ICEM 5th Virtual International Undergraduate Research Conference

(ICEM-5VIURC 2024)

4 – 5 December 2024

THEME: Innovative Pathways to a Sustainable Future

CONFERENCE PROCEEDINGS

EDITED BY:
Associate Prof. Dr. Majed A. A. Aldahdooh

HOSTED BY:
International College of Engineering and Management (ICEM), Muscat, Oman

IN COLLABORATION WITH:
Vimal Jyothi Engineering College, India
BRAINS Institute Peshawar, Pakistan

VIMAL JYOTHI ENGINEERING COLLEGE

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BRAINS INSTITUTE PESHAWAR

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Message from the Conference Chair

I extend my heartfelt gratitude to everyone who contributed to the success of the ICEM 5th Virtual International Undergraduate Research Conference (ICEM 5VIURC 2024). Special thanks to the Dean of the College for his unwavering encouragement, the Assistant Dean for Academic Affairs for his invaluable guidance, and our co-organizers, Vimal Jyothi Engineering College, India, and BRAINS Institute, Peshawar, Pakistan, for their steadfast support. I am deeply grateful to our keynote speakers, conference co-chairs, session chairs, moderators, and observers for ensuring seamless proceedings, and to the Chair and team of the Research and Ethics Committee, Heads of Departments, IT Department, and Marketing Team for their dedication and contributions. A special acknowledgment goes to all participants and presenters for sharing their exceptional research and fostering meaningful discussions. Together, we have demonstrated the critical role of undergraduate research in driving innovation, collaboration, and academic excellence.

Associate Prof. Dr. Majed A. A. Aldahdooh
Conference Chair

Conference Overview

ICEM 5th Virtual International Undergraduate Research Conference (ICEM-5VIURC 2024)
Innovative Pathways to a Sustainable Future
4–5 December 2024
Virtual Conference via MS Team

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*The **ICEM-5VIURC 2024** aimed to foster interdisciplinary collaboration and provide undergraduate students with a platform to showcase innovative research, contributing to sustainable global solutions.*

SUB-THEMES

Sustainable Energy and Environmental Management
Advanced Engineering and Technologies
Health, Safety, and Natural Science
Artificial Intelligence and Data Science
Business Management, Tourism, and Social Sciences
Teaching and Learning, Media, and Journalism Studies

HOSTED BY:

International College of Engineering and Management (ICEM), Muscat, Oman

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Vimal Jyothi Engineering College, India
BRAINS Institute Peshawar, Pakistan

CONFERENCE COMMITTEE:

CONFERENCE CHAIR:

Associate Professor Dr. Majed Aldahdooh

CO-CHAIRS:

Assistant Professor Dr. Nasir Khan
Assistant Professor Dr. Ajaya Kumar
Ms. Fatima Z

KEYNOTE SPEAKERS:

Associate Professor, Dr. Tarek Al-Arabi Omar Ganat, , Sultan Qaboos University
Associate Professor, Dr. Imran Khan, Sultan Qaboos University
Assistant Professor, Dr. Ihsanullah Obaidullah, University of Sharjah
Principal, Dr Benny Joseph,Vimal Jyothi Engineering College
Associate Professor, Dr. Qazi Adnan Ahmad, China University of Mining & Technology
Postdoctoral Researcher, Dr. Jafar Qajar, Utrecht University
Associate Professor, Dr. Rooh Ullah, University of Turbat

REVIEW COMMITTEE MEMBERS:

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Associate Professor Dr. Salem Abu Amr
Ali Imran Merchant
Amal Stanselaus George

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Associate Professor Dr. Majed A. A. Aldahdooh	Azza Humaid Rashid Al Saaidi
Assistant Professor Dr. Don Anton Robles Balida	Eldar Abdullayev
Assistant Professor Dr. Hashim Osman Elbadri	Lekha Kozhiparambath
Assistant Professor Dr. M. Shahnawaz Khan	Meet Arunkumar Panchal
Assistant Professor Dr. Riyad Ageli Saleh Mahfud	Rasha Ali Abdelrahim
Assistant Professor Dr. Sreejaya K V	Saada Salim Mohammed Al Habsi
Assistant Professor Dr. Suvarnaraju Palathoti	Shajira Seema T. Cheeruveettil
Assistant Professor Dr. Eiman Mohamed Ibrahim Ali	Sheikha Saif Hamdan Al Shekaili
Assistant Professor Dr. Nasir Khan	Sivi Varghese
Assistant Professor Dr. Ajaya Kumar	Victor Olabode Otitolaiye
Alex Bernard Viswanathan Kanaka Bai	Fatima Z

SESSION CHAIRS:

Assistant Professor Dr. Don Anton Robles Balida	Ali Imran Merchant
Assistant Professor Dr. Nasir Khan	Asif Zamir
Assistant Professor Dr. Riyad Ageli Saleh Mahfud	Lekha Kozhiparambath
Assistant Professor Dr. Ajaya Kumar	Meet Arunkumar Panchal
Assistant Professor Dr. Hashim Osman Elbadri	Sheikha Saif Hamdan Al Shekaili
Assistant Professor Dr. Eiman Mohamed Ibrahim Ali	Rasha Ali Abdelrahim
Assistant Professor Dr. Suvarnaraju Palathoti	Azza Humaid Rashid Al Saaidi
Assistant Professor Dr. M. Shahnawaz Khan	Victor Olabode Otitolaiye
Alex Bernard Viswanathan Kanaka Bai	

INTENDED PARTICIPATION WAYS:

Full Paper and Give an Online PowerPoint Presentation
Full Paper and Give an Online Poster Presentation
Full Paper and Attend as a Listener
Abstract and Give an Online PowerPoint Presentation
Abstract and Give an Online Poster Presentation
Abstract and Attend as a Listener

TOTAL NUMBER OF SUBMISSIONS and PARTICIPATION SUMMARY:

28 research submissions (20 abstracts, 8 full papers) from Oman, UAE, Pakistan, India, and beyond.

12 presenters showcased their research through PowerPoint and poster sessions.

250+ attendees participated, fostering global academic collaboration and excellence

REVIEW & EVALUATION PROCESS

All submissions underwent initial screening, double-peer review, and revisions, with final decisions ensuring academic rigor, while presentations were assessed for delivery, visual quality, and time management, recognizing outstanding presenters through awards.

AWARDS:

All participants received Certificates of Participation.

Best Presenter Awards recognized outstanding presenters:

Zeeshan Amjad, University of Chakwal, Punjab Pakistan.

Rasha Najeh Ahmad Abdulraheem, University of Dundee, UAE.

Al Waleed Yousuf Ali Harib Al Maharbi, International College of Engineering and Management, Oman.

Congratulations to Our Best Presenters

ICEM 5th Virtual International Undergraduate Research Conference

4 – 5 December 2024

Zeeshan Amjad
University of Chakwal, Pakistan

Al Waleed Al Maharbi
International College of Engineering & Management, Oman

Rasha Najeh Abdulraheem
University of Dundee, UAE

Your exceptional presentations and dedication have greatly enriched the success of ICEM-5VIURC 2024.

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Promotional Materials

Thank you all for making this conference a resounding success…...!

ICEM-5VIURC 2024 Tentative Program

Day 1: Opening ceremony and keynote talks were delivered in a hybrid format, combining in-person participation at Room E12, ICEM campus, and virtually via MS Teams.

Day 2: Research presentations were conducted entirely online through MS Teams, featuring PowerPoint and poster sessions.

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ICEM 5th Virtual International Undergraduate Research Conference
04 – 05 December 2024

Conference Tentative Program

Day 1: 4th December 2024

We are delighted to have you join us via the **MS Teams** link **[Click here to join]**
Meeting ID: 312 282 449 539, **Passcode:** eG2mn6q8

Time	Activity	Presenter/ Organizing Team
8:30 – 9:00 am	Registration	**Organizing Team**
9:00 – 9:02 am	Oman National Anthem	
9:02 – 9:05 am	ICEM Anthem	
9:05 – 9:15 am	Holy Quran	**Mr. Ahmed Abdullah Hamood AL Sumri** WE-Student, ICEM
9:15 – 9:30 am	Welcome Address	**Dr. Yingkui Zhao** Dean, ICEM
	Co-Organizers Talks	
9:30 – 9:45 am	Project Management and the Challenges in the Housing Sector	**Prof Dr. Engr. Muhammad Zeeshan Ahad** Director, BRAINS INSTITUTE PESHAWAR
9:45 – 10:00 am	Engineering Success: The Vimal Jyothi Educational Ecosystem	**Dr Benny Joseph** Principal, Vimal Jyothi Engineering College
	Keynote Talks	
10:00 – 10:30 am	The Energy Transition to Sustainability: Challenges and Opportunities for the Oil & Gas Industry	**Dr. Tarek Al-Arabi Omar Ganat** Associate Professor, Sultan Qaboos University
10:35 – 11:05 am	Ionic Liquids and Rhodamine B: A New Perspective on Aggregation in Mixed Solvents	**Dr. Imran Khan** Associate Professor, Sultan Qaboos University
11:10 – 11:30 am	**Break (20 minutes)**	
11:35 am – 12:05 pm	UN SDG 6 - Clean Water and Sanitation: Meeting Global Challenges Through Innovation	**Dr. Ihsanullah Obaidullah** Assistant Professor, University of Sharjah
12:10 – 12:40 pm	Fusion Energy: Challenges, Innovations, and the Path Forward	**Dr Benny Joseph** Principal, Vimal Jyothi Engineering College
12:45 – 01:15 pm	Towards forecasting volcanic eruption through the analysis of Vp/Vs ratios in media: application to Redoubt volcano, Alaska	**Dr. Qazi Adnan Ahmad** Associate Professor, China University of Mining & Technology
01:20 – 01:40 pm	**Break (20 minutes)**	
01:45 – 02:15 pm	Advanced imaging techniques to understand physico-biochemical processes in Subsurface Rocks	**Dr. Jafar Qajar** Postdoctoral Researcher, Utrecht University
02:20 – 02:50 pm	The Rational Design of Green Nanocomposites Materials for Environmental Detoxification of Pollutants	**Dr. Rooh Ullah** Associate Professor, University of Turbat
02:55 – 03:25 pm	**Discussion and Recommendation**	
03:30 pm	**Closing**	

For any assistance, feel free to reach out to us:
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ICEM 5th Virtual International Undergraduate Research Conference
04 – 05 December 2024

Conference Tentative Program

Day 2: 5th December 2024 (Presentation Sessions)

We are delighted to have you join us online for **Day 2** of **ICEM-5VIURC2024** via **MS Teams** link **[Click here to join]**, **Meeting ID:** 312 282 449 539, **Passcode:** eG2mn6q8

Time	Presentation Title	Presenter/ Organizing Team
08:30 – 09:00 am	Registration	**Organizing Team**
09:00 – 09:20 am	Enhancing Performance of Aircraft Radial Engine through Advanced 3D Modeling & Simulation Techniques	Zeeshan Amjad
09:20 – 09:40 am	Biopolymer Triboelectric Nanogenerators (BP-TENGs): Sustainable Energy Solutions for Wearable and IoT Devices	Abdul Rahman
09:40 – 10:00 am	Enhanced Methodology for Measuring the Thermal Conductivity of Acetone Using the EDIBON TCLGC Apparatus	Syed Raza Ali
10:00 – 10:20 am	**Break (20 minutes)**	
10:20 – 10:40 am	Optimizing Packaging Design Through Generative Design and Additive Manufacturing	Noor Ul Mustafa
10:40 – 11:00 am	A CFD Numerical Study of Wax Deposition in The Waxy Crude Oil Pipelines with and Without Nichrome Wire	Al Waleed Y. Al Maharbi
11:00 – 11:20 am	Design and fabrication of lifting system to support mud mixing operations at Oil Rig	Abdulmalik Marwan Salim AL-BREIKI
11:20 – 12:00 noon	**Lunch Break (40 minutes)**	
12:00 – 12:20 pm	Design and Optimization of a Cost-Effective XY CNC Pen Plotter with Integrated Feedback System	Zeeshan Amjad
12:20 – 12:40 pm	Project-Based Learning Between Theory and Practice	Ms. Rasha AbdulRaheem
12:40 – 01:00pm	Development Of Decision-Tree Based for The Prediction of Co_2 Emissions in The Sultanate of Oman	Nasser Hamood Al Sawwafi
01:00 – 01:20 pm	Analyzing the Strength of Aluminum Oxide (AL2O3) Nanoparticle-Fly Ash Class G Cement in Wellbore Conditions	Khalid Ghaniemi, Mr. Asif
01:20 – 01:40 pm	**Break (20 minutes)**	
01:40 – 02:00 pm	A Novel Approach to Developing a Unique Fire-Retardant Coating to Enhance Fire Safety and Environment	Shahad Salim Mohammed Alalawi, Mr. Amal
02:00 – 02:20 pm	Investigating the Effectiveness of Oil-Based Mud Modified with Nano-Silica for Cutting Transportation	Bayan Ahmed Al Nkhili, Mr. Asif
02:20 – 02:40 pm	Challenges and Benefits of BIM Implementation for Facilities Management in operation and maintenance.	Rawan Ahmed Al-farsi
02:40 – 03:00 pm	Discussion and Recommendations	
03:00 pm	**Closing**	

We look forward to your participation and hope you have a productive and engaging experience at ICEM-5VIURC 2024.

For any assistance, feel free to reach out to us:
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The event brought together inspiring talks and innovative research contributions, showcasing the value of undergraduate research in fostering academic excellence and collaboration.

Day 1: Opening ceremony, 4 Dec 2024, at 09:00 am.

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Chapter 1: Abstracts

This chapter presents the abstracts of selected research submissions, addressing key topics under the conference theme, *"Innovative Pathways to a Sustainable Future."* The abstracts reflect cutting-edge studies in engineering, sustainability, technology, energy, and management, fostering interdisciplinary solutions to global challenges. The following is the list of abstracts included in this chapter:

Optimizing Laser-Assisted Machining Processes Improves Precision in Titanium Alloys and High-Strength Steels

Zeeshan Amjad, Engr. Dr. Aqib Mashood Khan

Project-Based Learning Between Theory and Practice

Rasha AbdulRaheem

Review: Biopolymer Triboelectric Nanogenerators: Sustainable Energy Harvesting for the Next Generation of Wearable and Internet of Things Devices

Engr. Abdul Rahman

Study of Repair Needs at International Airports in Oman

Hiba A. Al-Jahwaria, Majed A. A. Aldahdooh, Shajira Seema T.C, Azza H. Al Saaidi, Sheikha S. Al Shukaili, Rami J. A. Hamad

Impact of Total Quality Management on Construction Projects

Salama S. Alkaabi, Majed A. A. Aldahdooh, Sheikha S. Al Shukaili, Rami J. A. Hamad, Shajira Seema T.C, Azza H. Al Saaidi

Exploring Awareness, Perceptions, and Decision-Making Factors for Residential Solar Adoption in Muscat

Hiba E. F. Al-Harrasi, Majed A. A. Aldahdooh, Rami J. A. Hamad, Azza H. Al Saaidi, Sheikha S. Al Shukaili, Shajira Seema T.C

Optimizing Packaging Design Through Generative Design and Additive Manufacturing

Noor Ul Mustafa

Evaluating the Effectiveness of Epoxy Resin and Modified Drilling Fluid for Corrosion Prevention on Drill Pipes

Abdul Rahman Mouhammed Youssef, Asif Zamir

Analyzing the Strength of Aluminum Oxide (Al_2O_3) Nanoparticle-Fly Ash Class G Cement in Wellbore Conditions

Khalid Mohammed Obaid Said Al Ghenaimi, Asif Zamir

Rheological Modeling of Saline Oil-Based Nanofluid

Zainab Mohammed Al-Malki, Asif Zamir

Investigating the Effectiveness of Oil-Based Mud Modified with Nano-Silica for Cutting Transportation

Bayan Ahmed Al Nkhili, Asif Zamir

Causes and Impacts of Poor Communication in Construction Projects in Oman

Rawaa Y. Al Hinai, Shajira Seema T.C, Majed A. A. Aldahdooh, Azza H. Al Saaidi, Sheikha S. Al Shukaili, Rami J. A. Hamad

Design and Fabrication of Lifting System to Support Mud Mixing Operations at Oil Rig

Abdul-Malik Marwan Salim Al-Breiki

A Novel Approach to Developing a Unique Fire-Retardant Coating to Enhance Fire Safety and Environmental Sustainability

Shahad Salim Mohammed Alalawi, Amal George

Random Forest vs. ANN for Predicting Gas Hydrate Formation Pressure

Hamed Ali Jahwari, Nasir Khan

Development of Decision Tree-Based Model for the Prediction of CO_2 Emission in the Sultanate of Oman

Nasser Al Sawwafi, Eman Al-Naamani, Nasir Khan

Experimental Study to Investigate the Effect of Fly Ash on the Rheological Characteristics of Water-Based Mud Under Static Condition

Abdullah Salem Al-Balushi

Each abstract demonstrates a unique approach to addressing real-world problems, combining innovative methodologies and technologies. This compilation highlights the diverse research contributions of undergraduate students and emphasizes their role in promoting sustainable development, scientific advancements, and practical solutions for contemporary challenges.

Optimizing Laser-Assisted Machining Processes Improves Precision in Titanium Alloys and High-Strength Steels

Zeeshan Amjad[1*], Engr. Dr. Aqib Mashood Khan[2]

[1]Department of Mechatronics Engineering, University of Chakwal, Punjab, Pakistan, zeeshan.mte07@gmail.com

[2]Nanjing University of Aeronautics and Astronautics, China, engr.aqib111@gmail.com

Abstract

This paper discusses optimized laser-assisted machining (LAM) as a potential means to enhance precision and efficiency in processing titanium alloys and high-strength steels. Combining laser ablation with traditional cutting methods addresses significant challenges, such as low material removal rates and excessive tool wear, resulting in benefits for both production efficiency and product quality. A comprehensive experimental framework was developed to examine the effects of key laser process parameters, including pulse width, wavelength, and energy density, on machining performance. Additionally, a predictive model integrating machine learning algorithms with finite element analysis (FEA) was designed to simulate thermal-mechanical interactions during the LAM process. The results demonstrate a strong correlation between optimized laser configurations and enhanced machining performance, highlighting improvements in precision, tool life, and production rates. This work underscores LAM's promising role in advanced manufacturing applications requiring high strength and precision.

Keywords: *Laser-Assisted Machining, Titanium Alloys, High-Strength Steels, Process Optimization, Predictive Modeling.*

Project-Based Learning Between Theory and Practice

Rasha AbdulRaheem

UCAM University, UAE. rashabdulraheem@gmail.com

Abstract

In recent years, educational reforms worldwide have emphasized preparing learners for real-world scenarios by equipping them with essential skills. Project-based learning (PBL) has emerged as a favored experiential approach, fostering deeper learning, motivation, and engagement compared to traditional didactic methods. This study explores strategies that schoolteachers in the U.A.E. employ to enhance student motivation and engagement in PBL environments. Using a social constructivist paradigm and a qualitative approach, the research applied descriptive phenomenology, collecting data through five semi-structured interviews analyzed thematically. The findings highlight a variety of motivating and engaging strategies, including the role of teachers as facilitators, technology integration (e.g., AI platforms), and strategies to support SEND (Special Educational Needs and Disabilities) students. Teachers' self-efficacy and autonomy were identified as critical factors in overcoming PBL challenges and maintaining student motivation. Additionally, the study underscores the use of technology to address student weaknesses and ensure better learning outcomes. These insights provide practical guidance for educators, particularly in the U.A.E., where PBL aligns with the nation's 21st-century educational vision. This research contributes to the broader understanding of PBL practices in the Middle Eastern context and serves as a resource for practitioners aiming to motivate and engage learners effectively.

Keywords: *Project-Based Learning, 21st-Century Skills, Social Constructivism, Motivation, Technology, Artificial Intelligence, Autonomy, United Arab Emirates (U.A.E.).*

Review: Biopolymer Triboelectric Nanogenerators: Sustainable Energy Harvesting for the Next Generation of Wearable and Internet of Things Devices

Engr. Abdul Rahman

Precision Systems Training Centre – PCSIR Lahore, abdulrahmana18@pm.me

Abstract

The growing demand for sustainable energy solutions, particularly for wearable devices and the Internet of Things (IoT), has led to advancements in Biopolymer Triboelectric Nanogenerators (BP-TENGs). BP-TENGs utilize eco-friendly, biodegradable polymers such as cellulose, chitosan, and silk fibroin as alternatives to synthetic materials. These biopolymers offer significant benefits, including flexibility, mechanical strength, and enhanced triboelectric properties, which enable applications in wearable sensors, health monitoring devices, and smart textiles. Advances in fabrication techniques, such as 3D printing and electrospinning, have allowed for customizable BP-TENG designs tailored for various applications. A comprehensive review of the literature indicates that BP-TENGs achieve large power densities, with cellulose-based devices reaching up to 200 mW/m², while demonstrating durability through extensive operational cycles. Despite these promising capabilities, challenges remain in scalability and environmental stability, which limit large-scale deployment. This review highlights the potential of BP-TENGs for sustainable and persistent energy harvesting, offering solutions for next-generation wearable and IoT devices. Future research directions are also proposed to address existing limitations and enhance their viability for real-world applications.

Keywords: *Energy Harvesting, Nano Energy and Nanosystem, Self-Powered Sensor, Triboelectric Nanogenerator, Wearable Sensor.*

Study of Repair Needs at International Airports in Oman

Hiba A. Al-Jahwaria[1], Majed A. A. Aldahdooh[2*], Shajira Seema T.C[3], Azza H. Al Saaidi[4], Sheikha S. Al Shukaili[5], Rami J. A. Hamad[6]

Department of Facilities and Construction Project Management, International College of Engineering and Management | University of Central Lancashire (UK), P.C. 111, Muscat, Oman.

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Abstract

This study examines the repair needs and facilities management practices at international airports in Oman. Using a mixed-methods approach, data were collected through structured questionnaires and online interviews with facilities management professionals. Quantitative data was analyzed using SPSS, and qualitative data was thematically analyzed. The findings indicate that while 70% of respondents identified critical repair needs in areas such as runway resurfacing and HVAC systems, 50% expressed satisfaction with current practices but highlighted inefficiencies in preventive maintenance. Key challenges include budget constraints and delays in procurement, with only 33% of airports adopting modern technology for facilities management. The study concludes that addressing these gaps will enhance the efficiency and sustainability of airport operations in Oman.

Keywords: Facilities management, repair needs, international airports, Oman, preventive maintenance

Impact of Total Quality Management on Construction Projects

Salama S. Alkaabi[1], Majed A. A. Aldahdooh[2*], Sheikha S. Al Shukaili[3], Rami J. A. Hamad[4], Shajira Seema T.C[5], Azza H. Al Saaidi[6]

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Abstract

This research explores the impact of Total Quality Management (TQM) on construction projects, focusing on project quality, cost control, and schedule management. Using a mixed-methods approach, data was collected from construction professionals through structured questionnaires and in-depth interviews. Quantitative data were analyzed using descriptive statistics, while qualitative data were thematically analyzed. The findings reveal that although TQM principles are moderately understood and have shown some improvement in project outcomes, significant barriers remain, including resistance to change (40%) and lack of top management support (60%). The study concludes that enhancing communication, training, and stakeholder involvement are crucial to overcoming these challenges and improving TQM implementation in the construction industry. These efforts will lead to better project performance and stakeholder satisfaction.

Keywords: Total Quality Management, Construction, Project Quality, Cost Control, Schedule Management

Exploring Awareness, Perceptions, and Decision-Making Factors for Residential Solar Adoption in Muscat

Hiba E. F. AL-Harrasi[1], Majed A. A. Aldahdooh[2*], Rami J. A. Hamad[3], Azza H. Al Saaidi[4], Sheikha S. Al Shukaili[5], Shajira Seema T.C[6]

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Abstract

This study explores the awareness, perceptions, and decision-making factors influencing the adoption of residential solar energy in Muscat, Oman. A quantitative approach was employed using stratified random sampling and a structured questionnaire distributed to Muscat residents. Data were analyzed using SPSS for quantitative data and NVivo for qualitative analysis. The findings reveal that **50%** of participants were familiar with solar energy, yet significant barriers such as high installation costs (**39%**) and concerns about system reliability (**35%**) hindered adoption. Government incentives were viewed as critical, with **36%** of respondents deeming them "very important" for adoption decisions. The study concludes that to increase adoption rates, enhanced awareness campaigns, technical education, and improved financial incentives are essential. These efforts will address barriers and promote a transition toward sustainable energy practices in Oman.

Keywords: Solar Energy, Awareness, Decision-Making, Renewable Energy

Optimizing Packaging Design Through Generative Design and Additive Manufacturing

Noor Ul Mustafa

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Abstract

Generative design and additive manufacturing techniques enable the creation of highly optimized, lightweight, and cost-effective solutions. This research explores the application of generative design using Fusion 360 to develop protective cases for fragile equipment and transport containers for medicines or hazardous materials. The study aims to create packaging that meets strength and durability requirements while reducing weight and material usage. Designs generated in Fusion 360 are validated through simulations to ensure they can withstand mechanical stresses typical to the intended use cases. Additive manufacturing is employed to produce these packaging solutions, achieving significant reductions in both weight and production costs. The findings demonstrate that combining generative design with 3D printing creates cost-effective, material-efficient packaging solutions suitable for industries such as electronics and pharmaceuticals. This method is particularly beneficial for made-to-order products, such as medicine vials, while promoting sustainability by minimizing environmental impact through the use of recycled filaments in 3D printing.

Keywords: *Generative Design, Additive Manufacturing, Fusion 360, Lightweight Packaging, Cost-Effective Solutions, Protective Cases.*

Evaluating the Effectiveness of Epoxy Resin and Modified Drilling Fluid for Corrosion Prevention on Drill Pipes

Abdul Rahman Mouhammed Youssef, Asif Zamir*

Well Engineering Department, International College of Engineering and Management | University of Central Lancashire (UK), P.C. 111, Muscat, Oman. *asif@icem.edu.om

Abstract

The oil and gas industry faces significant challenges during drilling and production operations, with corrosion being one of the most critical issues. Drill pipes are particularly susceptible to corrosion due to harsh environmental conditions, including the interaction of chemicals, drilling fluids, high pressures, temperatures, and acidity. Major contributors to internal corrosion include hydrogen sulfide (H_2S), carbon dioxide (CO_2), water, and microbiological activity, which exacerbate the degradation process. This study addresses the critical economic and operational losses caused by corrosion in the energy sector and investigates effective solutions. Among various mitigation methods, corrosion inhibitors and epoxy resin coatings have demonstrated significant potential as cost-efficient and durable approaches. This research focuses on the results of an experiment designed to protect drill pipes by applying corrosion inhibitors in modified drilling fluids and coating the pipes with epoxy resin. The findings confirm that this combination effectively mitigates corrosion, extending the operational life of drill pipes and minimizing economic losses in the oil and gas industry.

Keywords: *Epoxy Resin, Corrosion, Corrosion Inhibition, Drilling Fluid, Drill Pipe.*

Analyzing the Strength of Aluminum Oxide (Al_2O_3) Nanoparticle-Fly Ash Class G Cement in Wellbore Conditions

Khalid Mohammed Obaid Said Al Ghenaimi, Asif Zamir*

Well Engineering Department, International College of Engineering and Management | University of Central Lancashire (UK), P.C. 111, Muscat, Oman. *asif@icem.edu.om

Abstract

In oil and gas well construction, the cement sheet serves as a crucial bond between the formation and casing, ensuring well integrity and preventing fluid migration to the surface. Class G Portland cement is commonly used for this purpose; however, conventional cement formulations can exhibit defects under wellbore conditions. This study investigates the effects of aluminum oxide (Al_2O_3) nanoparticles and fly ash as additives to Class G cement, focusing on their impact on uniaxial compressive strength (UCS) under various curing times and concentrations. Six experimental designs were conducted to evaluate the influence of different combinations of nanoparticles and fly ash on cement strength. The results demonstrate that adding both fly ash and Al_2O_3 significantly improved UCS, particularly at 12 hours of curing time, where a 12% increase was observed compared to individual additives. However, increasing the fly ash concentration negatively affected UCS at 24 hours, reducing strength by 29% compared to base Class G cement. In contrast, UCS values for cement with Al_2O_3 remained stable at 24 hours, showing consistent improvement. Overall, UCS values increased with longer curing times, reaching their highest at 36 hours regardless of the additive combination. This study highlights the potential of nanoparticles and fly ash to optimize cement properties in wellbore conditions while emphasizing the need to carefully control additive proportions to avoid adverse effects on strength.

Keywords: *Compressive Strength, Nanoparticle, Cement, Drilling, Aluminum Oxide.*

Rheological Modeling of Saline Oil-Based Nanofluid

Zainab Mohammed Al-Malki, Asif Zamir*

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Abstract

In drilling operations, oil-based mud (OBM) is widely recognized for its superior properties. However, clay swelling caused by water movement from OBM into the formation can result in wellbore instability and hinder drilling operations. This study aims to develop a rheological model for saline oil-based fluids modified with nano-silica, focusing on their rheological behavior and ability to reduce clay swelling. Nanoparticles, such as nano-silica, enhance the rheological properties of OBM, while NaCl acts as a clay swelling inhibitor by regulating the water phase salinity. In this research, multiple experiments were conducted by adding 5g, 10g, and 15g of NaCl to OBM along with varying concentrations of nano-silica (0.5g, 1g, and 1.5g) to investigate rheological parameters such as plastic viscosity (PV), yield point (YP), and gel strength (GS). The results demonstrate that increasing the NaCl concentration, particularly at 10g and 15g, combined with 1.5g of nano-silica, significantly improves the rheological behavior of OBM while effectively reducing clay swelling. This combination enhances mud stability and ensures wellbore integrity during drilling operations. The findings highlight the potential of using nano-silica and NaCl as effective rheology modifiers and inhibitors for mitigating clay swelling, thus offering practical solutions for improving drilling performance.

