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RAISER Conference 2019

Organized by: School of Mechanical Engineering, Universiti Sains Malaysia

In collaboration with

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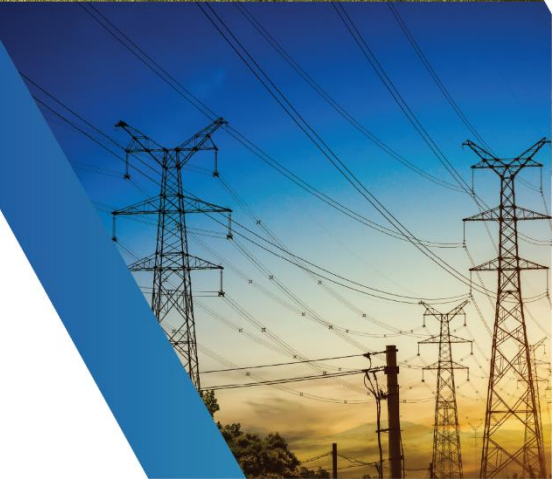
UOW MALAYSIA KDU PENANG UNIVERSITY COLLEGE

2019 INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN SUSTAINABLE ENERGY RESEARCH

16 December 2019

Dewan Persidangan Universiti (DPU)
Universiti Sains Malaysia,
Penang

Book of Abstract



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CONTENT

INTRODUCTION

International Conference on Recent Advances in Sustainable Energy Research 2019 (RAISER 2019) will take place at Penang, Malaysia during 16th December 2019. The main objective of this conference is to provide a platform for industrial players, academicians, researchers, engineers and scientists from various countries to share their ideas and latest research in the fields of sustainable energy. This conference focuses on key areas in sustainable energy, namely energy production, energy conversion and transportation, energy efficiency, energy storage, energy applications, etc.

FOREWORD

Assalamualaikum and greetings to all,

I wish to extend our warm welcome to our honorary guests, keynote speakers, delegates and participants of International Conference on Recent Advances in Sustainable Energy Research 2019 (RAISER 2019).

First, I would like to congratulate the organizing committee for their hard work and dedication in and planning and organizing this conference for the first time. Being the first edition, it must have been challenging but rewarding experience.

The main objective of this conference is to provide a platform for industrial players, academicians, researchers, engineers and scientists from various countries to share their ideas and latest research in the fields of sustainable energy. The theme of the conference 'promoting sustainable future through greener and cleaner energy research' is in line with the University's identity as a sustainability led University. It is a reflection of our commitment to sustainable future by harnessing on renewable, clean energy.

I believe all participants will benefit from meeting new friends, interact with each other and exchanging ideas to advance further in the area. I wish everyone a fruitful, engaging and meaningful conference in RAISER 2019.

Thank you our sponsors and all participants for the support to make this conference a success and warm welcome to all our guests.

Thank you.

Assoc. Prof. Dr. Jamaluddin Abdullah
Honorary Chairman

Dean,
School of Mechanical Engineering,
Universiti Sains Malaysia

Dear all,

I would like to offer you our warmest welcome on behalf of the organizing committee of International Conference on Recent Advances in Sustainable Energy Research 2019 (RAISER 2019) to be held in December 16, 2019 at Dewan Persidangan Universiti (DPU), Universiti Sains Malaysia, Malaysia. The conference is organized by the School of Mechanical Engineering, USM as a host.

We are very honoured to invite the prominent keynote speaker to deliver talk in order to enhance the knowledge of the participants: Emeritus Professor Ir. Dr. Masjuki bin Haji Hassan.

RAISER 2019 introduces a conference theme "Promoting Sustainable Future Through Greener and Cleaner Energy Research". A total of 66 papers submission to this conference have been acceptance. We are very pleased to welcome participants from various countries such as Malaysia, Thailand, Japan, Indonesia, Bangladesh, Brunei, Iran, Korea, Nigeria, Oman, and Saudi Arabia to express and share their ideas through writing and presenting them in this conference. I sincerely hope that this conference will deliberate and discuss all the different facets of science and advanced industry.

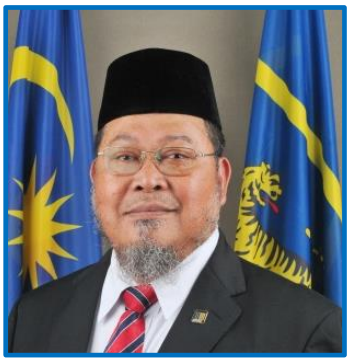
A successful conference is the result of many important parts. I would like to take the opportunity to delivery my gratitude to the Vice Chancellor of USM, the Dean of School of Mechanical Engineering, the honorary and advisory chairman for supporting this event. A special thanks to our honourable sponsors, MALAKOFF and Focus Applied Technologies, as well as our conference collaborators. I also wish to thank the participation of the keynote speaker in this conference. We will do our best to make your stay at this conference a pleasant one. Last but not least, I would like to thank the participants for participating for RAISER 2019.

I hope you will enjoy this conference and your stay in Penang.

Dr. Teoh Yew Heng
RAISER 2019 Chairman

Senior Lecturer,
School of Mechanical Engineering,
Universiti Sains Malaysia

KEYNOTE SPEAKER



Emeritus Professor Ir. Dr. Masjuki bin Haji Hassan

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

Ir. Dr. Masjuki Hj. Hassan was conferred Emeritus Professorship on 20th October 2018 in conjunction with the 58th University of Malaya Convocation. He was a '2017-Merdeka Award winner in the Outstanding Scholastic Achievement Category' and listed as '2017 and 2018 - Highly Cited Researchers by Clarivate Analytics'. He obtained his B.Sc.(Hons), Mech Eng from Leeds University, U.K. in 1977. This was followed by his M.Sc. in Tribology and Ph.D. in Mech Eng from the same university in 1978 and 1982 respectively. On completion of his PhD, he was appointed as a lecturer in 1983 at University of Malaya. He is a Senior Professor in Mechanical Engineering Department, University of Malaya and currently is also Visiting Professor at King Saud University, Riyadh, Saudi Arabia. He was Secretary of Council of National Professors - Engineering, Technology and Built Environment Cluster until 31st March 2016. He is Chairman of Council of National Professors - University of Malaya Chapter from 1st June 2016 to 31st May 2018. He was the founding President of Malaysian Tribology Society (MyTRIBOS) from 2007 to 2017. He is immediate past Vice - Presidents of International Tribology Council (ITC), UK. He is the Head of the Centre for Energy Sciences and Research Fellow at Center of Malay Excellence Study, University of Malaya. He received many other awards for his outstanding academic achievements and also member of many International and National professional organizations. He collaborated and is still collaborating with many international research organizations such as United State Agency for International Aid Agency (USAID), Asean-Australian Energy Conservation Program (AAECP), ASIAN Development Bank (ADB), ASIA-EU Grant, Japanese Society for the Promotion of Science (JSPS) and AUN-Seed Net Program and Universities. He has successfully supervised many local and foreign Master and PhD students. He has published more than 500 journal articles, received more than 17,000 citations and h index of 76. His major contribution to the nation is through his expertise in biodiesel fuel production and automotive engineering have been much sought for to strengthen Malaysian Government Policy to blend various percentages of biodiesel from palm oil with fossil diesel to be sold at petrol pumps throughout Malaysia. His other contribution to the nation is his involvement in more than 6 Technical Committees at SIRIM developing various Malaysian Standards for various Malaysian manufacturing industries. He reviewed and still being invited to review many journal articles by renowned publishers. He is a CEng(UK), MSAE(USA), PEng/Ir(Malaysia), FIMechE(UK) and Fellow, Academy of Sciences Malaysia.

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SCHEDULE

International Conference on Recent Advances in Sustainable Energy Research 2019 (RAISER 2019)

Time	Program
8.00 am	Registration of Participants
8.50 am	Arrival of DVC, Keynote Speakers, School of Mechanical Engineering Dean and VIPs at *Bilik Istirahat Utama*
9.00 am	National Anthem and Menara Ilmu
9.05 am	Welcoming speech by Chairman of RAISER 2019 **Dr. Teoh Yew Heng**
9.15 am	Welcoming speech by the Dean, School of Mechanical Engineering (USM) **Associate Professor Dr. Jamaluddin Abdullah**
9.20 am	Opening speech by Deputy Vice Chancellor (Sustainability and Institutional Development) of USM **Professor Dr. Md Roslan Hashim**
9.25 am	Token of appreciation to **Professor Dr. Md Roslan Hashim** By: **Associate Professor Dr. Jamaluddin Abdullah**
9.30 am	Keynote Address **Emeritus Prof. Ir. Dr. Masjuki bin Haji Hassan**
10.00 am	Token of appreciation to **Keynote speaker** By: **Prof. Dr. Zainal Alimuddin Zainal Alauddin**
10.05 am	Token of appreciation to **Sponsor** By: **Prof. Dr. Zainal Alimuddin Zainal Alauddin**
10.10 am	Photo session with all VIPs and participants
10.20 am	Morning tea break and networking
11.00 am	**Parallel Oral Presentations- A** • Session A1 (DPU) • Session A2 (Seminar Room A) • Session A3 (Seminar Room B)
1.00 pm	Lunch break
2.00 pm	**Parallel Oral Presentations- B** • Session B1 (DPU) • Session B2 (Seminar Room A) • Session B3 (Seminar Room B)
4.00 pm	Afternoon tea break and networking
4.30 pm	**Parallel Oral Presentations- C** • Session C1 (DPU) • Session C2 (Seminar Room A) • Session C3 (Seminar Room B)
5.00 pm	Closing speech by RAISER 2019 Chairman **Dr. Teoh Yew Heng**

Contents

Effects of Gas Area Fraction on Developing Flow of Shear Thickening Fluids in Circular Tube Having Superhydrophobic Transverse Grooves

Han Wei Lee, Kok Hwa Yu, Yew Heng Teoh, Mohd Azmi Ismail

[1]School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Penang, Malaysia.

