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9TH INTERNATIONAL CONFERENCE ON ADVANCES IN ENERGY RESEARCH

12TH TO 14TH DECEMBER 2023

ABSTRACT BOOKLET

ICAER 2023
IIT Bombay

Department of Energy Science and Engineering,
Indian Institute of Technology Bombay
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Preface

The Department of Energy Science and Engineering at the Indian Institute of Technology Bombay is one of the first dedicated departments in India to focus on energy science, engineering technology, and policy. The department is expected to provide critical manpower and research outputs that are crucial for the growth of India's energy sector and provide innovative technologies and systems to mitigate the global challenge of climate change. Keeping the vision of the department, "To develop sustainable energy systems and solutions for the future" in mind, the need to provide a common platform to the researchers in the field of Energy and allied domains, the Department organises the bi-annual conference: International Conference on Advances in Energy Research, since 2007, to provide an excellent forum to present new findings, exchange novel ideas, discuss new developments, and finally reflect on the challenges that lie ahead.

This book is a collection of all the abstracts of the papers selected for presentation at the 9th International Conference on Advances in Energy Research, organised from 12th to 14th December 2023 by the Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai. A total of 220 papers were received. After an academic review by subject experts, 153 papers were selected for presentation at the conference. Out of the selected papers, 93 papers have been scheduled for oral presentation and 60 papers have been scheduled for poster presentation. The conference is organised in 20 oral and 2 poster sessions in the fields of photovoltaics, solar thermal, wind energy, biomass and combustion, energy storage, energy efficiency and modelling, energy policy, fuel cells, and buildings, to name a few. The conference will also have 10 invited talks, a panel discussion and a workshop on technical writing by Springer. Selected papers will be considered for publication in Advances in Clean Energy and Sustainability (Green Energy and Technology), Springer Nature.

We would like to take this opportunity to thank all the invited speakers, delegates, sponsors, the members of the organising and academic committee and most importantly the students of the department for their dedicated efforts in organising this conference.

Prof. Sankara Sarma V Tatiparti
Organizing Secretary, ICAER 2023

Prof. Srinivas Seethamraju
Organizing Secretary, ICAER 2023

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Conference Schedule

Track 1	Solar Photovoltaics
Track 2	Oil and Gas, Coal, Conventional Energy, IC Engines, Biofuels
Track 3	Energy Systems - Policy, Economics, Optimization, Modelling
Track 4	Renewable Energy Technologies (Solar Thermal, Wind, Nuclear etc.)
Track 5	Energy Storage and Conversion
Track 6	Power Electronics, Systems and Microgrids

Day 1 (12-Dec-2023)

07:30-09:00	Breakfast and Registration (Location: Cafeteria Area, VMCC)				
09:00-09:45	**Inauguration** Location: Prof. B Nag Auditorium, VMCC				
09:50-10:50 **Plenary Talk**	Speaker: Dr. Pankaj Kumar Location: Prof. B Nag Auditorium, VMCC (Chair: Prof. Anish Modi)				
10:50 -11:15 (**Tea/Coffee Break**), Location: 1st floor Foyer, VMCC					
11:15-12:00 **Keynote Talk**	Speaker: Mr. Giridharan Shanmugavel Location: Prof. B Nag Auditorium, VMCC (Chair: Prof. Suryanarayana Doolla)				
12:00-13:15 **Oral Presentation**	**Track 1 Room: 02**	**Track 2 Room: 12**	**Track 3 Room: 13**	**Track 4 Room: 14**	**Track 5 Room: 15**
Paper No	018, 099, 102, 203	026, 043, 066, 166	016, 020, 048, 212, 218	013, 015, 169, 189, 193	009, 019, 040, 047, 055
13:15-14:15 (**Lunch Break**), Location: Cafeteria Area, VMCC					
14:15-15:15 **Plenary Talk**	Speaker: Prof. P Muthukumar Location: Prof. B Nag Auditorium, VMCC (Chair: Prof. Pratibha Sharma)				
15:15-16:00 **Keynote Talk**	Speaker: Prof. S N Pandey Location: Prof. B Nag Auditorium, VMCC (Chair: Prof. Sagar Mitra)				
16:00 -16:30 (**Tea/Coffee Break**), Location: 1st floor Foyer, VMCC					
16:30-17:45 **Oral Presentation**	**Track 2 Room: 12**	**Track 4 Room: 14**	**Track 5 & 6 Room: 15**		
Paper No	014, 025, 093, 137, 168	022, 090, 122, 156	017, 027, 030, 103, 105		
17:45-18:45 **Poster Presentation**	**Track 1** (128, 157), **Track 2** (178, 182, 202), **Track 3** (032, 034, 035, 037, 041, 056, 068, 126,167) (Interaction over Tea, Location: 1st floor Foyer, VMCC)				