Keywords: *Rheological Modeling, Nanoparticle, Brine, Saline, Drilling, Silicon Dioxide.*

Investigating the Effectiveness of Oil-Based Mud Modified by Nano-Silica for Cutting Transportation

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Abstract

The inability of drilling fluids to maintain appropriate rheological properties remains a significant challenge in drilling operations, often causing nonproductive time (NPT) and reduced rate of penetration (ROP) due to poor cuttings transport and inadequate hole cleaning. This research investigates the influence of nano-silica on the performance of oil-based mud (OBM) in enhancing cuttings transportation in shale formations. The study focuses on evaluating the rheological behavior of OBM with varying concentrations of nano-silica and analyzing improvements in cuttings suspension and transport. Standard laboratory procedures were employed to measure key rheological properties, including plastic viscosity (PV), yield point (YP), and gel strength (GS). The results demonstrate that the addition of nano-silica significantly enhances the rheology and carrying capacity of OBM. Specifically, a concentration of 0.5g nano-silica improved plastic viscosity, carrying capacity, and cuttings suspension ability up to an optimized point. However, beyond this concentration, efficiency decreased due to particle accumulation and over-saturation. The findings highlight the critical role of nano-silica in improving OBM performance, reducing NPT, and optimizing drilling efficiency through enhanced cuttings transport and hole cleaning.

Keywords: *Oil-Based Mud, Cutting Transport, Drilling Fluid, Nano Fluid, Nano Silica.*

Causes and Impacts of Poor Communication in Construction Projects in Oman

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Abstract

Communication is a critical aspect of the construction industry, as poor communication often leads to financial losses and project failures. The complexity of communication in construction projects arises due to the involvement of multiple stakeholders engaged in contractually driven, dynamic relationships. This research investigates the causes and impacts of poor communication within the construction industry in Oman. A systematic literature review and a questionnaire survey were employed as primary methodologies, with surveys distributed to experienced professionals working on various construction projects. The results revealed that the primary causes of poor communication include a lack of knowledge and inadequate communication training (31%), strained relationships between stakeholders (25%), and a lack of trust between project parties (25%). Other contributing factors include linguistic and cultural barriers, poor project management skills, and unmotivated employees (19%). The study concludes by proposing strategies to improve communication, such as conducting regular meetings, preparing daily reports, and utilizing email to enhance collaboration among stakeholders. These findings provide practical insights for improving stakeholder relationships and project outcomes in Oman's construction industry.

Keywords: *Construction Industry, Stakeholder Relationships, Project Management, Communication Barriers, Oman Construction Projects.*

Design and Fabrication of Lifting System to Support Mud Mixing Operations at Oil Rig

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Abstract

Mud mixing operations are essential processes in oil and gas well drilling, facilitating drilling speed and pressure control inside the hole. The use of chemical sacks, such as Xanthan gum polymer sacks, plays a critical role in removing large cuttings through high-viscosity pressure. This study addresses the lack of efficient lifting systems in Wilayat Adam, a prominent oil exploration area in Oman, which poses safety risks for drilling rig workers handling dangerous chemicals and heavy sacks daily. A field visit to a drilling rig in Adam was conducted to identify challenges and gather data for designing a practical lifting solution. Using SolidWorks software, a lifting system (Break System) was designed, with an estimated total weight of 539 kg and a cost of $2211 (approximately 847 Omani Riyals). The system is designed with medium dimensions to accommodate the limited space near the hopper on the drilling platform. Additionally, it considers environmental challenges, such as high pressures and wind speeds reaching 40 km/h. The results of this study confirm the feasibility of designing a lifting system that enhances worker safety, improves material handling efficiency, and meets the spatial and environmental constraints of drilling rigs in Oman.

Keywords: *Analytical Methods, Simulation, Mechanism, Prototype, Lifting.*

A Novel Approach to Developing a Unique Fire-Retardant Coating to Enhance Fire Safety and Environmental Sustainability

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Abstract

This experimental study aims to develop fire-resistant paint by incorporating fire-retardant materials to enhance fire safety and minimize environmental risks. Fire-resistant paint plays a crucial role in reducing damage, delaying ignition, protecting surfaces from fire spread, and lowering smoke emissions. Gypsum, known for its excellent fire resistance properties, was used as the primary material for creating the fire-retardant coating. The benefits of gypsum-based coating include providing a protective layer that shields surfaces from flames, reducing toxic smoke emissions, and increasing the duration of fire protection. The paint was applied to specific wooden specimens to evaluate its effectiveness. Ignitability tests were conducted in a controlled combustion chamber, assessing key parameters such as flame spread and temperature resistance. The findings demonstrate that the developed fire-resistant coating significantly improves heat resistance, delays ignition, and offers enhanced fire protection for wooden surfaces, presenting a sustainable solution for fire safety.

Keywords: *Fire-Resistant Paint, Gypsum, Heat Resistance, Ignition Time.*

Random Forest vs. ANN for Predicting Gas Hydrate Formation Pressure

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Abstract

Understanding the conditions for gas hydrate formation is crucial for efficient management in processes like flow assurance and deep-water drilling operations. This study focuses on predicting hydrate formation pressure using machine learning (ML) techniques based on two input parameters: temperature and specific gravity. A predictive model was developed in Python 3.11.3 utilizing open-source libraries such as scikit-learn (v1.2.2) and Keras with TensorFlow. The temperature range considered spans from -35.3°F to 114°F, and specific gravity ranges from 0.4 to 0.85. The dataset was normalized and split into 70% for training, 15% for validation, and 15% for testing. Two ML models—Random Forest (RF) and Artificial Neural Networks (ANNs)—were compared using performance metrics such as the coefficient of determination (R^2) and Root Mean Squared Error (RMSE). The results demonstrated that the RF model outperformed the ANN model, achieving an R^2 of 0.999 and an RMSE of 99.06, compared to an R^2 of 0.96 and an RMSE of 4327.344 for the ANN model. These findings provide a practical solution for predicting gas hydrate formation conditions, enabling operators to take preventive measures, improve operational safety, and enhance process efficiency in the petroleum industry.

Keywords: *Gas Hydrate, Artificial Neural Networks, Random Forest, Artificial Intelligence.*

Development of Decision Tree-Based Model for the Prediction of CO_2 Emission in the Sultanate of Oman

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Abstract

Fossil fuels play a critical role in the Gross Domestic Product (GDP) of the Sultanate of Oman; however, their significant contribution to greenhouse gas emissions, particularly CO_2, remains a challenge. This research develops a decision tree-based predictive model to analyze CO_2 emissions in Oman, utilizing historical data from 1965 to 2022. The study employs Python 3.11.3 and its robust libraries, including scikit-learn (version 1.2.2) and Keras with TensorFlow, to process and analyze eleven parameters influencing CO_2 emissions. The dataset was divided into training (70%), validation (15%), and testing (15%) sets, with data normalization applied beforehand. The model achieved high accuracy, with R^2 values of 1.00, 0.98, and 0.99 and RMSE values of 0.0, 2.44, and 2.14 for training, validation, and testing stages, respectively. Results indicate that electricity generation is the largest contributor to CO_2 emissions, followed by natural gas usage. This highlights the urgent need to develop renewable energy sources and alternative solutions. The findings provide valuable insights for policymakers and environmental initiatives, aligning with Oman's net-zero emissions goal by 2050 as outlined in the 2023 national report.

Keywords: *CO_2 Emissions, Decision Tree, Machine Learning, Artificial Intelligence, Oman.*

Experimental Study to Investigate the Effect of Fly Ash on the Rheological Characteristics of Water-Based Mud Under Static Condition

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Abstract

This experimental study investigates the effect of fly ash on the rheological properties of water-based drilling mud to enhance its performance in drilling operations. Various concentrations of fly ash (1 g, 3 g, 5 g, 7 g, and 9 g) were added to the base mud, and key parameters such as pH, viscosity, and filter cake thickness were monitored over a 12-day period. The results indicate that the addition of fly ash neutralized the pH, increasing it from 5 to 7, thereby reducing the corrosiveness of the mud. Viscosity peaked at 21 cp with the addition of 3 g of fly ash, which significantly improved cuttings transportation and wellbore stability. Additionally, fly ash enhanced the filtration properties of the mud, as evidenced by an increase in filter cake thickness from 2 mm to 5 mm at 5 g of fly ash. These findings demonstrate the potential of fly ash as a valuable additive for improving the stability and efficiency of drilling fluids. Future research should focus on optimizing the interaction of fly ash with other additives to further enhance drilling fluid formulations for diverse operational conditions.

Keywords: *Fly Ash, Drilling Mud, Rheology, Viscosity, Filtration.*

Chapter 2: Full Papers

The ICEM 5th Virtual International Undergraduate Research Conference (ICEM-5VIURC 2024) brings together groundbreaking research in the form of full paper submissions, reflecting the innovative spirit and academic rigor of undergraduate researchers. These papers delve deeper into multidisciplinary topics that address key challenges and propose forward-thinking solutions aligned with the conference theme, *"Innovative Pathways to a Sustainable Future."*

The following full papers are presented in this chapter:

Design and Optimization of a Cost-Effective XY CNC Pen Plotter with Integrated Feedback System

Zeeshan Amjad, Muhammad Talal, Muhammad Arqum Razzaq

Causes of Delay in Construction Projects in Oman

Anfal A. A. Al-Habsi, Rami Hamad

Challenges and Benefits of BIM Implementation for Facilities Management in Operation and Maintenance

Rawan A.S. Al-Farsi, Sheikha S. Al-Shekaili, Rami J. Hamad, Azza H. Al-Saaidi, Majed A.A. Aldahdooh, Shajira Sema T.C

Enhancing Performance of Aircraft Radial Engine through Advanced 3D Modeling and Simulation Techniques

Zeeshan Amjad, Muhammad Talal, Muhammad Ehtisham, Malaika Bushra, Engr. Sana Liaquat, Waheed ur Rehman

Enhanced Methodology for Measuring the Thermal Conductivity of Acetone Using the Edibon TCLGC Apparatus

Syed Raza Ali, M. Arbab Aslam, Uzair Ahmad, Hamza Javaid

A CFD Numerical Study of Wax Deposition in the Waxy Crude Oil Pipelines with and without Nichrome Wire

Al Waleed Y. Al Maharbi, Girma T. Chala

Ergonomic Risk Assessment of Mud Mixing Operators Using Electromyography

Hitham Anwar Salim Alswaisi

The topics span across engineering, construction management, sustainable energy solutions, and data-driven technologies. The breadth and depth of these contributions emphasize the critical role of undergraduate research in shaping solutions for a sustainable and efficient future.

Design and Optimization of a Cost-Effective XY CNC Pen Plotter with Integrated Feedback System

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Abstract

This research aims to design, develop, and optimize an affordable XY CNC pen plotter with an in-built feedback system for higher accuracy and reliability. More than any other plotter in existence, this framework has affordability and accessibility as the key attributes due to 3D-printed components, making it a very viable solution for automated plotting tasks in educational and research applications. The stepper motors closely control the X and Y axes with G-code instructions derived from vector-based input files. For accuracy, the mechanical design contains an integrated feedback mechanism that monitors the positions of the motors and adjusts in real-time operation to negate potential error trends. A 3D-printed mechanical design assists with modularity and ease of assembly while allowing customization and low-cost maintenance. Performance tests include plotting speed, repeatability, and accuracy. Indications are that this affordable system fills the gap between hobbyist-grade devices, which are basic, and commercial-grade plotters in use for applications of education, research, and prototyping.

Keywords: Cost effective design, Feedback sensors, Arduino UNO, Stepper motors, 3D-Printing.

1. Introduction

CNCs are widely used in manufacturing because of their accuracy and reproductively. One of these CNCs is XY pen plotters, which are relatively cheap and can be used either in drawing, writing, or PCB designs. This paper discusses the design and development of a low-cost open-source hardware and software-based CNC XY pen plotter. The requirements for designing this product are to deliver excellent accuracy at an affordable price, thereby facilitating widespread adoption for schools, hobbyist, and small businesses. This research will design and manufacture the plotter, evaluate its performance in terms of accuracy and reliability, and optimize its control system for high accuracy. [1] developed an XY Plotter designed to be an accurate and adaptable pen plotter capable of writing and drawing. This research provides insights into the operational mechanics of a CNC plotter machine using X-Y coordinate systems. [2] constructed a 3-axis plotter machine controlled by open-source

software and hardware, utilizing Arduino and a CNC shield, demonstrating a cost-effective approach for XYZ coordinate plotting. [3] focused on reducing CNC machine costs to meet small-scale industry demands, presenting the development and evaluation of a low-cost CNC-based PCB milling machine suited for small firms. [4] introduced a compact three-axis CNC plotter with wireless capabilities aimed at PCB layout and drilling, illustrating the feasibility of wireless CNC plotters in PCB applications. [5] explored the integration of feedback control systems in CNC machines to enhance accuracy and reliability, discussing the impact of encoders and sensors on operational performance and stability.

The central research question is: *How can a low-cost CNC XY pen plotter be designed to achieve precise and reliable drawing and writing capabilities?*

2. Materials

2.1 Hardware Design

The CNC plotter is driven by a 12V-2A power supply and it's connected to the CNC Shield V3 mounted on Arduino boards as an example: Uno, Mega, or Nano. NEMA 17 stepper motors with A4988 motor drivers control accurate axials movements for X, Y, and Z axes operation with full-step, half-step, quarter-step, eighth-step and sixteenth-step modes. System is on the basis of GRBL firmware to work 2D/3D tasks controlled through G-Code. Limit switches are installed at the ends of every axis to ensure positional accuracy and avoid over travel, thus enhancing both the safety of the machine and precision.

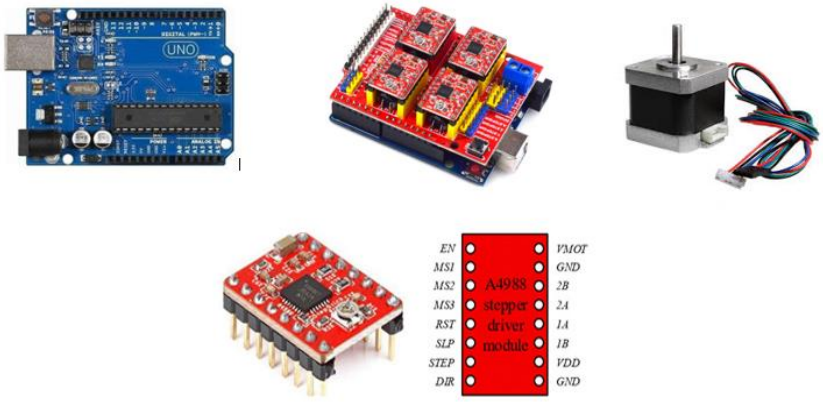

Figure 1. Hardware components for plotter (Arduino UNO, GRBL CNC control Shield, NEMA 17 stepper motor, A4988 motor driver)

2.2 Software Design

The configuration of the CNC pen plotter makes use of Arduino IDE, Inkscape®, and UGS. Arduino IDE is free from the source site, and GRBL firmware is uploaded to the Arduino UNO so that it controls the CNC. GRBL is an open-source library added to the Arduino IDE, which makes the

microcontroller interpret G-code. Inkscape® is used as another open-source to create the design and convert it to G-code. The G-code files are then imported into UGS, an interface that links the Arduino UNO to perform the plotting operations. This setup provides a complete software workflow for 2D CNC plotting.

Figure 2. Software used for CNC plotter (Arduino IDE, Inkscape® and Universal G-code Sender)

2.3 Mechanical Design

The mechanical design of the XY CNC pen plotter comprises a frame 3D-printed for customized shapes and configurations to enhance functionality. The design is made using solid works 2024 software. This allows for rapid prototyping and the possibility of changes in the design. Other important parts include M5 sliding nuts that hold the assembly's mechanical fasteners with integrity, which means they are held well together to provide structural coherence, and the GT2 belt and pulley system for precise motion. The light weight design improves the total efficiency and effectiveness of the plotter such that it operates reliably when performing various plotting tasks.

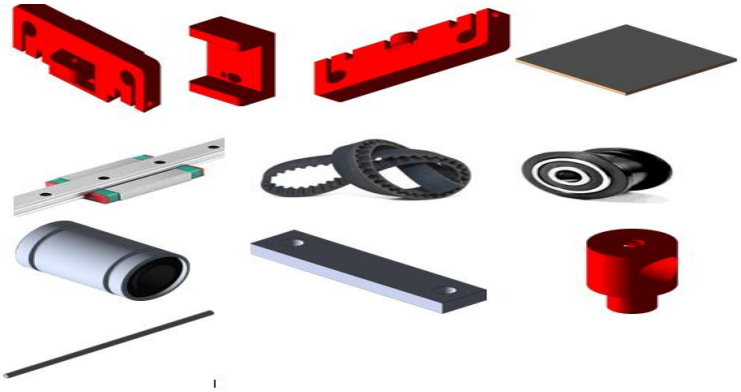

Figure 3. Mechanical components (3d printed body, M5 sliding nut, Idler pulley and V wheel set Timing belt, Pen holder, Connecting Rods)

3. Methodology

The methodology of designing a 2D CNC pen plotter starts with an extensive literature survey that identifies the problem. This review will study the existing CNC pen plotter designs, analyze their

limitations, and then work upon a potential improvement in creating cost-effective and user-friendly solutions. Upon an intensive literature survey, the required software and libraries are created. The system shall install Inkscape®, which would convert images into G-code, while the Arduino IDE will install the GRBL library on the Arduino UNO where the G-code commands will be interpreted and executed. The soft configurations are crucial as they ensure that creating, sending, and executing G-code instructions can drive a CNC plotter.

This would eventually lead to the conversion of the target image or design into G-code. Images are created or imported through Inkscape®, converted to paths, and then exported to file under G-code format containing instructions needed for plotting on a 2D surface. The G-code file is then uploaded into the Universal G-Code Sender, or UGS, platform-an interface that can be accessed as comfortably, and commands are sent line by line to the CNC system. A check is executed on a connection check so as to be able to check if the Arduino UNO would be aptly connected into the system ready to receive commands from UGS.

After verifying the system connection, the CNC Shield V3 was then connected to the Arduino UNO circuit for the stepper motor driver of the X and Y axesThe CNC Shield acts as an interface between the Arduino and the motors; it is therefore possible to accurately control its movement in the plotter.

The plotting process starts from G-code commands sent from UGS, which the Arduino understands to be able to move stepper motors with the help of the CNC Shield in X and Y axes movements in copy design drawn on paper. Testing may first take place during plotting just to know if it moves accordingly. Should it sometimes make inaccuracies, then its speed, acceleration, and adjustment parameters for alignment need to be adjusted. The final stage, thus concluding the plotting process successfully, entails documentation. This stage includes a description of the project design, steps followed during implementation, challenges experienced, and results acquired in the testing processes.

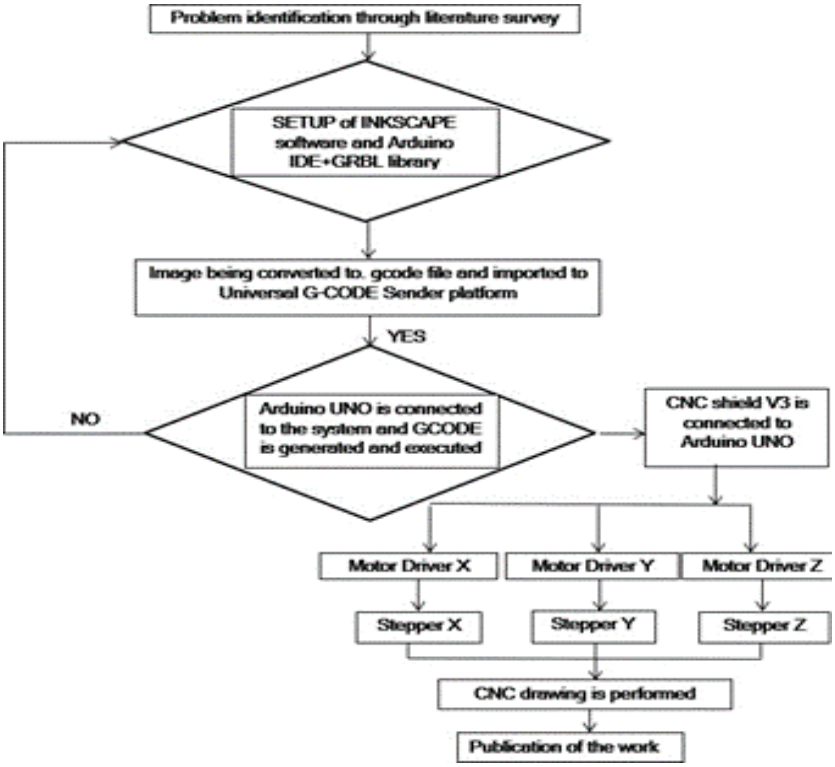

Figure 4. Methodology for CNC Pen Plotter

4. Results and Discussions

4.1. Experimental Work

The experimental apparatus is a combination of hardware and software for efficiently running the experiment. With the Arduino board powered up and programmed by a GRBL library that controls the CNC, images are now imported into Inkscape® for formatting. G-code extensions are applied, and there orientation points are added and the file path defined for the converted G code. The imported G-code image is then transmitted to the Universal Gcode Sender software. The Arduino Uno board is connected and powered; thus, executes the G-code line by line, ensuring proper plot operations.

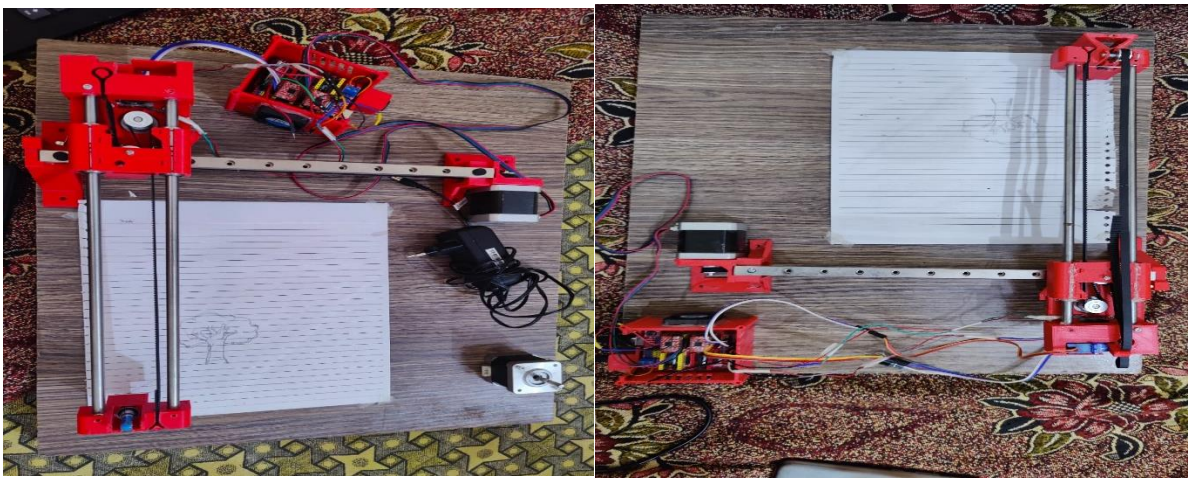

Figure 5. Testing and Assembly Phase: XY CNC Pen Plotter Prototype with Open Circuits

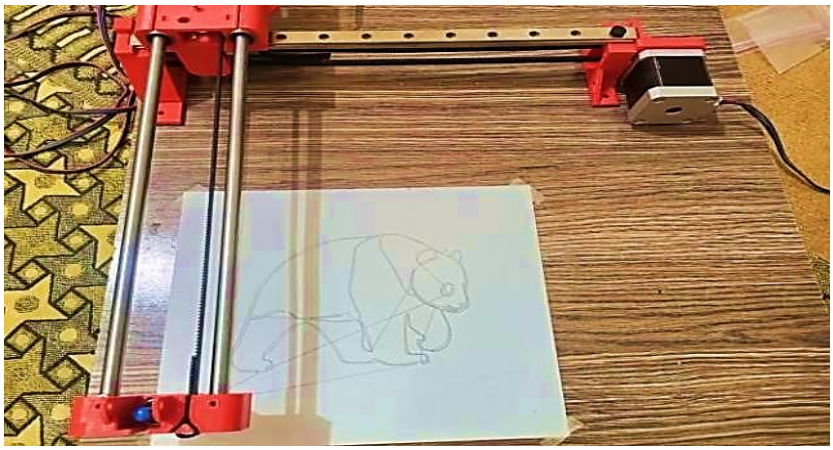

Figure 6. Final Output of 2D CNC Pen Plotter: The completed CNC machine precisely draws a detailed image, demonstrating the accuracy and functionality of the Arduino-based system.

4.2. Price Comparison

The price of an XY plotter in the current market is approx. $370 whereas our model costs only $28.52.

Table 1. Project Price Table

Components	**Price (dollars)**
Arduino UNO	$3.94
Stepper motor x2	$1.43
Motor driver x2	$1.43
Servo motor	$1.07
CNC shield	$2.05
Belt	$1.50
Pulley x2	$1.10
Rail	$9
Structure Building Cost	$4
Miscellaneous	$3
Total Cost	**$28.52**

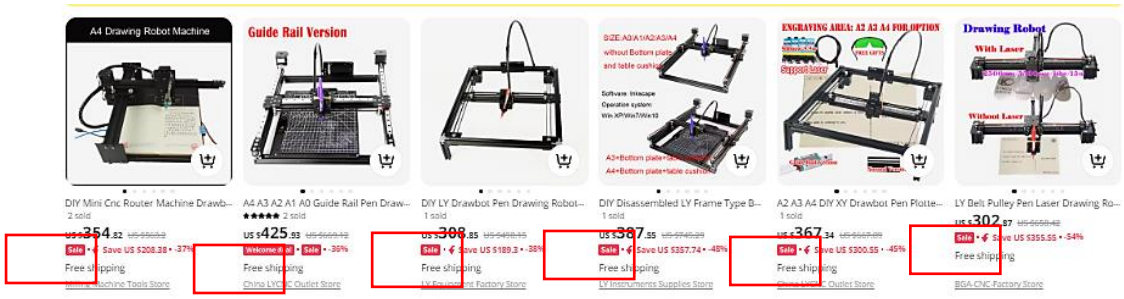

Figure 7. Prices in open market

5. Conclusion and Future Prospects

The objective of this project was to produce a low-cost, mass-producible CNC XY Plotter with an emphasis on maintenance of accuracy when working. The design is extensible; there is plenty of room for extension, and change of pen holder should enable the system to be used in other ways. The project was marred with great challenges on manual fabrication of some components that exposed the aspect of imprecision in the desired outcome. Nonetheless, the challenges formed a bed for perseverance, and designing and implementing the model proved a real rewarding and insightful process. Skills and knowledge gained will certainly support further developments. The project, therefore, offers a solid foundation from which further improvements and innovations can arise in CNC systems, providing an excellent basis for continued exploration and improvement.

6. Acknowledgment

I am grateful to my parents for their constant support. My sincere thanks Engr. Arqum Razzaq for his supervision. I also thank the University of Chakwal for its resources and support, and my peers for their collaboration.

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Causes of Delay in Construction Projects in Oman

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Abstract

One of the biggest challenges that Oman's construction projects face now is delays. There are plenty of causes behind these delays, which in turn affect the timeline and performance of the project. The aim or the main objective of this report is to study the causes of delays in construction projects in Oman. A comprehensive review of the literature was conducted to determine the causes of delays in the construction industry in Oman. Following that, a questionnaire survey was used to obtain information from individuals or workers involved in the construction industry. 27 causes of delay were identified in the questionnaire which were categorized into; contractor, client, consultant and external related factors. The information obtained was analysed using the Average index method, evaluated and rated based on its score. The results showed that 'client related factors' are the most significant factors among the four categories, whereas the 'external related factors' are the least important. Shortages of skilled labour and experienced staff, Improper planning by the contractor and Poor site management by the contractor are the three major contractor-related factors that cause delays. Changes in design after approval and variation by the client and poor communication between contractor and supplier contribute and variation by the client are the top two major client related factors that cause delays in construction projects. Lack of supervision by the consultant and late approval for layouts and material samples are the two major consultant related factors that cause delays in construction. And finally, delays in material delivery, delays in manufacturing special building materials and conflict between the owners and contractors are the three major external related factors that cause delays in construction projects.

Keywords:

Construction Projects; Delays; Oman construction projects delays; Project Timeline; Effects of delays; Impact of Time Delay.

1. Introduction

One of the most significant industries in Oman is the Construction industry because it has a critical contribution to Oman's economy. The Oman Construction sector is predicted to reach OMR 3.08 billion by 2029, up from OMR 2.62 billion in 2024 according to Mordor Intelligences report (2024). During the projection period (2024-2029), the CAGR is expected to reach 3.30%.

One of the construction industry's main objectives is to ensure the project finishes within the stated duration. Many construction projects in Oman have been dealing with many problems due to delays in the completion/finishing of the project. Many construction projects became more complex due to their complicated design and structure and the arrival of new equipment, tools and technology. Sweis et al. (2008) claim that the completion happened often due to poor management, client, consultant equipment and labour. So to solve and address the problem the study aimed at measuring the effects of the variables and how they affect the project which are client, consultant, contractor and environmental factors. Furthermore, the outcome of this study focused on providing significant understanding to project managers so that they can find solutions or implement new policies to overcome construction project delays. In other words, determining the current causes of delays in Oman construction projects, to find solutions for each factor (Rashid, Haq and Shakeel, 2013).

