International Journal of Technology 15(2) 240-246 (2024)

International Journal of Technology

http://ijtech.eng.ui.ac.id

Unveiling Innovations Across Multidisciplinary Horizons

Arnas[1], Yudan Whulanza[1]*, Eny Kusrini[2, 3, 4]**

[1]*Department of Mechanical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia*
[2]*Department of Chemical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia*
[3]*Research Group of Green Product and Fine Chemical Engineering, Laboratory of Chemical Product Engineering, Department of Chemical Engineering, Universitas Indonesia, Kampus Baru UI, Depok, 16424, Indonesia*
[4]*Tropical Renewable Energy Research Center, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok, 16424, Indonesia*

In this edition of the International Journal of Technology (IJTech), we embark on a journey through the diverse landscape of multidisciplinary research, where innovation knows no bounds. Our contributors explore a spectrum of fields, offering insights that transcend traditional disciplinary boundaries. The tapestry of knowledge woven within these pages exemplifies the spirit of collaboration and the limitless possibilities that emerge when different engineering disciplines converge. Each article in this edition represents a beacon of innovation, reflecting the interdisciplinary nature of contemporary research. From advancements in fluid dynamics to urban finance, biomedical engineering and sustainable architecture, our authors illuminate the vast landscape of possibilities when ideas and expertise from various engineering domains converge.

The Digital Twin Paradigm: A Call for Collaborative Innovation

A key highlight of this edition is the exploration of the Digital Twin paradigm, a technological symphony that resonates across industries. The Digital Twin concept, as highlighted in various articles, presents a virtual replica of physical systems. It enables real-time insights, predictive capabilities, and promotes a new era of efficiency and precision in different engineering fields. The inception of digital twins can be traced back to the last decade's surge in personal computing, epitomized by the widespread use of smartphones and smartwatches. These devices, more than mere gadgets, are conduits for a vast stream of personalized data, feeding sophisticated mathematical and statistical models. They stand as a testament to how intimately technology has woven itself into the fabric of our daily lives, monitoring and predicting our health, habits, and preferences.

Digital twins represent a seamless integration of data and models. This integration, also known as data assimilation, allows models to continuously update and evolve with new data. As such, the digital twin becomes a dynamic, personalized replica of a physical system, whether it be a human body monitored by a smartwatch or an aircraft evaluated through

*Corresponding author's email: yudan.whulanza@ui.ac.id, Tel.: +62-217270032; Fax.: +62-217270033
**Corresponding author's email: eny.k@ui.ac.id, +62-21-7863505 ext. 204; Fax.: +62-217270033
doi: 10.14716/ijtech.v15i2.6933

sensors. In engineering, digital twins have revolutionized the way we interact with complex systems. These personalized models of complex structures, such as aircraft, enable engineers to accurately anticipate the behavior of these systems in different scenarios, thereby enhancing both safety and efficiency. Although the concept of digital twins is not novel, it has gained significant momentum in recent years thanks to advancements in sensor technology and computational power.

The roots of digital twins can be traced back to NASA's Apollo program. During the Apollo 13 mission, National Aeronautics and Space Administration (NASA) effectively used a digital twin of the spacecraft to simulate and resolve a life-threatening situation. This historical event underscores the power of digital twins in crisis management and problem-solving. Today, the application of digital twins extends far beyond aerospace. They are pivotal in environmental science, where they model forests, oceans, and climate patterns. In medicine, digital twins are reshaping personalized treatment plans and drug testing, promising a future of tailored healthcare. However, the journey to fully realize the potential of digital twins is not without challenges. Creating comprehensive digital replicas of complex systems like entire aircraft or the human body remains daunting due to computational limitations. Furthermore, ethical considerations, particularly around data privacy and security, are paramount.

Despite these challenges, the future of digital twins is bright. The convergence of predictive physics-based models, advanced machine learning techniques, and high-performance computing holds promise. The interdisciplinary field of computational science is playing a critical role in navigating these challenges, from enhancing engineering systems and understanding the natural world to improving medical outcomes. The potential of digital twins to tackle some of society's most pressing problems is not just a distant dream but an emerging reality.