Day 2 (13-Dec-2023)				
08:00-09:30	Breakfast and Registration (Location: Cafeteria Area, VMCC)			
09:30-10:30 **Plenary Talk**	Speaker: Prof. Gour Gopal Roy Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Manaswita Bose)			
10:30-11:15 **Keynote Talk**	Speaker: Prof. Manoj Kumar Soni Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Lalit Kumar)			
11:15 -11:45 (**Tea/Coffee Break**), Location: 1st floor Foyer, VMCC				
11:45-13:00 **Oral Presentation**	**Track 3 Room: 13**		**Track 5 Room: 15**	
Paper No	024, 036, 051, 180, 205, 094		050, 058, 062, 165, 219, 028	
13:00-14:00 (**Lunch Break**), Location: Cafeteria Area, VMCC				
14:00-15:00 **Plenary Talk**	Speaker: Mr. Jiten Prajapati Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Gurubalan Annadurai)			
15:00-16:00 **Workshop**	Springer Workshop on Scientific Writing by Dr. Swati Meherishi Location: Prof. B. Nag Auditorium, VMCC			
16:00 -16:30 (**Tea/Coffee Break**), Location: 1st floor Foyer, VMCC				
16:30-17:45 **Oral Presentation**	**Track 2 Room: 12**	**Track 3 Room: 13**	**Track 4 Room: 14**	**Workshop: Particle Image Velocimetry (PIV) Room: 02**
Paper No	075, 087, 171, 190, 201	108, 114, 130, 206, 208, 211	045, 127, 214, 215, 217	Speaker: Prof. Manaswita Bose
17:45-18:45 **Poster Presentation**	**Track 4** (038, 053, 059, 060, 152, 154, 162, 176, 191, 195), **Track 5** (091, 153, 175), **Track 6** (111) (Interaction over Tea, Location: 1st floor Foyer, VMCC)			
Gala Dinner 19:30-22:00 at Location: Gulmohar Lawns				

Day 3 (14-Dec-2023)		
08:00-09:30	Breakfast and Registration (Location: Cafeteria Area, VMCC)	
09:30-10:30 **Plenary Talk**	Speaker: Prof. S. K. Samdarshi Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Asish Kumar Sarangi)	
10:30-11:15 **Keynote Talk**	Speaker: Prof. Sudipta De Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Santanu Bandyopadhyay)	
11:15 -11:45 (**Tea/Coffee Break**), Location: 1st floor Foyer, VMCC		
11:45-13:00 **Oral Presentation**	**Track 4** **Room: 14**	**Track 4 & 5** **Room: 15**
Paper No	098, 109, 121, 196	100, 104, 113, 116
13:00-14:00 (**Lunch Break**), Location: Cafeteria Area, VMCC		
14:00-15:00 **Plenary Talk**	Speaker: Prof. Raman Singh Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Venkatasailanathan Ramadesigan)	
15:00-15:30 **Vendor Talks**	Vendor Talk 1 Location: Room 21, VMCC (Chair: Prof. Karthik Sasihithlu)	Vendor Talk 2 Location: Room 22, VMCC (Chair: Prof. Gurubalan Annadurai)
15:30 -16:00 (**Tea/Coffee Break**), Location: 1st floor Foyer, VMCC		
16:00-17:30 **Panel Discussion**	Panel Discussion on "Energy Transition Planning and Sustainability" Location: Prof. B. Nag Auditorium, VMCC (Chair: Prof. Shireesh B Kedare)	
17:30-18:00 **Closing session**	Awards and closing ceremony Location: Prof. B. Nag Auditorium, VMCC	