Abstract:
Superhydrophobic surface is extensively used in lab-on-a-chip technology, thermal management, self-cleaning and condensation arising from its ability to reduce fluid flow resistance. There are many existing studies conducted on fluid flow in channels and tubes having superhydrophobic surface, especially focusing on Newtonian fluid in a fully-developed flow region. In this study, the effects of gas area fraction on hydrodynamic entrance region of shear thickening fluids in a circular tube with alternating superhydrophobic grooves and ribs arranged in the transverse direction are investigated. Superhydrophobic transverse grooves of normalized groove-rib periodic spacing $L = 0.1$ with different gas area fractions δ are considered in this study with the assumption of laminar, steady and incompressible flow in the tube. The influence of the superhydrophobic surface on the velocity field, centerline velocity distribution and hydrodynamic entrance length are examined. From the numerical results, for Reynold number, Re of 1×10^{-4} and power-law index, n ranging from 1.0 to 1.5, the hydrodynamic entrance length is found to be longer, in the presence of superhydrophobic surface. In microfluidic applications, this implies that for shear thickening flow through tube patterned with these regular microstructures of hydrophobic condition, flow developing region can be altered.

Keywords:
Water Repellent, Non-Newtonian, Surface Roughness, Air Cavity, Power-Law Index

Heat Transfer Analysis of Diffusion Furnace for Wafer Annealing Process

Siew Aun Tan, Mohd Zulkifly Abdullah and Kok Hwa Yu

School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Penang, Malaysia.

Abstract:
Diffusion furnaces in semiconductor manufacturing processes are used to grow oxide on silicon wafer surfaces or diffuse dopants into semiconductor wafers. During such process, the silicon wafers are heated in furnaces to temperatures typically in the range between 973K and 1523K. In this study, a two-dimensional axisymmetric model is employed to simulate the vertical furnace that operates at temperature 1123K. The simulation results on profile temperature distribution of a baseline case having 175 silicon wafers with diameter size of 200mm in the process tube are in good agreement with that of experimental data. It is also shown that uniform heating can be applied on the bulk region of the stacked wafers. In this study, the influences of heater temperature and the gap between wafers arranged in the process tube on temperature field in the process tube have been explored. From the simulations, it is worth highlighting that the temperature distribution over the bulk region of the stacked wafers is in accordance with heater temperature. In addition to that, it is found that annealing process over lesser wafers (with larger wafer gaps) in the boat may not significantly affects the heating performance in the furnace.

Keywords:
Vertical Furnace, Quartz Tube, Radiation, Heater, Insulation, Spike Temperature, Profile Temperature.

Virtual Flow Meter With Energy Balance Method

Nofirman Firdaus[1,2], Bambang Teguh Prasetyo[3], Hasnida Ab-Samat[2], Prayudi[1]

[1]Department of Mechanical Engineering, Sekolah Tinggi Teknik PLN, Jakarta, Indonesia
[2]School of Mechanical Engineering, Universiti Sains Malaysia, Seberang Perai Selatan, Malaysia
[3]Balai Teknologi Termodinamika Motor dan Propulsi (BT2MP)-BPPT, Serpong, Indonesia

Abstract:
Keeping the chiller performance at an optimum level is desirable because chiller is one of the energy-consuming equipment in buildings. Chiller is responsible for 40% to 70% of building energy consumption. Therefore, monitoring chiller performance is essential to keep its performance at a desirable level. Knowing chiller performance needs information about the water flow rate. Unfortunately, not every chiller is equipped with the flow meter. Fortunately, in the last decade, some researchers have been developing virtual flow meters (VFM) to eliminate the need for flow meter equipment. One of the well-known methods of VFM is the energy balance method. There are two types of energy balance methods. Firstly, using theoretical work input to a compressor in calculating energy balance to estimate the flow rate. However, the method needs free-fault data from manufacture or field measurement to obtain the theoretical compressor work input from a regression analysis. The second method uses actual compressor work input in energy balance analysis. This method needs trend data generated from the building automation system (BAS) for the energy balance analysis. Our research proposes the use of isentropic compressor work input to estimate the water flow rate. The proposed method may eliminate the need for manufacturer or field measurement data or trend data from BAS. The result shows that the comparison with the measurement values indicates that the use of isentropic work to estimate the water flow rate has good accuracy. However, it is sensitive to a low-temperature difference in evaporator and condenser and refrigerant overcharged fault.

Keywords:
Virtual Flow Meter, VFM, Virtual Sensor, Fault Detection And Diagnosis, Chiller FDD.

Design and Analysis of A Vortex Induced Vibration Based Oscillating Free Stream Energy Converter

Ratan Kumar Das[1], Muhammad Taharat Galib[2] , Prasanjit Das[1]

[1]Department of Mechanical Engineering, Chittagong University of Engineering and Technology, Chittagong-4349, Bangladesh
[2]Department of Mechanical Engineering, City University, Dhaka, Bangladesh

Abstract:
The Kar Man Vortex Shedding is one of the special type of vortex that is generated from asymmetric flow separation. For many years engineers tried to suppress the vortex shedding as it brings unnecessary motion to the static members inside the flow field. A converter model is designed and studied to harness the energy associated with this vortex shedding and convert it into usable form rather than suppressing it. It is a bluff body placed on the free stream incurring vortex induced vibration and giving out a swinging pendulum motion. This motion is utilized to produce electricity. The model is analyzed on the free stream of water and a conversion efficiency of 8.9% is achieved. A theoretical formula is derived regarding the force acting on the bluff body during the motion. Various parameters such as aspect ratio, flow velocity, lock-in delay, frequency of oscillation etc. as well as their relations are studied by simulating the model in ANSYS for different configurations. From the simulated results it is obvious that as the of lift force on the bluff body increases, the more power generation is possible. Also, the possibility of using this model for large scale implementation is verified.

Keywords:
Vortex Induced Vibration, Oscillating Converter, Free Stream Energy, Energy harnessing, Lock-in-delay

On The Correlation between Main Characteristics of Fuel-Efficient Driving and Safe Driving

Y.R. Tan, A. Yamin Saad

School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Penang, Malaysia.

Abstract:
Part of sustainability in automotive industry is to inculcate fuel-efficient driving. On the other hand, sustainability of life is also paramount by safe driving. In this research, semi-qualitative and quantitative research methods are used to determine the correlation between key characteristics of fuel-efficient driving and safe driving. It aims to give correct motivation on fuel-efficient driving towards safe driving. The key characteristics of fuel-efficient and safe driving are identified and the relationships for both variables are analysed. Due to lack of standard methods to measure each of the key characteristics, analytical scaling method is used to quantify each of key driving characteristics. The scaling and ranking are attempted for fuel-efficiency according to the degree of fuel improvement based on the level of idling, accelerating and braking, as well as speed of travel. While for safe driving, they are based on tendency for accident to occur and degree of impact caused by respective driving characteristics. Several approaches are used to obtain numerical values for correlation coefficient between fuel-efficient driving and safe driving. It has been found that the correlation coefficients between these two variables are overall positive but less significant especially among the top quartile of respondents.

Keywords:
Fuel-Efficient, Safe Driving, Correlation, Sustainability

The Potential of Solar Energy for Domestic and Commercial Buildings in Malaysia

Chee Kar Wei, Abdul Yamin Saad

School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Penang, Malaysia.

Abstract:
The rise in electricity consumption can affect global warming and climate change. Exploitation of solar energy is amongst the most sustainable and relatively cheap solution in Malaysia. It is imperative to study the potential of its application for domestic and commercial buildings. In this paper, financial viability of grid-connected solar photovoltaic (PV) system for domestic and commercial buildings is analysed using payback period and return on investment (ROI). The payback period and ROI are determined and compared based on Feed-in Tariff (FiT) and revised Net Energy Metering (NEM) schemes. Various scenarios and case studies were conducted using factors such as availability, installation, maintenance and depreciation. It was found that domestic consumers i.e homes with monthly electricity bills of RM2500 and RM5000 had the shortest payback period at 8.7 years for both schemes. For the commercial buildings with average bill of RM5003.43 the shortest payback period was 8.2 years for both schemes. The ROI of solar PV system installed for this commercial building were 155.03 % (FiT) and 203.65 % (revised NEM). Thus, solar PV system under FiT and revised NEM schemes would be financially viable for commercial buildings with monthly electricity bills of RM2500 and RM5000.

Keywords:
Solar Energy, Photovoltaic, Payback Period, Domestic Consumers

Simulation and Analysis of Thermodynamic Cycles Using Coco Simulator: A User-Friendly Free-Software Package

Sayedus Salehin, Mohaimin Rahman, ASM Redwan Haider, Md. Hamidur Rahman

Department of Mechanical and Chemical Engineering, Islamic University of Technology, Organization of Islamic Cooperation (OIC), Board Bazar, Gazipur 1704, Bangladesh

Abstract:
Analysis of thermodynamic cycles is imperative in understanding the underlying thermodynamic processes. Such analysis is essential in apprehending the effect of different parameters on the performance of different thermodynamic cycles that are extensively used in power generation, cooling and heating. Several software are currently available, both on commercial and freeware basis, having modeling, simulation, analysis and optimization capabilities for different thermodynamic processes. CAPE-OPEN to CAPE-OPEN (COCO) simulator, based on CAPE-OPEN standard, was primarily developed for chemical engineering to model steady-state processes. Use of this software to simulate the thermodynamic power and refrigeration cycles has been found to be infrequent in the literature despite having the required functionality. In this paper, COCO simulator has been used to model and analyze different power and refrigeration cycles with phase change and gaseous working fluids. Hybrid dual fuel (natural gas and municipal solid waste) combined cycle, recompression closed-loop supercritical CO2 Brayton cycle (driven by solar thermal tower), vapor compression cascade refrigeration cycle and reverse Brayton cycle have been considered for modeling. The results obtained from COCO simulator have been validated against the results available in the literature. The results suggest COCO simulator to be a viable alternative for simulation and analysis of thermodynamic cycles.