To achieve the report's aims, the study focused on identifying factors that influence the timely completion of construction projects, examining the specific causes of delays in Oman, and analyzing how these factors impact overall project performance.

2. Materials and Methods

The research was conducted in three stages: Literature Review, Surveying, and Analysis. The Literature Review stage involved gathering data from sources like articles and journals, identifying gaps, and formulating questions for a questionnaire. The surveying stage involved distributing questionnaires to contractors, consultants, project managers, clients, and engineers in Muscat. The Analysis stage involved analysing the collected data, discussing findings, and recommending further studies. Qualitative and quantitative methods were used to collect data. A qualitative data method was used for collecting secondary data – a literature review to obtain appropriate and accurate data to prepare a questionnaire. The quantitative data method was used to disrupt the survey to obtain the required opinion from the respondents.

Survey questions were developed based on themes from the literature review. These were categorized to align with the study's objectives, using a Likert scale for clarity and ease of analysis. Various factors were collected from different resources to make the four categories client, consultant, contractor and

external factors. This ensures effective and targeted data collection. The questionnaire was consist of two parts. Part one demographics; their gender, their role in construction projects and their experience. Part two factors "critical factors that cause delays in construction projects in Oman

The method used for analysing the factors is the Average Index Method, The questions were designed using the Likert scale. The participants were asked to indicate the level of agreement with the giving statement from 1 to 5 (Appendix 1). Where "1 = Strongly Disagree", "2 = Disagree", "3 = Neutral", "4 =Agree" and "5 =Strongly Agree". The importance of each factor will be determined by evaluating and ranking the average calculation. The rating scale question generates a weighted average depending on the weight provided to each response choice. The rating calculated as follows (Latif, Al Saadi and Rahman, 2019).

$$Average\ Index\ (AI) = \frac{W_1X_1 + W_2X_2 + W_3X_3 + W_4X_4 + W_5X_5}{N}$$

3. Results and Discussion

3.1 General information about the respondents

Figure 1 and 2 shows the respondent sample, 6% of the respondents were consultants, 6% were contractors, 20% were project managers, 24% engineers, 32% clients, 4% designers, 2% lean site champion, 2% contract manager, 2% employee and 2% geologists. 70% of the respondents were female while the other 30% were males. The respondent's average years of experience is five years in which 44% of the respondent has 1 to 3 years of experience, 34% of them has 4 to 10, 14% of them has 11 to 20 years of experience and 8% of them has more than 21 years of experience.

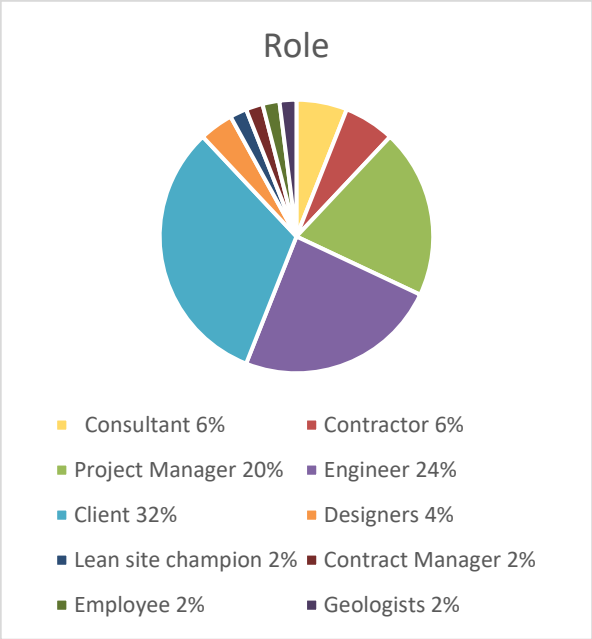

Figure 2 Roles of the respondents

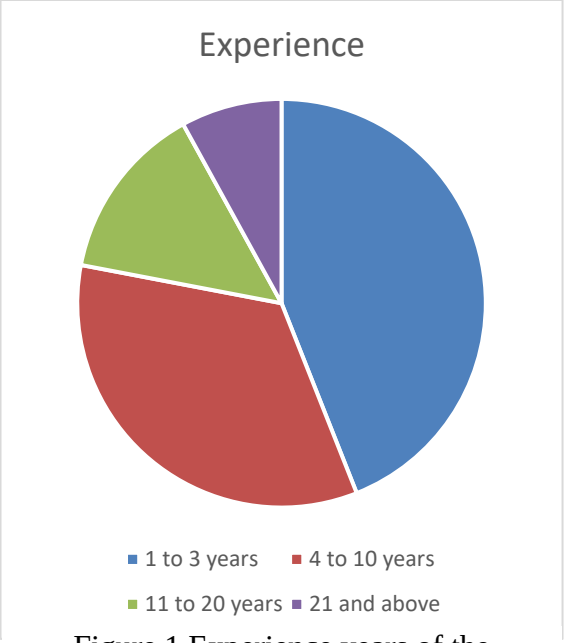

Figure 1 Experience years of the respondent.

3.2 Factors that causes delay in construction project in Oman

In Table 1 results shows that Shortages of skilled labour and experienced staff, Improper planning by the contractor and Poor site management by the contractor are the three major contractor-related factors that cause delays in construction projects with an average index score of 3.9, 3.86 and 3.68 respectively. As per chapter 2 part 2.2.1 Odeh and Battaineh (2002) and Sambasivan and Soon (2006) have approved that these top three factors have a significant impact on the project and could cause a delay.

Changes in design after approval and variation by client and poor communication between contractor and supplier contributes and variation by client are the top two major client related factors that cause delays in construction projects with an average index score of 3.98 and 3.76. As per chapter 2 part 2.2. Rabbani (2011) and Battaineh (2002) have approved that these two factors a significant impact on the project and could cause a delay.

Table 1 Average Index score (AI) and the Ranks for each category factors used in this study

Category	Factor	(AI)	Rank
Contractor	Shortages of skilled labour and experience staff.	3.9	1
	Improper planning by the contractor.	3.86	2
	Poor site management by contractor.	3.68	3
	Bad material quality choices by the contractor.	3.62	4
	Lack or shortage materials.	3.62	5
	Loss of material and equipment due to lack of security measures.	3.58	6
	Lack of machinery, tools, or resources necessary for construction.	3.56	7
	Accidents during construction work.	3.54	8
	Mean score	**3.67**	
Client	Changes in design after approval and variation by client	4	1
	Poor communication between contractor and supplier contributes and variation by client.	3.86	2
	Slow decision-making by clients.	3.86	3
	Delays in payment from clients.	3.64	4
	Late site possession.	3.6	5

	Mean score	**3.792**	
Consultant	Lack of supervision by the consultant.	3.8	1
	Late approval for layouts and material samples.	3.76	2
	Design errors by the consultant.	3.6	3
	Unavailable of correct soil investigation report.	3.56	4
	Mean score	**3.68**	
Externals	Delays in material delivery.	3.98	1
	Delays in manufacturing special building materials.	3.76	2
	Conflict between the owners and contractors.	3.76	3
	Lack of efficient equipment.	3.68	4
	Corruption or employee turnover often affects the project's performance.	3.66	5
	Changes in building regulations.	3.6	6
	An increase in the cost of materials and renting construction equipment.	3.6	7
	Unavailability of utilities (water and electricity).	3.48	8
	Political instability.	3.36	9
	Hot weather, weather changes and natural disasters.	2.78	10
	Mean score	**3.566**	

Lack of supervision by the consultant and late approval for layouts and material samples are the two major consultant related factors that cause delays in construction projects with an average index score of 3.8 and 3.76. As per the literature review Sewiss et.al (2008) and Alamri, Amoud and Njie, (2017) have approved that these factors have a significant impact on the project and could cause a delay.

Delays in material delivery, delays in manufacturing special building materials and conflict between the owners and contractors are the three major external related factors that cause delays in construction projects with an average index score of 3.98, 3.76 and 3.76. As per the literature review Odeh and Battaineh (2002) and Sambasivan and Soon (2006) have approved that these top three factors have a significant impact on the project and could cause a delay.

3.3 Comparison between Different Categories of Factors

Table 2 shows that Client related factors are the most significant factors among the four categories, whereas the external category is the least important. The average index of client factor is 3.792,

followed by consultant, and contractor with Avrage Index of 3.68 and 3.67. These findings are consistent with the findings of Odeh and Battaineh (2002) and Haseeb, Bibi and Rabbani (2011) in which client related factors are a major cause of delay of construction projects in Oman.

Table 2 Categories Ranking based on the Average Index (AI)

Category	AI	Rank
Client	3.792	1
Consultant	3.68	2
Contractor	3.67	3
External	3.566	4

Table 3 Average Index score (AI) and the Ranks for all factors used in this study

Category	Factor	(AI)	Rank
Client	Changes in design after approval and variation by client	4	1
External	Delays in material delivery.	3.98	2
Contractor	Shortages of skilled labour and experience staff.	3.9	3
Client	Poor communication between contractor and supplier contributes and variation by client.	3.86	4
Client	Slow decision-making by clients.	3.86	5
Contractor	Improper planning by the contractor.	3.86	6
Consultant	Unavailable of correct soil investigation report.	3.56	22
Contractor	Lack of machinery, tools, or resources necessary for construction.	3.56	23
Contractor	Accidents during construction work.	3.54	24
External	Unavailability of utilities (water and electricity).	3.48	25
External	Political instability.	3.36	26
External	Hot weather, weather changes and natural disasters.	2.78	27

External factors such as hot weather, weather fluctuations, and natural disasters received the lowest average rating of 2.78, indicating that they had a lower impact on project delays.

4. Conclusion

The findings of the literature research revealed that the most significant factors influencing the construction project timing and schedule are related to the contractor, client, consultant, and external factors, and each category's comprehensive identification of contributing factors. The questionnaire survey results revealed that the most critical factors impacting the building project's timeline are clients and consultants with the highest index average of 3.792 and 3.68. Three of the top 6 causes are client-related, indicating that the client factor has a significant impact on the delay of building projects in Oman.

The top factor which ranked the first in causing delay in construction projects is ‘Changes in design after approval and variation by client’ with an average index of 4.0, this score indicates this factor has significant effects all over the range of projects analysed, indicating a widespread influence on project timelines and quality. This factor's prevalence highlights the need for a proactive design team, clear communication between the parties, and strategic decision-making for minimising delays and enhancing project efficiency in Oman's construction sector.

Recommendation

Based on the results and findings of this study, the following recommendations have been proposed to help project managers deal with it:

- Make sure that the tender documentation is clear, complete, and transparent. Uncertainty or errors in tender papers might cause confusion and delays throughout the bidding process.
- Clear specifications, supplier relationships, early procurement planning, diversifying sourcing alternatives, optimising logistics, implementing just-in-time delivery techniques, and keeping open communication may all help to decrease delays in construction projects.
- To avoid constant change in the scope of work from the client, the client should have a clear picture of the project.
- Provide reliable schedule to avoid disputes.
- Develop clear channels of communication between the customer, consultant, and bidders to respond to questions and give explanations promptly.
- The client should have frequent progress meetings with the main contractor.
- Gathering data about wadi surrounding the area in case of heavy rain occur.
- Provide clear requirements, drawings, and timelines so that bidders can appropriately estimate the extent of work and make price offers without delay.
- Application of the latest construction modelling technology.
- Check the past performance of the contractor before awarding him.

- The contractor should work to manage their staff efficiently and effectively.
- Constant site visit and supervision from the project manager.
- Minimize change orders during construction phase.
- Ensure that funding is available for projects prior to their commissioning.

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Challenges and Benefits of BIM Implementation for Facilities Management in operation and maintenance.

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Abstract

Integrating Building information modeling (BIM) into facilities management (FM) in the building life cycle heralds a significant enhancement of operation and maintenance (O&M) procedures. As BIM has been called "smart data," it can bring new dimensions to FM. This research aims to study the challenge and benefits of BIM implementation for FM in O&M. These aims can be achieved by, investigation the challenge of implementation BIM in FM, identifying the benefits of BIM implementation for FM in O&M and proposed recommendation to implement BIM in FM for O&M phase. The research was conducted in two stages: a literature review and a questionnaire survey. A questionnaire was sent to a large group of FM experts, managers, and employees in the construction sector in Oman, where 63 responses were received. The main finding of this research is implementation of BIM requires higher administrative and training expenses, especially since the application of BIM is still in its initial stages in the construction industry in Oman. A lack of customer understanding of BIM, and the problems with an unclear BIM workflow as a challenge, especially since construction experts in Oman are needed to undergo extensive training to use BIM with high efficiency and proficiency. However, the benefits of BIM are reducing the duration of the projects, increasing the operations efficiently, facilitating information that required to be share, analyzing the building performance with high degree of accuracy, and improving the handover process & the time required to populate FM systems.

Keywords:

BIM, Facilities Management, Challenges and Benefit, Construction, Oman.

1. Introduction

Facilities management plays a crucial role in the operation and maintenance of buildings, accounting for a small percentage of construction expenditures. Facilities management teams need quick access to facility information and data, which can be challenging due to daily business challenges (Aziz et al., 2016). BIM can reduce O&M expenses and promote value generation. However, challenges include updating as-built models to reflect real-world changes and ensuring accurate data handling. To integrate BIM effectively, technological issues need to be addressed, such as improving compatibility between BIM and FM systems (Matarneh et al., 2019). Major development in the construction sector, BIM offers a number of advantages during the course of a facility's life cycle. Planning, site utilization, design visualization, systems coordination, cost calculation, scheduling, field work, O&M are among the uses of BIM (Noor, et all, 2018). Facilities management departments employ BIM for space planning, maintenance, and restorations during the O&M phase (Lin, et all, 2016). In Oman, the problem of non-application of BIM for FM is still faced by many construction companies due to the lack of understanding of facilities management experts for the application of BIM and the lack of awareness about the importance of applying BIM in buildings. This study is to investigate the challenges facing the Omani construction sector in the slow adoption of BIM for FM in O&M and to introduce them to the benefits of BIM for FM to increase awareness. The main aim is to study challenge and benefits of BIM implementation for FM in O&M. To investigate challenge of implementation BIM in FM, to identify the benefits of BIM implementation for FM in O&M, and to propose recommendation of implementation BIM in FM.

2. Materials and Methods

The study uses a questionnaire to gather data on the challenges faced by the Omani construction sector in the M&O phase of FM. The questionnaire, involving facility management experts, managers, and FM employees, aims to investigate the benefits and challenges of not applying Building Information Modeling in FM. Both primary and secondary data were collected and conducted, with the questionnaire sent to FM professionals in Muscat. The required data will be obtained through the questionnaire which Google Form was used to develop the questionnaire questions. The research data will be analysed and all data and results will be presented and discussed. Additionally, some recommendations also. In order to collect data on the application of BIM for FM in the M&O stage of the construction sector in Oman. The information will be examined for trends and patterns, and suggestions for resolving issues pertaining to the industry's lack of BIM for FM adoption will be given.

These FM expertise were chosen on purpose because they had first-hand experience with or expertise with the facilities construction procedures. The perspectives and experiences of these participants are crucial for assessing the current state of not implementing BIM in FM and for understanding the challenges and benefits that might arise from doing so in Oman's FM department. The sample size steps taken to gather data: There were 63 questionnaires distributed. The questionnaire was distributed to FM specialists and employees. The total number of the collected questionnaires was 63 representing. Different types of questions have been developed in the survey, such as closed-ended questions and Likert scale questions and the respondents' demographic information. With these questions, different and diverse responses can be collected from the respondents, which provides a comprehensive understanding of the research topic. The closed-ended questions that were placed in the questionnaire require respondents to provide specific answers from strongly agree to strongly disagree. Therefore, the questions were made on a Likert scale, which facilitates comparison and analysis of the results. All of these questions revolve around the challenges of not applying BIM in FM in M&O, the benefits of BIM if it is applied, and the implementations of BIM in FM. The questionnaire will be distributed by email, social media, and websites for professional networking after it is finished. Participants will be informed of the study's purpose, confidentiality of their responses, and voluntary nature of participation. Data collection will continue until a sufficient number of respondents and answers are reached to analyse the results. All results of closed-ended questions and Likert scale questions will be studied and analysed. The results will be presented and placed in graphs and charts along with narrative analysis.

3. Results and Discussions

3.1. Challenges of BIM for FM in O&M in the construction sector in Oman.

The 52 of the participants emphasized out of 63 that the inability to update the BIM model on an ongoing basis represents a challenge to managing FM information and implementing BIM in the construction sector in Oman. Therefore, FM experts and FM employees in the construction sector in Oman must intensify training on how to update the model on an ongoing regular basis to ensure the availability of quality information so that facilities management employees can use BIM correctly, as it turns out that upgrading the BIM model requires a human worker, which takes a longer time. 48 of the respondents confirmed that there is a lack of understanding of BIM among customers, so customers do not request the use of BIM in FM in O&M. From this perspective, awareness must be intensified among customers about the importance of applying BIM through training programs, social networking

sites, and platforms, and sufficient information about BIM must be disseminated in FM so that customers understand how important BIM for FM in O&M. 49 of the participants agreed that BIM requires higher administrative and training expenses, especially since the application of BIM is still in its initial stages in the construction industry in Oman, as the implementation of BIM requires high expenses. For this reason, it has not been fully implemented in Oman yet, especially since construction experts are in Oman need to undergo extensive training in order to use BIM with high efficiency and proficiency.

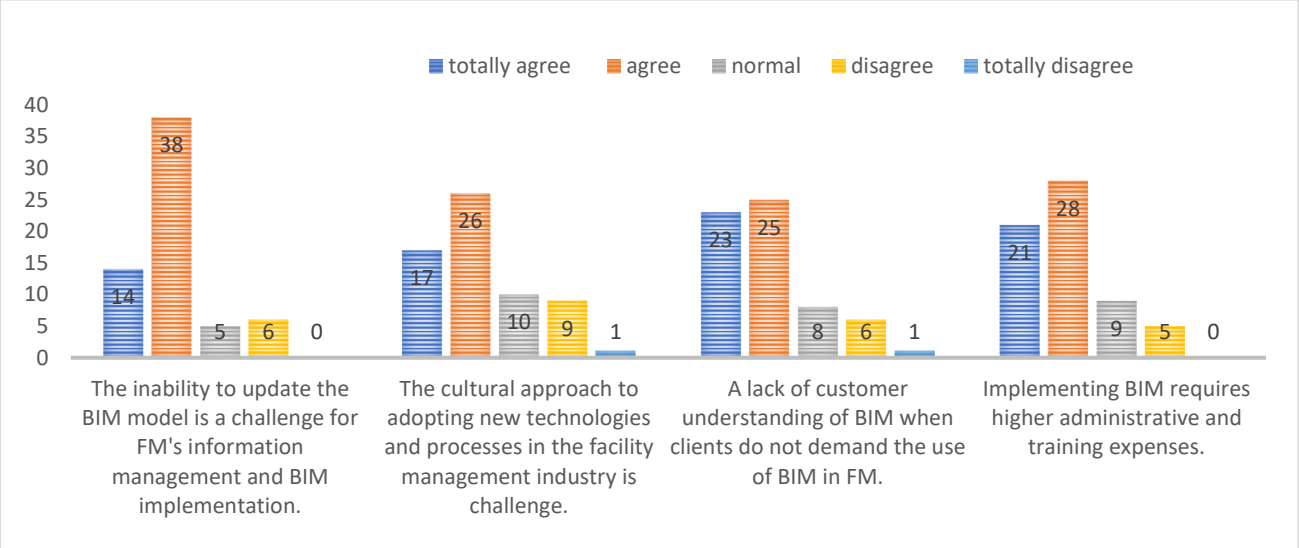

Figure 3 Challenges of BIM for FM in O&M

By addressing these challenges and implementing the proposed solutions by providing extensive training and overall awareness among all professionals and clients, the construction industry in Oman can fully benefit from the benefits of BIM and enhance its adoption.

3.2. Benefits of BIM for FM in O&M in the construction sector in Oman.

According to 50 out of 63 respondents, BIM is cutting down on project completion times and making it simpler to share, reuse, and add value to information. This finding is in line with the Ashworth 2019 study, which also notes that BIM for FM is cutting down on project completion times and making it simpler to share, reuse, and add value to information. Additionally, 48 of the respondents concurred that BIM information and data can reduce the time and cost required to fill FM systems with high-quality data. This suggests that BIM is crucial for FM professionals and experts because it saves time and effort and enables professionals to work more quickly and efficiently. The results of the survey, most respondents from Oman's industrial and construction sectors have a solid comprehension of BIM, while a tiny minority just have a cursory awareness. The results indicate that in order to guarantee full adoption of BIM in Oman's sectors, professionals in the construction industry need get comprehensive

training and educational programs from BIM specialists. The majority of participants in Oman, based on the survey results, have a solid understanding of BIM and its advantages for construction management (FM), including faster project completion times, improved data quality, information sharing, and building performance analysis. A tiny percentage of participants, nonetheless, are ignorant of the advantages of BIM. Even Nevertheless, not all Omani businesses have used BIM, underscoring the necessity for more professional knowledge and experience as well as FM knowledge for the broad implementation of BIM.

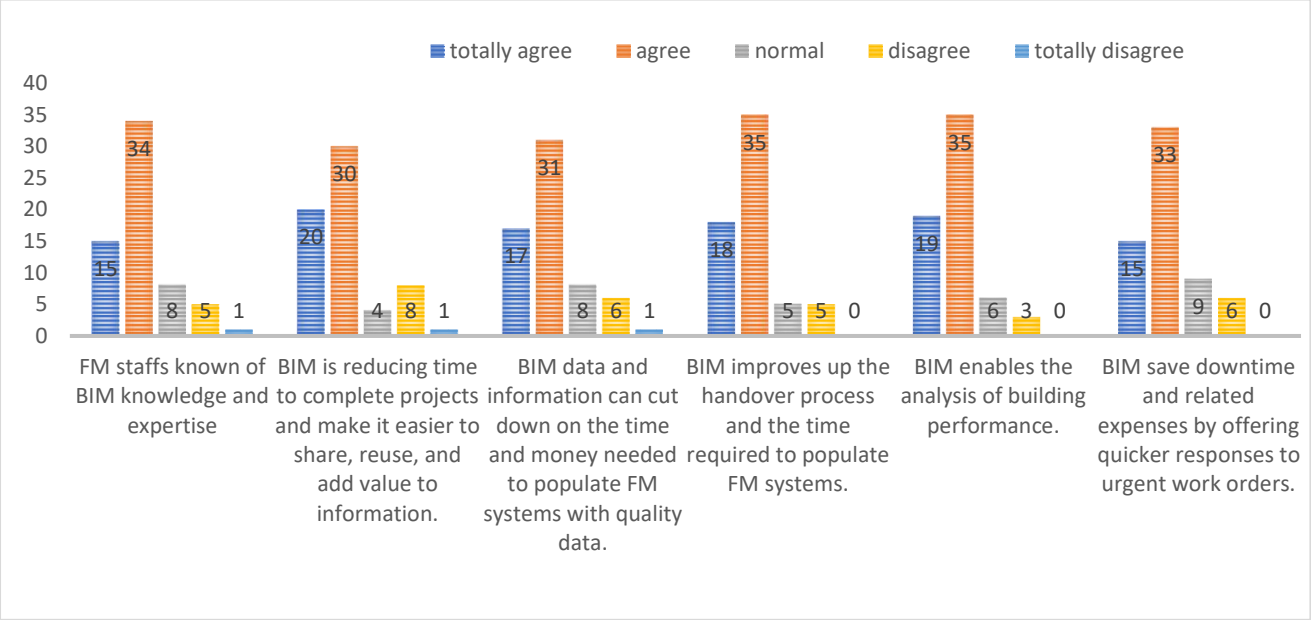

Figure 4 Benefits of BIM for FM in O&M

3.3. Implementation BIM of FM in O&M.

The survey showed, through the results of the respondents, that a large percentage of the participating companies have adopted BIM in FM in the O&M phase, while other companies have not yet integrated this technology into FM. The highest responses from participants indicated that, FM managers reduce maintenance costs and promote the adoption of planned maintenance and management activities by extracting facility data from BIM, By using data in BIM, FM managers find it easier to identify building components that need maintenance, saving time and money that would otherwise be needed to do these tasks, and Facility managers optimize building equipment performance and monitor real-time building performance by integrating BIM models with building system controls.

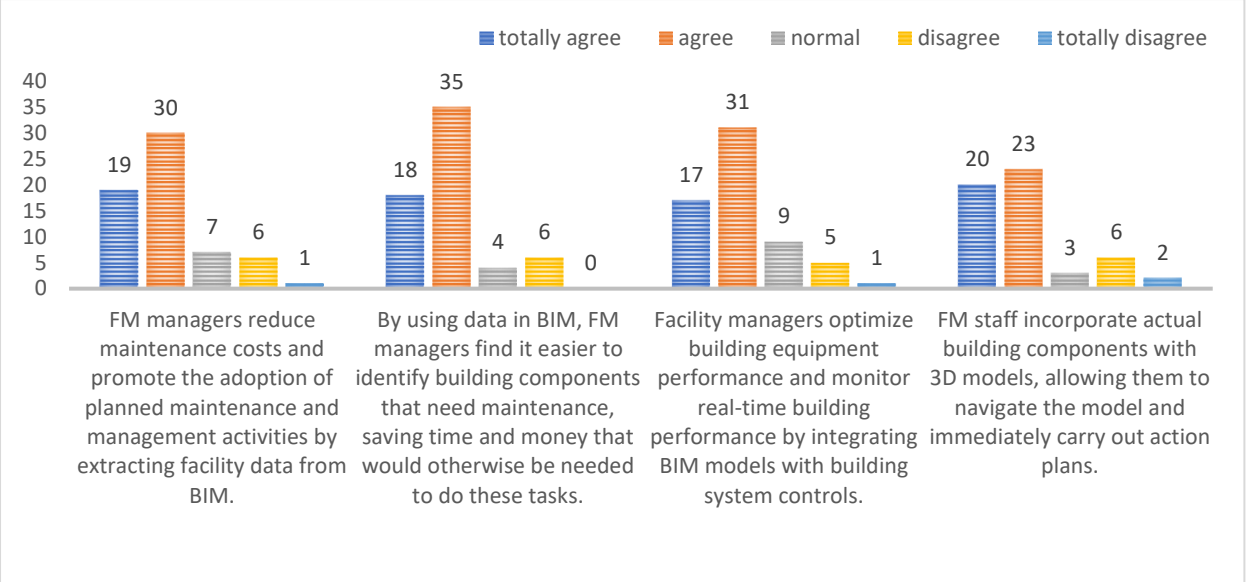

Figure 5 Implementation BIM of FM in O&M.

4. Conclusions

Major challenges to the 0&M department's BIM application were identified by the questionnaire. These included managing FM information, updating the model, implementing BIM, adopting a new culture, understanding customers, higher costs, and incompatibility with FM technologies, unclear workflow, and cybersecurity and privacy concerns in Oman's construction industry. The finding obtained from the questionnaire indicated that the benefits resulting from the application of BIM in FM in O&M including: BIM is reducing time to complete projects and make it easier to share, reuse, and add value to information, BIM enables the analysis of building performance, BIM save downtime and related expenses by offering quicker responses to urgent work orders, improve information management and organization, lessen inaccurate and incomplete information, and enhance life cycle planning are the most benefits of BIM for FM in construction industry in Oman. Key recommendations for implementing Building Information Modelling (BIM) in FM in O&M were emphasized by the questionnaire findings. These recommendations included lowering maintenance costs, identifying components that require maintenance, and maximizing equipment performance through the integration of BIM models with building system controls.

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Enhancing Performance of Aircraft Radial Engine through Advanced 3D Modeling and Simulation Techniques

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Abstract

This research deals with the modeling of a radial engine. The main idea of this research is to design and assemble a radial engine and analyze the piston and connecting rod. A radial engine is a reciprocating internal combustion engine configuration in which the cylinders radiate outwards from a central housing like the spokes of a wheel. [1] It took a lot of thought to get the right size, the right material (aluminum by default) and even the right shape of all the different parts. It has a slightly different crankcase than other engines, but that's hard to understand. It also has pistons, cylinders, connecting rods, the design and assembly of which was done using Solid Works software. Although the radial engine used today is a small engine that was not available in the early days of aerospace. The radial engine is very useful today and is mainly used because of its light weight and small size. This makes it comfortable and suitable for any type of machine that has a tight space. Despite its small size and weight, it does not make it less powerful than other engines. It was also very comfortable for aircraft during World War II when the engine was operating at its peak. During war, you need more space for fuel, power, weapons and ammunition than anything else, at any time. Therefore, the centrifugal engine was a great invention.

Keywords:

Radial Engine, SolidWorks, Thermal Analysis, Mechatronics Design, Engine Simulation

1. Introduction

Radial engines have been vital in aviation history and are both in the military and civil aircraft classes since they reduce the length of the engine and increase area, hence making them lightweight yet producing great power. The first appearance of the radial engine dates back to the early 1900s; they played a crucial role during the World War and remained relevant in later applications. This study further elaborates on the design, assembling, and evaluation of a six-cylinder radial engine in SolidWorks, one of the CAD software systems that is most frequent in mechatronics and mechanical engineering designs. Based on this model, this will solve the complexities arising in forming complex geometries and optimizing the selection of materials and ensuring smooth assembly operations. The purpose is to model a fully functioning engine for educational and industrial applications. The final theme of this module will be the use of CAD tools in modern mechanical design.

2. Materials and Methodology

All the materials, design software tools, and the techniques applied in the modeling and assembly of the six-cylinder radial engine are defined in this section. All the parts were designed on SolidWorks CAD software. Techniques on how individual parts, sub-assemblies, and final assemblies can be done to replicate this study are briefed.