Invited Talks

	Time	Invited Speaker	Title
1	09:50-10:50 **Plenary Talk**	Dr. Pankaj Kumar	Using concentrating solar thermal technology for industrial applications to reduce the dependence on fossil fuels
	11:15-12:00 **Keynote Talk**	Mr. Giridharan Shanmugavel	Drivers and Challenges in High-Performance Power Conversion Systems - An Overview
	14:15-15:15 **Plenary Talk**	Prof. P. Muthukumar	Design, development and testing of metal hydride-based devices for hydrogen storage, purification and compression applications
	15:15-16:00 **Keynote Talk**	Prof. S.N. Pandey	Advanced energy storage materials for supercapacitor application
2	09:30-10:30 **Plenary Talk**	Prof. Gour Gopal Roy	Exergy analysis of RHF-EAF process towards sustainable steelmaking
	10:30-11:15 **Keynote Talk**	Prof. Manoj Kumar Soni	Handling of alternative fuels and their mix in Indian cement plants – issues, challenges, and solutions
	14:00-15:00 **Plenary Talk**	Mr. Jiten Prajapati	Climate responsive design and case studies
3	09:30-10:30 **Plenary Talk**	Prof. S. K. Samdarshi	Solar Cookers – Scope of innovation through a holistic performance parameter
	10:30-11:15 **Keynote Talk**	Prof. Sudipta De	Distributed hybrid renewable energy systems for rural India: Exploring optimized sustainable solutions
	14:00-15:00 **Plenary Talk**	Prof. Raman Singh	Graphene-coated Ni-Cu alloys for durable degradation resistance of bi-polar plates for Proton Exchange Membrane Fuel Cells

Oral Presentation, Day 1, Time: 12:00-13:15

Room	Track	Paper Id	Paper Title
2	1	18	Synthesis, characterization and solar cell properties of Polyaniline nanocomposites
		99	Performance of Bifacial Lead-free All-Perovskite Tandem Solar Cell for Indoor Applications
		203	Electronic and optical features of halide perovskite CsGeBr3 using modified Becke Johnson potential within DFT
		102	Net zero energy assessment of multistoried residential buildings integrated with onsite solar rooftop PV System: A case study
12	2	26	Characterizations of Cyclic Combustion Variations in RCCI Engine using Multifractal Detrended Fluctuations Analysis
		43	A Comparative Study of the Performance and Emissions of SI Engine Fuelled with Isopropyl Acetate, n-butyl Acetate, and Premium-gasoline
		66	CO2 hydrate formation kinetics in the presence of TBAB
		166	Experimental Investigation of Biogas and Karanja Biodiesel Blend On the Effect of Performance and Emissions of Dual Fuel C.I Engine
		010	Evaluation of building energy efficiency measures using statistical simulation
13	3	16	Economic viability analysis of rooftop solar and vertically mounted BAPV on a multi-storied commercial building in Kolkata
		48	Comparative analysis of two different storage modules for techno-economically optimum and environmentally benign decentralized hybrid energy systems for EV charging stations: A case study of Kolkata
		20	Multi-objective optimization of envelope retrofits for improved energy performance in an educational building
		212	Adsorption of Light Oil on Rock Surfaces: A Molecular Dynamics Study
		218	Economic and emissions analysis of behind-the-meter energy storage with rooftop solar: A case study for Indian residential consumers
14	4	13	Numerical analysis to optimize the corrugation angle of pentagonal corrugated absorber plate of solar air collector in an indirect solar dryer for enhanced heat transfer characteristics
		15	Wind Power Potential Assessment using Reanalysis Data - Case study of Indian Offshore Site
		169	Natural Water Cooler: An Innovative, Energy-Efficient and Low-Cost Solution for Cooling Water
		189	Assessing the impact of integrating triangular grooves on the performance of a double pass solar air heater
		193	Effect of Inner Arc Extension on the Performance of Vertical Axis Wind Turbine
15	5	9	Transient thermal behaviour of sensible energy storage system
		19	Enhanced electrochemical performance of polyaniline/chitosan/titanium carbide nanocomposite
		40	Combustion, Performance, and vibrations of dual fuel engine modified with hydrogen reactor
		47	Microwave Assisted Mechanochemical Synthesis of Na0.67CoO2 as Potential Cathode Material Application in Sodium-Ion Batteries
		55	Characterization of heat generation and its impact with cell ageing in a lithium-ion cell using coupled electrochemical-thermal model