Keywords:
Free Software, Modeling And Simulation, Thermodynamic Cycle, COCO Simulator, Power Cycles, Refrigeration Cycles

Exploiting the Steam Exergy of Throttling Valve in Boosting Potable Water Production of MEDAD Hybrid Cycle

Doskhan Yaybraiymkul, Muhammad Wakil Shahzad, Kim Choon Ng

Water Desalination and Reuse Center (WDRC), King Abdullah University of Science & Technology (KAUST), Thuwal 23955-6900, Saudi Arabia

Abstract:
Thermal desalination processes played a dominant role in seawater desalination within GCC countries, due to its high efficiency, low maintenance and ability to operate in higher silt and salt concentrations.. The practice of throttling low pressure steam supplied to the top brine (TB) stage of multi-effect distillation (MED) is commonly used for the control of hard scales formation on the outer surfaces of tubes. This operational convenience of throttling steam to 65oC is conducted at the expense of steam exergy destruction. In this paper, a thermal vapor compressor (TVC) to exploit the available exergy of input steam prior to TB stage directly, is presented. It produces a low vacuum (<1.5kPa) at its throat which is used for regeneration of saturated adsorbent (silica gel). This innovative operation of a TVC in the MED-adsorption (AD) cycle, or MEDAD in short, has boost the water production to two folds and yet maintaining almost the same energy input vis-a-vis of a conventional MED. Consequently, the figure of merit based on the consumption of primary energy or universal performance ratio (UPR), has boost from 13% of thermodynamic limit (TL) of conventional MED to more than 22%. The experiments of the hybrid MEDAD cycle supplied across assorted feed temperatures and operating states of the TVC is presented.

Keywords:
Thermal Seawater Desalination, Pressure-Swing Desorption, Multi-Effect Distillation Cum AD Cycle.

Experimental Study on Pyrolysis Characteristics of Woody Biomass at Low-Temperature

Toshiyuki Katsumi, Satoshi Kadowaki

Nagaoka University of Technology, 1603-1 Kamitomioka, Nagaoka, Niigata, JAPAN

Abstract:
In recent years, woody biomass attracts attention as one of renewable energy, and the technology of combustion has been developed but still has many problems. Currently, we focus on the pyrolysis of low-quality woody biomass, Japanese cedar, under low-temperature and the combustion of its product gas in order to achieve low cost and high energy efficiency. In low-temperature pyrolysis of woody biomass, it was reported that tar is easily generated and less gas can be extracted as fuel. Therefore, in order to understand pyrolysis characteristics of woody biomass, the pyrolysis experiments were performed varying the heating temperature in the range from 523K to 773K and the water content of woody biomass in the range from 10 to 40 wt.%. In the experiments, the pressure inside a test vessel, the temperature of a sample, and components of the product gas were measured. The results showed the tendency that the gas products reduced as the temperature decrease by a simple pyrolysis method. In this paper, we will report the detail of the experimental results and discuss the influences of heating temperature and water content on the pyrolysis characteristics.

Keywords:
Woody Biomass, Pyrolysis, Low-Temperature, Water Content, Gas Component.

Calorific Value of Dried Branches of Coconut Plant at Different Moisture Contents

Mohammad Ali Basunia, Muhammad Hamzi Bin Haji Zaini

Mechanical Engineering Programme Area (MEPA), Faculty of Engineering, Universiti Teknologi, Brunei (UTB), Tungku Link, Gadon BE1410, Brunei Darussalam

Abstract:
The reserves of non-renewable energy sources such as coal, crude oil and natural gas are not limitless, they gradually get exhausted and their price continually increases. This project showed how coconut branches could be an alternative source of energy. The calorific values of dried coconut branches were determined by using the bomb calorimeter along with the data of moisture content. The calorific values were noticed to be indirectly proportional to the moisture content. The calorific values (kJ/kg) of the sample as a function of the moisture content is correlated with correlation coefficient (R2) was 0.92. Ten out of fifteen specimens collected were shown to have moisture content in the range of 10% to 30%. With this moisture content, the amount of calorific values acquired were shown to be in the range of 14-16 MJ/kg which is enough to show its importance and practicality as a source of renewable energy.

Keywords:
Coconut Dried Branches, Calorific Value, Moisture Content, Biomass Fuel.

Experimental Investigation on a Desiccant Silica Bed for Dehumidification

Pravinth Balthazar[1, 2], Mohd Azmi Bin Ismail[1], Mohammad Nazmi Bin Mohammad Nasir[1] , Hussin Bin Mamat[3], Muhammad Iftishah Bin Ramdan[1]

[1]School of Mechanical Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia,
[2]Department of Mechanical Engineering, South Eastern University of Sri Lanka, 32360 Oluvil, Eastern Province, Sri Lanka
[3]School of Aerospace Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia

Abstract:
Energy demand is getting higher from time to time all over the world especially in Malaysia. In order to cope with energy cost and climate change that taking place to achieve the thermal comfort, alternative cooling methods should be placed to reduce consumption of energy. Desiccant cooling technique is one of the promising alternative method, avoids the refrigerants use and eliminate effect on the ozone layer. This study focused on single layer hollow silica gel bed dehumidification ability as the solid desiccant material under variable air velocity between 1 ms^{-1} to 5 ms^{-1}. Experimental investigation concluded that moisture adsorption ability is increased respect to air velocity for hollow desiccant arrangement for 1 ms^{-1} to 2.1 ms^{-1} range. However, 2.1 ms^{-1} to 5 ms^{-1} showed steep decrease in moisture adsorption. 5 ms^{-1} air velocity illustrated 10.5 times lower dehumidification than 3.7 ms^{-1}.

Keywords:
Silica gel, Solid desiccant, Dehumidification, Adsorption, Hollow cylinder

A Model Identifying Factors Affecting The Sustainable Use of Solar Dryers: A Case Study

Ali Mostafaeipour[1], Mojgan Zarezade[1], A. Joshuva[2]

[1]Industrial Engineering Department, Yazd University, Yazd, Iran.
[2]Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India.

Abstract:
Solar energy has been used to preserve agricultural products which require drying through a consistent application of relatively low heat. In the present study, the feasibility of implementation the solar dryer system in the city of Yazd in Iran is evaluated by examining the effective factors. By identifying factors which may somehow affect the design, construction and operation of solar drying systems, a questionnaire was prepared and distributed. Among the results of the analysis, six main factors were identified: "performance," "geographical location," "infrastructures," "interactions," "financial support" and "social, cultural and political issues." According to the results obtained from factor analysis and with Structural Equations Modelling (SEM) method, a model was introduced. Subsequently, the final model was developed with the use of path analysis method and with AMOS. Based on the final model, the three factors of infrastructures (with the coefficient of 0.44), interactions and cultural, social and political issues (both with the coefficient of 0.12) directly affect the possibility of implementing the solar dryer in Yazd. According to the proposed model, it was concluded that authorities should mainly focus their attentions on finance, science, economy and infrastructures to develop and promote use of solar drying systems.

Keywords:
Solar dryer, Structural Equations Modelling (SEM), Path analysis, Sustainability, Yazd City.

CFD Simulation on Ventilation of an Indoor Atrium Space

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Abstract:
Atrium is a large enclosed space with various shape and height. The design of the atrium is exceptional and unique which gives a challenge and complexity to architect and engineer to provide acceptable thermal. A previous study indicates that CFD simulation can be used to successfully simulate the heat transfer and fluid flow in atrium geometries and provides recommendations turbulence and radiative heat transfer modeling. The variables which affect the atrium ventilation system can be categories into 3 elements which are external variables such as ambient and outdoor temperature, solar radiation and wind, secondly, an internal variable such as internal heat load, expected comfort level and the last one ventilation technique such as natural ventilation or forced ventilation. The purpose of this study is to predict the air ventilation system and evaluate thermal comfort in an atrium using CFD simulation. An atrium of an indoor theme park will be used as the case study. Since the location of the atrium is located at a hot-humid climate, the thermal comfort range is higher than expected by international standard, ASHRAE 55-2004 Standard. However, the standard still can be used to validate the result of the simulation by comparing it with Malaysia Standard 1525:2007.

Keywords:
Atrium, CFD Simulation, Ventilation.

Turbulence Modelling of a Helical Savonius Wind Turbine Operating at Low Reynolds Number

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Abstract:
In this paper, two turbulence modeling methods for predicting the performance of a helical Savonius wind turbine with 90º twist operating at low Reynolds number are evaluated. The first method is Reynold-Averaged Navier-Stokes Simulation (RANS) and the other is Detached Eddy Simulation (DES). For each method, two turbulence models namely Sparlat-Almaras (SA) and Shear Stress Transport (SST) are used. The results are then compared with wind tunnel experimentation where the turbine power is computed by using the measured voltage and current relationship. RANS-SA and RANS-SST predicted a low power coefficient compared to DES-SA and DES-SST models. However, the difference between the two methods is minimal (about 3%). It is also observed that the computational time is dependent on the turbulence model. RANS-SST and DES-SST models took more than 1.5 times compared to RANS-SA and DES-SA to complete the analysis. At 5 m/s of wind speed, the power predicted by both turbulence modeling is about the same as the actual power output measured by the experiment. It can be concluded that RANS-SA model is sufficient to predict the performance of a wind turbine at a low Reynolds number. Another interesting finding in this research is that the DES method provides a detailed wake structure around and at the downstream region of the turbine. This information is beneficial in a wind farm design.