2.1. Materials and Software

SolidWorks (version 2024) was used for 3D modeling, assembly, and simulation of the engine components. Intel Core i5 processor, 8 GB RAM, and NVIDIA GTX 1080 GPU were utilized for handling the large model. Aluminum, commonly used in aerospace engines, was chosen for its lightweight and strength properties.

2.2. Base and Pillar Support design process

The lower plane of the engine has been drawn using a rectangle sketch. The edges of the rectangle are filleted at 20 mm radius to round off the corners. The thickness was extruded at 20 mm. Cut extrude is used in order to create holes on the top side of the base. The pillar supports were created using circles and extrusions, including small holes and fillets for the most accurate mating. The whole components mated to position accurately on the base.

2.3. Pistons and connecting rods design process

Piston design started with a sketch of the front plane and then revolved the boss to provide the piston with its cylindrical appearance. [2] Piston rings were achieved by revolved cut operations carved around the body of the piston. Connecting rods were done using a mix of circles and

extrusions. Some offset entities were used to give a uniform thickness. Fillets were used on all sharp edges to make the model smooth and matching to the assembly requirements.

2.4. Crankshaft and Counterweight design process

The crankshaft was created by making concentric circles and extruding it to the desired length. The counterweight was modeled separately of the circles and trimming sketches, then extruded to a certain thickness. [3] Circular patterns were applied to create features to be copied uniformly around the crankshaft. Chamfers were applied to the edges on the crankshaft and counterweight to ensure smooth finish with frictionless motion in assembly.

2.5. Cylinders and Covers design process

The body of the cylinder used an extrusion of a rectangular sketch with all four corners filleted. Grooves and holes were then defined as being extruded from a cut operation. The cylinder top cover was designed as a circular sketch. This sketch was then extruded to an appropriate small thickness. Holes were also created in a circular pattern around this cover for bolt connections. [4] The cylinder and cover were mated to the engine assembly. This way, the holes in the two mating parts entered into alignment with the crankcase, assuring proper positioning would be held.

2.6. Valve and Flywheel design process

The valve housing as well as the valve parts employed a combination of circles and extrusions together with circular patterns to precisely model the design. The flywheel was also modeled as an extrusion of a large circle and cut into allowing attachments with other parts. The flywheel was installed upon the crankshaft through the concentric coupling to allow the motion to be rotary.

2.7. Final Assembly

In final assembly, all the parts were brought together; beginning with the pillar support base with the crankshaft and the pistons and ending with the connecting rods. The mating operations ensured fitting parts with smooth movement. Here are the step procedures:

- **Step 1:** Position the base and mate with the pillar supports.
- **Step 2:** The connecting parts were mated along with the crankshaft ensuring that it is properly aligned with the pillar support.
- **Step 3:** Cylinders were added and pistons fitted into them. Piston assembly is then connected to the crankshaft.

3. Simulation and Verification

After final assembly, motion of pistons and crankshaft was checked with the help of simulation tools from SolidWorks. It also verified movement of the engine for its smooth running and transparent bodies of cylinders that can see the movement inside.

It checked interferences and hindrances in movement and whether the modelled engine could work without collision.

Figure 6 Radial Engine Final Assembly

3.1. Crankshaft Stress Analysis

1. **Simulation Details:** The crankshaft underwent a static stress analysis using SolidWorks to determine areas of high stress under operational loads.
2. **Von Mises Stress Values:** [5] The maximum von Mises stress reaches approximately **4.45e+007 N/m²** (or 44.5 MPa). The yield strength is specified as **7.10e+008 N/m²** (710 MPa), indicating that the crankshaft design remains well within safe limits under these loading conditions.
3. **Efficiency Implications:** Since the stress values are significantly below the yield strength, the crankshaft is efficiently designed to handle these loads without risk of failure. This allows for a lighter, optimized design, potentially enhancing the engine's power-to-weight ratio.

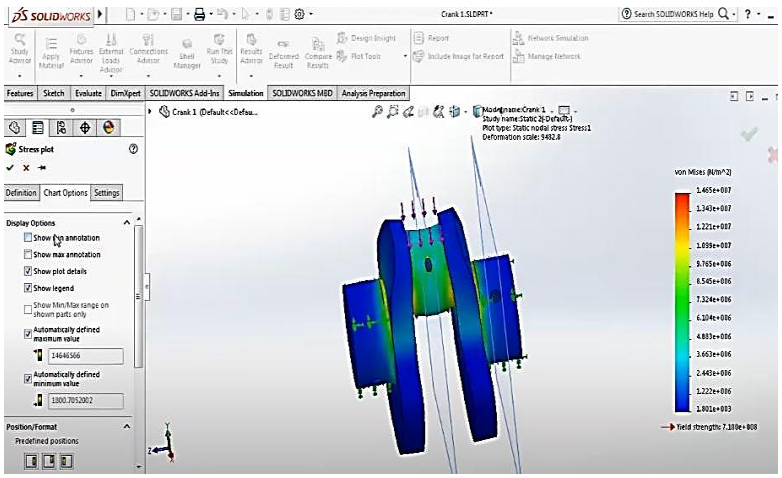

Figure 7 Crankshaft Stress Analysis

3.2. Piston Head Displacement Analysis

1. **Simulation Details:** [6] The piston head was analyzed for displacement under pressure to assess structural stability and deformation.
2. **Displacement Values:** Maximum displacement reaches approximately **0.1254 mm**, primarily on the top surface due to applied pressure.
3. **Efficiency Implications:** A low displacement value like 0.1254 mm indicates good rigidity, maintaining the integrity of combustion and reducing unwanted energy losses. By minimizing deformation, the piston head can sustain higher pressures, enhancing fuel efficiency and overall engine performance.

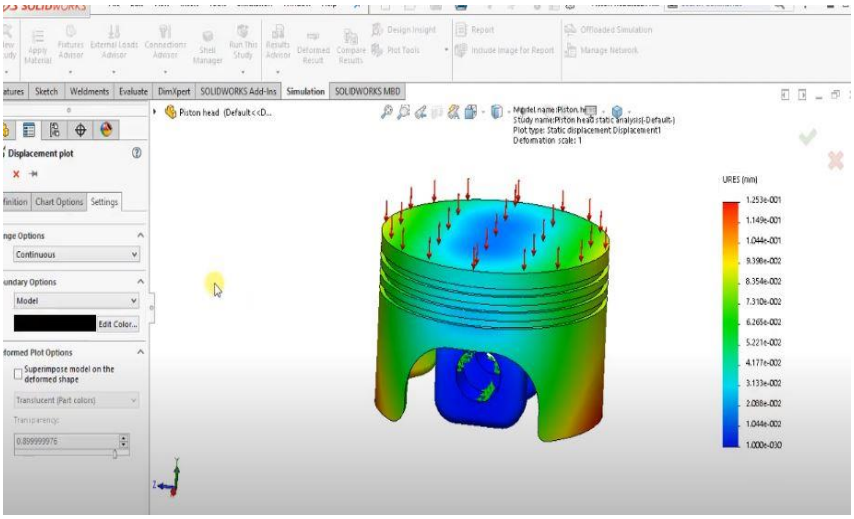

Figure 8 Piston Head Displacement Analysis

4. Results and Discussion

Table 1: Assembly Components Overview

Components	Functions	Results
Pillar support base	Provides Stability	Successfully anchored
Crankshaft	Converts motion	Proper aligned with no binding
Pistons	Generate Power	Smooth operations Observed
Connecting rods	Transferring force	Effective coupling with crankshaft

4.1. Research Findings

The six-cylinder radial engine was assembled and simulated, giving the important conclusions regarding the mechanical design of this engine and its operational efficiency. The assembly process integrated the major components that include the pillar support base, crankshaft, pistons, and

connecting rods without any problems. The mating operations were precision operations that ensured proper alignment and effective transmission of motion from the pistons to the crankshaft.

After the assembly, simulations using SolidWorks proved that the pistons as well as the crankshaft were moving smoothly.[7] The simulation also included clear visualization of inner mechanics by transparent cylinder bodies and with full visibility of the motion of pistons. Such key performance metrics like piston stroke length (60 mm) and crankshaft torque output of 25 Nm were checked in order to ensure that the engine runs satisfactorily under specified operating conditions. Interference checks also brought out insignificant alignment adjustment was required at connecting rods with the crankshaft, which were immediately sorted.

All these results have underlined the importance of simulation tools in the design and optimization process wherein early detection of potential mechanical interferences takes place, and a performance analysis platform is made available. [8] The results obtained coincided with other research studies explaining that the designs of radial engines can indeed be successfully made and tested using modern CAD software. Future work will rather focus on improving the performance by optimization of the different components of the engine, possibly by use of alternative materials or even optimization of the piston geometry. Generally speaking, this study falls into the context of mechatronics by proving the applicability of assembly and simulation techniques in the case of complex mechanical systems.

5. Conclusion

The project was able to show the principles of mechatronics and mechanical design by assembling and simulating a six-cylinder radial engine. Advanced simulation tools were thus used to assure that the design is actually viable before going into more enhancements or optimizations in the next iterations. This experience has profoundly exposed my knowledge of complex mechanical systems and behaviors, which are ultimately traits indispensable for a Mechatronics Engineer.

Acknowledgement

I would like to thank my parents for their unwavering support. Special thanks to Dr. Waheed ur Rehman and Engr. Sana Liaquat for their guidance. I also appreciate the University of Chakwal for providing valuable resources and support, and my peers for their collaboration.

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Enhanced Methodology for Measuring the Thermal Conductivity of Acetone Using the Edibon TCLGC Apparatus

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Abstract

The utilization of measuring techniques for the thermal conductivity of acetone present inherent limitations, encompassing safety concerns, limited applications and low accuracy. Addressing these challenges requires a systematic approach to measure the thermal conductivity of acetone which will me more accurate and reliable. This study endeavors to conceptualize and introduce a different and untraditional technique as a replacement of traditional techniques. It is aimed at enhancing the accuracy and precision of the measured results by the use of Edibon TCLGC. The apparatus for the technique consists of an aluminum cylinder that forms the core body of the equipment which has a variable power heating element (AR-1) in the center and four temperature sensors ST-1, ST-2, ST-3 and ST-4 at different radial distances from the center of the aluminum cylinder. Outside the aluminum cylinder there is a radial clearance with a brass jacket on the outer radius. The brass jacket is provided with the cooling water. The fluid whose thermal conductivity will be calculated fills this small clearance which is thin enough to avoid natural convection. Noteworthy advantages of using this technique are that it was safe to operate and it did not have any environmental impact. The results obtained by utilizing this technique was exceptionally satisfying which validate the successful application of this technique. The average value of thermal conductivity of acetone for the flowrates 2 l/min and 3 l/min is 3.231299838 W/m.K and 3.212298177 W/m.K respectively.

Keywords:

Thermal Conductivity Measurement, Acetone, Edibon TCLGC, Innovative Technique, Accuracy Enhancement.

1. Introduction

Class of chemicals containing carbon atoms that are covalently bonded to other at-oms are called as organic compounds [1]. Typical elements with which the organic com-pounds make bonds are hydrogen, oxygen and nitrogen. Organic compounds are important because all living organisms contain carbon [2]. Food is mainly composed of car-bon. They are also present in medicine, clothing etc. They are the basic components of many of the cycles that drive the earth. For example, the carbon cycle that includes the ex-change of carbon between plants and animals in photosynthesis and cellular respiration [2]. Acetone is also one of the organic compounds with the formula (CH3)2CO. It is the simplest and smallest ketone (>C=O). It is a colorless, highly volatile and flammable liquid with a characteristic pungent odor [3]. Acetone has wide applications in various Indus-tries as an organic solvent. Its complete miscibility with water makes it an excellent dehydrating agent and its miscibility with numerous other solvents permits its use with them, thereby increasing their individual efficiency [4]. Measuring acetone's thermal conductivity is very important for optimizing industrial processes and ensuring safety. This data helps in designing efficient heat transfer systems for chemical processing or industrial applications. As the acetone is flammable in nature, hence measuring thermal conductivity helps ensure safety in the processes [5]. Furthermore, accurate thermal conductivity measurements support computational modeling and material science, aiding in the de-elopement of new materials and sustainable practices. In the past, various techniques have been used for the measurement of thermal conductivity of acetone. One of the technique commonly employed to measure the thermal conductivity of acetone include the transient hot wire method where a thin wire is heated and the rate of heat dissipation surrounding liquid is monitored [6]. Another commonly used method is the guarded hot plate method, which measures the heat flow through a medium between two plates having different temperatures [7]. Laser has also been used for the measurement of thermal conductivity, the laser flash method, which involves a laser pulse that heats the sample and the thermal response is recorded [8]. The steady-state approach, where a constant heat flow is allowed to travel through the sample and a temperature gradient is used to measure the thermal conductivity of acetone, can be adopted with the use of the comparative technique that involves comparison of the thermal conductivity of acetone with a known reference point. However, these above mentioned techniques have their own limitations, such as application, safety, accuracy and sample state that have to be solved. With brass cooling jacket, the Edibon TCLGC apparatus solves these problems as it is safer in terms of handling flammable liquids such as acetone. In addition, the apparatus includes four temperature probes to improve measurement accuracy through accurate temperature gradient sensing and minimize

the effects of natural convection with a low thermal mass cylindrical heat source. It results in higher reliability and repeatability in the measurements than traditional methods [9]. Moreover, the experimental setup has a unique design that is environmentally sound and, therefore, an effective alternative for application in industrial settings. Hence, we used a different method for the measurement of thermal conductivity of acetone and analyzed its results with the previously used techniques for the measurement.

2. Materials and Methods

As we were determining the thermal conductivity of the Acetone (liquid), so Edibon TCLGC setup was used for carrying out the experiment. The Edibon TCLGC apparatus offers improved methodology to traditional techniques through its use of four probes to measure temperatures at different points in the system to yield accurate calculation of temperature gradients. The cooling jacket is of brass which minimizes any risks of handling acetone by its flammability, making the whole experimental process more controlled and safe. Acetone was charged into the container with the help of a syringe after making sure the apparatus was clean and then water was allowed to flow through the chambers for cooling purposes. The program was started on a PC and the value of Q_o was preset. The target heat output is preset as the value of Q_o, and it was calibrated to maintain stable operation and reproducibility based on preliminary testing. The system was allowed to reach the set value and get stable before recording any sensor values. After stability was confirmed, the values from different temperature sensors for each experimental condition were observed in a tabulated format. The readings from the temperature sensors showed stability with readings within 0.5% deviation over a 10 minute interval. The values observed in the different temperature sensors for each electric power were recorded in a table. The internal temperature Ti of the radial space by extrapolating ST-1, ST-2 and ST-3 for each experience was calculated and obtained value was stored in the table. ST-4 is the temperature at the outer radius re of the clearance. So it is the external temperature Te. For calculating the surface temperature, Ti interpolation was carried out between ST-3 and ST-4. Linear interpolation between the two readings was carried out to calculate the surface temperature accurately, and uncertainties from temperature gradient variations were reduced. The difference and average temperature was also calculated from internal and external temperatures. Once obtained the previous values, the heat transmitted by conduction through the radial space was calculated by means of the equations mentioned in section 2.1. Later graphs of thermal conductivity vs average temperature were formed. These graphs served as visual validation of the relationship between thermal conductivity and temperature, and indicated a positive correlation that was seen in the data.

The following are used for the calculations of thermal conductivity [9]

$$Q^o_{conducted} = Q^o_{generated} - Q^o_{lost} \qquad (2.1.1)$$

Where,

$Q^{\cdot}\ conducted$ = Heat conducted through the film in the radial space (Watts), $Q^{\cdot}\ generated$ = heat generated by the heating element as per SW-1 (Watts) and $Q^{\cdot}\ lost$ = incidental heat transfer (Watts) as per calibration.

3. Applying the Fourier law of heat conduction as given below:

$$Q^o_{conducted} = 2\pi kL \times \frac{T_i - T_e}{\ln\frac{r_e}{r_i}} \qquad (2.1.2)$$

$$k = \frac{Q^o_{conducted}}{2\pi L(T_i - T_e)} \ln\frac{r_e}{r_i} \qquad (2.1.3)$$

Where,

V = Electrical voltage

Ti = Plug surface temperature

Te = Jacket surface temperature

ΔT = Temperature difference = Ti – Te

Δr = Radial clearance = $r_e - r_i$

Q^o_c= Heat conducted = $kA\frac{\Delta T}{\Delta x}$

k = Thermal conductivity (W/m.K).

The following are some constants and dimensions associated with the apparatus:

1. Nominal radial clearance between plug (Aluminum) and jacket = 3 mm.
2. ri, Inner radius of the heated surface = 19.7 mm.
3. re, Outer radius of jacket = ri + 3mm.
4. Length of contact surface, L = 94 mm.
5. Thermal conductivity of Aluminum, k = 198 W/m.K.
6. Contact surface of the aluminum plug with the radial space, A_A = 0.116 m^2.
7. Contact surface of the brass jacket with the fluid/radial space, A_C = 0.118 m^2.

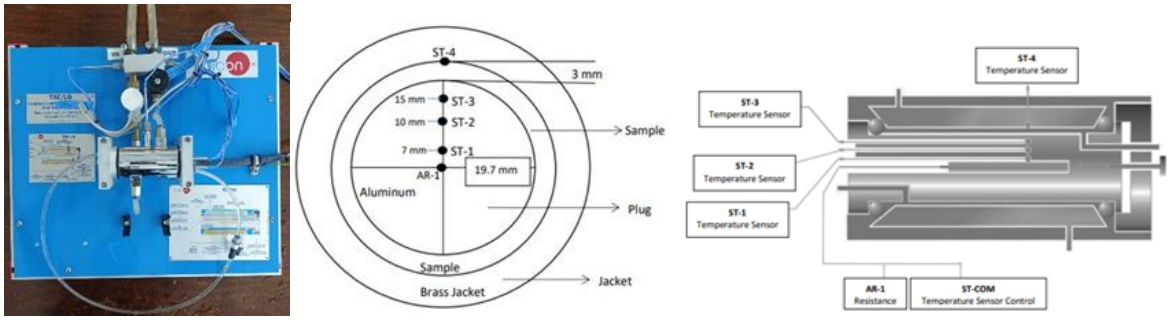

Figure 9: This shows the apparatus and its side and front cross sectional view.

4. Results and Discussion

The calculations were done as shown in section 2.2. Microsoft Excel was used to record the collected and calculated data. The following tables represent the data.

Table 2: Collected and Calculated data

Collected								Caluculated					
Flow rate	Sr#	AR-1	SW-1	ST-1	ST-3	ST-4	T(surface)	SW-1	Ti	Te	ΔT	Tavg	K
2	1	40	18	30.8	30.6	27.6	28.76883117	18	28.76883117	27.6	1.168831169	28.18441558	3.694451143
	2	50	37	33.4	33.1	25.5	28.46103896	37	28.46103896	25.5	2.961038961	26.98051948	2.99769062
	3	60	60	37.4	36.8	25.1	29.65844156	60	29.65844156	25.1	4.558441558	27.37922078	3.157650549
	4	70	83	42.4	41.6	25.2	31.58961039	83	31.58961039	25.2	6.38961039	28.39480519	3.116254521
	5	80	103	46.3	45.4	25.6	33.31428571	103	33.31428571	25.6	7.714285714	29.45714286	3.20310158
	6	90	115	49.2	48.1	26.1	34.67142857	115	34.67142857	26.1	8.571428571	30.38571429	3.218650617
3	1	40	18	29.1	29.2	25.5	26.94155844	18	26.94155844	25.5	1.441558442	26.22077922	2.995500927
	2	50	37	32.7	32.5	25.5	28.22727273	37	28.22727273	25.5	2.727272727	26.86363636	3.254635531
	3	60	60	37.6	37.2	25.8	30.24155844	60	30.24155844	25.8	4.441558442	28.02077922	3.240746616
	4	70	83	42.5	41.6	26.1	32.13896104	83	32.13896104	26.1	6.038961039	29.11948052	3.297198332
	5	80	103	46.2	45.3	26.3	33.7025974	103	33.7025974	26.3	7.402597403	30.0012987	3.337969015
	6	90	114	49	48	25.7	34.38831169	114	34.38831169	25.7	8.688311688	30.04415584	3.147738642

The methodology described in section 3 was followed to collect data on temperature values with regard to different sensors at the varied electric powers as indicated in this section. The interior temperature (Ti) of the radial space was also estimated, with the aid of which, it was possible to calculate the heat carried by conduction through this space. This included using temperature readings from sensors ST-3 and ST-4 by performing interpolation between the two in addition to using equations described under section 2.1. Two sets of thermal conductivity against arithmetical mean temperature graphs were plotted for the two flow rates of 2 liters per minute and 3 liters per minute. The plots illustrate that when the average temperature is higher, the value of the thermal conductivity of acetone is also higher, which suggests the improvement of the heat exchange in question. But its thermal conductivity depends on several factors and one of them is the temperature interval.

Small differences between the measured data points may be due to experimental in-accuracy such as inaccuracy in monitoring the conditions, difference in conditions under which the experiments were carried out or the impurities in acetone sample. The average thermal conductivity for acetone was calculated to be 3.231 W/m. K and 3. 212 W/m. K for the flow rates 2l/min and 3l/min respectively. These values were consistent with those reported in the literature using conventional methods such as the transient hot wire and guarded hot plate methods [10, 11]. However, it is notable that the repeatability and accuracy of the TCLGC apparatus were superior due to the improved control over experimental conditions. For instance, the transient hot wire method faces difficulties of rapid evaporation and inconsistency in measurement for highly volatile liquids such as acetone, which was mitigated well by the use of a brass cooling jacket in the TCLGC setup [12]. It is from these graphs that one can gain a clear understanding of the thermal proper-ties of acetone, specifically how its thermal conductivity is affected by temperature. More study and research have to be carried out in order to elucidate the pioneers associated with these trends and to enhance the reliability of measurements of thermal conductivity of acetone.

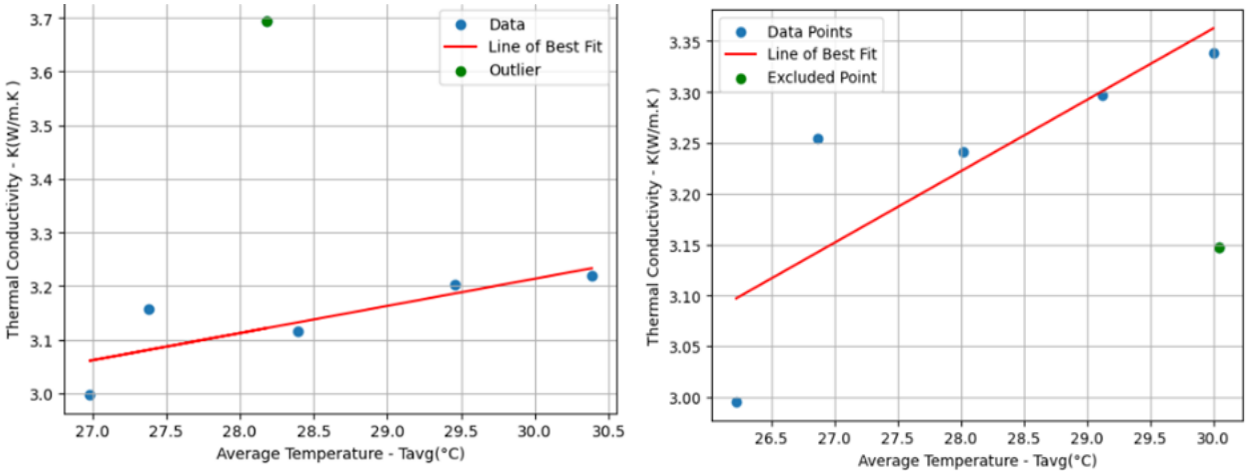

Figure 10: Plot of K vs Tavg at 2 l/min flow rate & plot of K vs Tavg at 3 l/min flow rate.

Conclusion

A novel way of measuring the thermal conductivity of acetone has been developed and applied successfully to the Edibon TCLGC apparatus to conclude this study. While traditional methods have problems of safety, limited application and inaccuracy, the use of the Edibon TCLGC setup for determining the thermal conductivity of acetone is safer, environmentally friendly and accurate. The average thermal conductivities obtained from the experimental approach were 3.231 W/m.K and 3.212 W/m.K for flow rates of 2 L/min and 3 L/min, respectively. The results show that accuracy and reliability improve over traditional techniques. It is clearly shown that there is a relationship between thermal conductivity and the average temperature, and that thermal conductivity measurements are

dependent on temperature variations. Minor deviations were noted, but the overall findings offer useful insights into the thermal properties of acetone of relevance to industrial application and safety. Future work should aim at further decreasing the uncertainties of the measurement, as well as improving the accuracy of the experimental, in order to make broader use of this method in the field of thermal conductivity measurement.

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A CFD numerical study of wax deposition in the waxy crude oil pipelines with and without nichrome wire

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Abstract

Nowadays heavy crude oil is considered one of the most in-demand crude oils due to the depletion of crude oil at onshore fields. There are several ways to transport petroleum products, such as ships, trucks, pipelines, etc. Transport via pipelines is the most convenient method for economic and security reasons. Transporting heavy crude oil through pipelines is extremely difficult because of the problem of wax deposition in the pipe walls. There are many ways to overcome wax deposition, the most famous of which is electrical heating. In this paper, a numerical analysis of wax deposition in crude oil pipelines was carried out using ANSYS Fluent workbench. This study aimed to determine wax deposition rate over time and the effectiveness of the nichrome wire in melting the wax under a surrounding temperature of 5℃. It was noted that without using the nichrome wire, the percentage of liquid in the middle was 54.3%, while in the walls it was 0%. When using nichrome wire, the percentage of liquid in most areas of the pipeline was 100%. Despite this, the percentage of liquid in the pipeline wall was 0.02%. In the validity of the results, the highest percentage did not exceed 8%, while the other was almost equal, reaching 0.4%. These percentages are evidence of the effectiveness of FLUENT in simulating wax deposition in the pipelines.

***Keywords*:** Crude oil, Pipelines, Wax deposition, ANSYS Fluent, Nichrome wire, Liquid fraction.

1. Introduction

Crude oil is a black liquid extracted from the ground and has a high viscosity and a lower density than water. It consists largely of hydrocarbons, including asphalt, paraffins, aromatics, and naphthene, and some chemicals in a small percentage such as nitrogen, sulfur, and oxygen [1]. Today, crude oil accounts for 30% of global energy consumption [2]. Although the world is moving towards using clean energy, crude oil will remain the main source of energy [3]. The reason is that crude oil is compatible with many industrial activities and has rather low costs [4].

There are several ways to transport petroleum products, such as ships, trucks, pipelines, etc. Transport via pipelines is the most convenient method for economic and security reasons. Ensuring the easy flow of crude oil is an important issue given the heavy reliance on it in most daily and industrial activities [5]. Transporting heavy crude oil through pipelines is extremely difficult. The reason is the high viscosity, which requires huge pumping as well, not to mention the problem of wax deposition in the pipe walls [6]. This deposition reduces the internal diameter of the pipeline, which leads to an increase in pressure drop. To overcome this drop, it may require increasing the pumping force which increases costs and risks of leakage into the environment [7]. Transporting crude oil through the seabed is one of the challenging scenarios for engineers due to the temperature gradient given that the relationship between temperature and wax deposition is inverse [8]. When crude oil moves towards refineries, it begins to lose heat, causing wax to appear and begin to precipitate over time [9]. 85% of crude oil suffers from wax deposition worldwide [10].

Waxes are substances that are solid at room temperature and liquid at high temperatures. It is composed primarily of hydrocarbons, which are usually insoluble in water [11]. A large percentage of transported petroleum products contain a high percentage of heavy hydrocarbons [12]. Crude oil usually contains more than 30% of wax substances [10]. When the temperature drops below (WAT) Wax Appearance Temperature, the wax begins to appear and accumulates in the pipeline walls. While forming a mesh chain that clogs and reduces the flow area of the pipeline, as well as the deposition of paraffin substances in the wax will make it worse. WAT may vary depending on the type of crude oil and the percentage of hydrocarbons such as asphaltenes and paraffins [13]. Temperature and shear rates are the main factors in controlling the percentage of wax deposition during the transportation of crude oil [5]. Also, when the pumping stops, the wax contained in the crude oil gets enough time to precipitate and crystallize along the pipeline, then the problem worsens, and it becomes more difficult and

increases the crisis capacity when restarting the pipelines. The reason is that when pumping stops, the crude oil is in a static state, which means that the shear rate is zero. As Vinay et al [14] proved, the lower the shear rate, the greater the percentage of precipitated wax.

There are many ways to overcome wax deposition, the most famous of which is electrical heating. The principle of this method is very simple, in general, it is heating pipelines to maintain the Newtonian behavior of crude oils to avoid the appearance of wax and clogging of pipes. This method may be effective, but it is often very expensive, as rapid heat loss is a hindrance due to the low temperatures on the seabed. As well as the need for a large number of heating stations, high energy costs and constant maintenance. However, when the temperature decreases, the viscosity of the oil depends on the shear rates, that is, the resistance is lower with high shear rates, as the gelatin disintegrates parallel to the flow direction and the viscosity decreases [15]. Nichrome is considered one of the best options for heating wires. As it provides high resistance to electricity and oxidation and has high thermal conductivity [16]. In addition, one of the most important qualities that nichrome wires possess is its ability to maintain its performance over time and does not melt easily even with very high electric currents [17]. Computational Fluid Dynamic (CFD) is an alternative to laboratory experiments, which are usually expensive, difficult, and sometimes dangerous. The objective of this study was to investigate the wax deposition in pipelines with and without nichrome using ANSYS Fluent workbench. Wax accumulation in the pipeline due to the low temperature was simulated for the flow analysis of heavy crude oil.