Oral Presentation, Day 1, Time: 16:30-17:45

Room	Track	Paper Id	Paper Title
12	2	025	Assessment of Lung Loading of Nanoparticle Emissions from Diesel and Methanol Diesel-RCCI Engine
		093	Experimental studies on the gasification potential of saw-dust and high-ash Indian coal blends in a fluidized bed gasifier
		137	Gas hydrate-based post-combustion carbon dioxide capture and separation from flue gas
		168	Effect of the sediment sizes on the CO2 hydrate formation: Applicable to Carbon Capture and Sequestration
14	4	022	Comparative analysis of Sunshine Models for Estimation of Monthly global Solar Radiation at Bhopal, India
		090	Concept of Solar Thermal Energy Utilization in Cement Plants
		122	Evaluation of Optimal Weibull Parameter for Wind Resource Assessment at Coastal Terrain by Metaheuristic Optimization Algorithms using Reanalysis Data
		156	Experimental investigation of effect of a transverse crack on Wind Turbine Blade using vibration-based method for the development of SHM
		067	The Impact of Training Algorithms and Transfer Functions on the Accuracy of Neural Network-Based Temperature Prediction of 3S4P Battery Module
15	5 & 6	017	Batteries by Algorithm: Unleashing the Potential of Machine Learning in RUL Prediction
		027	Exergy analysis of single-stage metal hydride hydrogen compressor
		030	Computational workflow for investigating hydrogen permeation in novel hydrogen storage materials
		103	Energy Efficient Field Emission Characteristics of Graphene Wrapped Zinc Oxide Rods
		105	Molybdenum Disulfide Flake Functionalized Defect rich Carbon Nanotubes as Effective Cold Emitter: A Possible Low Energy Solution for Efficient Electron Gun

Oral Presentation, Day 2, Time: 11:45-13:15

Room	Track	Paper Id	Paper Title
13	3	024	An Empirical Study on Factors Influencing Energy Efficiency in Metal Industry Cluster
		036	Multi-objective optimization approach for envelope design in naturally ventilated building of Jaipur city: A case study of residential building
		051	Designing and Application of MATLAB App Designer for conducting Techno-Economic Analysis of Grid-Tied Rooftop Solar PV System
		180	Application of EV Trucks: An Emerging future in Indian Cement Industry
		205	Tariff Structures for Residential Electricity Consumption in India: An Analysis of Disparities and Effect on Consumption
		094	Environmentally Extended MRIO-SDA Analysis on India's CO2 Emissions during 2005-2014
15	5	050	An Approach to Improve the Computational Accuracy of Power Factor in Thermoelectric Energy Conversion
		058	A comparison of battery thermal management systems for Li-ion batteries in electric vehicles
		062	Phosphonated Poly (2,5 enzimidazole) /zirconium phosphate nanocomposite membranes for vanadium redox flow battery application
		165	Investigation of cooling performance of hybrid battery thermal management system using nanoparticle-enhanced composite PCM and nanofluid-charged pulsating heat pipe for electric vehicles
		219	Tuning the Solvothermal Method for the Synthesis of Nanostructured Free-standing Supercapacitor Electrodes
		028	Effect of Transverse Fin configuration on the Performance of Adsorption Cooling System