The collaborative efforts of researchers, engineers, and policymakers will be instrumental in harnessing the full potential of this technology for the betterment of society. The journey of digital twins, from a concept to a transformative technology, is a vivid example of the boundless possibilities that lie at the confluence of data, modeling, and real-world application.

The Environmental Considerations for Sustainable Innovation

Innovations for the present and the future present challenges that must be overcome in order to achieve a better quality of life and reap more benefits. Deforestation and exploration of critical minerals and mining materials have been a hot issue in Indonesia for more than two decades. For example, palm oil (*Elaeis guineensis jacq*) is a plantation crop that originated from West Africa, and initially, this palm oil was imported by Sir Thomas Stanford Raffles to the Bogor Botanical Gardens in 1848. Currently, palm oil holds significant economic value for both domestic and international industries. It serves as a crucial raw material for the production of oils and green renewable energy resources. This palm oil plantation and its derivatives products have a lot of functions in life, upstream, and downstream industries. Not only as resources for oil production, but it also produces a lot of waste that can be treated and reused for many derivative products, including the energy sector such as electrode materials, the medical sector such as wound dressings, and the biopolymer sector such as biosurfactant and bioplastics. In order to promote sustainability, various biomass waste can be treated and reused for development of value-added including biomaterials that present the huge potential for medical applications such as bone Tissue Engineering, and bioaerogel scaffolds.

On the other hand, many researchers have reported and explored palm oil waste as an advanced material for producing a graphene family. Graphene as a layered structure and a structural parent of all carbon allotrope has characteristics such as monoatomic, two-dimensional (2D), sp^2 hybridization with a honeycomb lattice structure and usually has sheets types including single-layer, bilayer and few-layer less than 10. Graphene is a thermodynamically stable, and a world's thinnest material. Furthermore, the graphene is considered as an advanced material that is changing the world of science due to its extraordinary properties, including strong mechanical strength, high values of Young's modulus, extraordinary chemical stability, high surface area (2630 m^2/g), and excellent thermal conductivity (5000 W/m·s). A honeycomb-like discrete structure of graphene has the Young's modulus of 1.04 TPa. In addition, the finite element method (FEM) showed the Young's modulus value of graphene is 1.367 TPa. For graphene with zigzag and armchair sheets possess the values of modules Young are in the respective order 1.040 and 1.042 TPa, where TPa = Terapascal. The deviations in Young's modulus measurements of graphene are especially due to the intrinsic factors, defects and or uncertainties of microstructural. Usually, these defects are typically randomly distributed throughout the graphene lattice and also unpredictable. Since 2004 discovery of graphene for more than two decades is very important in the fields of scientific-technology and play a significant role in modern life.

Palm oil biomass also can be used as a carbon source such as for producing biochar and an activated carbon. These waste materials are cheaper, eco-friendly, and sustainable. They are easily and abundantly available, making them suitable as sustainable sources for synthesizing graphene families and others derivated carbon materials. Palm oil and its biomass waste have the potential to extend peoples's lives and high values to build an advanced civilization with a high impact on modern life. The potential of palm oil products is no less than that of fossil fuels and mining sources. The largest palm oil plantations in the world have been developed by many countries, including Indonesia, Malaysia, Thailand, Colombia, Nigeria, Guatemala, Papua New Guinea, and Honduras.

Beyond Disciplinary Boundaries

The overarching theme of this edition invites us to reflect on the power of collaboration. As we witness the fusion of ideas and methodologies from various engineering disciplines, it becomes evident that the future of innovation lies at the intersection of diverse fields. The call for collaborative innovation echoes loudly, challenging engineers, practitioners, and policymakers to break free from traditional boundaries and embrace a multidisciplinary approach.

The 18th International Conference on Quality in Research (QiR) 2023 aspires to serve as a global forum for deliberations on the pivotal role of science and technology in the 21st century, placing a distinct emphasis on their impact on human well-being and the cultivation of a sustainable environment. The overarching goal of this conference is to initiate a comprehensive international dialogue on the crucial contribution of sustainable technologies and environmentally conscious policies toward the realization of Net Zero Emissions in 2060, with particular attention directed towards the context of Indonesia.