Keywords:
Turbulence Model, RANS, DES

Numerical Performance Study for the Buoy Shape of Point Absorber Wave Energy Converters

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Abstract:
The ocean wave is among the most promising renewable energy available. However, the idea of commercializing wave farm requires high operating cost compared to other RE sources. Effectiveness of wave energy collection device is highly depend on the location and condition of the wave. Three-dimensional simulation tool is an ideal tool at preliminary design stage to optimise the device. In this paper, a wave structure interaction with application to wave energy device was studied numerically. The computational fluid dynamic analysis based on the Reynolds Average Navier-Stokes equations was used to investigate the interaction between wave and structure, and array effects among devices. Validation and predication of the performance of wave point absorber were done in this paper. Five different models were chosen as the object to study. The influence of wave point absorber devices array on their performance was investigated under the irregular wave conditions to improve the overall performance. Results show that optimum phase condition of buoys can be obtained by adjusting the mass density and diameter. Studies found that cylindrical buoy of mass density of 100kg/m^3 with 0.2m diameter is the optimal size for the condition set in this research with the produced maximum force of 136.49 N.

Keywords:
Buoy, Point Absorber, CFD, Numerical

Empirical Modelling of Einstein Absorption Refrigeration System

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Abstract:
A single pressure absorption refrigeration system was invented by Albert Einstein and Leo Szilard nearly ninety-year-old. The system is attractive as it has no mechanical moving parts and can be driven by heat alone. However, the related literature and work done on this refrigeration system is scarce. Previous researchers analysed the refrigeration system theoretically, both the system pressure and component temperatures were fixed merely by assumption of ideal condition. These values somehow have never been verified by experimental result. In this paper, empirical models were proposed and developed to estimate the system pressure, the generator temperature and the partial pressure of butane in the evaporator. These values are important to predict the system operation and the evaporator temperature. The empirical models were verified by experimental results of five experimental settings where the power input to generator and bubble pump were varied. The error for the estimation of the system pressure, generator temperature and partial pressure of butane in evaporator are ranged 0.89-6.76%, 0.23-2.68% and 0.28-2.30%, respectively. In addition, all the estimated generator temperatures and partial pressures of butane are within the error bar range that derived from the standard deviation of the experimental results.

Keywords:
Absorption Refrigeration, Empirical Modelling, System Pressure, Generator Temperature, Partial Pressure

Investigation of The Corrosion Metals In Non-Edible Biodiesel Fuel

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Abstract:
One of the many problems that engineers face are the failure of numerous automotive parts due to corrosion. This investigative project was instituted to study the immersion of different types of metal surfaces such as aluminium, mild steel and copper in Moringa non-edible biodiesel at 60˚C for 1100 hours. This project gave an insight on the corrosion performance of similar metals immersed in Moringa biodiesels. Besides that, this project had fulfilled its objective to study the elemental composition of selected corrosion spots on the surface of the metal as there were presence of aggressive pitting corrosion on unpolished metal surface than on polished surface. In additions, any colour changes of biodiesels were also recorded as proof of chemical reactions between the metal and biodiesel. The results show that copper had the highest corrosion rate followed by aluminium and lastly, by steel. Marginally changes in biodiesel colour for aluminium and steel when immersed in Moringa biodiesel but the complete opposite was seen when copper was immersed in Moringa biodiesel.

Keywords:
Corrosion, Non-Edible, Biodiesel.

Treatment of Electrical And Electronic Waste to Reduce Environmental Issues

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Abstract:
Electrical and electronic wastes (E-Waste) are harmful to the environment and human life due to it contain non degradable and hazardous components. Treatment of e-waste is important in order to reduce the environmental issues. Conversion of e-waste into valuable products including liquid oil is believed as to be one of the good ways to solve the problem. For this purpose, application of microwave technology for e-waste pyrolysis and liquid oil product distillation is very interesting because of the rapid heating processes of materials. This study reported on e-waste processing techniques and specifically highlights the use of microwave technology to convert e-waste into liquid oil. The treatment of e-waste in this work included microwave pyrolysis of e-waste and microwave distillation of liquid oil product.

Keywords:
E-Waste, Pyrolysis, Distillation, Liquid Oil, Environmental Issue

Design and Performance Analysis of A Biomass Fueled Mono-Tube Boiler for Humid Air Turbine Cycle

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Abstract:

Externally fired gas turbine (EFGT) is one of the few power generation configurations capable of utilizing biomass in its solid form without any additional equipment to convert it to liquid or gas. Due to its high thermal output capability for drying applications, EFGT is one of the most suitable configurations for the off-grid rural areas in Malaysia with abundant biomass waste and high demand of heat for crops drying. The main downside of EFGT is the necessity for high temperature heat exchanger which compromises the system feasibility due to the high cost and other technical challenges. This can be eliminated by the addition of steam in a configuration known as humid air turbine (HAT), thus, limiting the required temperature and allowing for the use of common low-temperature heat exchanger types. Several mono-tube steam boiler designs were compared to fulfil the required steam flow rate of 2 kg/min for the available EFGT system. Counter-flow design was found to be more suitable with its higher efficiency. The boiler was characterized experimentally at output steam flow rate range of 0.4-2 kg/min using off-cut waste wood from furniture industry. Maximum achieved boiler efficiency and specific fuel consumption were 73% and 0.29 kg/kWh, respectively.

Keywords:
Mono-Tube Boiler; Biomass; Humid Air Turbine; Externally Fired Gas Turbine.

Combustion Stability Analysis Of Liquid Biofuels Using Acoustic Signals

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Abstract:
Low-grade liquid biofuels from agricultural wastes are promising renewable alternatives for distributed cogeneration. They contribute to the wellbeing of the underdeveloped rural areas as well as the reduction in carbon footprint. However, such fuels suffer from the poor atomization and flame fluctuation. The conventional method to determine combustion completion is by analysing the temperature and emission profiles, but it does not provide explicit indication on flame stability. The unsteady heat release rate from flame provides unique pressure wave signature that can be captured as acoustic wave. A pressurized combustion chamber was developed and connected to a vehicular turbocharger for liquid biofuels combustion. Microphone probes at the chamber inlet and outlet were used to capture the acoustic signals to be analysed through the Fast Fourier Transform (FFT) using MATLAB program. Combustion stability and emissions of biodiesel and blends of palm oil/diesel were investigated and compared to diesel as the benchmark fuel. The analysis of the sound pressure revealed distinguishable deviation patterns between diesel and other biofuels where biodiesel was comparable to B30, while increasing palm oil blend (vol. %) resulted in higher deviation. Chamber pressure also showed positive effect on combustion stability and reduced the deviation between diesel and other biofuels.

Keywords:
Liquid Biofuels; Combustion Acoustics; Micro Gas Turbine; Combustion Stability.

Optimization of The Through-The-Road Parallel Hydraulic Hybrid Drive Train

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Abstract:
The through-the-road hydraulic hybrid parallel architecture is a practical solution to achieve high fuel economy in passenger vehicles because it allows the use of hybrid technology using an existing conventional vehicle. This paper discusses the development of the architecture that involves the hydraulic circuit design and the optimization of the components size. The study simulates 972 vehicle models and finds the suitable model uses a 25cc/rev hydraulic pump, a 50 cc/rev hydraulic motor and a 10 liter hydraulic accumulator.

Keywords:
Hydraulic Hybrid, Energy Consumption, Affordability, Retrofitting, Attainability

Optimization of Deflector Angle on VAWT Using Savonius Tandem Blade Rotor

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Abstract:
Generally, Savonius VAWT has a low efficiency compared to any type of HAWT due to the flow that is in contrast to the convex movement of savonius blades when it receives the wind from the mainstream direction. The conventional Savonius blade also gives a low TSR effect and a negative torque due to the limited sweep area and some of the wind in the mainstream crashing the convex blade. The novelty in this study is to use the Savonius tandem blade aimed at expanding the sweep area and "jet effect" which can increase the production of drag forces on the blade, thereby increasing turbine rotation. Installing a deflector at a suitable tilt angle serves as a wind guide that hits the turbine blades to convert negative torque to positive torque. The optimization methodology employed is Response Surface Method (RSM) based CFD simulation and wind tunnel testing. The variation of the operation of turbine testing is angle of deflector (α), wind velocity (v),and Power (P) as the response variables. Based on CFD simulation, wind tunnel experimental result and analytical review, the optimum value of deflector angle was found.

Keywords:
Deflector Angle, Savonius Tandem Blade, VAWT, RSM.