Oral Presentation, Day 2, Time: 16:30-17:45

Room	Track	Paper Id	Paper Title
12	2	075	Degradation Assessment through Prediction Approaches for Solar PV system in South India
		087	Carbon dioxide storage using gas hydrates and kinetics modelling in a large-scale reactor
		171	Evaluating HHV Prediction Equations Using Proximate and Ultimate Analyses
		190	Compressed Biogas with Biodiesel as Pilot Fuel Performance on Novel Variable Compression Ratio Mechanism Assisted DI Diesel Engine
		201	Optimization of biodiesel synthesis parameters of waste cooking oil through Response Surface Methodology
13	3	108	Global estimates of energy efficiency savings in electricity supply
		114	An Effective Model for Performance Prediction of a Centrifugal Pump with Nose Caps Using CNN
		130	Structural analysis and optimization of a shell and tube condenser employed in the Low-temperature thermal desalination (LTTD) process
		206	Analyzing Trends in Appliance Ownership and the Residential Electricity Consumption in Rural India: A Case Study of Maharashtra State
		208	Systemic Approach for Sustainability Assessment of Mini-grids: A Review and Some Causalities
		211	Implications of Time of Day Tariff Policy on Residential Consumers with Grid-connected Rooftop Solar PV Systems in Ahmedabad, India
14	4	045	Experimental evaluation of a falling film liquid desiccant cooling system with solar assistance
		127	Assessment of extent of crystallization of CuCl2 (from quaternary system of CuCl, CuCl2, HCl, water) and its limiting conditions in crystallization step of thermochemical Cu-Cl cycle
		214	Comparative analysis on performance of solar air heater by using nanomaterial-black paint coating on absorber plate
		215	Standalone on-wheel Solar Milk Pasteurization
		217	An Experimental Investigation to Determine the Optimal Nanomaterial for Coating a Solar Thermal Absorber Panel

Oral Presentation, Day 3, Time: 11:45-13:00

Room	Track	Paper Id	Paper Title
14	4	098	Representative Days for the Calculation of Annual Optical Efficiency of Solar Power Tower Systems
		109	Thermohydraulic Performance Due Turbulators of Multiple Hemi-Circular Geometries in Solar Thermal Collector
		121	Optimal Model Parameter Estimation of PEM Fuel cell using Mountaineering Team Based Optimization
		196	Experimental Investigation of Active-Passive Solar Drying Process
15	5 & 6	100	Performance evaluation of parabolic trough collector with internal longitudinal hybrid-fins receiver tube
		104	Effect of PCM embedding on indoor temperature through building wall
		113	Effect of Ionic Salt in Synthesized Biopolymer for Electrochemical Applications
		116	Fabrication and thermal characterization of carbon-based composite phase change material for latent heat thermal energy storage applications

Invited Talks

Prof. Raman Singh
Professor
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Brief Biography

Professor Raman Singh's primary research interests are on relationships between nano/micro-structure and environment-assisted degradation and fracture of metallic and composite materials, and nanotechnology for advanced mitigation of such degradations. He has worked extensively on the use of advanced materials (e.g., graphene) for corrosion mitigation, stress corrosion cracking, and corrosion. His work includes corrosion-mitigation of magnesium alloys (including the use of magnesium alloys for aerospace, defence and bioimplant applications).

Prof Singh is a senior professor at Monash University, Australia. He is a guest professor at ETH Zurich, Switzerland (2020, 2023, 2024), the US Naval Research Lab, the Indian Institute of Science, and the University of Connecticut. He worked as a scientist at Indian Atomic Energy and as a post-doc fellow at the University of New South Wales, Australia.

Prof Singh's professional distinctions and recognitions include Guest Professor of ETH Zurich, Editor of a book on 'Cracking of Welds' (CRC Press), Lead Editor of a book on 'Non-destructive Evaluation of Corrosion' (Wiley), Editor-in-Chief of an Elsevier and two MDPI journals, leader/chairperson of a few international conferences and numerous plenary/keynote lectures at international conferences. He has more than 270 peer-reviewed international journal publications, 15 book chapters, and several competitive research grants (that includes four discoveries, seven linkages, and one Industrial Transformation Research Hubs (ITRH) grants of Australian Research Council).