2. Methodology

The wax deposition due to the heat reduction and melting by heating wires was simulated in the ANSYS Fluent. It provides a solidification and melting model, which in turn solves the wax deposition present in crude oil. But provided that special parameters of crude oil such as density and viscosity should be defined at different temperatures, the external temperature and the initial crude oil temperature must also be specified.

2.1. Geometry

Geometry at millimeter scale was created using DesignModeler as Figure 1 shows that. A hollow pipe was drawn with a length of 1000 mm and an outer and inner diameter of 51 and 50 mm, respectively.

The heating wire passes through the middle of the pipe, where it has a diameter of 10 mm, as shown in Figure 2.

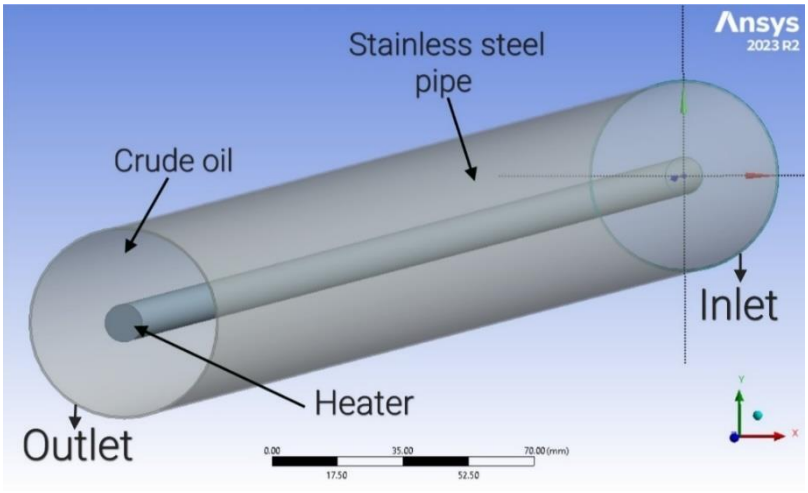

Figure 11. Solidification and melting geometry.

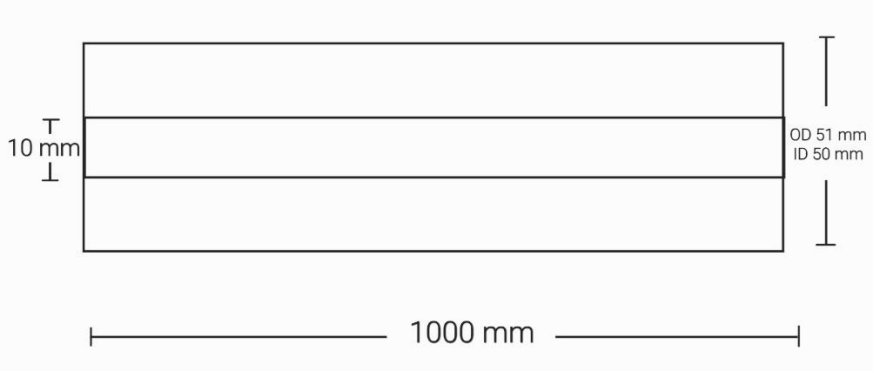

Figure 12. Solidification and melting geometry dimensions.

2.2. Mesh

Mesh in CFD is very important, as the importance lies in solving the governing equations, and the solution cannot be applied directly to the geometry due to the complexity of the shape. The accuracy of the results was closely related to the quality of the mesh. The smaller and more structured mesh size, the more accurate the simulation will be. The large size of the meshing will not lead to accurate results, also unstructured mesh may adversely affect the accuracy of the results [18].

The mesh was generated in all parts with different element sizes using the sweep meshing method with axisymmetric as an element order, each part has a different sweep number division, where the pipe has 60 divisions, the heater with 6, and the crude oil zone has a division of 20. Face sizing has also been applied to all bodies with an element size of 10mm. The number of nodes was 217706 and 199280

elements. The quality of the mesh was checked for more accurate results (See Figure 3). As it was reported by Adam et al [19] the maximum number of skewness should be less than 0.95.

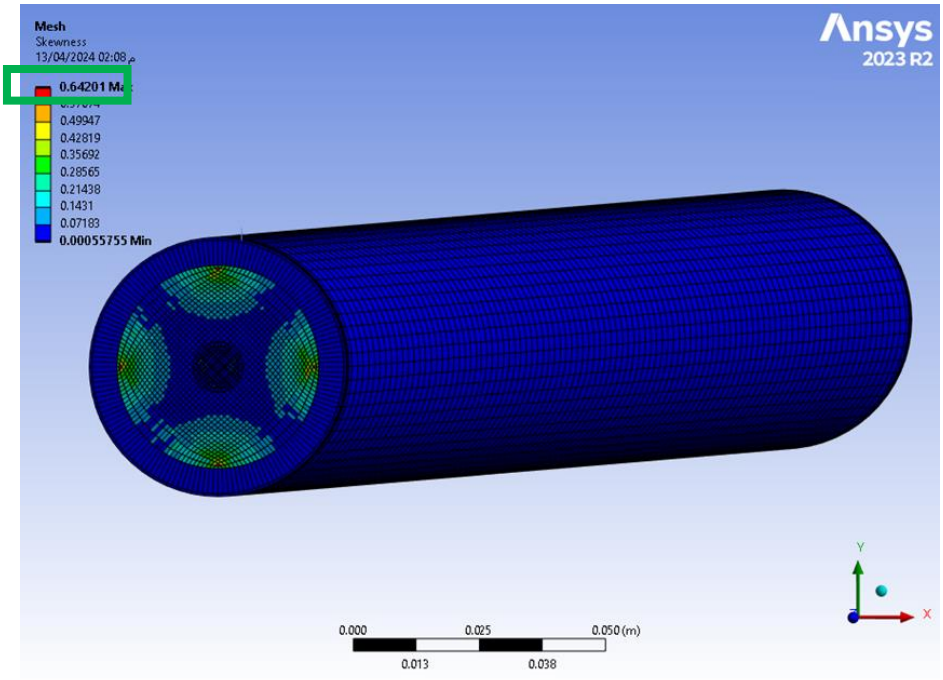

Figure 13. Solidification and melting geometry with Skewness's quality.

2.3. Material Properties

The properties of the crude oil were obtained in the laboratories, and the stainless-steel properties were provided in the program itself. The characteristics of crude oil, pipes and heating wires properties are given in Tables 1 and 2, respectively. Crude oil-specific heat, Thermal conductivity, and latent heat were taken from [20]. The solidus and liquidus temperatures were assumed according to WAT and PPT. As for the viscosity, NDJ-9S viscometer was used to determine the viscosity of the crude oil at various temperatures and for the density, EXPRO Convert Utility software was used to predict the density of the crude oil at different temperatures. Note that the heating wire contains Nichrome inside, but the outer layer was made of stainless steel, so it was assumed that the heating wire was completely made of stainless steel and the surface temperature was fixed according to the real wire temperature in an experiment.

Table 3. Crude oil properties used in FLUENT.

Specific heat	2420 J/kg- K
Thermal conductivity	0.147 W/m- K

latent heat	306446 J/kg	
Solidus temperature	6 ℃	
Liquidus temperature	36 ℃	
Dynamic viscosity	Temperature ℃	Viscosity kg/m-s
	5	4.443
	15	3.058
	25	2.230
	35	1.368
	45	0.873
	55	0.485
	65	0.382
Density	Temperature ℃	Density (kg/m3)
	5	938
	15	931.5
	25	925.4
	35	919.3
	45	913
	55	906.5
	65	899.9

Table 4. Stainless steel properties.

Density	7750 kg/m3
Thermal conductivity	15.1 W/m- K
Specific heat	480kg- K

2.4. Mathematical Model

i. Energy equation

Equation (1) is the equation of the energy modulus used in the Fluent [21].

$$\frac{\partial(\rho H)}{\partial t} + \nabla \cdot (\rho \vec{v} H) = \nabla \cdot (k \nabla T) + S \qquad (1)$$

Where:

H = enthalpy

ρ = crude oil density

$\vec{v}$ = crude oil velocity

S = temperature source

Using Equation (2) (H) enthalpy can be found.

$$H = h + \Delta H \quad (2)$$

Where:

h = sensible enthalpy

ΔH = change in enthalpy

h and ΔH were calculated as follows.

$$h = h_{ref} + \int_{T_{ref}}^{T} c_p \, dT \quad (3)$$

$$\Delta H = \beta L \quad (4)$$

h_{ref} = reference enthalpy

T_{ref} = reference temperature

c_p = crude oil specific heat at constant pressure

β = liquid fraction

L = crude oil latent heat

L is equal to zero when the crude oil is 100% solid $\beta = 0$, and L will be higher when the crude is liquid $\beta = 1$. Equation (5) was used to calculate (β).

$$\beta = \frac{T - T_{solidus}}{T_{liquidus} - T_{solidus}} \quad (5)$$

$T_{solidus}$ = Assumed to be below the PPT by 3 ℃

$T_{liquidus}$ = Assumed to be above the WAT by 1 ℃

2.5. Boundary Conditions

Table 3 shows the boundary condition of the Inlet, Outlet, and Walls where each section has initial values. The velocity, temperature, and initial pressure of the crude oil were assumed. The temperature of the outer surface of the heating wire was fixed according to the nichrome wire temperature in the experiment.

Table 5. Solidification/Melting boundary conditions.

Zone name	Type	Boundaries	
Inlet	Velocity inlet	Initial temperature	25 ℃
		Initial velocity	0 m/s
		Initial pressure	200000 Pa
Outlet	Outflow	Flow rate weighting	1
Pipe & Heater	Wall	Pipe temperature	5 ℃
		Heater temperature	100℃

2.6. Simulation Procedure

- Using Fluent launcher, the solver option was double precision with 4 solver processes.
- The flow of crude oil through the pipe was made under a temperature of 5 ℃.
- The transient time was used to measure wax deposition and melting with respect to time.
- Activation of the Energy and Solidification/melting models as well as the viscous model was adjusted to be laminar to eliminate the shear rate effect.
- The data of the above materials (stainless steel, crude oil) were entered.
- One phase flow condition (Crude oil).
- For the density and viscosity of the crude oil will be entered in Piecewise-linear order with 7 points, where the density was defined in terms of temperature as well as for viscosity.
- In the cell zone condition, the materials zones were defined. Where in the crude oil zone it was in a liquid state, which was crude oil, while for the pipe and heater, it was in a solid state, which was stainless steel. The heater temperature was fixed at 100℃, which was the approximate surface temperature of the heater in the experiment. The pipe temperature set to be 5℃ which in turn simulates the impact of the low temperature.
- In the boundary condition, the inlet was set as velocity inlet with an initial velocity of 0 m/s and an initial pressure gauge of 200000 Pa. The temperature of the crude oil temperature assumed to be 25℃.
- The outlet was set as outflow.
- The pipe and heater were set as walls.
- The solution method was in SIMPLE scheme.
- Standard initialization method was used.

- The calculations were run with 450 number of time steps, each time step assigned to be for 16 seconds. The total time was 2 hours.

After the calculation, the liquid fraction and temperature of the crude oil were studied with respect to time and the results appeared in graphical colors.

Note: the same steps were used to simulate the wax deposition in the pipeline but without nichrome wire, to find out the behaviour of the wax with and without a heating source and to compare the results.

2.7. Previous Experimental Results

Al Waleed, & Chala [22] conducted a previous experiment on cooling crude oil in a pipeline with and without nichrome wire under the same conditions used in the simulation (see Figure 4). These results were used to prove the validity of ANSYS Fluent in simulating wax deposition. The temperature of the crude oil expresses the internal temperature of the pipeline, while the temperature of the pipeline expresses the external temperature.

Figure 14. Crude oil pipeline under cold condition.

3. Results and Discussion

3.1. Temperature Effect on Wax Deposition

Wax deposition in the pipeline was simulated using Fluent. Crude oil was assumed to be in a static state (0 m/s) where the pumping was stopped. The purpose was to eliminate the shear rate effect because the wax deposition occurs more when the transport stops. Initially, it was assumed that the temperature of crude oil was equal to 25℃ and the surrounding temperature was equal to 5℃. As far as possible, the actual characteristics of the crude oil were used. Figure 5 illustrates the relationship between the temperature and the liquid fraction of the wax in the crude oil. It was noted that after a temperature of 36℃, the wax was 100% liquid. Because 36℃ was the assumed liquidus temperature.

As the temperature decreases, the percentage of liquid begins to decrease to reach 0% at a temperature of 6℃, considering it the solidus temperature.

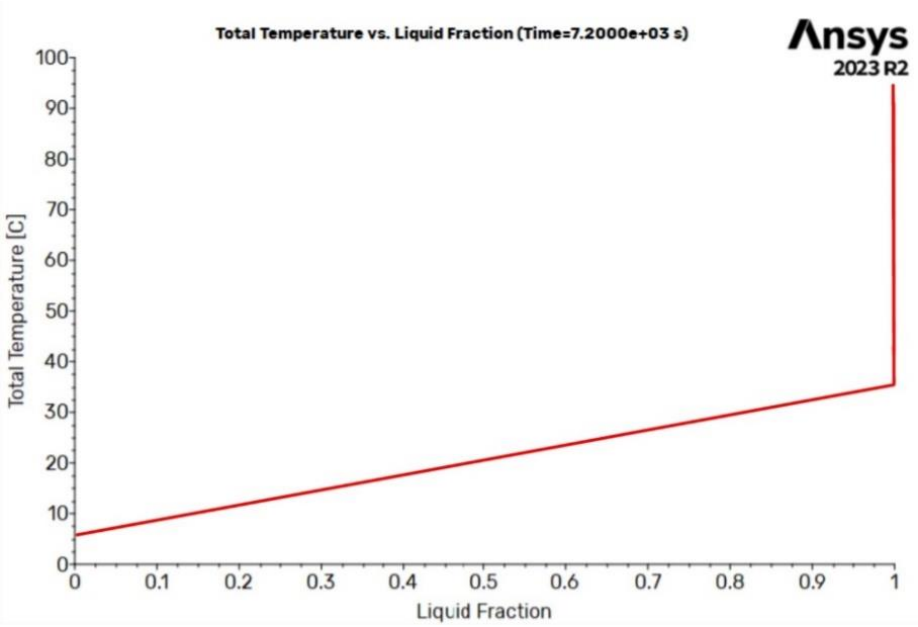

Figure 5. Total temperature vs Liquid fraction.

Below, the effect of temperature on wax deposition in the pipeline has been studied, as well as the efficiency of the nichrome wire in removing wax deposits was analyzed.

3.2. Wax Profiles in the Pipelines at Cold Condensations

Figure 6 shows wax deposition, indicating liquid part in red and the solid part in blue. It can be seen that initially, the liquid percentage was equal to 63.4%, which was due to the initial crude oil temperature of 25℃, which is less than the liquidus temperature. Over time, the percentage of the liquid decreases, and this is evidence that the wax was constantly deposited. After two hours the highest percentage of liquid reached 54.3% in the middle and the lowest was almost 0% at the pipeline walls. The reason for the rapid hardening of the wax in the pipeline walls was the sharp drop in temperature, as shown in Figure 7. Two hours later, the highest temperature of crude oil reached 22.3℃ in the middle, while in the walls it was almost equal to 5℃. Crude oil may have a high specific heat that enables it to maintain its temperature in the middle, but if it is constantly exposed to low temperature, complete blockage may occur in the pipeline.

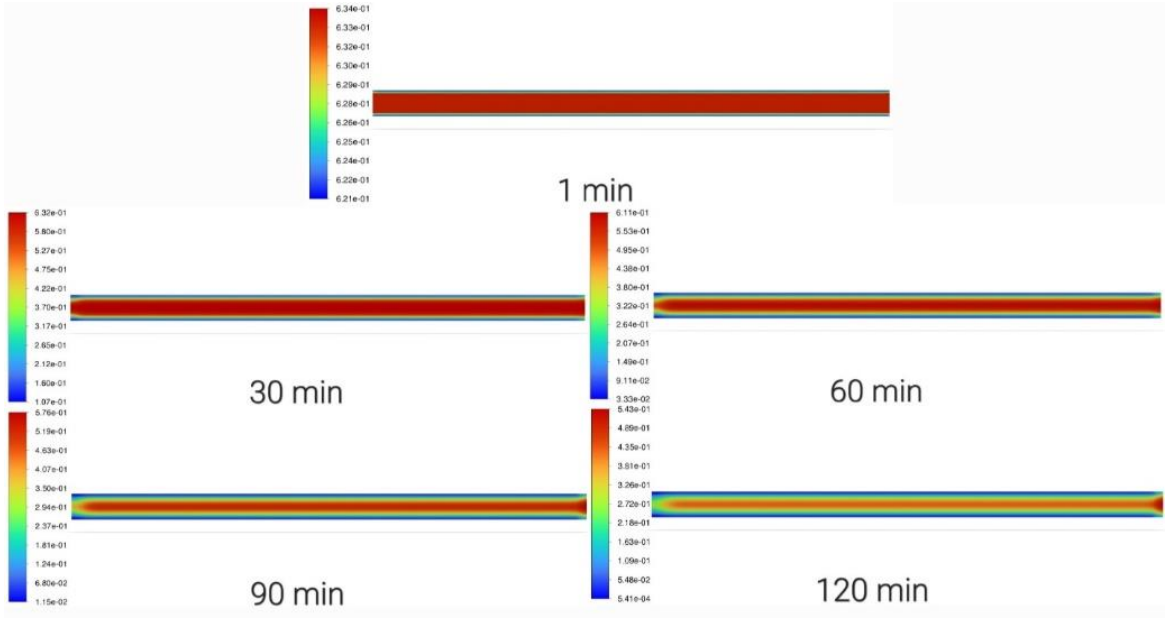

Figure 6. Liquid Fraction without nichrome wire.

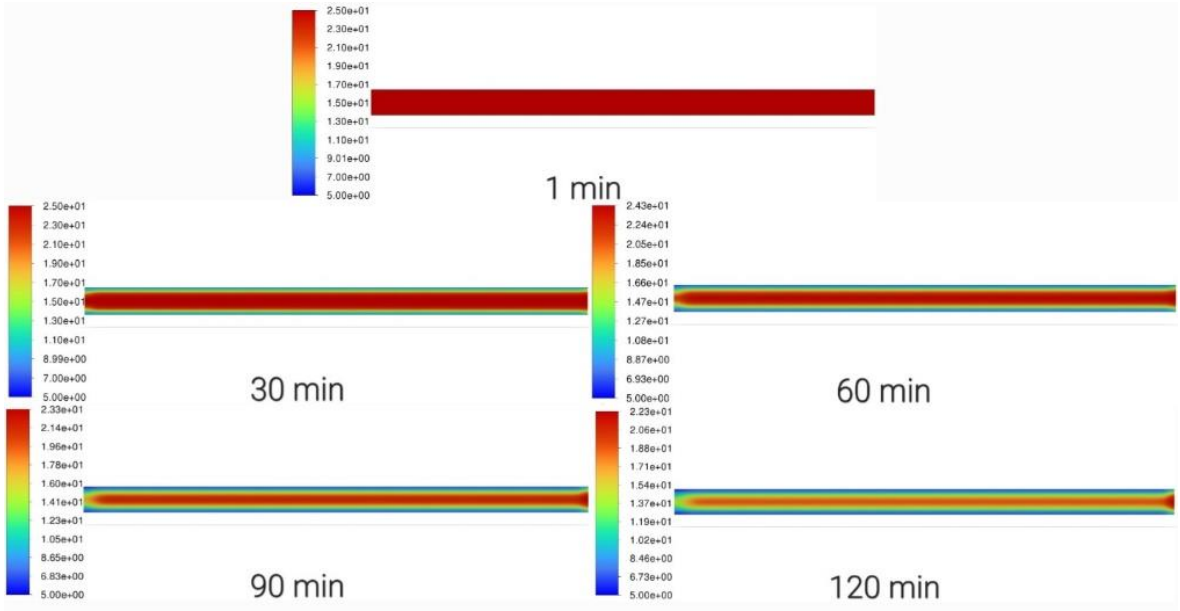

Figure 7. Crude Oil temperature (℃) without nichrome wire.

3.3. Nichrome Wire Efficiency Against Wax Deposition

The efficiency of the nichrome wire in removing wax deposits can be observed in Figure 8. After two hours, the highest percentage of the liquid was observed to be 100% in most areas of the pipeline. While the lowest was in its walls by 0.02%. From the results, it can be noted that the liquid fraction was somewhat stable, and this is evidence that the heating rate was almost equal to the cooling rate in

some areas, as the temperature results prove in Figure 9. Two hours later, the highest temperature of crude oil was observed to be equal to 52.5℃ and the lowest was 14.5℃.

Despite the positive results, a percentage of the wax deposited on the walls remains, which indicates that the nichrome wire cannot deliver sufficient heat to all areas of the pipeline. The reason was that the cooling rate exceeded the heating rate on the pipeline wall. This may be due to the distance from the nichrome wire and also considering that the walls were always directly exposed to the surrounding environment.

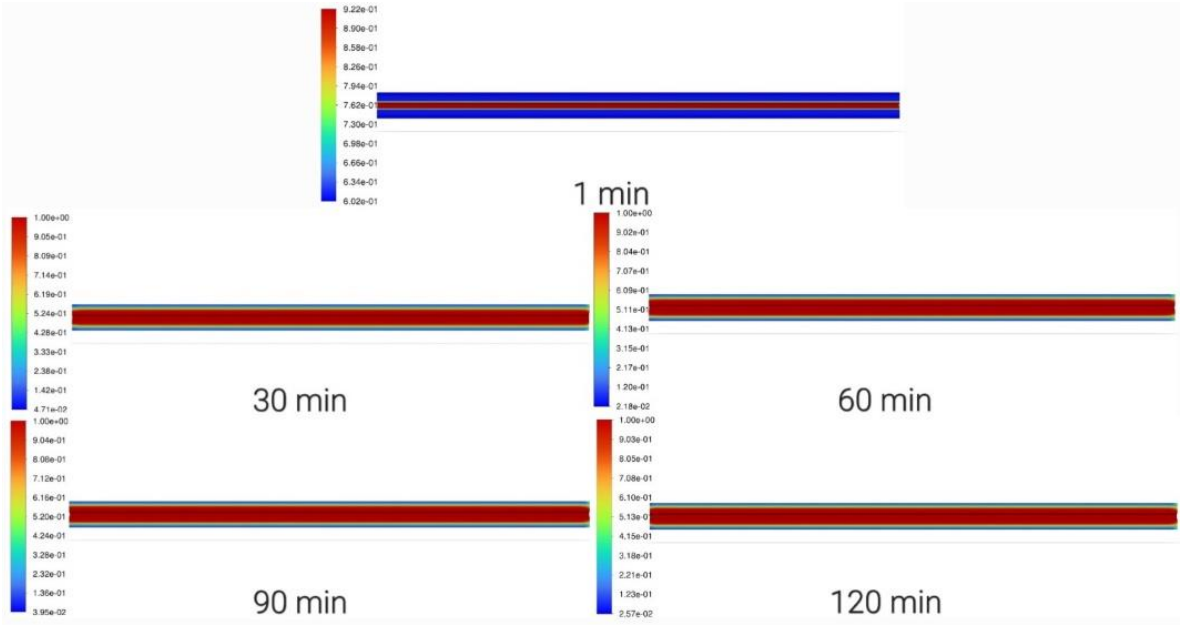

Figure 8. Liquid Fraction with nichrome wire.

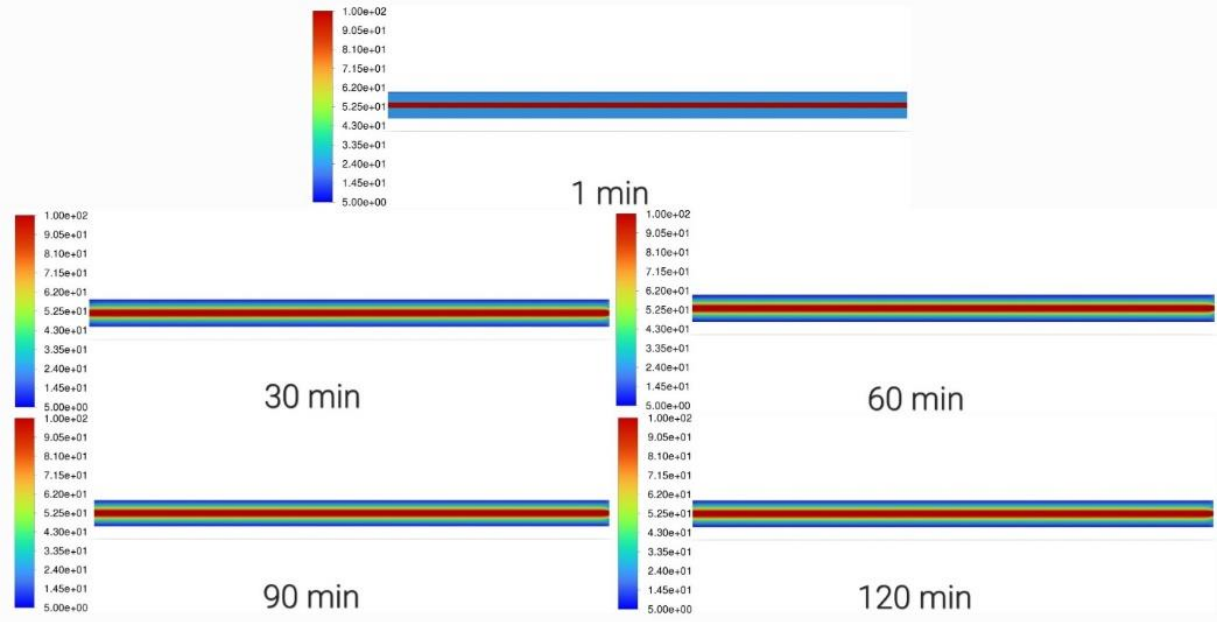

Figure 9. Crude Oil temperature (℃) with nichrome wire.

3.4. Simulation Accuracy Relative to the Experiment

Figure 10 shows a comparison between the simulation and experiment results. It shows that the results of the crude oil and the pipeline temperatures were very close. For a fair comparison, several assumptions have been made to ensure reliable results. First, the temperature readings were taken from the simulation to be from the same position of the thermostats on the experimental setup. Secondly, as for the time, the results of the experiment and simulation were collected when the nichrome wire was not used within 30 minutes. While using the nichrome wire, the readings were collected within 15 minutes.

Table 4 shows the accuracy percent of the simulation results relative to the experimental results. The accuracy proves the reliability of Fluent on the simulation of wax deposition in pipelines as reported by [23]. However the correct data and parameters must be entered because mostly the accuracy depends on them.

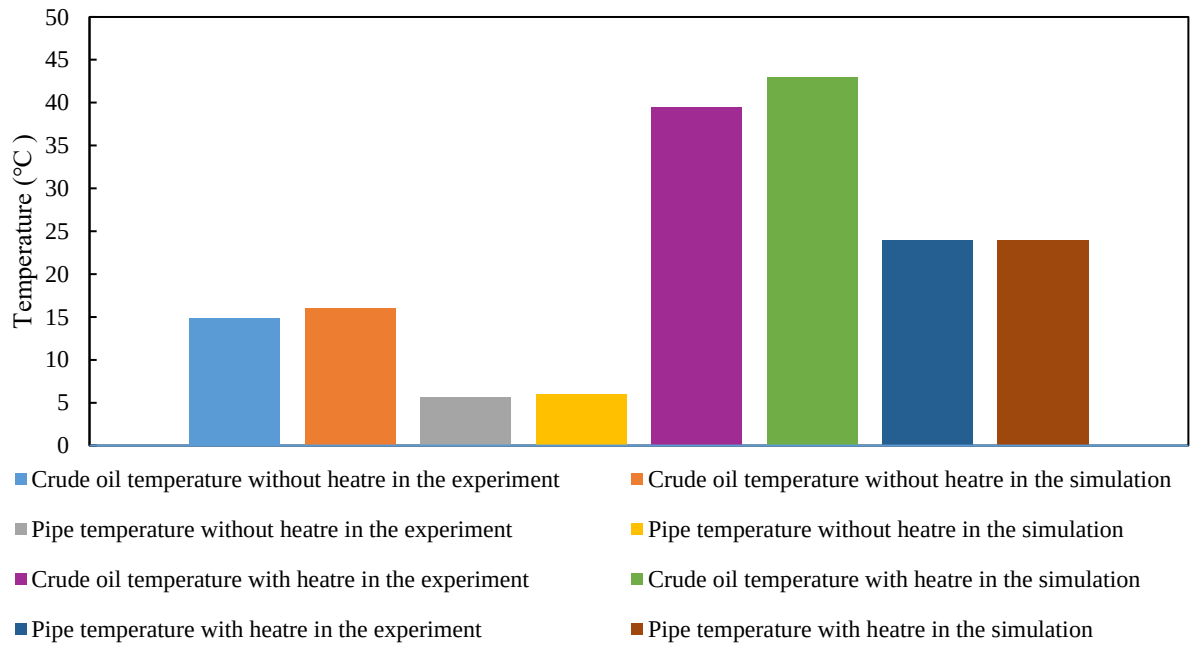

Figure 150. Comparison between experiment and simulation results.