Feasibility Analysis of Wind Power Plants in GCC connected to GCC Super Grid

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Abstract:
Gulf Cooperation Council (GCC) Energy consumption and demand is increasing significantly due to multiple factors. Energy security is an essential for the council members hence, GCC interconnections (Super Grid) was built to cover in case of emergency outages. The underutilization of the connection is a wasted opportunity in seizing the low hanging fruit such as are high renewable energy penetration. GCC countries has more than 1400 h full load of wind per year which qualify it to harvest wind energy for electrical demand coverage. This feasibility study is planned to utilize GCC super grid by adding wind power plants across the countries with high potential and high power output. The methodology exploit technical modeling such as wind power model to make determination of the technical viability of the project. Furthermore, will use economic modeling NPV, PBP and IRR to determine economic viability. Lastly, GHG model used to measure impact on the environment. The thesis will compare between the base scenario of conventional generation and the new scenario of wind technology through the feasibility for locations across GCC region utilizing RETScreen as a tool and Vestas wind turbines for the analysis. The most feasible locations are 9 across the GCC region and configuration is recommended of Wind Power Plants integrated to the GCC Super Grid. The configuration is expected to cover 13% of 2022 energy demand in GCC region.

Keywords:
Wind, Super grid, Feasibility.

Open Source Thermophysical Property Library, Coolprop, Coupled with Python for Analyzing Thermodynamic Cycles in Classroom and Research

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Abstract:
Thermodynamics deals with the study of energy conversion and is an integral part of the course curriculum of various engineering disciplines. Thermodynamic cycles are extensively used in power generation, automotive and aerospace, refrigeration and air-conditioning among other wide area of applications. Consequently, analysis of thermodynamic cycles is pivotal in understanding the underlying thermodynamic processes and in apprehending the effect of different parameters on the performance of these cycles. A vast range of software are currently available being used for analyzing thermodynamic cycles both in teaching and research worldwide. A user-friendly open source software capable for seamlessly analyzing thermodynamic cycles would be invaluable for teaching and research in developing countries as the academic institutions there are often unable to purchase the commercial software due to budget constraints. CoolProp, written in C++, is an open source thermophysical property library having wrappers for the majority of programming languages e.g. MATLAB, Python, Octave, FORTRAN, R, Java. CoolProp, as an open source library, can conveniently be used for solving thermodynamic cycles when coupled with a programming language. In this paper, CoolProp, coupled with Python has been used to model and analyze various power and refrigeration cycles for classroom teaching. Also, Hybrid dual fuel (natural gas and municipal solid waste) combined cycle and CO2-NH3 vapor compression cascade refrigeration cycle have been simulated from the literature utilizing CoolProp to show its effectiveness in research. It is shown that CoolProp, coupled with Python, could be utilized as an effective and convenient tool for analyzing the thermodynamic cycles, both from teaching and research perspective.

Keywords:
Open Source Software, Modeling And Simulation, Thermodynamic Cycle, Coolprop, Power Cycles, Refrigeration Cycles, Classroom Teaching

Development of an Improved Hybrid Back propagation ANN for Low Wind speed prediction and Wind Energy Evaluation

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Abstract:
This paper shows a potential of wind energy at two locations based on wind speed data and a prediction model. Wind data was obtained from Malaysia Meteorological Department (MMD) for a period of ten years starting from 2008-2018. The wind energy evaluation was conducted at 10m-40m meters respectively. In the areas with limited data or without data a prediction model was developed using different Artificial Neural Networks (ANNs) structures. The model was trained, tested and validated using measured wind speed in the nearby location. The optimized model in terms of less structure with high prediction accuracy was selected for the final prediction. Detailed wind resource assessment was conducted in the areas based on most fitted wind speed distribution model. It was found that Weibull and Rayleigh fitted the wind speed in the areas examined. At the end of the analysis, low wind speed turbine was selected for the wind farm sitting; the results show that wind energy can be harnessed for small Pico scale application such as rural electrification, and grain grinding. Because it all the cases the wind power density falls within class 1 ($PD \leq 100$ W/m^2). The outcomes of this study would be useful for policy makers to implement 3-Es Model (Earth-Energy and Empowerment) in rural and remote areas of Sarawak.

Keywords:
Wind Energy, Power Density, ANN, Sarawak

Thermocatalytic Treatment for Tar Removal With Ni/AC Catalysts

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Abstract:
Despite its effectiveness to produce useful gas comparing conventional biomass utilization, biomass gasification technology is still facing one of the drawbacks, that is the natural production of Tar, that later can cause several problems including blockages and pipe corrosion, and most importantly potentially decreasing the final gas production in the system. In order to get rid of tar, in its development there are several methods that have been utilized for removing tar. In this study will be focusing the use of combination treatments from modified microwave as the heat source for the thermal treatment, as well as the use Activated Carbon Supported Nickel (Ni/AC) Catalysts from commercial grade for the catalytic treatment. Tar model compound was also used to represent the complex mixture of real tar in the laboratory scale experiment. The result shows that thermocatalytic treatment is an effective option to be used in tar removal process, as the specific heat needed can be reached in quick time with lower energy consumption compared to the conventional heating mechanism. Furthermore, the Ni/AC also performed well during the experiment as it can remove tar perfectly, and there is possibility to produce in bigger scale as its affordable price.

Keywords:
Tar Removal, Biomass Gasification, Thermocatalytic, Ni.AC Catalysts

Electrochemical Properties of Si Film Electrodes Containing Cu Nanorod Current Collector

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Abstract:
Among many anode active materials to replace carbon-based anode materials, Silicon(Si) has a high theoretical capacity of 3579 mAh/g during the discharging process when reacted with Lithium(Li), thus attracting much attention as a next-generation high capacity lithium ion battery anode active material. Despite its high theoretical capacity, it is subject to high structural stress due to severe volume expansion during Li and charge and discharge processes. As a result, electrode was damaged such as cracking and crushing occurs in the electrode, resulting in deterioration of the cycle characteristics of the electrode. The cycle performance of the Si electrode is known to be superior to the electrode of the thin film form compared to the electrode of the conventional powder form. It has been reported that the nanostructured Cu current collector has a large surface contact area between the current collector and the active material, can easily maintain a short lithium ion diffusion length, and can well control the structural deformation imposed by the electrochemical reaction. In this study, Si thin film electrodes using Cu nanorod current collectors were heat-treated at various temperatures and were deposited at various hours. In addition, the electrochemical properties were evaluated using FEC additives.

Keywords:
Silicon(Si), Cu Nanorod Current Collectors, Heat-Treated, FEC Additives

Silicon embedded Polyacrylonitrile (PAN) composite electrodes for lithium ion batteries

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Abstract:
Silicon (Si) is the most promising candidate owing to its high available capacity of 3579 mAh/g (based on the formation of the $Li_{15}Si_4$ phase at room temperature), and low working potential (approximately 0.5 V for Li/Li+). Nevertheless, Si electrodes suffer from a severe drawback in that they undergo a massive change in volume (approximately 310%) during the charge-discharge (lithiation-delithiation) process. The resulting structural instability generates high internal stress, which may lead to electrode cracking and pulverization, causing high irreversible capacity loss in the first cycle and rapid capacity fading. One possible approach to break through the drawbacks of Si is the utilization of electrochemically inactive materials which can alleviate the mechanical stresses during the repeated discharge and charge process and physically suppress the volume expansion. For this, various materials such as carbon, metal or metallic compound were coated on the surface of Si materials via the typical coating way. In this work, Polyacrylonitrile (PAN) containing nano Si particles was fabricated by using electrospinning process. The structural and electrochemical properties of the composite anode were investigated with various carbonizing temperatures. In addition, the effect of FEC additive on the electrochemical properties was examined with EIS analysis.

Keywords:
Electrospinning, PAN, Si, Carbonization

CFD Modeling Analysis on Biomass Boiler Fueled by Empty Fruit Bunch

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Abstract:
The need to reduce the use of fossil fuels in the recent decades has led to the investigation of alternative fuels. Therefore, biomass appears to be a solution as it is a solid fuel formed from waste of industries that creating a renewable energy source. A computational fluid dynamic (CFD) has been developed to evaluate the performance of a boiler fueled by biomass from empty fruit bunch as wasted of palm oil mills in Indonesia. The model was developed in commercial software ANSYS. The temperature distribution, gas composition, and boiler performance during processes were examined based on two different biomass local feedstocks. The model is also applied to study the effect of air enrichment in boiler performance and gas emissions. The boiler operation is simulated using different air fuel ratio. The results show that the boiler thermal performance affected by increasing the oxygen concentration.

Keywords:
Biomass, CFD, Boiler, Empty Fruit Bunch, Performance

Computational Simulation of Nanoparticles Addition in Lead-free Solder During Reflow Soldering-A Review

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Abstract:
Surface mount technology (SMT) is a method of electronic components mounting or placed directly on the surface of the circuit board. The solder will be printed onto the substrate on the printed circuit board (PCB) and then undergoes reflow soldering process. As the used of lead (Pb) is restricted by the restriction of hazardous substances (RoHS) directive in 2006 and Waste Electrical and Electronic Equipment (WEE), the study on the addition of nanoparticles into the lead-free solder has increased as to increase the reliability and quality of the lead-free solder. Researchers have added Cobalt, Silver, Molybdenum, Diamond, Silicon, Zinc, Zinc oxide and many more to increase few solder criteria such as the wetting properties, mechanical properties and the intermetallic compound (IMC) layers. Many numerical simulation methods such as finite element (FEM), finite volume (FVM), fluid-structure interface (FSI), Lattice Boltzmann method (LBM) and discrete phase method (DPM) have been used to clearly show the reflow soldering process and to cut the cost of experimental work.