Prof Singh has supervised 58 PhD students. His vibrant research group at Monash University comprises of PhD students from different disciplines (Mechanical, Chemical, Materials and Mining Engineering, and Science) as well as from different cultural backgrounds (Australian, Middle-Eastern, Chinese, Malaysian, Indian, African, North American and Israeli).

Title

Graphene-coated Ni-Cu alloys for durable degradation resistance of bi-polar plates for Proton Exchange Membrane Fuel Cells

Abstract

Bipolar plates, a critical component of Proton Exchange Membrane Fuel Cells (PEMFC), are constructed out of alloys of Ti, Pt, Cr, or graphitic materials that have limitations. Electrical conductivity, cost, and corrosion resistance are among the critical considerations for bi-polar plate material. Graphene possesses impressive conductivity and toughness, making it an attractive option as a coating on metallic substrates of PEMFC bipolar plates. The corrosion resistance and durability of vapour-deposited graphene on pure Ni-Cu alloy and a commercial Ni-Cu alloy in a 0.5 M H_2SO_4 environment are investigated for exploring its use in the

construction of PEMFC bipolar plates. The graphene coating on the pure alloy showed remarkably superior corrosion resistance than the commercial alloy which is attributed to the former's ability to develop considerably defect-free graphene.

Graphene has triggered unprecedented research excitement for its exceptional characteristics. The most relevant properties of graphene as a corrosion resistance barrier are its remarkable chemical inertness, impermeability, and toughness. These properties fulfil the requirements of an ideal surface barrier coating for corrosion resistance, making graphene coating a disruptive approach to corrosion mitigation. However, the extent of corrosion resistance due to chemical vapour deposition (CVD) graphene coatings has been found to vary considerably in different studies. The author's group demonstrated the ultra-thin graphene coatings developed on copper and nickel by CVD to improve the corrosion resistance of the metals by two orders of magnitude in aggressive aqueous chloride environments. In contrast, other reports suggest the graphene coating enhances the corrosion rate of copper, particularly during extended exposures. The author's group has investigated the reasons for such contrast in corrosion resistance due to graphene coating as reported by different researchers. Based on the findings, they have succeeded in developing multilayer graphene coatings that conferred durable corrosion resistance to copper and nickel in the aggressive chloride environment. However, developing graphene coating on the most common engineering alloy, mild steel by CVD is a non-trivial challenge. The presentation will discuss the challenges and their successful circumvention that enabled graphene coatings on mild steel, and present results demonstrating the durable and remarkable corrosion resistance of graphene-coated mild steel.

Prof. Gour G Roy
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Brief Biography

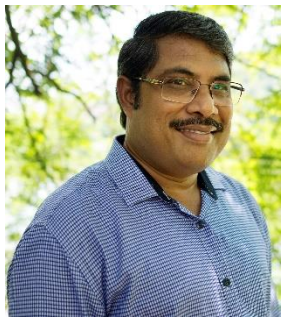
Dr. Gour Gopal Roy presently holds the position of Professor at the Department of Metallurgical and Materials Engineering (MME), IIT Kharagpur. He served as Head of Department, MME between 2014-2017 and as Associate Dean, SRIC IIT Kharagpur between 2017-2020. His specialisations are in alternative routes of ironmaking, clean steel, electron beam welding, and modelling and simulation. He was conferred the 'Eminent Engineering Personality' by the Institute of Engineers (India), Kolkata on 21st January 2023 during the 35th National Convention of the Institution of Engineers (India) at NIT Durgapur. He was awarded 'Metallurgist of the Year 2015' instituted by the Ministry of Steel, Government of India. He is on the editorial board of Science and Technology of Welding and Joining, and Transactions of the Indian Institute of Metals. He has 110 publications in referred journals with total citations of 3708, an H-index of 28, and an i10 index of 60.