Table 6. Accuracy percentage between simulation and experimental results.

conditions	Without nichrome wire		With nichrome wire	
	Crude oil	Pipeline	Crude oil	Pipeline
Results accuracy %	7%	5%	8%	0.4%

Conclusion

In this paper, a numerical analysis of wax deposition in crude oil pipelines was carried out using ANSYS Fluent. The aim of this study was to determine wax deposition rate over time and the effectiveness of the nichrome wire in melting the wax under a surrounding temperature of 5℃. The agreement between the simulation results and the experimental results was very close. It was noted that without using the nichrome wire, the percentage of liquid in the middle was 54.3%, while in the walls it was 0%. When using nichrome wire, the percentage of liquid in most areas of the pipeline was 100%. Despite this, the percentage of liquid in the pipeline wall was 0.02%, and this indicates that the nichrome wire is unable to conduct heat to the pipe walls due to the distance from it. The validity of FLUENT has been proven in wax deposition simulations with and without nichrome wire. The simulation results were compared with respect to the experimental results. Percentage difference between the experimental and simulation results were maximum at 8%, while the other was almost equal, reaching 0.4%. These percentages are evidence of the effectiveness of FLUENT in simulating

wax deposition in the pipelines. However, there may be shortcomings such as the fact that crude oil contains many components that have different chemical and physical properties, which should be identified and included in the simulation to obtain more accurate results. Also, the use of accurate parameters may lead to a significant increase in processing time, so simplifying the inputs may be resorted to speeding up the simulation process. Providing powerful equipment for research may open great horizons for studying and exploring new methods and techniques while saving effort, money and eliminating risks.

Acknowledgements

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ERGONOMIC RISK ASSESSMENT OF MUD MIXING OPERATORS USING ELECTROMYOGRAPHY

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Abstract

Due to repetitive operations and physical manipulation of heavy equipment, workers in the construction and drilling industries frequently suffer severe musculoskeletal risks. Operators who mix mud, in particular, face serious ergonomic risks. This study examines these concerns by measuring muscle activation and fatigue during mud mixing operations on onshore rigs using electromyography (EMG). Subjective assessments of effort and discomfort are collected in addition to EMG data from the back and upper extremities of operators in real-world settings. To give a thorough assessment of ergonomic risks, the methodology integrates surveys with ergonomic evaluation instruments including OWAS, RULA, REBA, and PERA. The goal of the study is to find patterns of muscular tension and fatigue that lead to musculoskeletal problems by analyzing EMG data. By combining subjective evaluations with objective physiological data, this integrative approach aims to identify important occupational risk factors that impact mud mixing operators. With the ultimate goal of lowering the prevalence of musculoskeletal disorders among mud mixers, the findings are anticipated to guide the creation of focused ergonomic interventions and recommendations. The goal of the study is to increase workplace safety, worker well-being, and operational efficiency in sectors of the economy where mud mixing is common.

Keywords: *Ergonomic risks, EMG, mud mixing, Musculoskeletal disorders, Occupational health*

1. Introduction

In industries such as construction and drilling, workers are frequently exposed to physically demanding tasks that put them at risk of developing musculoskeletal disorders. One of the most hazardous operations in these fields is mud mixing, which involves repetitive physical manipulation of heavy equipment. Workers who perform these tasks, particularly in onshore drilling rigs, are subject to significant ergonomic risks that can lead to long-term health problems.

This study focuses on assessing the ergonomic risks faced by mud mixing operators through the use of electromyography (EMG) to measure muscle activation and fatigue. By combining physiological data with subjective assessments of discomfort and effort, this research seeks to identify key occupational hazards that may contribute to musculoskeletal disorders among these workers. Additionally, ergonomic evaluation tools such as OWAS, RULA, REBA, and PERA are integrated to provide a comprehensive analysis.

The primary objective of this study is to analyze patterns of muscular tension and fatigue during mud mixing operations, with the aim of identifying risk factors that can be mitigated through targeted ergonomic interventions. The ultimate goal is to enhance workplace safety, improve worker well-being, and increase operational efficiency in sectors where mud mixing is common. The research addresses a critical need for occupational health improvements in physically demanding jobs and offers insights into reducing musculoskeletal injury risks.

2. Materials and Methods

This study employed a combination of observational and physiological techniques to assess ergonomic risks during mud mixing operations on onshore rigs. Data was collected from three workers who regularly perform mud mixing tasks. The study consisted of two main components: ergonomic assessment using OWAS, RULA, REBA, and PERA, and muscle activity analysis through electromyography (EMG).

Ergonomic evaluations were conducted on the three workers using four distinct methods: the Ovako Working Posture Analysis System (OWAS), the Rapid Upper Limb Assessment (RULA), the Rapid Entire Body Assessment (REBA), and the Posture, Activities, Tools, and Handling (PATH) method. These tools were applied to evaluate the workers' postures during different phases of mud mixing. Each worker was observed and assessed in three critical positions commonly encountered during mud mixing operations.

Muscle activity was recorded from the back and upper extremities of the three workers using surface

EMG. EMG electrodes were placed on specific muscle groups to monitor muscle activation and fatigue during the task. The EMG readings were taken while workers performed mud mixing in three distinct positions, covering various physical exertion levels typical of this operation. Muscle activity was monitored in real-world conditions to ensure accurate representation of occupational demands.

By combining subjective and objective measures, this methodology provided a comprehensive assessment of both the physical demands and ergonomic risks involved in mud mixing operations. The approach ensures that the results are representative of actual working conditions and offers a solid foundation for identifying key ergonomic risk factors.

3. Result and Discussion:

The ergonomic assessments and EMG readings reveal significant risks for mud mixing operators:

First Worker: OWAS score of 2 suggests moderate ergonomic concerns. However, RULA (4) and REBA (5) indicate serious issues, particularly with upper limb tasks. PERA score of 6 highlights the need for intervention to prevent health risks.

Second Worker: OWAS score of 3 reflects moderate concerns. RULA (6) and REBA (7) indicate severe ergonomic problems. PERA score of 8 emphasizes the urgency of addressing these issues to mitigate health risks.

Third Worker: OWAS score of 3 suggests moderate issues, with RULA (6) and REBA (7) pointing to notable ergonomic difficulties. PERA score of 6 indicates potential health risks if not addressed.

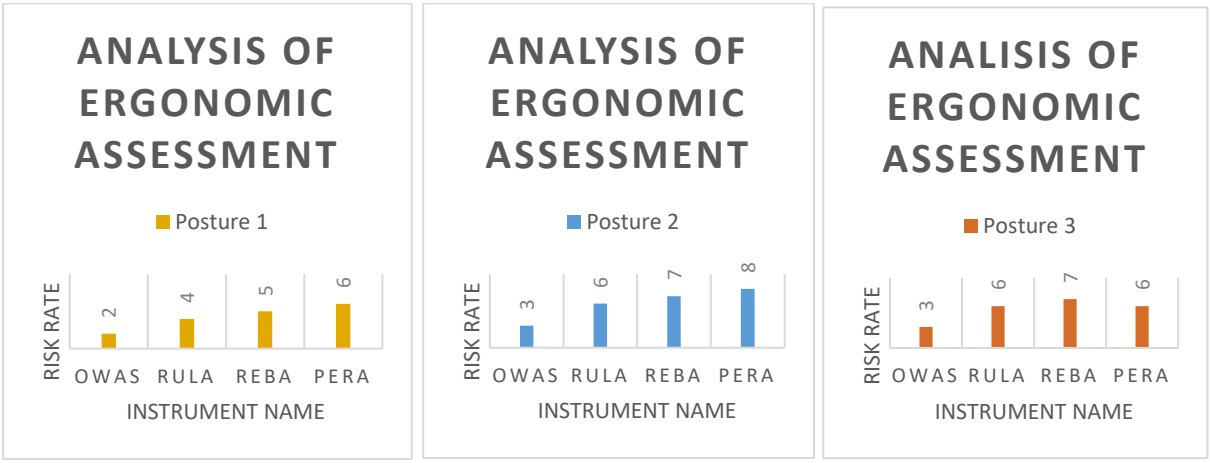

Figure 1: Analysis of Ergonomic Assessment Result

EMG Results: Fatigue levels varied by task. Balanced stances showed low fatigue (50 mV), while heavy lifting (e.g., soil sacks) caused high fatigue (up to 200 mV). Moderate (100 mV) and high (150 mV) fatigue levels reflect alternating strain periods.

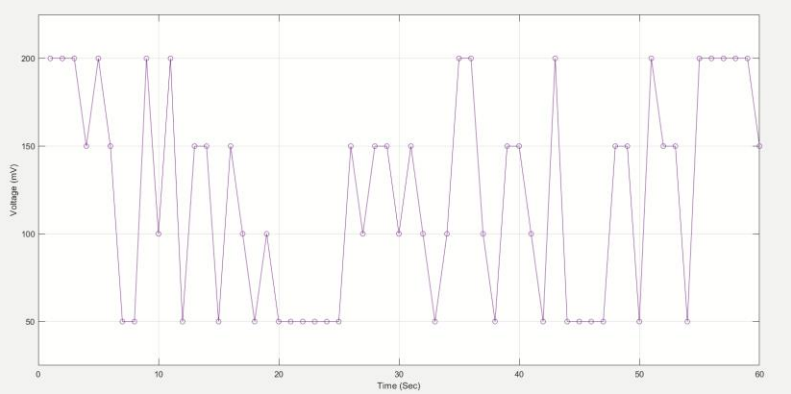

Figure 2: EMG Graph Layout

Graphs illustrate muscle fatigue patterns, highlighting the physiological stress of mud mixing. Insights can inform interventions to reduce strain and improve safety, fostering a positive work environment that enhances employee well-being and reduces workplace accidents.

4. Conclusion

The comprehensive Ergonomic Risk Assessment of mud mixing operators utilizing Electromyography (EMG) yielded several critical findings:

- Ergonomic Hazards: Significant risks, including uncomfortable postures, repetitive motions, and prolonged standing, contribute to musculoskeletal disorders (MSDs) among operators.
- Lifting and Loading Risks: High injury potential exists when lifting and loading sacks due to excessive loads, improper techniques, and inadequate rest, necessitating immediate ergonomic interventions.
- Muscle Fatigue Insights: EMG data revealed increased muscle fatigue after prolonged activity, indicating a need for ergonomic modifications to reduce strain.
- Targeted Intervention Opportunities: Analysis of EMG data identified specific muscles with high fatigue levels, informing the development of focused interventions to mitigate MSD risks.

These findings emphasize the necessity of customized ergonomic solutions to improve worker health and safety. By integrating evidence-based practices and insights from EMG data, organizations can foster a culture of ergonomic excellence, reducing injury risks and enhancing workplace safety.

Future Research Directions:

- Conduct longitudinal studies to assess the long-term effectiveness of ergonomic interventions.
- Investigate the application of similar assessments in other physically demanding occupations.
- Explore advanced EMG technologies for deeper insights into muscle fatigue patterns.
- Research tailoring ergonomic solutions based on individual worker characteristics and tasks.

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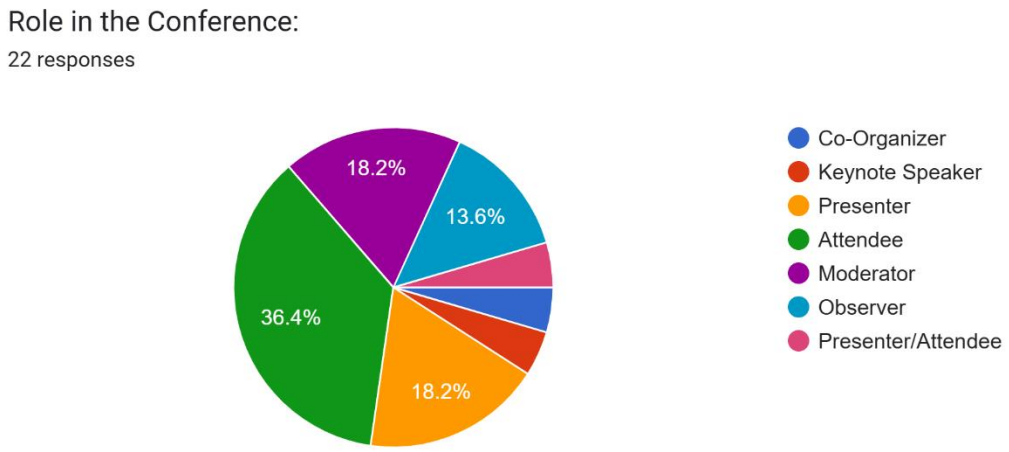
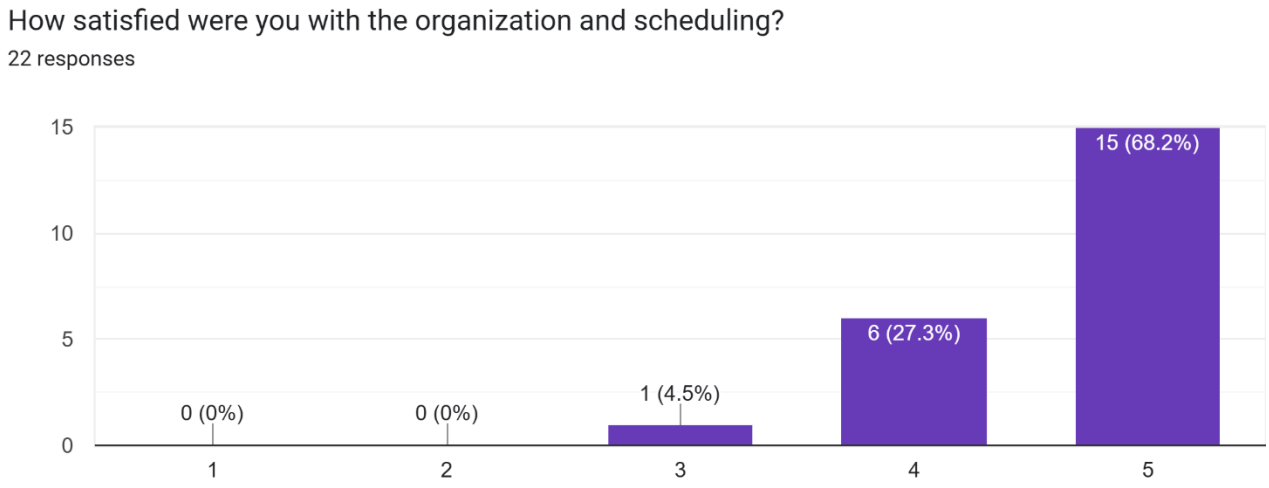
Feedback and Recommendation

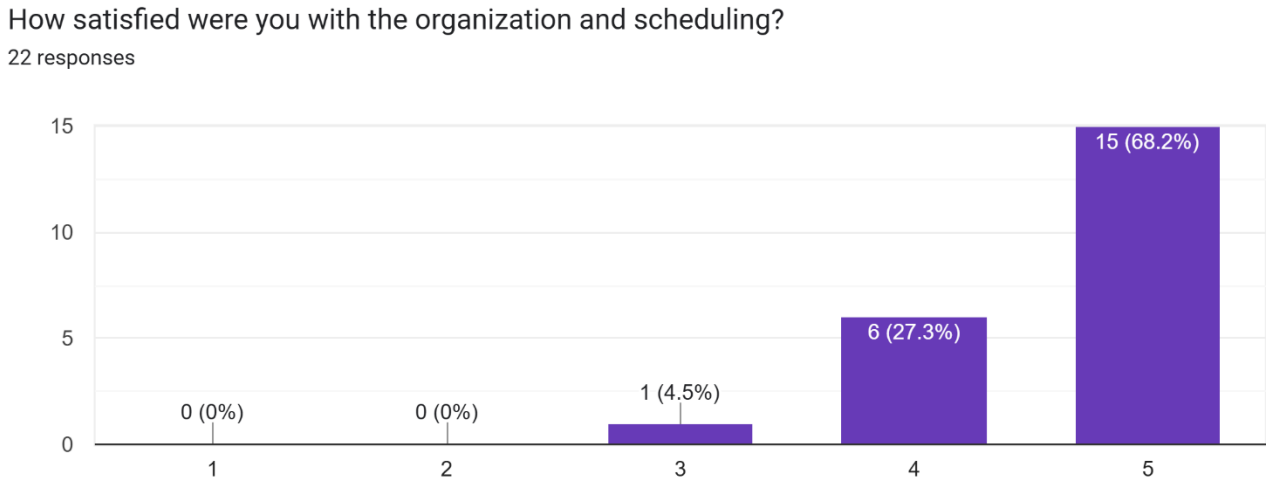
A total of 22 responses were collected to identify participants' roles during the conference. The majority, 36.4%, attended the event as Attendees, showcasing a strong interest in listening and learning. Moderators and presenters each represented 18.2% of the participants, playing critical roles in facilitating discussions and delivering research findings. 13.6% attended as Observers, contributing to the knowledge-sharing atmosphere. Smaller but significant roles were played by Co-Organizers (9.1%), Keynote Speakers (4.5%), and Presenter/Attendees (4.5%). This diverse participation highlights the conference's inclusivity and the successful engagement of individuals in various capacities.



Participants were asked to rate their satisfaction with the organization and scheduling of the conference on a scale of 1 to 5. The feedback was overwhelmingly positive, with **68.2%** (15 respondents) rating their satisfaction as **5** (very satisfied), while **27.3%** (6 respondents) rated it as **4**. Only one participant (4.5%) rated their experience as **3**, reflecting a neutral stance. Notably, no one expressed dissatisfaction with scores of 1 or 2. This overwhelmingly positive feedback—**95.5%** satisfaction, reflects the meticulous planning and seamless execution of the conference schedule, ensuring a smooth and productive experience for all participants.

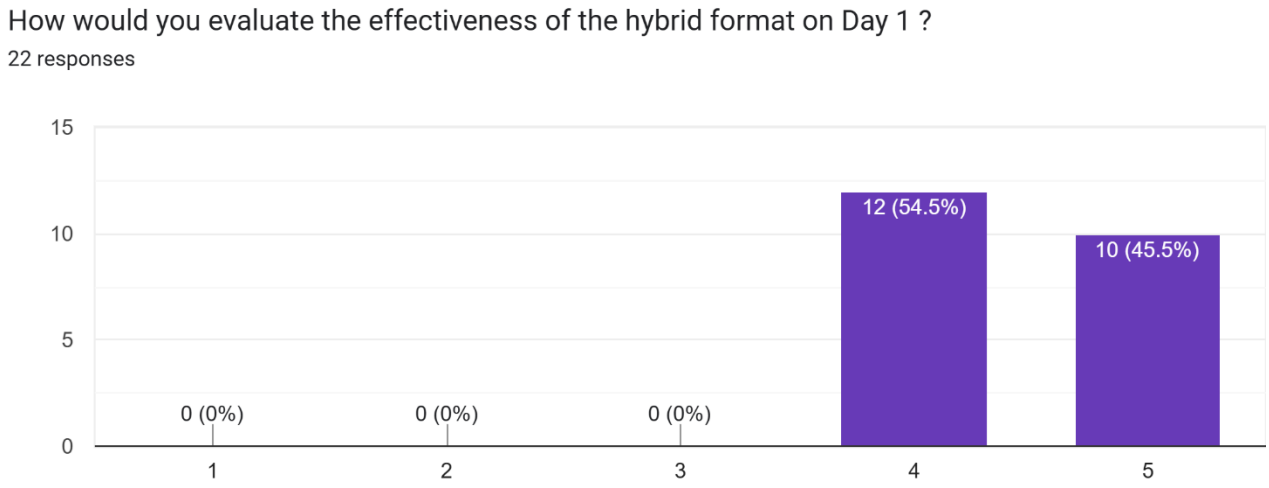


When asked to evaluate the effectiveness of the hybrid format on Day 1, participants demonstrated strong approval. The majority, **54.5%** (12 respondents), rated the format as **4** (satisfactory), while **45.5%** (10 respondents) rated it as **5** (highly effective). Notably, no participants rated the hybrid format as ineffective or neutral. This result indicates that the hybrid model successfully met participants' needs, accommodating both virtual and in-person attendees while facilitating engagement and participation seamlessly.

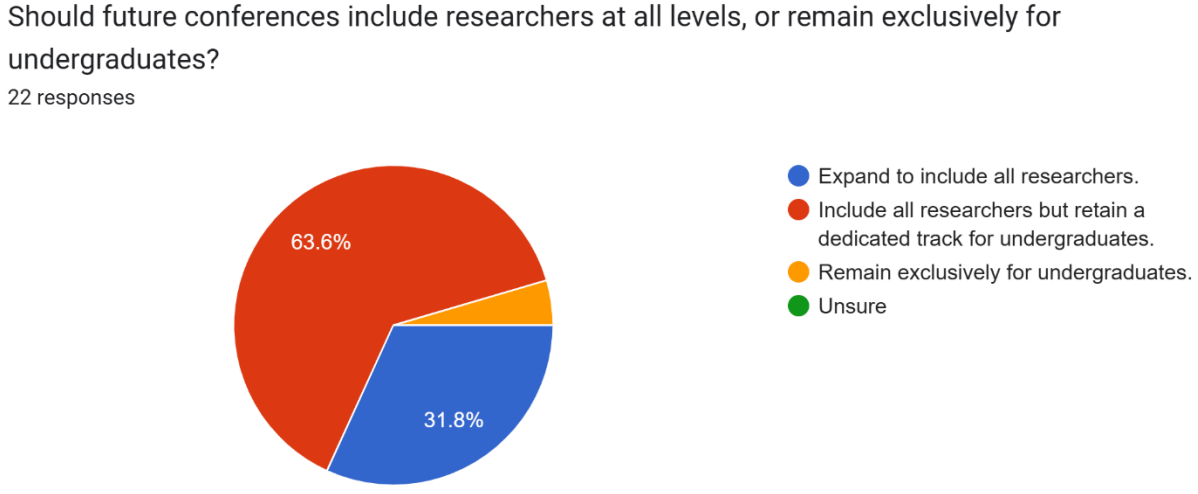


Participants were surveyed on whether future conferences should include researchers at all levels or remain exclusive to undergraduates. A strong preference emerged for inclusivity, with **63.6%** of respondents suggesting the conference should include all researchers while retaining a dedicated

track for undergraduate participants. Another **31.8%** supported expanding the conference to include researchers at all levels without restrictions. The feedback highlights a balanced view, ensuring undergraduate researchers remain a focus while broadening participation to foster richer knowledge exchange.



Participants were surveyed on whether future conferences should include researchers at all levels or remain exclusive to undergraduates. A strong preference emerged for inclusivity, with 63.6% of respondents suggesting the conference should include all researchers while retaining a dedicated track for undergraduate participants. Another 31.8% supported expanding the conference to include researchers at all levels without restrictions. The feedback highlights a balanced view, ensuring undergraduate researchers remain a focus while broadening participation to foster richer knowledge exchange.



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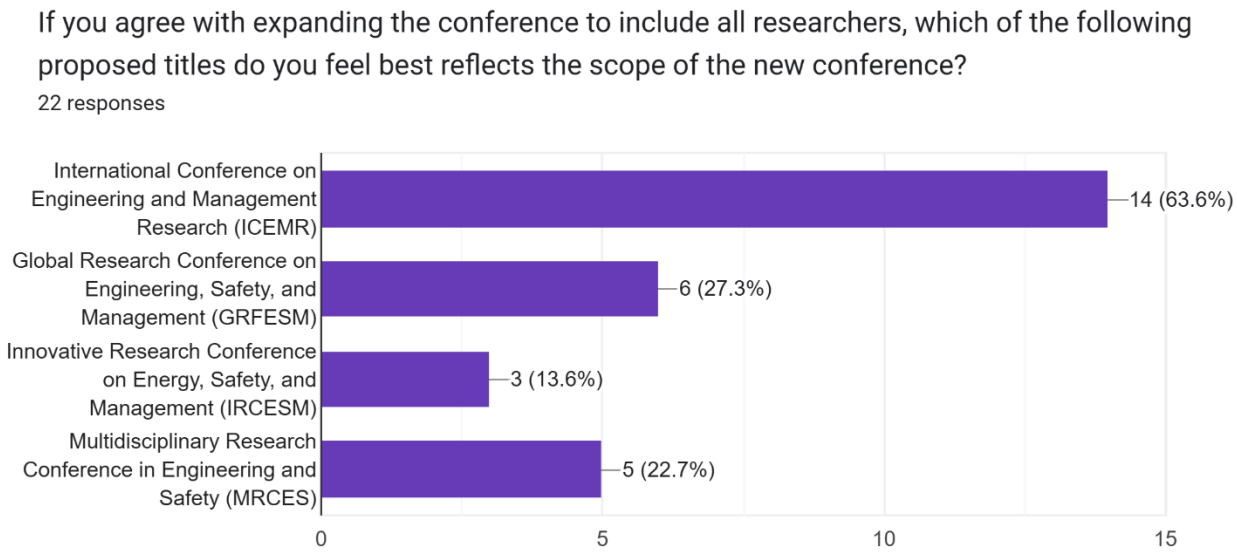
For those supporting the expansion of the conference scope, participants were asked to select the most suitable title for the new conference. The title “International Conference on Engineering and Management Research (ICEMR)” received the most support, with 63.6% (14 respondents) favoring it for its broad appeal and relevance. The Global Research Conference on Engineering, Safety, and Management (GRFESM) followed with 27.3% (6 respondents), while the Multidisciplinary Research Conference in Engineering and Safety (MRCES) received 22.7% (5 respondents). Lastly, the Innovative Research Conference on Energy, Safety, and Management (IRCESM) gathered 13.6% (3 respondents). The results reflect a clear consensus on adopting a title that aligns with the conference's expanded vision while maintaining its identity and focus.



What Participants Liked Most:

Participants provided thoughtful feedback on what they liked most about the conference. Many praised the organization and management of the event, highlighting its seamless execution and professional handling. Comments included: “Meticulous planning and seamless communication by the Conference Chair” and “The smooth run of the busy timetable.” Participants also appreciated the diverse topics and participation, with statements such as “Different topics included in the conference” and “Participation of students from various countries.” The interactive sessions, particularly the Q&A segments, were another major highlight, with several responses emphasizing the value of “question sessions” and the opportunity for dialogue. Additional positive feedback included the accessibility of the online format and the focus on undergraduate student participation. Overall, participants expressed strong satisfaction with the event's execution, content, and inclusiveness.

Additional Comments and Suggestions:

When asked for additional comments or suggestions, participants provided valuable feedback for improving future conferences. Several respondents expressed appreciation, with comments like “Keep it up. Looking forward to more conferences alike” and “Pl. continue with the good work. Congratulations.” Suggestions for improvement included incorporating more interactive features, such as live polls and extended Q&A sessions, to increase attendee engagement. Others recommend enhancing interaction with students through tools like QR codes for submitting questions and introducing poster presentations. Some participants proposed conducting the conference physically at college campuses or exhibition centers to provide a more immersive experience. Broader promotional strategies were also suggested, including appointing ambassadors in universities and elevating the conference to include all levels of research to ensure greater sustainability.

Summary of Feedback

- The feedback collected for the ICEM 5th Virtual International Undergraduate Research Conference reflects a high level of satisfaction and strong support for the conference's future growth. Participants were overwhelmingly positive about the organization and scheduling, with 95.5% rating their experience as satisfactory or very satisfactory. The hybrid format was also well-received, with 100% of respondents finding it effective.
- There is a clear preference for expanding the conference to include researchers at all levels, with the title “International Conference on Engineering and Management Research (ICEMR)” emerging as the favored option. Open-ended feedback highlighted the conference's strengths in organization, topic diversity, and interactive sessions, while providing valuable suggestions for future improvements, such as incorporating more interactive tools, poster presentations, and broader promotional strategies.
- Overall, the ICEM-5VIURC 2024 successfully achieved its objectives of fostering collaboration, innovation, and knowledge-sharing. The feedback underscores the event's success while offering actionable recommendations to ensure its continued growth and impact in future editions.

APPENDICES

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Appendix A : Feedback and Recommendations (Raw data)

Timestamp	Role in the Conference:	How would you rate the overall conference experience?	How satisfied were you with the organization and scheduling?	How effective was the virtual platform (MS Teams) for the event?	How would you evaluate the effectiveness of the hybrid format on Day 1 ?	Should future conferences include researchers at all levels, or remain exclusively for undergraduates?	If you agree with expanding the conference to include all researchers, which of the following proposed titles do you feel best reflects the scope of the new conference?	What did you like most about the conference?	Any additional comments or suggestions?
12/05/2024 12:05	Attendee	5	5	5	5	Include all researchers but retain a dedicated track for undergraduates.	Global Research Conference on Engineering, Safety, and Management (GRFESM), Multidisciplinary Research Conference in Engineering and Safety (MRCES)	Topics & innovation	none

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12/05/2024 12:09	Attendee	4	4	4	4	Expand to include all researchers.	Innovative Research Conference on Energy, Safety, and Management (IRCESM)	All	No
12/05/2024 12:12	Co-Organizer	5	5	4	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	Meticulous planning and seamless communication by the Conference Chair.	Pl. continue with the good work. Congratulations.
12/05/2024 12:20	Keynote Speaker	5	4	5	5	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR), Global Research Conference on Engineering, Safety, and Management (GRFESM)	organization	no

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12/05/2024 12:21	Attendee	3	4	4	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	NA	NA
12/05/2024 12:40	Attendee	4	5	5	4	Expand to include all researchers.	International Conference on Engineering and Management Research (ICEMR)	Well organized conference	No comments
12/05/2024 12:45	Presenter	5	5	5	5	Expand to include all researchers.	International Conference on Engineering and Management Research (ICEMR), Global Research Conference on Engineering, Safety, and Management (GRFESM), Innovative Research Conference on Energy, Safety,	The timing and the idea that is being held online.	NA

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							and Management (IRCESM), Multidisciplinary Research Conference in Engineering and Safety (MRCES)		
12/05/2024 12:47	Presenter	5	5	5	5	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	question sessions	Great experience
12/05/2024 14:28	Moderator	5	5	5	5	Expand to include all researchers.	Multidisciplinary Research Conference in Engineering and Safety (MRCES)	Different topics included in the conference	All good

12/05/2024 15:29	Presenter	5	5	5	5	Expand to include all researchers.	Multidisciplinary Research Conference in Engineering and Safety (MRCES)	Q/A session.	For future conferences, I suggest incorporating more interactive features, such as live polls or extended Q&A sessions, to increase attendee engagement. I would gladly attend again and highly recommend the conference to my peers.
12/05/2024 15:50	Presenter	4	3	4	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	easy assessment	more promotion, appoint ambassadors or representatives in different universities, call a few person to engineering college/ universities in Oman to attract more people.