Keywords:
Lead-Free Solder, Nanoparticle, Reflow Soldering Process, Numerical Simulation

Symmetrical Unit-Cell Numerical Approach for Flip-Chip Underfill Flow Simulation

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Abstract:
This paper presents a new symmetrical unit-cell approach to simulate the flip-chip underfill encapsulation process. The current numerical simulation is based on the finite volume method scheme. By exploiting the repetitive symmetry of bump array in flip-chip, the computational domain was simplified into a long array of unit-cells of one-pitch thick while the symmetrical walls between adjacent unit-cells were modelled using the periodic boundary condition. Accordingly, the computational costs can be greatly reduced. Alongside with the introduction of new numerical approach, the variation effect of bump pitch was studied by considering four flip-chip cases with bump pitches ranging from 0.08 mm to 0.16 mm. The numerical findings were found to in great consensus to the referencing experimental data, with the discrepancy not more than 14.54%. Additional validation with the analytical filling time model revealed that both the numerical and analytical filling progressions are comparable. It is found that the increases in bump pitch can reduce the filling time at a particular filling distance, such that the filling time was halved within the investigated range of bump pitch. Generally, this new numerical approach is particularly useful for the simulation works of underfill process, especially the design and process optimization.

Keywords:
Bump Pitch, Electronic Packaging, Finite Volume Method, Flip Chip, Underfill Encapsulation

Effect of Contact Angle on Meniscus Evolution and Contact Line Jump of Underfill Fluid Flow in Flip-Chip Encapsulation

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Abstract:
Despite the contact angle of underfill fluid is largely correlated to the flowability, it was scarcely being investigated in the design optimization of flip-chip underfill encapsulation process. Furthermore, the detailed implication of the variation of contact angle on the flow mechanism was never being discussed. Thus, this paper is devoted to study the variation effect of contact angle on both spatial aspects of meniscus evolution and contact line jump of underfill flow menisci. The governing analytical equations that describe both meniscus evolution and contact line jump were well-validated with the past experimental and numerical findings. It was revealed that the bump contact angle critically determined the separation between concave and convex menisci. Generally, larger bump contact angle yields the earlier formation of convex menisci that is nearer to the bump entrant. Consequently, the occurrence of convex menisci in the bump region increased for the case of high bump contact angle. Moreover, when the contact angle increases, the equilibrium positions of entrant jump meniscus locates nearer to the bump entrant; while the equilibrium meniscus of exit jump becomes further away from the bump exit. These findings provided microscopic insights of the influence of contact angle on the characteristic and dynamic of flow menisci upon interacting with the solder bump array, which may benefit both electronic packaging and microfluidics sectors in general.

Keywords:
Contact Angle, Contact Line Jump, Electronic Packaging, Flip Chip, Meniscus, Underfill Encapsulation

Feasibility Study of A 50 MW Wind Farm Project in Pakistan

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Abstract:
Wind energy is the most developed source of renewable energy, because of advanced technology, low operational cost, and less environmental impacts as compared to fossil fuels. Due to the electricity load shedding and high carbon emissions, Pakistan direly needs a clean and economical energy source. Pakistan has enormous wind potential especially in remote areas of Sindh which can cover the energy demand of the local communities. This paper aims to study the feasibility of the 50 MW wind project in four different geographic locations of Sindh province in Pakistan. The selected sites are technically and financially analysed in renewable energy technology (RETScreen) software. Financial analysis is also carried out according to the renewable energy policy of Pakistan with the values of the discount rate, debt ratio and inflation rate. The results showed that all sites are technically and economically feasible, but Hyderabad is the most favorable site with the highest capacity factor of 41.8%, and lowest simple and equity payback period of 7.4 years and 4.9 years respectively as compared to the other sites. So, it is concluded that wind energy is the most suitable option as technically and financially in the remote areas of Sindh province in Pakistan.

Keywords:
Renewable Energy, Wind Energy, Carbon Emission, Energy Financial Analysis, Pakistan

Analytical Study of Performance and Emission Characteristics of a Palm Biodiesel Fueled Engine Using Response Surface Methodology

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Abstract:
Alternative fuels are in the limelight due to depleting fossil fuel reserves and alarming environmental impact of pollution. Even though electric mobility is encouraged by the government to reduce the dependence on fossil fuel, lack of high energy density batteries still downplays the mass marketable scope of electric vehicles due to drivable range in which liquid fueled vehicles have the advantage. Response Surface Methodology (RSM), a statistical mathematic technique is utilized to analytically study the impacts of Palm Biodiesel (PBD) blended diesel fuel at enrichment ratio of 10%, 20%, and 40% on performance and emission characteristics of a multi cylinder compression ignition (CI) engine. The study concludes that engine torque and power improve with mild palm oil enrichment of 10% notably at low end speed of 2000 rpm. CO2 and CO emissions and smoke decline while higher O2 content present in PBD compared to pure Diesel gives rise to NOX emissions.

Keywords:
Palm Oil, Diesel, Response Surface Methodology

Spontaneous polarization and Piezoelectric Tensor of Polyvinylidene Fluoride (PVDF) in α and β Phases.

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Abstract:
Combining the first principles density functional theory (DFT) and non-equilibrium Green's function we have investigated the electronic, dielectric polarization and piezoelectric properties of polyvinylidene fluoride (PVDF) in alpha and beta phases comparatively. PVDF is having a chemical formula −(C2H2F2)n−. We have also calculated the dynamical charge properties via Born effective charges. We report the finite value of spontaneous polarization 0.914 C/m^2 and 0.625 C/m^2 for α and β Phases, respectively. These results showed that PVDF is a dielectric material with outstanding electrical response to external stimuli. These findings provide some valuable insight in understanding the quantum mechanical responses of ions and electrons in the nanoscale-materials under external applied field which enable the novel possibilities for next-generation energy materials.

Keywords:
DFT, PVDF, Spontaneous Polarization, Piezoelectric Tensor, Band Structure.

Investigation of Small Wind Turbine Noise as per IEC 61400-11 and AWEA 9.1 Standard

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Abstract:
This paper analyzes the noise generated from a 5 kW test wind turbine generator (WTG) with hub height, rotor diameter, cut-in and rated speed of 15m, 4m, 3 m/s and 12 m/s respectively according to IEC 61400-11 (acoustic noise) standard. It discusses the realistic and comparable performances of small WTG that sets its own characteristics in terms of power and acoustic performances. Standard set by American Wind Energy Association (AWEA 2009) has also been incorporated together with IEC 61400-11. For the measurements of noise level, the averaging period has been considered to be 10-second as per AWEA 2009. The study attempts to analyze time-series noise data recorded at different distance from the WTG for finding Noise (dB)-Frequency (Hz), RPM-Volt and Noise-RPM relationship. The analysis has been done with the help of wind speed histogram bin each of size 1 m/s which estimates that, RPM ranges between 0 - 170, overall noise ranges between 45.17 (dB) - 48.78 (dB) and background noise ranges between 33.2 (dB) - 65.6 (dB). The correlation between the WTG noise and background noise indicates for the research that the environmental impact due to noise for the WTG is subject to analyze and may not be underrated.

Keywords:
Small Wind Turbine, Noise Analysis, IEC 61400-11, AWEA 9.1, Health Impact

The Improvement of Energy Efficiency for Refrigeration System in Thailand Convenience Store by Digital Scroll Compressor

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Abstract:
In this research will present energy saving of R448A refrigeration system in convenience stores 150 m^2 by digital scroll compressor that energy used 40,997 kWh/Year/Store replaced for fix speed scroll compressor that energy used 62,364 kWh/Year/Store. The digital scroll compressor can operated in unload status and full load status that controlled by evaporator temperature (Tev) set point at -10 degree and condenser temperature (Tcd) set point at 38 degree and superheat temperature (Tsh) at 10 degree, in unload status the power consumption for digital scroll compressor will decreased 50% that impact for energy saving and important for night time when low requested cooling load because compressor started–stopped many time. The methodology was measured power consumption (W), voltage (V), current (I), power factor (PF), frequency (Hz), evaporator temperature (Tev), condenser temperature (Tcd), liquid temperature (Tlq), sub cool temperature (Tsc), gas temperature (Tg), superheat temperature (Tsh) by power meter data logger and temperature data logger. The result summarized relation of all parameter and showed energy saving 34%, 21,367 kWh/Year/Store of compressor.

Keywords:
Digital Scroll Compressor, Refrigeration System, Energy Technology

The Improvement of Energy Efficiency and Environmentally Friendly Using R448A for R404A Refrigeration System in Thailand Convenience Store

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Abstract:
In this research will present energy saving of R404A refrigeration system in 5 convenience stores 150 m^2 at central region Thailand by R448A. The hydrofluorocarbons/ hydrofluoroolefins (HFCs/HFOs) R448A (GWP=1390) was azeotropic mixture of R32 (26%), R125 (26%), R1234yf (20%), R134a (21%) and R1234ze (E) (7%) could retrofit in the refrigeration system using R404A. The hydrofluorocarbons (HFCs) R404A (GWP=3735) was azeotropic mixture of R125 (26%), R143A (52%), R134A (4%). Bolt refrigerants are no frame propagation and lower toxicity and used polyol ester oil (POE). The R448A had higher cooling capacity (Qe) than R404A by hydrofluorocarbons (HFCs) R32 in component and lowerglobal warming potentials (GWP) than R404A by hydrofluoroolefins (HFOs) by R1234yf and R1234ze (E) in component. The methodology was measured power consumption (W), voltage (V), current (I), power factor (PF), frequency (Hz) , Ambient temperature (Tab)by power meter data logger and temperature. The result summarized relation of all parameter and showed energy saving average 7.9%, 28,273 kWh/Year/5 Store of digital scroll compressor and increased global warming potentials (GWP) 70%.