Title

Exergy analysis of RHF-EAF process towards sustainable steelmaking

Abstract

Exergy analysis is one of the tools to characterize a sustainable steelmaking process with minimal resource usage and environmental impact. Today, 70 % of the total 2 billion tons of steel produced in the world is contributed by the Blast Furnace (BF)-Basic Oxygen Furnace (BOF) steelmaking route, which emits an average of 2.0 tons CO_2/tons of crude steel (tcs) much exceeding the permissible limit of 0.6 t CO_2/tcs to follow the suggested carbon trajectory for 2DS pathway. The BF is productive and efficient but is a major capital and carbon-intensive asset in the integrated steel plant, leading to high emission rates. Since replacing it in a coal-intensive economy is difficult, the steel industry must adopt a progressive amalgamation approach with alternative and renewable energy-based processes that can reduce the emission intensities. A Rotary Hearth Furnace (RHF) based process, that converts iron-bearing solid waste to value-added sponge iron or iron nugget using dual fuel involving low carbon natural gas for heating and stoichiometric coal for reduction, is a potentially sustainable alternative for solid metallic generation, which could be melted in Electric Arc Furnace (EAF). Exergy analysis and CO_2 emission of the RHF-EAF process are studied using mathematical models and compared with the BF-BOF process. The results indicated that the exergy efficiency and carbon footprint of the RHF-EAF process were comparable to the BF-BOF process and even superior with process flow modification in RHF-EAF, like using more scrap and hot transfer of sponge to EAF. Suggested process flow modifications in RHF-EAF may lead to a decrease in specific CO_2 emission, accompanied by an increase in exergy efficiency, meeting both the requirement for sustainable development, i.e., minimising environmental impact and resource utilization.



Prof. Muthukumar Palanisamy
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Brief Biography

Prof. P. Muthukumar received his PhD degree in Mechanical Engineering from IIT Madras in 2005. He joined IIT Guwahati as an Assistant Professor in January 2006 and became Professor in January 2015. He moved to IIT Tirupati as a Professor in Mechanical Engineering in May 2022. He received 'Deutscher Akademischer Austauschdienst (DAAD)' German Academic Exchange Service research fellowships during September - December 2000, June - July 2008, and June - July 2010. He is the recipient of the 'IEI Young Engineer Award - 2010' in Mechanical Engineering from the Institute of Engineers (India). He received the 'Bhaskara Advanced Solar Energy Fellowship (BASE Fellowship)' from Indo - U.S. Science and Technology Forum (USIEF), in January 2014 and 'Er. M P Baya National Award 2015' instituted by the Institution of Engineers (India). He is a fellow of the Institute of Engineers (India). He is one of the commission members to represent India in the International Institute of Refrigeration (IIR). He received a 'Fulbright-Nehru' Academic and Professional Excellence Fellowship from USIEF in 2018. He was awarded the 'Mechanical Engineering Design Award 2017', from the National Design and Research Forum (NDRF) of The Institution of Engineers (India), on 21st Dec 2017. He was honoured as an 'Eminent Engineer - 2019' by The Institution of Engineers (INDIA), Assam State Centre. In 2020 and 2022, he appeared in the World's Top 2 % Scientist published by Stanford University, USA report. He has won the BIRAC - Innovation Challenge Award-SoCH 2020-21 for stage 1 and stage 2. He was conferred with an award of 'Outstanding Engineering Service' to the country by the Institution of Engineers (India), Rajasthan State Centre on 15th September 2021 to recognise his outstanding contributions to the development of Porous Radiant Burners and his contribution to the growth of the country's engineering profession. He was awarded the prestigious 'Abdul Kalam Technology Innovation National Award 2021'. He has been serving as a visiting Professor in many universities in the USA and Germany and also has research collaborations with over 25 international universities.