12/05/2024 16:06	Moderator	5	5	4	4	Expand to include all researchers.	International Conference on Engineering and Management Research (ICEMR), Multidisciplinary Research Conference in Engineering and Safety (MRCES)	Participation of the students from the various countries. Management and handling of the conference event.	Keep it up. Looking forward to more conferences alike.
12/08/2024 8:41	Observer	4	5	4	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	the proper organizing of the conference	I suggest to conducted physically at the college campus or at the exhibition center.
12/08/2024 8:56	Attendee	5	5	4	4	Include all researchers but retain a dedicated track for undergraduates.	Innovative Research Conference on Energy, Safety, and Management (IRCESM)	well orgonised	NA

12/08/2024 9:00	Moderator	5	4	5	5	Expand to include all researchers.	Global Research Conference on Engineering, Safety, and Management (GRFESM)	Event Management	Keep it up
12/08/2024 9:32	Moderator	5	5	4	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	The overall management of the conference as well as team work	It is time to elevate the conference to a higher level to include all research and not only exclusive to undergraduates to be more sustainable.
12/08/2024 9:35	Attendee	5	5	5	5	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	Very well organized	No comments

12/08/2024 9:39	Presenter/Attendee	5	5	5	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	-	-
12/08/2024 9:59	Observer	5	5	5	5	Include all researchers but retain a dedicated track for undergraduates.	Global Research Conference on Engineering, Safety, and Management (GRFESM)	The professional organization& the valuable information had shared by the researchers.	N/A
12/08/2024 11:28	Observer	5	4	5	4	Include all researchers but retain a dedicated track for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	smooth run of the busy timetable	better to focus on more interaction with students and questions could be sent via QR code to avoid hesitation

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12/08/2024 11:44	Attendee	5	4	4	4	Remain exclusively for undergraduates.	International Conference on Engineering and Management Research (ICEMR)	-	-
12/08/2024 13:44	Attendee	5	5	5	5	Include all researchers but retain a dedicated track for undergraduates.	Global Research Conference on Engineering, Safety, and Management (GRFESM)	Undergraduate students' participation	Poster presentations may be included in the future conference.

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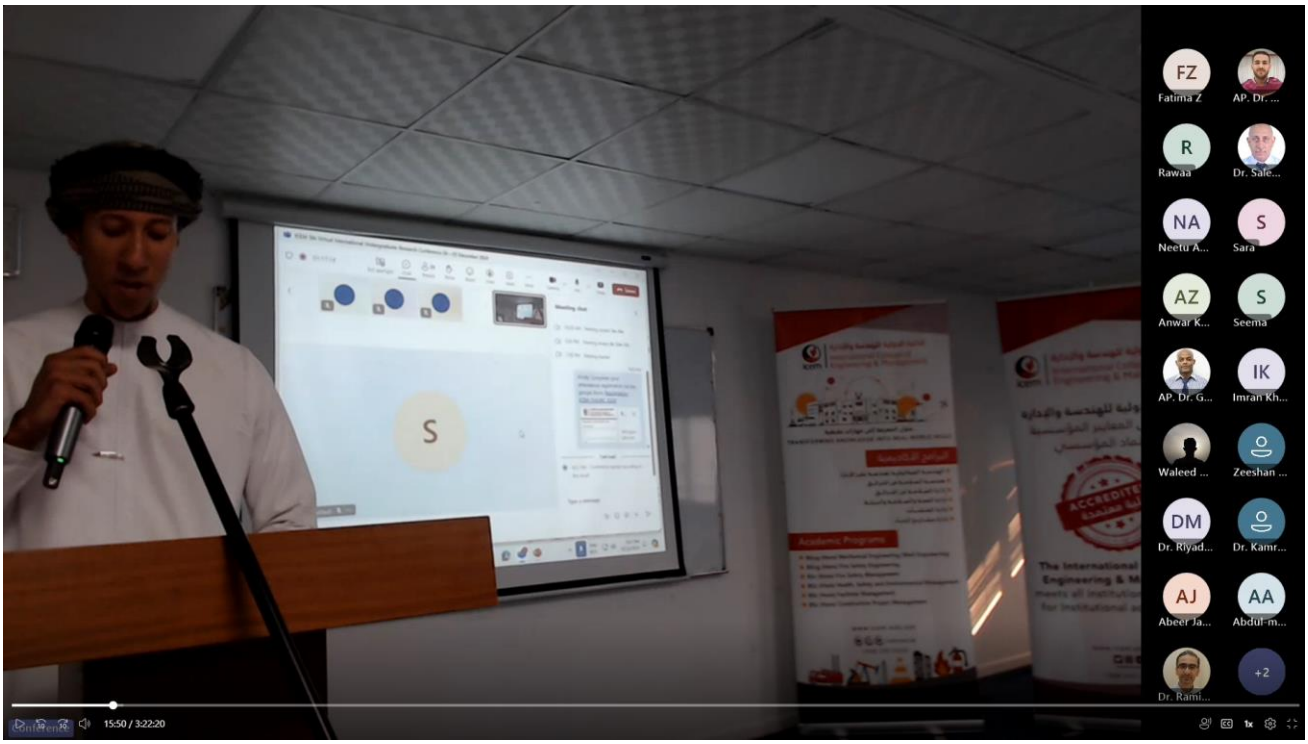
Appendix B : Photo Gallery

Day 1: Opening ceremony

Day 1: Opening ceremony



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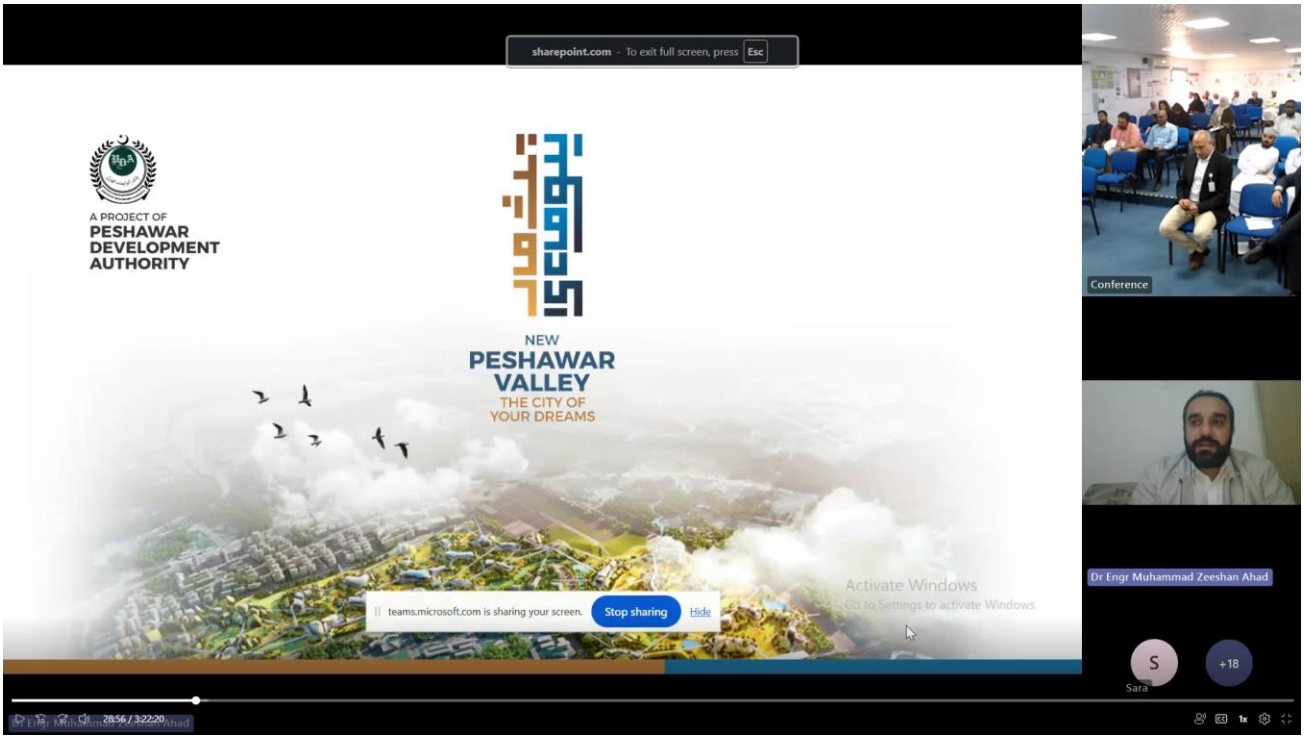
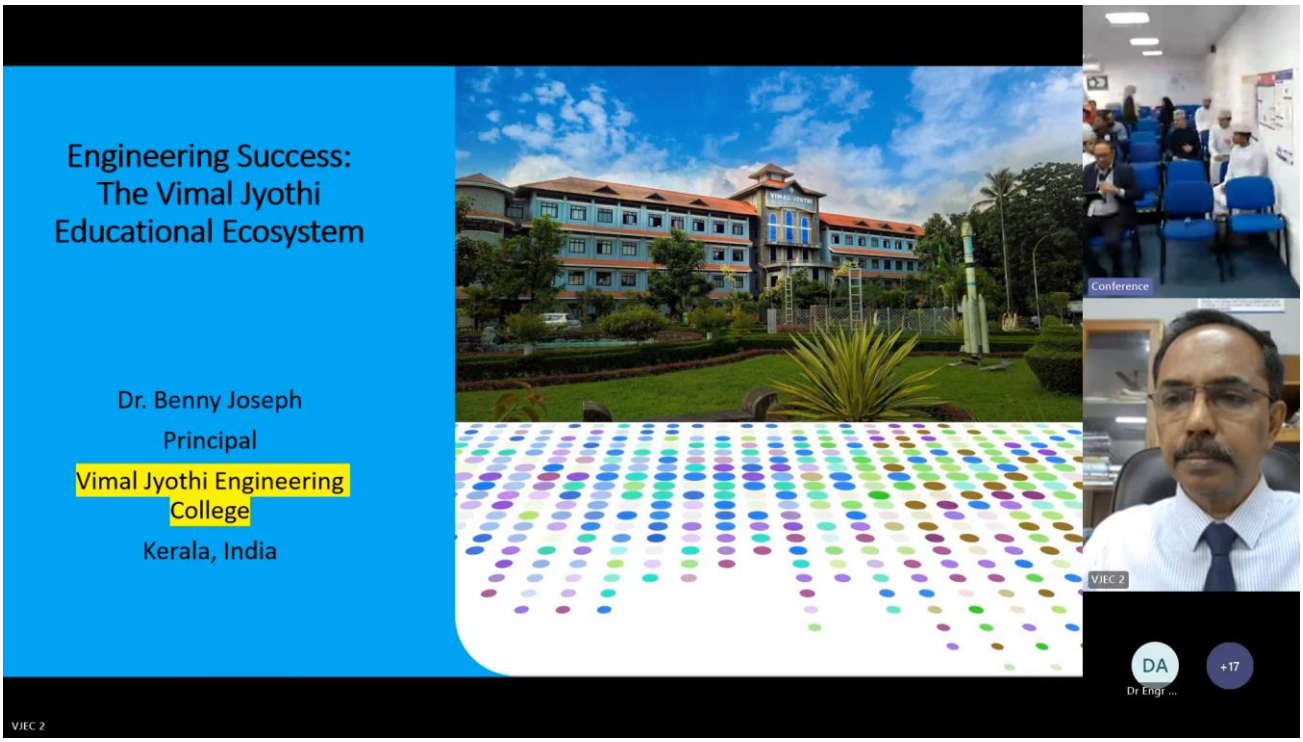


Day 1: Co-organizers-talk



Day 1: Co-organizers-talk

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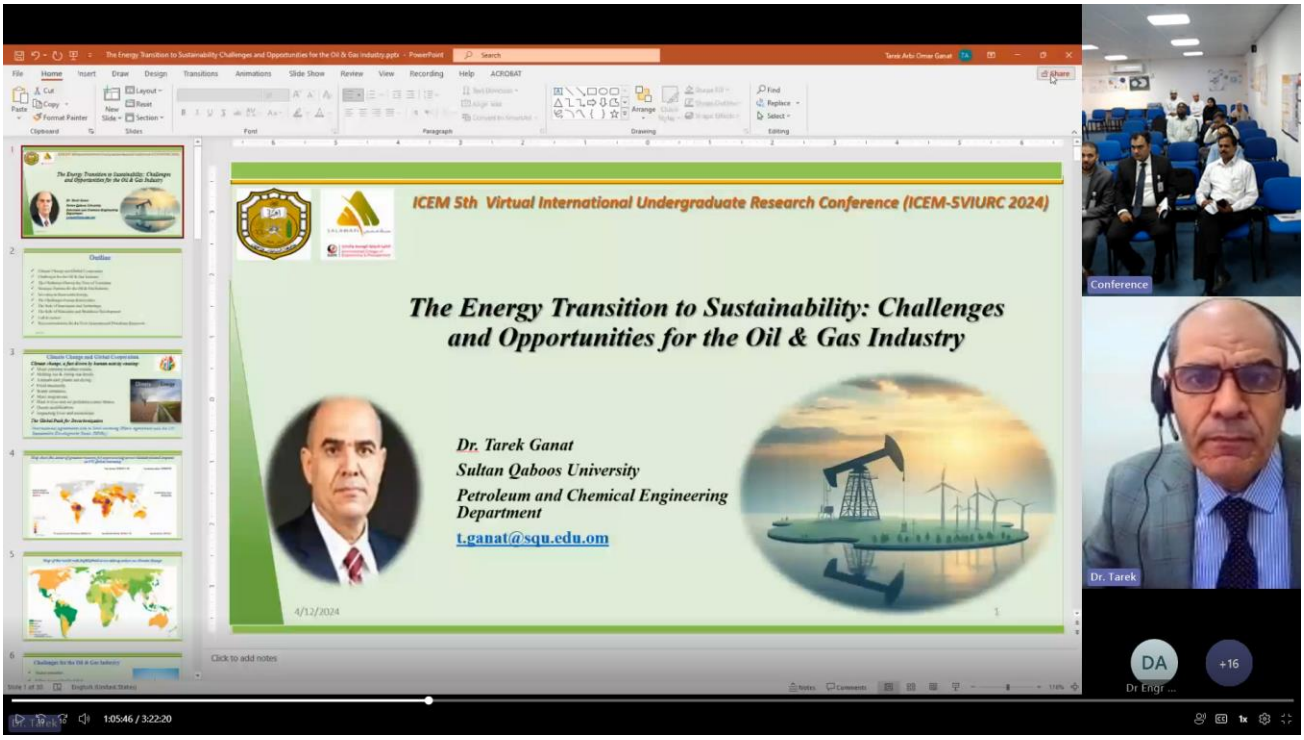
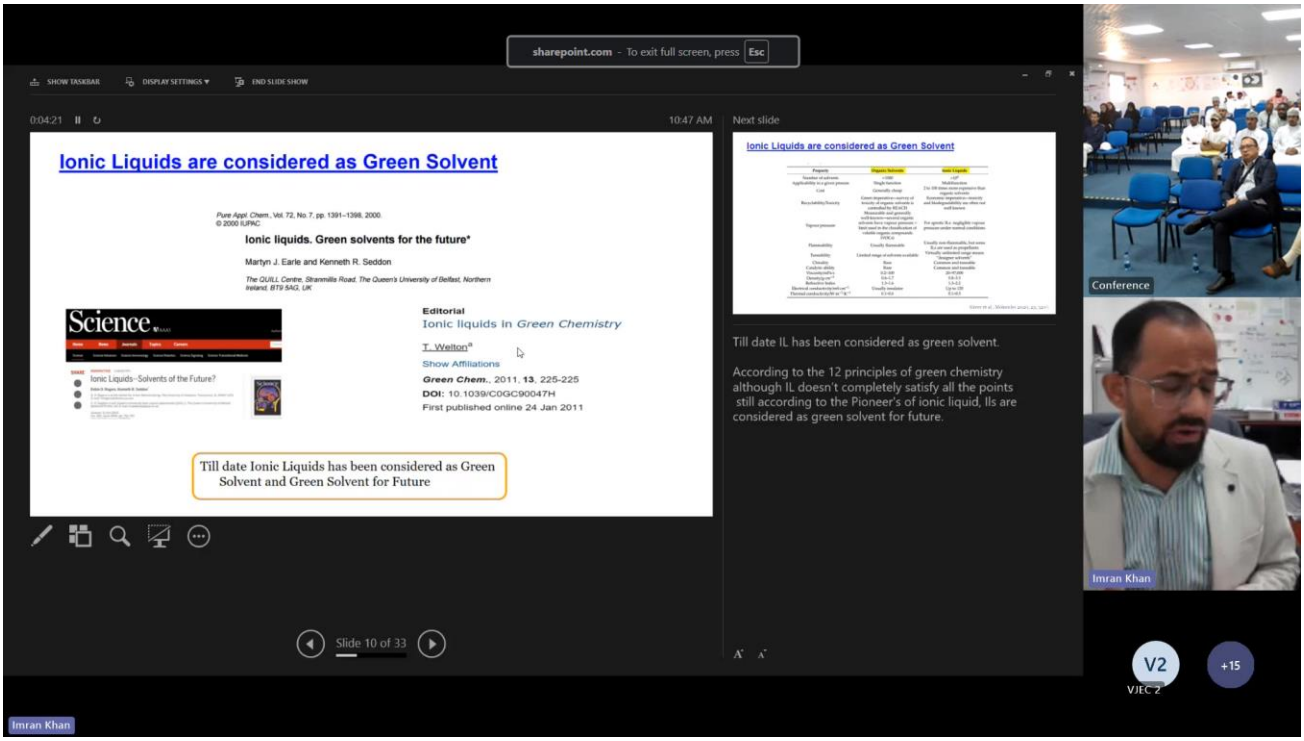


Day 1: Keynote speakers - talk

Day 1: Keynote speakers - talk



Day 1: Keynote speakers - talk

Day 1: Keynote speakers - talk

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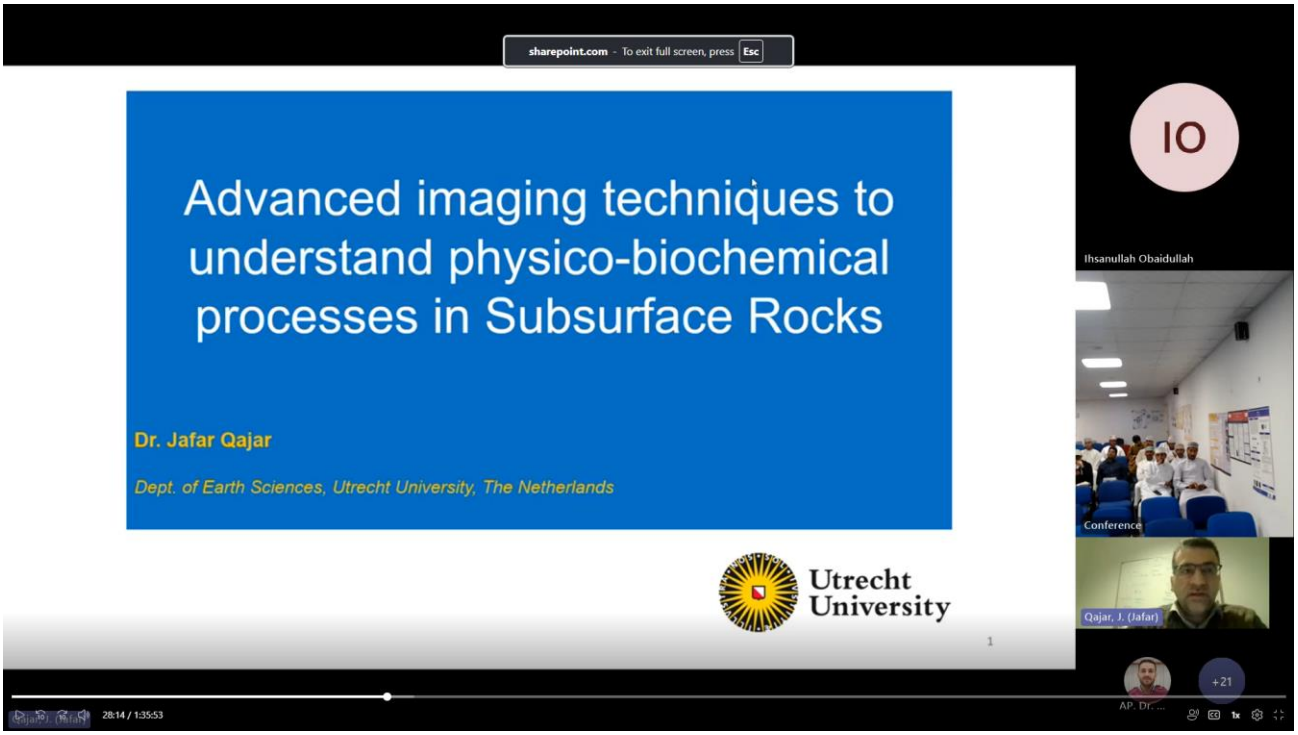
Day 1: Keynote speakers - talk



Day 1: Keynote speakers - talk

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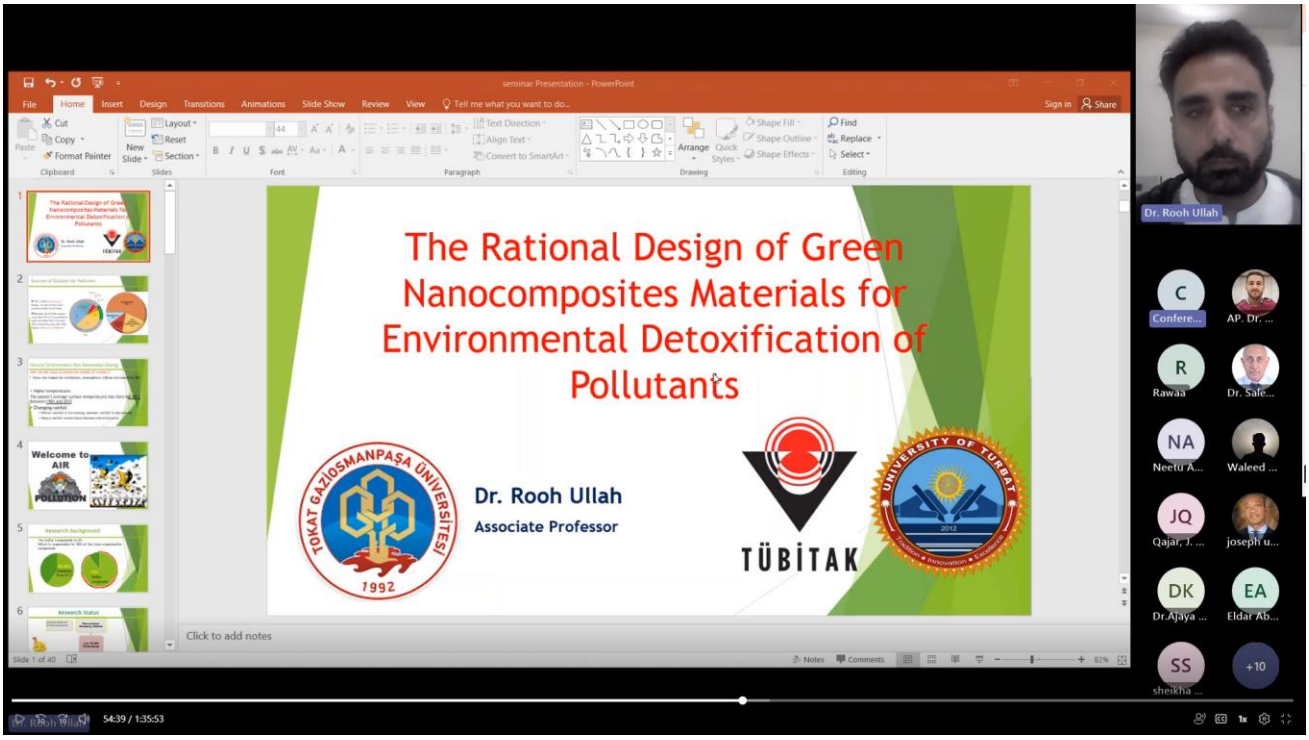

Day 1: Keynote speakers - talk

Day 1: Discussion

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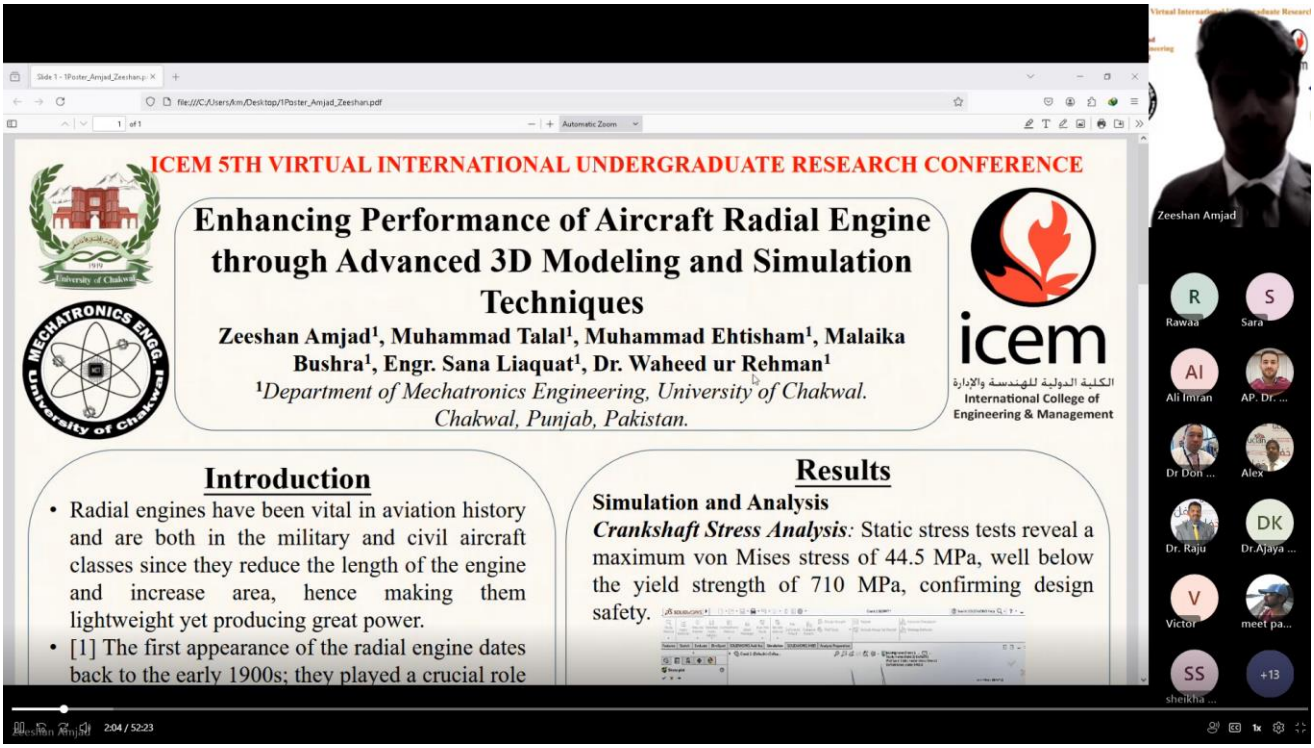
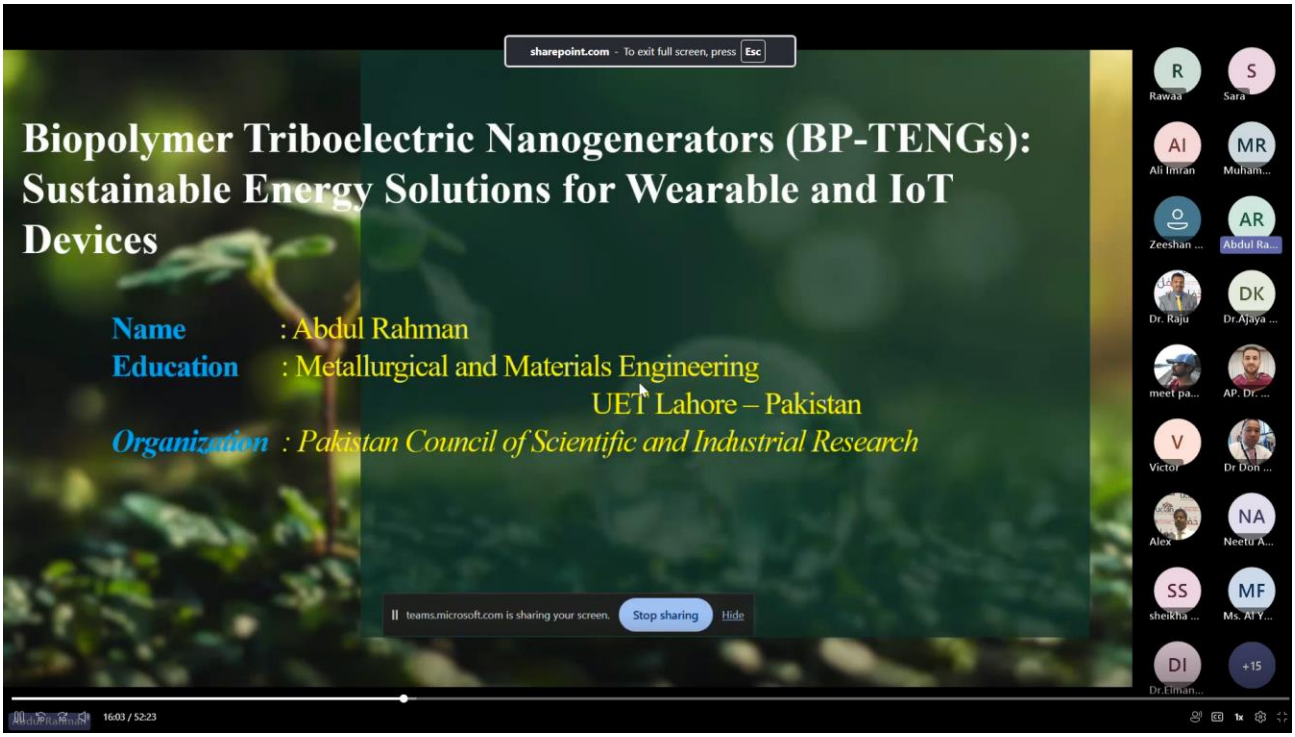
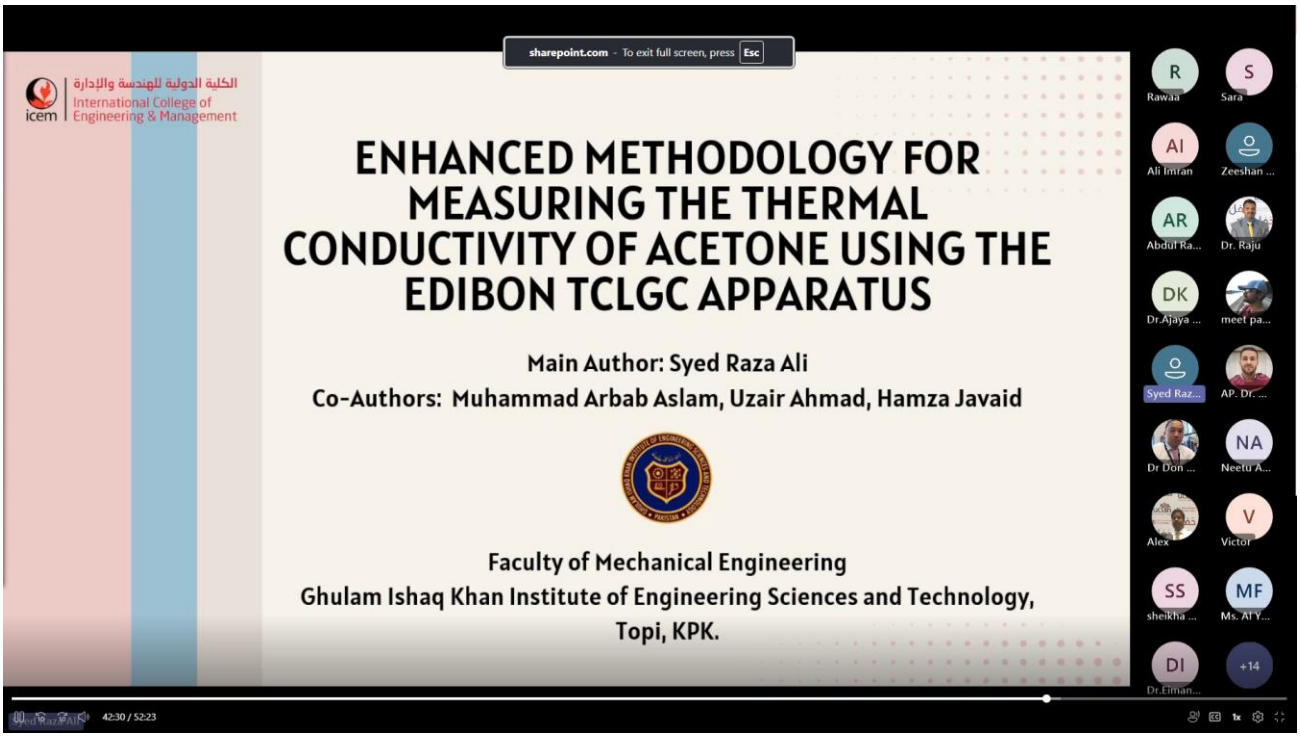
Day 1: Closing



