Framework (VIEEF), comprising six interlocking components: Outcome Attainment, Engineering Technology Pathway, Industry Immersion, Industry Leadership, Societal Engagement, and Value-Based Formation. The framework integrates Washington Accord engineering pathways with Sydney and Dublin Accord engineering technology pathways while positioning industry as a continuous co-educator rather than merely a destination for final-stage industrial placement. Benchmarking observations from QVTU further demonstrate the potential of early industry immersion, embedded industrial schools, permanent industry experts, industry-as-campus arrangements, and visually reinforced industrial learning environments. VIEEF consequently offers a Malaysia-grounded and internationally benchmarked framework for developing graduates who combine technical competence with ethical judgement, adaptability, sustainability awareness, leadership, professional resilience, and lifelong learning. The framework contributes to engineering education by extending rather than replacing OBE and provides a basis for future empirical validation across Malaysian and international higher education contexts.

Keywords: Outcome-Based Education; Value-Based Education; Industry-Embedded Learning; Engineering Technology; Industry 5.0; Work-Integrated Learning; VIEEF.

T9-V-A109

Redefining Engineering Competencies in the AI Era: A Human-Centered AI Competency Model Based on the CDIO Syllabus

Nik Roselina Nik Roseley^{1*}, Nor Hayati Saad¹, Salmiah Kasolang¹, Amalina Amir¹, Nurzaki Ikhsan¹
and Saltanat Suiubayeva²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam,
Selangor, Malaysia

²D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Republic of Kazakhstan

*roselina_roseley@uitm.edu.my

ABSTRACT

Artificial Intelligence (AI), especially generative AI, is revolutionizing the field of engineering by reshaping the way students learn, solve problems, and apply engineering practices. Students are able to master the engineering solutions through the personalised learning, intelligent tutoring, AI-supported content creation and AI-assisted design using AI technologies. The increasing use of AI, however, also poses risks of diminishing critical thinking, analytical thinking, engineering judgment, academic honesty, and professional responsibility. Although significant focus has been directed to leveraging AI to enhance learning outcomes, relatively little attention has been paid to maintain the human skills and values necessary to accountable engineering practice. This paper introduces a conceptual and review of opportunities, obstacles, and implications of AI usage in engineering education. The study integrates the human competencies, AI competencies, and key human values that future engineering students need to acquire, based on the CDIO Syllabus, Version 3.0, the Ethics of Artificial Intelligence of UNESCO, Industry 5.0 and engineering codes of ethics as well as more recent competency literature on AI. From this synthesis, a Human-Centered AI Competency Model and AI-Extended CDIO Framework are proposed to facilitate responsible use of AI across the engineering education life cycle. The proposed framework highlights the complementary nature of human and AI skills and affirms the importance of engineering judgement, ethical considerations, and professional responsibility as key engineers' functions. It is a conceptual base for engineering programmes that aim to incorporate AI in a responsible manner, whilst maintaining human-centred values, and training future engineers to solve the growing technological and societal challenges.

Keywords: Artificial Intelligence; human-centered; engineering education; CDIO.



T9-O-A82

Digital Operationalization of the Taqwa-Driven Business Model Canvas: A Practical Decision-Support Architecture for Ethical Entrepreneurship

Salmiah Kasolang¹*

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, Selangor, Malaysia

*salmiahk@uitm.edu.my

ABSTRACT

Entrepreneurship education has become a strategic priority in higher education institutions and national development agendas, particularly within the context of Malaysia's National Entrepreneurship Policy 2030 (DKN2030). While numerous entrepreneurship frameworks and digital tools have been developed to support venture creation, many primarily focus on business planning and commercial viability, with limited emphasis on ethical intention, entrepreneurial reflection, impact assessment, and continuous improvement. This creates a need for integrated digital solutions that support both entrepreneurial development and responsible decision-making. This paper presents the digital operationalization of the Taqwa-Driven Business Model Canvas (TD-BMCTM) through the design of a practical decision-support architecture for ethical entrepreneurship. The platform was developed by translating the TD-BMCTM framework into a structured digital environment comprising registration, intention declaration, integrity screening, business model development, impact mapping, outcome assessment, continuous quality improvement (CQI), and reporting functions. The platform architecture further incorporates administrative, governance, and Training Needs Analysis (TNA) capabilities to support programme monitoring and entrepreneurial capability development. The resulting TD-BMCTM Platform functions as a multifunctional entrepreneurial development ecosystem that integrates learning, decision support, assessment, TNA, and governance within a single digital environment. The platform generates centralized entrepreneurial data that can support individual learning, institutional monitoring, evidence-based intervention planning, and entrepreneurship programme evaluation. The significance of this work lies in demonstrating how a conceptual entrepreneurship framework can be translated into a practical digital solution that supports ethical entrepreneurship, entrepreneurial capability development, and ecosystem-level monitoring. The platform provides a foundation for future implementation within universities, entrepreneurship centres, incubators, training providers, and entrepreneurship support agencies.

Keywords: Digital Entrepreneurship Platform; Entrepreneurship Mindset Development; Ethical Entrepreneurship; Decision-Support System; Training Needs Analysis (TNA).



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Faculty of Mechanical Engineering, UiTM Shah Alam