The first paper is written by M.A. Budiyanto, F. Naufal, G.L. Putra, A. Riadi, D.T. Suprayogi, M. Iqbal and T.W. Pribadi. The paper utilizes computational fluid dynamics to analyze the impact of duct vane application on patrol boats. It demonstrates that duct vanes can significantly improve speed and reduce resistance by up to 40%. This research offers critical insights for enhancing the hydrodynamic performance and design of high-speed patrol boats.

The second paper is written by M.A. Berawi, M. Sari, V. Lumbantobing, S.I. Susilowati, B. Susantono, R. Woodhead and P.M. Sejatiguna. The paper focuses on enhancing the economic potential of Micro, Small, and Medium Business (MSMEs) in urban green spaces using crowdfunding. It presents a case study of Ruang Terbuka Hijau (RTH) Kalijodo in Jakarta, analyzing business opportunities in the agriculture, fisheries, and processing sectors. The study proposes a crowdfunding model, evaluating its feasibility through financial analysis like Internal Rate of Return (IRR) and payback period. It demonstrates its effectiveness in supporting MSMEs and community-based economic growth in urban green spaces.

The third paper is written by A.C. Khayrani, M. Fahmi, R.W. Nurhayati, N.H.A. Manas, and M. Suhaeri. The paper explores the impact of freeze-thaw cycles on transfersome properties for protein encapsulation. It finds that incorporating freeze-thaw cycles increases encapsulation efficiency, particle size, and polydispersity of transfersomes. The study concludes that this method significantly enhances the characteristics of dipalmitoylphosphatidylcholine (DPPC)-based transfersomes, suggesting its potential for improved drug delivery systems.

The fourth paper is written by H.R. Chaidir, Y.Y. Hng, J. Stavik, and Rochmadi. The paper investigates how different pulp fractions affect the properties and performance of the viscose process. The study reveals notable variations in chemical composition and fiber characteristics among the fractions, particularly in viscosity, molecular weight, and fiber morphology. The study concludes that certain fractions, like medium fiber-long (MFL), are more suitable for the viscose process due to their favorable properties.

The fifth paper is written by S. Octavia, H. Madeali, N. Junus, and M.M. Sir. The paper explores the unique construction and design of Rumah Kancingan, a prevalent housing style in Merauke, Indonesia. It emphasizes the use of timber and brick, examining how these materials affect the building's structure, appearance, and evolution. The research highlights the adaptability, affordability, and environmental sustainability of Rumah Kancingan, reflecting changes in material usage and architectural style over time.

The sixth paper is written by B. Annisa, and I.J. Maknun. The paper examines stormwater management strategies at the Universitas Islam Riau campus. Using the EPA’s SWMM software, the study tests three improvement scenarios: traditional drainage enhancement, low-impact development (LID) technologies, and a combination of LID techniques with rainwater harvesting. The research finds that the third scenario, incorporating various LID methods, is the most effective in reducing runoff, aligning with water conservation strategies, and supporting SDGs related to water management, resilient infrastructure, and sustainable cities.

The seventh paper, authored by R. Ardi, T. Widjaya, S.A. Putri, and D.H. Syaifullah, delves into the factors influencing the use of public transportation in Jakarta among Generations X and Y. The study integrates the Theory of Planned Behavior and the Technology Acceptance Model, assessing environmental concerns and demographic factors through expert interviews and Structural Equation Modeling. It finds that environmental concern significantly influences Generation X's behavioral intention, while Generation Y is also influenced by perceived ease of use, usefulness, and subjective norms.

The eighth paper is written by H. Ramadhan, J. Stavik, Y.Y. Hng, and M. Fahrurrozi. The paper aims to improve the suitability of palm oil empty fruit bunch fiber for Kraft pulping by focusing on optimizing the concentration of sodium hydroxide and temperature for silica removal. The study includes a two-stage process: washing to remove external silica and an alkali treatment for internal silica. Findings suggest that a combination of washing and

optimized alkali treatment effectively reduces silica content, enhancing the fiber's potential for pulp and paper industry use.