Day 2: Research presentations



Day 2: Research presentations



Day 2: Research presentations

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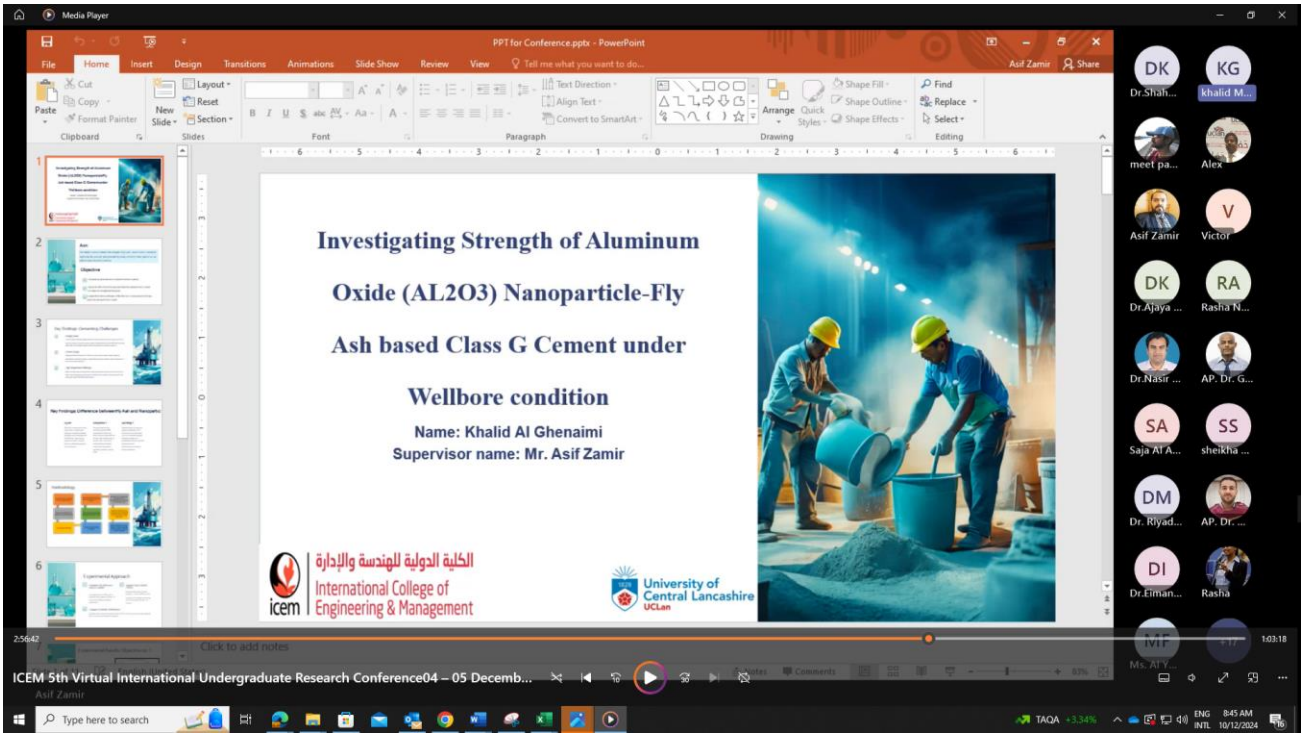
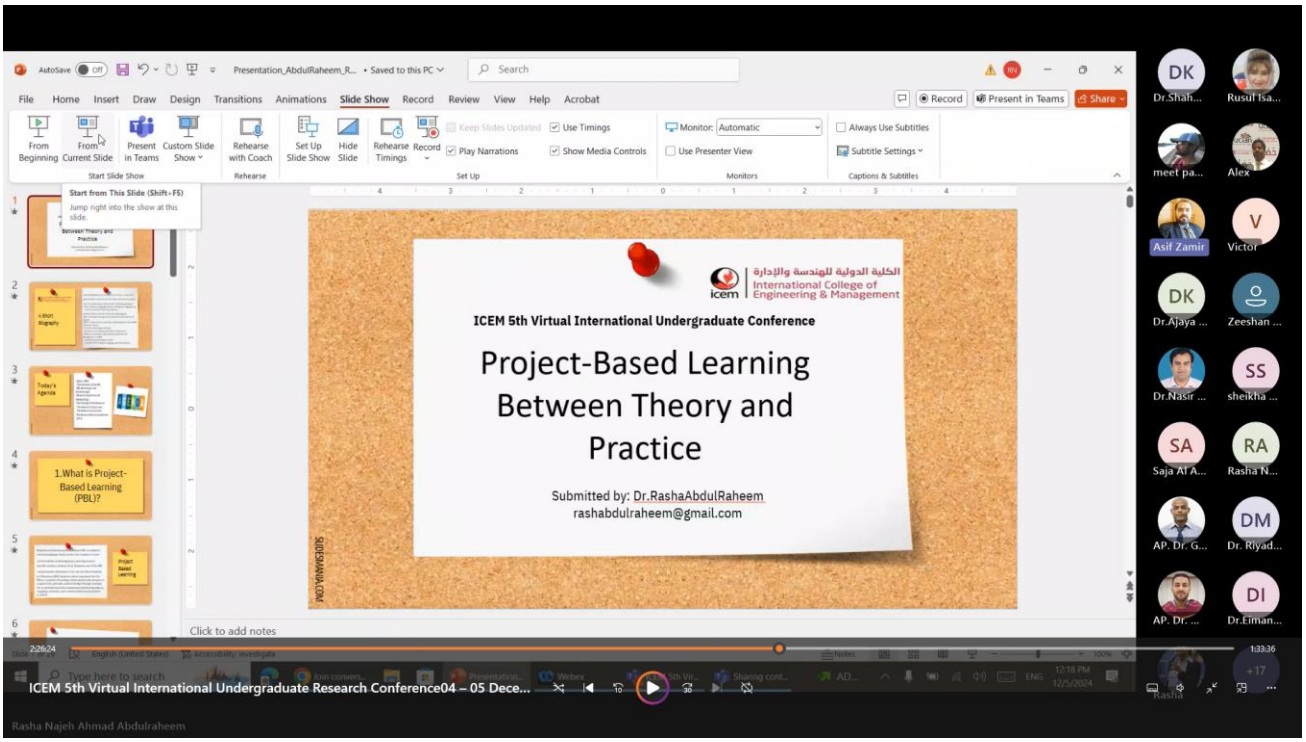


Day 2: Research presentations



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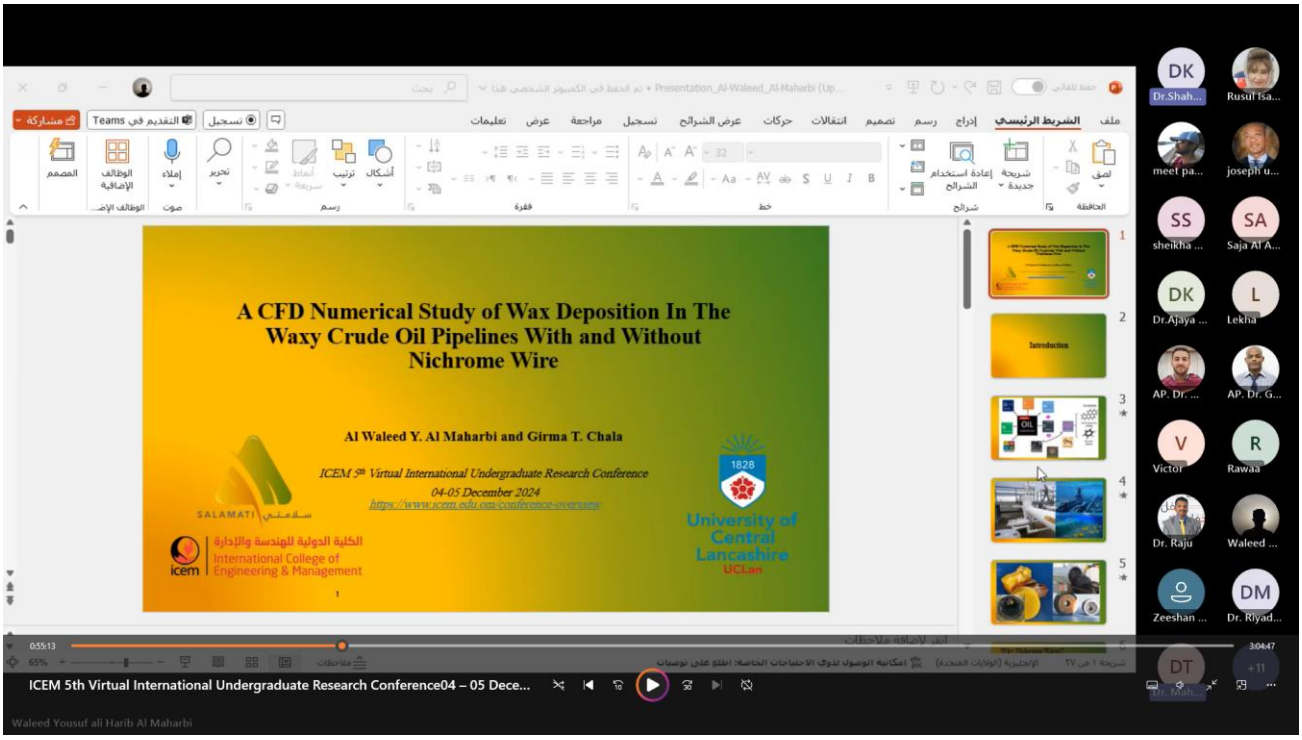

Day 2: Research presentations

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Day 2: Research presentations

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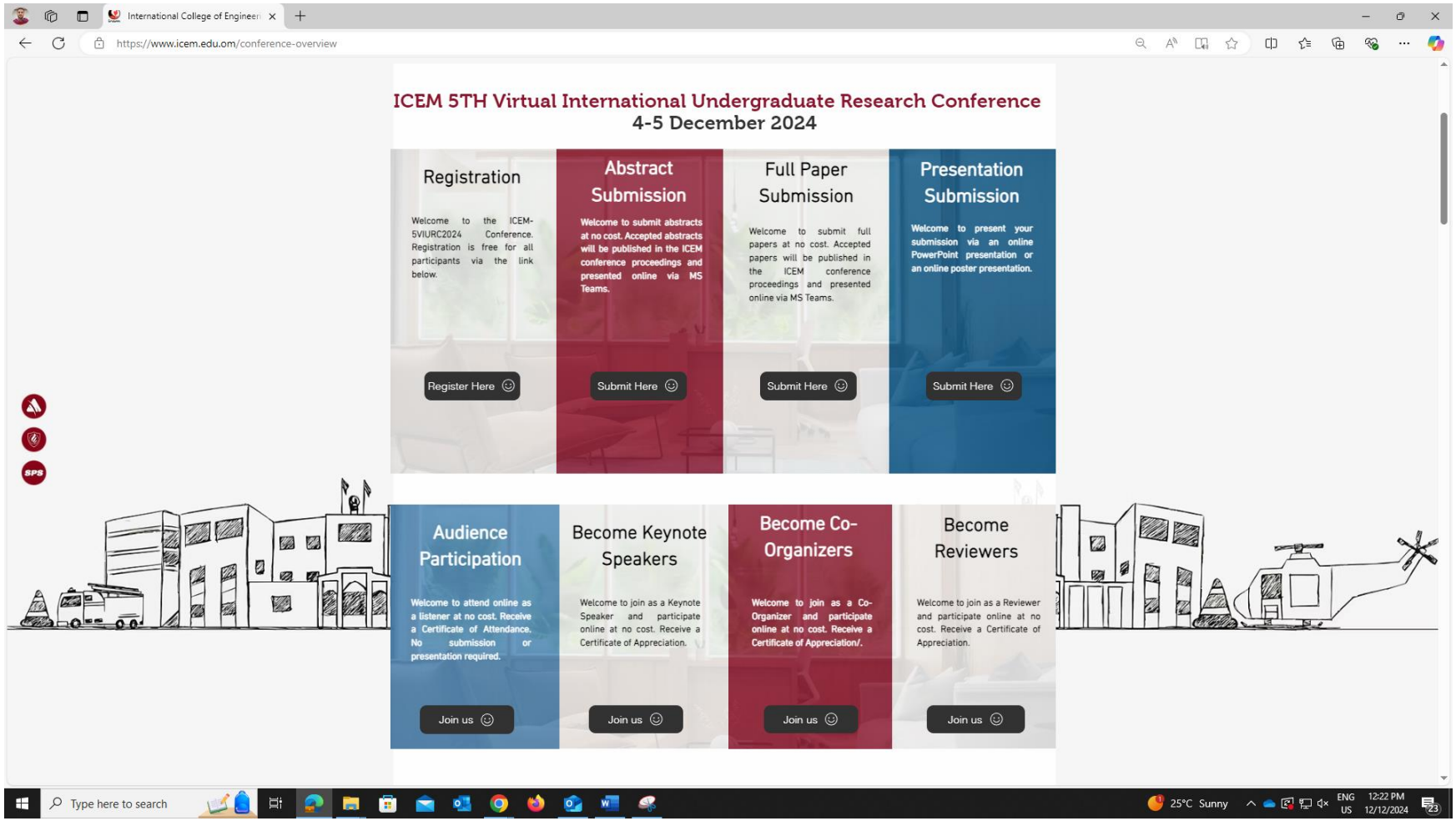
Appendix C Conference Webpage



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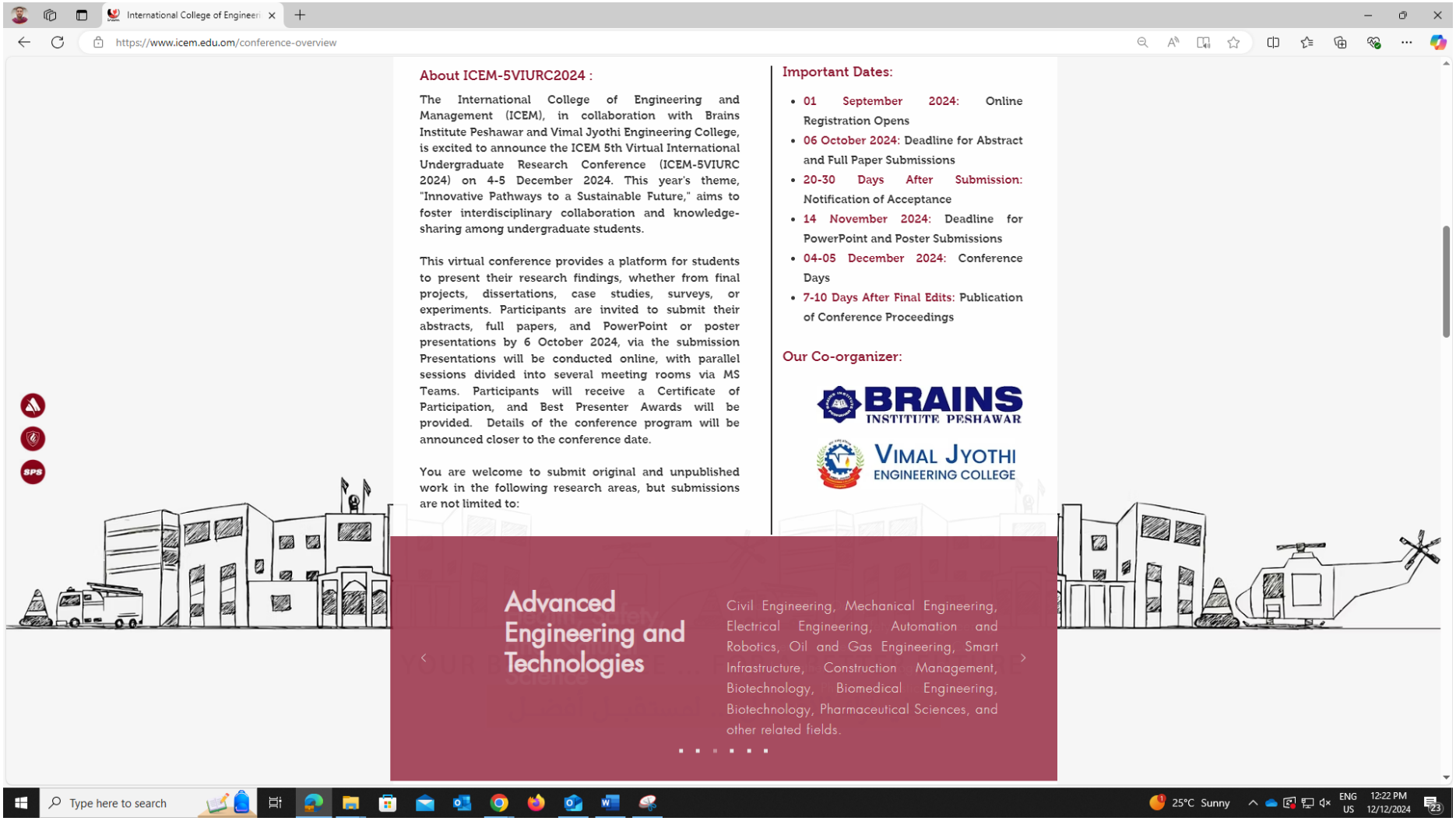

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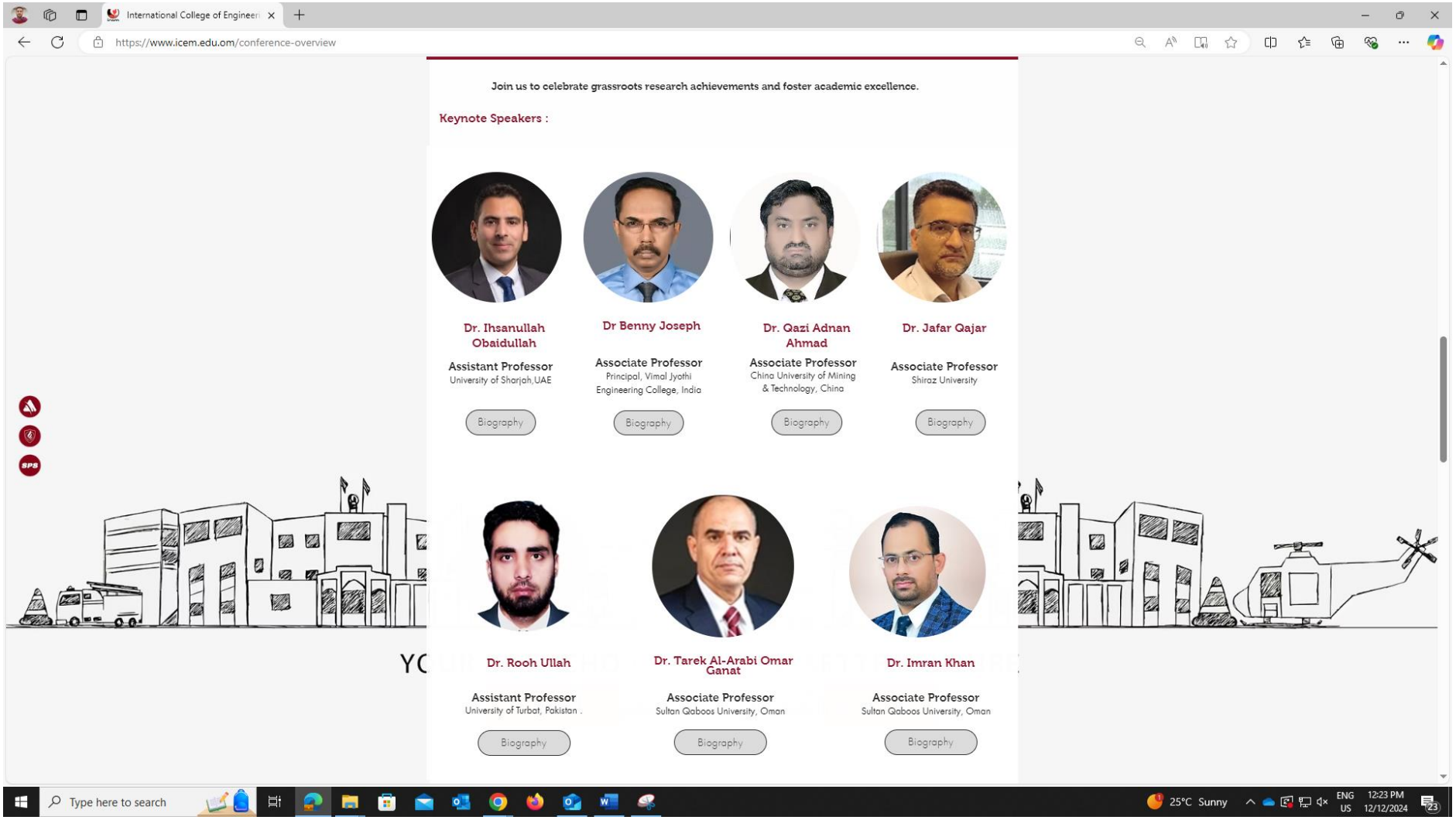
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Shiraz University
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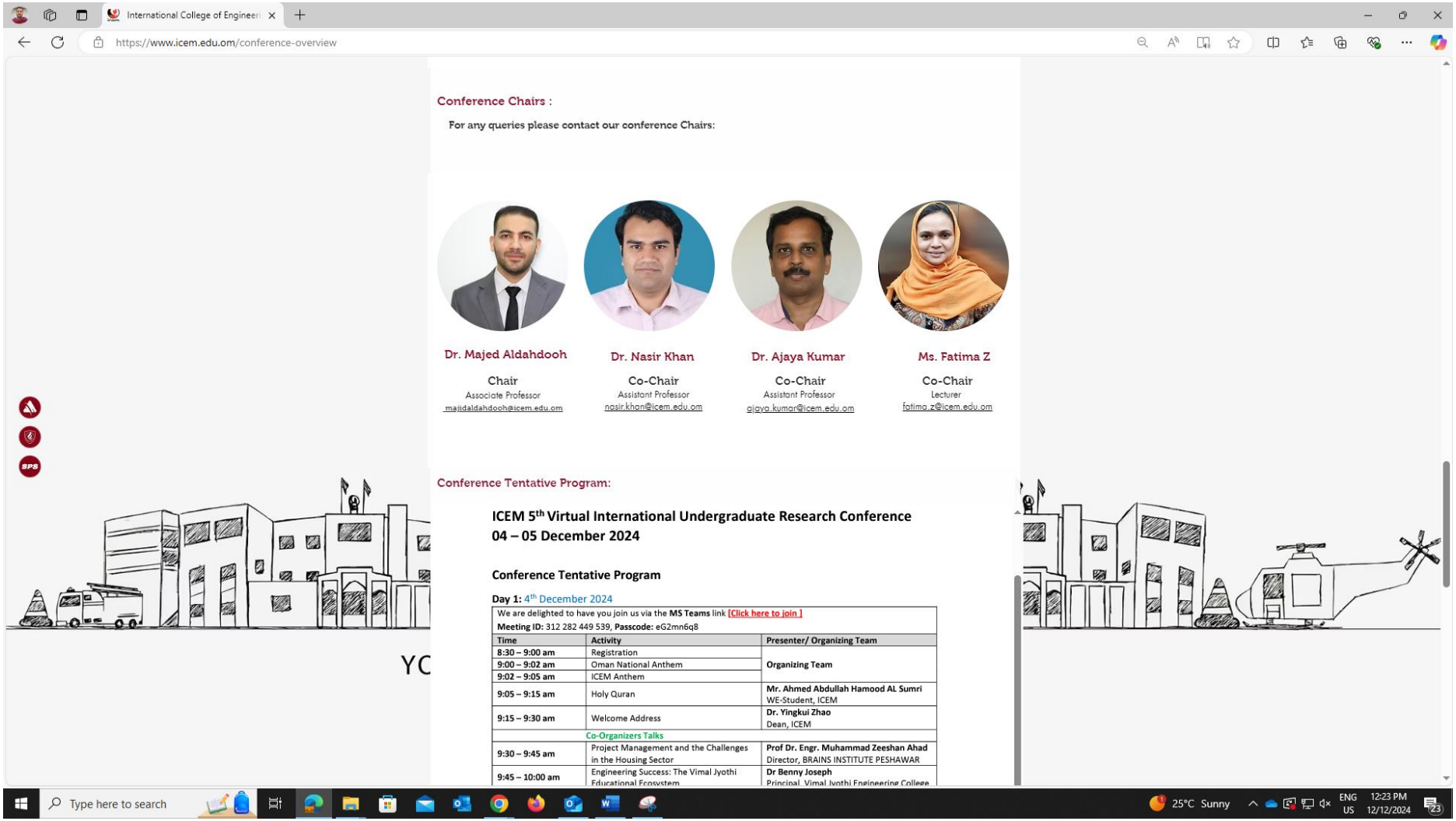
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04 – 05 December 2024
Conference Tentative Program
Day 1: 4th December 2024
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Meeting ID: 312 282 449 539, Passcode: eG2mn6q8
Time
Activity
Presenter/ Organizing Team
8:30 – 9:00 am
Registration
Organizing Team
9:00 – 9:02 am
Oman National Anthem
9:02 – 9:05 am
ICEM Anthem
9:05 – 9:15 am
Holy Quran
Mr. Ahmed Abdullah Hamood AL Sumri
WE-Student, ICEM
9:15 – 9:30 am
Welcome Address
Dr. Yingkui Zhao
Dean, ICEM
Co-Organizers Talks
9:30 – 9:45 am
Project Management and the Challenges in the Housing Sector
Prof Dr. Engr. Muhammad Zeeshan Ahad
Director, BRAINS INSTITUTE PESHAWAR
9:45 – 10:00 am
Engineering Success: The Vimal Jyothi Educational Ecosystem
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Associate Professor, Dr. Majed Aldahdooh
(Chair)

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(Co-Chair)

Assistant Professor, Dr. Ajaya Kumar
(Co-Chair)

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