Keywords:
Refrigeration System, Energy Technology, R448A Refrigerant, Environmental Friendly,

Performance Analysis of Electric Vehicle Powertrain System with Two-Speed Transmission

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Abstract:
This study analysed the powertrain electric vehicle (EV) system performance with two-speed transmission. This research analysed various terrain conditions as a variable that will be used as a reference in measuring the level of reliability of the vehicle's performance, refers to its specification, center of gravity and tires radius. The results were obtained by selecting suitable transmission ratio which are 1.96 for the first gear and 1.25 for second gear. The required traction to do gearshift by the motor is not big enough thus the gearshift becomes smoother. Base on the friction analysis with traction, it can be concluded that in a 10° road slope, the vehicle is unable to yield traction of 6000 rpm at second gear due to the slope drag is higher than the vehicle traction. As a result, the vehicle is able to travel of 65.30 km/h at second gear while of 49.98 km/h at the first gear. Whereas at a slope of 20°, the result showed that the vehicle is able to yield traction of 5000 rpm at first gear due to the slope drag is higher than the vehicle thrust/traction. Therefore, the vehicle is able to travel of 41.65 km/h at the second gear and of 49.98 km/h at the first gear.

Keywords:
Electric Vehicle, Performance, Powertrain, Traction, Two-Speed Transmission.

Time-Series Wind Data Analysis Of Southern Thailand

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Abstract:
In order to protect the environment and secure future energy, it is significant to contemplate the possibilities of wind as a resource for electrical energy supply. This study assesses the wind characteristics of southern Thailand. Ten years' wind speed and wind direction data of the 19 meteorological stations have been collected. To understand the wind energy potential of southern Thailand, wind speed distribution of 19 meteorological stations has been calculated using Weibull probability distribution function (PDF). Two Weibull parameters i.e. shape parameters 'k' and scale parameters 'c' were determined from wind atlas. Along with, average wind speed 'U' (m/s) and power density 'P' (W/m^2) have been measured for each station using Wind Atlas Analysis and Application Program (WAsP). The results revealed that Trang, Hat Yai and Phuket stations have average wind speed of 5.37 m/s, 5.44 m/s and 6.06 m/s with high power density of 204 W/m^2, 259 W/m^2 and 357 W/m^2, respectively.

Keywords:
Green Energy, Probability Distribution Function, Low-Speed Wind, Thailand.

Wind Energy Data Analysis in Eastern Thailand

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Abstract:
Over the past decades, wind turbines have been used to convert wind energy to generate electricity. Wind energy potential in a certain region may be sufficient to produce a reasonable amount of electrical energy from wind turbines. To achieve the maximum yield of wind power generation, a micro setting of wind speed, wind direction, frequency distribution, wind rose, power density, roughness and elevation was extensively evaluated in each specific location. This research aims to study the wind potential of the areas in the eastern provinces of Thailand. Data from 13 meteorological stations were collected. Using a wind power pole at 11-meter height above ground level (AGL), wind data were collected every 3 hours over a period of 10 years (2009-2018). Using Weibull Probability Distribution Function (PDF), the maximum average wind speeds from three locations were found in Chabang (7.72 m/s), Rayong (5.36 m/s), and Pattaya (4.83 m/s). The power density in Chabang, Rayong, and Pattaya regions was 703 W/m^2, 275 W/m^2 and 168 W/m^2, respectively. In all locations, wind direction was detected mainly from Southwest (SW) and Northeast (NE). In a nutshell, comparatively low wind speed was noticed in the eastern provinces of Thailand. Hence, small scale wind turbines are recommended for power generation. After extensive evaluation of wind power in each specific region in eastern Thailand, low speed wind energy might be a promising choice for electrical production.

Keywords:
Wind Power, Weibull Distribution Function, Average Wind Speed, Eastern Thailand.

Analysis of Vacuum Insulation Panels to Reduce Fuel Consumption in Cold Storage Trucks

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Abstract:
Thailand is in the top rank of the world which produces and exports agricultural products whether it is a group of vegetables, fruits or seafood products. Temperature controlling during transportation is very necessary to reduce the spoilage that may occur during transportation in order to provide fresh and standard products to the recipients which meet the requirement of the buyer. Compressor is used for this purpose and it consumes large amount of energy. The fuel is used to drive compressor for chilled pick-up truck. This study aims to reduce fuel consumption in transportation systems. The vacuum insulation panels were designed and installed in chilled pick-up truck to investigate the fuel reduction. Various sensors were installed for analysis i.e. temperature sensors for measuring interior and exterior temperatures of the mentioned truck. The test result of driving a chilled pick-up truck in case of without and with vacuum insulation panels were investigated with a total distance of the central Thailand to the southern part of Thailand covering 944 kilometers. Results implied that the fuel consumption is only 8.3 kilometers per liter in case of installation vacuum insulation panels which fuel saving 16.90 % can be obtained.

Keywords:
Fuel Reduction, Vacuum Insulation Panel, Logistic.

Time-Series Wind Data Analysis of Northern Thailand

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Abstract:
In this study, wind energy potential of 9 Northern provinces of Thailand were analyzed for the period of ten years from 2009 -2018 by using Wind Atlas Analysis and Application Program (WAsP) software for the calculation of average speed (m/s) and power density P (W/m^2) for 13 meteorological stations. This research investigates wind speed distribution from the data of 13 meteorological station of 9 provinces of the projected region using Weibull probability distribution method (PDF). Two significant Weibull parameters, shape parameters 'k' and scale parameter 'c' were measured by using wind speed and wind direction data of 10 years, obtained from Thai meteorological department. The results show only Mae Sariang, Mae Hong Son station has a high-power density of 135 W/m^2. However, a significant amount of missing data effected the results which didn't produce expected results, using Weibull probability distribution function.

Keywords:
Wind Farm, Green Energy, Probability Distribution Function, Low-Speed Wind, Northern Thailand.

The Effect of Gas Area Fraction on Mixing Flow in Microchannel

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Abstract:
Mixing in microchannel cannot be carried out by exciting the liquid streams in turbulent flow to enhance its mixing performance because the Reynolds number (Re) is typically below the critical value where transition to turbulence would occurs. It is thus a challenging problem for passive micromixers to mix fluids of different species within a desired range of mixing channel length in the absence of enhanced mixing techniques. This study presents numerical approach that investigates the mixing performance in microchannel having alternating superhydrophobic grooves and ribs. A 2D channel that bounded by two parallel walls patterned with alternating superhydrophobic grooves and ribs is employed throughout the study and the simulations show that normalized mixing length is increase monotonically with the gas area fraction The mixing performance is also explored in the region close to the superhydrophobic walls, at y/H=0.1, 0.5 and 0.9 respectively and it tends to give rise to a relatively slower mixing. Besides that, the influence of flows Reynolds number is also obtained and it show that the mixing length is not significant difference as compared to smooth wall at low Reynolds number due to the use of superhydrophobic grooves of Λ=0.1. With the use of superhydrophobic wall, it could be potentially beneficial in mixing channel with limited pumping power without significantly affect the mixing performance.

Keywords:
Water Repellent, Micromixer, Surface Roughness, Air Cavity.

CFD HVAC Study of Modular Badminton Hall

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Abstract:
Modular badminton hall is proposed to Badminton Association Malaysia in 2017. It has several advantages including easy to transport and relocate; and fast installation and dismantling. Air ventilation is one of the important aspects in designing modular badminton hall. Low room temperature and air velocity are important parameters and need to take into account during design and calculation. Therefore, the present work employed CFD ANSYS Fluent to study the effect of exhaust fan arrangements on room temperature and air velocity. The heat source are contributed by humans and solar radiation are included in this computational. Five different design with various number of exhaust fans and arrangements are studied. According to the result, Design 5 produces the lowest average room temperature, 26.52°C. Although the average air velocity of Design 5 is the highest; around 0.083m/s, it still acceptable as it has local air velocity lower than 0.1m/s. In the present work, Design 5 is the best performances and the best air ventilation design for Modular Badminton Hall in Malaysia.

Keywords:
CFD, HVAC, Badminton Modular Hall

Numerical Study of Heat Transfer Characteristics of Laminar Nanofluids Flow in Oblique Finned Microchannel Heat Sink with Varying Based Fluid and Volume Fraction of Nanoparticles.

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Abstract:
This paper demonstrated a numerical study of heat transfer characteristics of laminar flow in oblique finned microchannel heat sink using nanofluid with Al_2O_3 nanoparticles added to various base fluids including water, ethylene glycol and turbine oil as coolant fluid. The width of the primary channel was 0.5 mm and the secondary channel was less than 0.15 mm in the oblique finned microchannel heat sink with an aspect ratio equal to 3. Single phase model and constant heat flux boundary condition were used in this numerical study. The modeling was validated by comparing the published data for conventional and enhanced microchannel heat sink. The base fluid acted as a comparison baseline to the nanofluid with volume fraction of 1.0% and 4.0%. ANSYS Fluent was adopted to model the flow in the geometry of microchannel. Besides, the study was carried out in laminar flow regime, whereby the Reynold number ranged between 320 and 700. It was found that turbine oil based nanofluid had the highest Nusselt number among all fluids, followed by ethylene glycol and water to be the least. However, the heat transfer coefficient among all fluids were contrary to the Nusselt number where water achieved the highest heat transfer coefficient. The addition of nanoparticles increased the heat transfer coefficient of all fluids but it did not enhance their Nusselt number except water.

Keywords:
Nanofluids, Laminar Flow, Heat Transfer Enhancement, Microchannel.

Simulation of 5G Mobile Electromagnetic Energy Effects on Human Head Tissues

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Abstract:
This paper presents the investigation of an amount of the 5G electromagnetic energy absorbed in the human head tissues in order to study the specific absorption rate (SAR) effects on it. The penetration of the electromagnetic radiations in human body will produce induced electric field, resulting in absorption of power. To determine the SAR in the human head tissue, the ANSYS-HFSS has been used to construct a model of the human head with mobile phone antenna and the full-wave analysis has been performed then. Based on the simulation results, the penetration depth of 5G electromagnetic radiations and SAR have been characterized.