The ninth paper is written by R. Fajarani, S.F. Rahman, A.I. Pangesty, P.A. Katili, D.-H. Park, and Basari. The paper focuses on developing and analyzing scaffolds for bone tissue engineering. It examines the effects of incorporating various materials like multi-walled carbon nanotubes (MWCNT), reduced graphene oxide (rGO), titanium dioxide (TiO_2), and zinc oxide (ZnO) into a collagen/alginate/PVA matrix. The study evaluates the scaffolds' structural and chemical properties, including morphology, mechanical strength, porosity, and degradation rate, to determine their suitability for biomedical applications.

The tenth paper is written by Nurhayati, H.E. Irianto, R. Riastuti, A.I. Pangesty, A.F. Nugraha, M. Todo, A. Jumahat, and M. Chalid. The paper presents a study on extracting micro-fibrillated cellulose (MFC) from rice husk for potential biomedical uses. It details the processes involved in extraction, including alkalization, bleaching, and mechanical treatment, and analyzes the resultant MFC's chemical structure, morphology, and crystallinity. The study concludes that the mechanical treatment method enhances the crystallinity and potential biomedical applications of MFC, making it a promising material for medical fields such as drug delivery and tissue engineering.

The next paper is written by S. Arumsari, S.I. Wanandi, R.A. Syahrani, Y. Watanabe, and S. Mizuno. The paper focuses on designing an effective sgRNA for CRISPR/Cas9 to target superoxide dismutase 2 (SOD2) in breast cancer stem cells It assesses various sgRNAs to identify their effectiveness in gene editing, ultimately choosing the most promising candidate for effectively reducing SOD2 expression. The study contributes to understanding the role of SOD2 in breast cancer aggressiveness and the potential of CRISPR/Cas9 in targeted gene therapy.

The twelfth paper is written by W.N. Putra, M. Ariati, B. Suharno, A. Noviyanto and I.M. Riko. The paper investigates how adding multi-walled carbon nanotubes (MWCNT) and polyethylene glycol (PEG) to a quenching medium affects steel hardness. It shows that higher MWCNT and PEG concentrations significantly enhance the thermal conductivity of the quench medium, resulting in greater hardness of quenched steel. The study concludes that optimizing MWCNT and PEG concentrations can lead to improved heat treatment processes, offering a potential solution for the steel industry.

The thirteenth paper is written by D. Dhaneswara, A. Tsania, J.F. Fatriansyah, A. Federico, R. Ulfiati, R. Muslih, and M.S. Mastuli. The paper focuses on creating mesoporous silica from sugarcane bagasse for environmental applications. The study investigates the efficiency of this silica as an adsorbent for textile industry colorants, particularly methyl blue. It concludes that the synthesized mesoporous silica, characterized by techniques like Small-Angle X-ray Scattering (SAXS) and Scanning Electron Microscopy (SEM), shows high adsorption capacity, making it a promising, eco-friendly option for dye adsorption and heavy metal treatment in industrial waste.

The fourteenth paper is written by B. Ryan and D.N. Bristow. The paper focuses on evaluating moisture management in wood-frame building envelopes. The study utilizes hygrothermal simulations to investigate how factors such as material properties, moisture infiltration, and climatic conditions affect the risk of biodeterioration in building walls. The research provides insights into optimizing building envelope designs for improved moisture management, contributing to the sustainability and longevity of buildings.

The fifteenth paper is written by J. Sjah, N. Handika, N.K. Adnanta, M.Y. Nurhakim and E. Vincens. The paper explores the use of Modified Expanded Polystyrene (MEPS) as a partial aggregate substitute in concrete. It assesses the mechanical properties of concrete using Digital Image Correlation (DIC) and Ultrasonic Pulse Velocity (UPV), finding that

MEPS enhances these properties. The study highlights MEPS's potential in sustainable construction, showing its effectiveness in non-structural lightweight concrete applications.

The sixteenth paper is written by H. Rashid, C.M. Haremy, A.D. Othman, N.M. Hashim, N.A. Nor Izmin, and A.H. Abdullah. The paper details the design and fabrication of a custom 3D-printed assistive device for a patient with brachial plexus injury. The study utilizes finite element analysis to ensure the strength and functionality of the device, comparing materials like Polylactic Acid (PLA) and Acrylonitrile Butadiene Styrene (ABS) for optimal performance. The final prototype, created using 3D printing technology, demonstrates the potential to aid daily activities and improve the quality of life for individuals with brachial plexus injuries.

The seventeenth paper is written by D.A. Winarto, C. Liza, M.I. Fathurrohman, A. Masa and M. Chalid. The paper explores an innovative method for the hydrogenation of natural rubber using a biphasic system. It examines the effectiveness of different solvents and catalysts in enhancing the hydrogenation process. The study finds that this method can significantly improve the thermal properties of natural rubber, offering potential applications in various industries.

The eighteenth paper is written by M. Sudibandriyo and A. Rizki. The paper explores the use of activated carbon in improving ethanol purification. It investigates different influent concentrations and activated carbon weights, finding that this technique surpasses the azeotropic point and achieves high ethanol purity. The study concludes that activated carbon is effective in producing fuel-grade ethanol, indicating its promise as an alternative fuel source.

The nineteenth paper is written by H. Madani, A. Wibowo, D. Sasongko, M. Miyamoto, S. Uemiya, and Y.W. Budhi. The study focuses on enhancing CO_2 photocatalysis for solar fuel production. It explores the use of nitrogen-doped TiO_2 with cellulose nanocrystals (CNCs) and CO_2 nanobubbles. The findings of the study reveal an enhanced methanol yield and a reduction in mass transfer limitations. Ultimately, the research showcases the potential of this innovative system in facilitating efficient CO_2 conversion and generating solar fuel.

The twentieth paper is written by A. Suzianti, G.A.R.K. Devi and S.N. Fathia. The paper explores factors influencing blue-collar workers' adoption of e-recruitment tools in Indonesia. Utilizing the Unified Theory of Acceptance and Use of Technology (UTAUT) model and Partial Least Squares Structural Equation Modeling (PLS-SEM), it assesses variables like performance expectancy, effort expectancy, social influence, and facilitating conditions. The study's findings, based on responses from 212 participants, offer insights for enhancing the acceptance and use of e-recruitment platforms among blue-collar workers.

The twenty-first paper is written by M.H.M. Norli, A.H. Abdullah, A.K.A. Sukimi, and J. Mahmud. The document focuses on the static structural analysis of topology-optimized transtibial prosthetic legs. It discusses the need for prosthetic sockets to be comfortable and stable for amputees, emphasizing the use of Finite Element Analysis (FEA) to evaluate different designs. The study aims to optimize the socket design for better performance using topology optimization, revealing that lighter designs increase stress, potentially affecting durability and comfort. The ultimate goal is to create a customized, efficient prosthetic leg that improves user satisfaction.

The last paper is written by M.A. Tjhia, M.N.F. Yahya, and R.M. Ulum. The document outlines a study on enhancing the recovery and grade of rare earth elements (REEs) from monazite, a by-product of tin mining. It focuses on the mechanochemical decomposition and roasting processes to convert REE phosphate in monazite to REE hydroxide and oxide forms. The research highlights the influence of particle size on REE recovery and grade,

noting an unexpected trend of decreasing recovery and grade with finer particles, which warrants further investigation.

In conclusion, this edition of IJTech offers a glimpse into a sustainable, connected future driven by engineering innovation. As we navigate the multidisciplinary landscape and explore the potentials of the Digital Twin paradigm and carbon trading, we are propelled toward an engineering world where technology serves to enhance and support as a catalyst for positive change to achive high economic levels and at least good standards of living in the world.

May the articles within these issues inspire new ideas, foster cross-disciplinary dialogue, and contribute to the collective pursuit of engineering knowledge that transcends disciplinary confines. We extend our gratitude to the authors, reviewers, and readers who play a vital role in establishing IJTech as a platform for cutting-edge engineering research and collaborative exploration.

With sincere gratitude from the editorial desk,

Dr. Arnas
Editor Board

Prof. Dr. Yudan Whulanza
Editor in Chief

Dr. Eny Kusrini
Managing Editor