Keywords:
Specific Absorption Rates, Electromagnetic Energy And 5G Wireless Mobile.

Effect of Peak Temperature on Sac Nano-Reinforced Fillet Height

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Abstract:
This paper aims to analyse the effect of peak temperature towards the fillet height of ultra-fine Sn-Ag-Cu (SAC) solder joints doped with TiO_2 nanoparticles in an electronic assembly. For the purpose of this research, the weight percentage of the nanoparticles TiO2 with the SAC305 lead-free reinforced solder is varied at different peak temperature and investigated in terms of particles distribution, fillet height and thermal strain. This paper presents a 3D numerical simulation of nano-reinforced lead (Pb)-free solder at the ultra-fine joint component for 01005 capacitor with dimension of 0.2 x 0.2 x 0.4 mm^3. Furthermore, this paper also presents a preliminary study of the interaction between two models of numerical simulation namely volume of fluid (VOF) and discrete phase model (DPM). The results obtained are confirmed by conducting an experiment using a field emission scanning electron microscope (SEM) joined with an EDS and X-ray diffraction machine, and a high-resolution transmission electron microscope system equipped with an energy dispersive X-ray spectrometer (EDS).

Keywords:
Nano-Reinforced Solder, Fillet Height, Nanoparticles Distribution, Discrete Phase Model, Nanocomposite Solder Paste.

Computation of Nonlinear Thermoelectric Effects with Adaptive Methods

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Abstract:
An implementation for a fully automatic adaptive finite element method (AFEM) for computation of nonlinear thermoelectric problems in three dimensions is presented. Adaptivity of the nonlinear solvers is based on the well-established hp-adaptivity where the mesh refinement and the polynomial order of elements are methodically controlled to reduce the discretization errors of the coupled field variables temperature and electric potential. A single mesh is used for both fields and the nonlinear Thomson effect is accounted in the computation of a posteriori error estimate where the residuals are computed element-wise. Mesh refinements are implemented for tetrahedral mesh such that conformity of elements with neighbouring elements is preserved. Multiple nonlinear solution steps are assessed including variations of the fixed-point method with Anderson acceleration algorithms. The Barzilai-Borwein algorithm to optimize the nonlinear solution steps are also assessed. Promising results have been observed where all the nonlinear methods show the same accuracy with the tendency of approaching convergence with more elements refining. Anderson acceleration is the most efficient among the nonlinear solvers studied where its total computing time is less than half of the more conventional fixed-point iteration.

Keywords:
Thomson Effect, Thermoelectricity, Adaptive Nonlinear Solvers

Present Initiatives, Challenges and Future Strategics for Practising Sustainable Energy in Asean Countries: A Case Study in Japan and Singapore Countries.

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Abstract:
Sustainable energy is the practices using energy in a systematic way which meets the present and also sustaining the needs of future generations. Our world is getting worse due to irresponsible humans activities and destroying the quality of environment and our sources of energy are going to be limit time to time. Same thing happened to Asian Countries such as Japan and Singapore. In this paper, will be highlighted the present strategics of both countries to supports the sustainable energy and challenges facing by them. A the end, apart form it, the writer will analyses the suggest few strategics to practicing the sustainable energy more efficiently especially in Asian Countries. This paper will using the literature reviews from various secondary sources. The findings clearly shows that, both countries have a initiatives to supports the sustainable energy by amendment the acts, made transformation in industry and many more but they also facing some challenges. Anyway, at the end suggestions strategics are hoping that will help the countries to practicing the sustainable energy with excellency level for benefits world and humans.

Keywords:
Present, Initiatives, Challenges, Future, Strategics, Sustainable, Energy, Asean, Countries

Empirical Viscosity Modeling for SiO_2 And Al_2O_3 Nanofluids using the Response Surface Method

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Abstract:
The ability of nanofluids, an engineered fluid, to effectively remove heat has been proven to exceed that of a conventional fluid. However, dynamic viscosity may put a limitation on this ability. This paper presents the results of the experimental measurement of the dynamic viscosity for two water-based nanofluids and the development of empirical viscosity models using the response surface method (RSM). The two nanofluids are silicon dioxide (SiO_2)-water and aluminum oxide (Al_2O_3)-water at concentration of 0.01, 0.055 and 0.1 vol.%. Experiments were designed and analyzed according to the face-centered central composite design (CCD) in the RSM. ANOVA was used to evaluate the significance of the independent factors; which are the nanoparticle concentration and temperature. Empirical models to predict the dynamic viscosity of both nanofluids at a specific temperature and volume concentration were developed and validated. Excellent fits of the models were demonstrated by their high coefficient of determination, R2. Results indicate that dynamic viscosity increases with nanoparticle concentration and decreases with temperature. It is also observed that the addition of less or equal than 0.1 vol.% of SiO_2 in water would not significantly change the viscosity.

Keywords:
Empirical, Viscosity, Modeling, SiO_2, Al_2O_3.

Development of Environmentally-Friendly and Energy Efficient Refrigerant for Medium Temperature Refrigeration Systems

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Abstract:
In this research will present the development of environmentally-friendly and energy efficient refrigerant for medium temperature refrigeration systems that new azeotropic refrigerant mixture of hydrofluorocarbons and hydrocarbon that can retrofit in the refrigeration system using R404A. The medium back pressure refrigeration testing standard that follow CAN/ANSI/AHRI540 standard air-conditioning, heating, and refrigeration institute (AHRI) and The properties of refrigerants and refrigeration simulation system that used REFPROP and CYCLE_D-HX software from national institute of standards and technology. The result of decision tree function in datamining of rapid minor software that first of KDnuggets annual software poll that showed new azeotropic refrigerant mixture had cooling capacity, refrigerant effect, GWP and boiling point were lower than R404A but work and pressure for medium temperature refrigeration system of azeotropic refrigerant mixture were higher than R404A that summarize the artificial intelligence (AI) by data mining technic can predictive environmentally-friendly and energy efficient refrigerant for medium temperature refrigeration.

Keywords:
Refrigerant, Refrigeration System, Energy Efficiency, Environmentally Friendly, Data Mining

Tar Removal from Gasification/Pyrolysis by Emulsion Liquid Membrane: A Short Overview

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Abstract:
Tar is among undesirable by-products of producer gas generated from gasification/pyrolysis of biomass. Due to the erosive and corrosive characteristics of tar, a number of tar removal studies have been done. However, considering tar availability in very low concentration, a highly selective and energy economics method is of important. Emulsion liquid membrane is a choice of selective and economics method. Some studies on tar removal using emulsion liquid membrane were reported. Information about definition and transport mechanism of emulsion liquid membrane was given. Effects of emulsion formulation on tar removal were described. Effects of some operating conditions in permeation process on tar removal were also presented. Application of Taylor-Couette column for further tar removal study is proposed.

Keywords:
Emulsion Liquid Membrane, Tar Removal, Taylor-Couette Column

Methodology for Modified Whale Optimization Algorithm for Solving Appliances Scheduling Problem

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Abstract:
Whale Optimization Algorithm (WOA) is considered as one of the newest metaheuristic algorithms to be used for solving a type of NP-hard problems. WOA is known of having slow convergence and at the same time, the computation of the algorithm will also be increased exponentially with multiple objectives and huge request from n users. The current constraints surely limit for solving and optimising the quality of Demand Side Management (DSM) case, such as the energy consumption of indoor comfort index parameters which consist of thermal comfort, air quality, humidity and vision comfort. To address these issues, this proposed work will firstly justify and validate the constraints related to the appliances scheduling problem, and later proposes a new model of the Cluster based Multi-Objective WOA with multiple restart strategy. In order to achieve the objectives, different initialization strategy and cluster-based approaches will be used for tuning the main parameter of WOA under different MapReduce application which helps to control exploration and exploitation, and the proposed model will be tested on a set of well-known test functions and finally, will be applied on a real case project i.e. appliances scheduling problem. It is anticipating that the approach can expedite the convergence of meta-heuristic technique with quality solution.

Keywords:
Scheduling Problem, Swarm Intelligence, Whale Optimization Algorithm

Enhancing Optimization Solution for Facility Layout Problem with Thermal Comfort

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Abstract:
Facility Layout Problem (FLP) can be considered as a classical problem in quantitative studies. However, the literature in FLP are largely neglected the thermal comfort as part of the objective function. In recent years, there are an increasing concerns in energy savings for buildings since they are responsible for a large proportion of energy use. A public room in buildings could hold a number of persons who may prefer dissimilar thermal environment. Furthermore, different areas in such rooms may have different temperatures. Also, facility layout in such a room has effect on the distribution of the people in the room. Thus, it may affect its thermal environment and energy consumption as well. It is meaningful and challenging to effectively operate an air-conditioning control (ACC) system by taking the above mentioned factors into account such that the thermal environment is improved and energy is saved. With the lack of research reports on this issue, this work aims at optimally and dynamically controlling the set-point temperature of an ACC system and designing the facility layout so as to maximize the total thermal satisfaction rate (TSR) as well as energy savings in our formulation. To do so, a non-linear mathematical programming model is proposed to optimize TSR by determining the set-point of an ACC system and the room layout. At the end of the article, we proposed Evolutionary Algorithm (EA) to find a quality solution or near optimal since it is hard to solve a non-linear mathematical programming problem in a reasonable time.

Keywords:
Facility Layout Problem, Thermal Comfort, Meta-Heuristic Algorithm

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