He has published around 400 research articles in various international journals and conference proceedings, edited four books, and written 16 book chapters. He has 13 national patents for his credit. He has supervised 30 PhD, 65 MTech and 8 MS student's theses. He has completed 14 sponsored research projects and is currently handling 10 research projects worth 1,500 lakhs. He has been serving as an expert member in several ministries including DST, MHRD, Ministry of Oil and Natural Gas, Ministry of External Affairs, etc. for research project funding and monitoring. He is also an expert/steering committee member in BIS, AICTE, NAAC and many other professor organizations.

Title

Design, development and testing of metal hydride-based devices for hydrogen storage, purification and compression applications

Abstract

Storage of hydrogen in the form of solid-solution using metal hydrides has been recognized as one of the safe methods of storing hydrogen for onboard as well as stationary applications. In addition to hydrogen storage, metal hydride-based systems can also be effectively used for hydrogen compressors, hydrogen purification, cooling and heating, and thermal upgradation applications. Prof Muthukumar's research team at IIT Tirupati has successfully designed and developed several metal hydride-based hydrogen storage systems of various capacities for onboard and stationary applications. Further, a pre-industrial scale metal hydride-based hydrogen purification system of capacity 12,000 litres was also fabricated and successfully demonstrated at the National Thermal Power Corporation (NTPC) power station. Recently, his team also developed large-scale metal hydride-based hydrogen storage system cum compressor and transferred the technology to NTPC. These systems can purify hydrogen from 20 % to 99.999 % just by utilizing thermal inputs in the range of 25 to 95 °C. Further, Metal Hydride Hydrogen Storage System (MHHSS) also produce a substantial cooling effect, while discharging hydrogen from the system due to endothermic reaction. In this presentation, with a brief introduction about the importance of hydrogen energy, some of the important research and developmental activities on the various metal hydride-based engineering applications will be discussed.

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Brief Biography

Dr S K Samdarshi is a Professor and Head of the Department of Energy Engineering at Central University of Jharkhand(CUJ) Ranchi. He was the former Head of the Department of Energy (2007-10), Tezpur Central University (NIRF 2022 Rank 59) and Department of Energy Engineering (2014-17, 2017-20) CUJ; and Dean, School of Engineering and Technology (2014-17, 2017-20), CUJ. He is an alumnus of the Indian Institute of Technology Delhi, India. He is the Coordinator and Principal investigator of the prestigious Centre of Excellence in Green and Efficient Energy Technology set up with the support of the Ministry of Human Resources Development (MHRD), New Delhi under its Frontier Areas in Science and Technology (FAST) program. He has been a Visitor's nominee of the Academic Council of Nagaland Central University (NIRF Rank < 200), a member of the Academic Council of Tezpur University (2007-2013), Central University of Jharkhand, and a member of the Court of Central University of Jharkhand from 2023. He was a Leadership of Academicians Programme (LEAP) fellow of MHRD in 2019 at Nanyang Technological University, Singapore. He has been actively associated with Solar Energy research in the country and has made substantial contributions to policy, design, simulation, materials, applications and systems in the diverse area of solar and renewable energy technologies which resulted in important research publications (100 international, 24 national), and books (03 edited). He has guided 12 PhDs and four are working under him. He has executed 07+01 research and 04 developmental projects in different areas of solar energy from MHRD, UGC, AICTE, DST, MNRE, and UGC-DAE CSR. One of his significant contributions is in the area of visible active nanomaterials includes the development of highly active homojunctions/homo-composites of titania, zinc oxide cerium oxide, niobium oxide, tungsten oxide, and carbon nanodots-based nano-systems through doping, sensitisation, nano-structuration, and composition. The development of zinc oxide homojunctions with a metastable phase using transition metal substrate-cum-dopant is one of the major contributions in the synthesis and development of visible active photoactive materials which promises to be future materials for solar photovoltaic energy conversion, solar fuel(hydrogen) production and carbon valorisation. He has also done collaborative international work in the development of bio-mimicked hierarchical morphology of the photoactive systems at the nanoscale. Recently he has developed a comprehensive generalised performance parameter for solar cookers of different designs and their hybrids which is being used by researchers of different continents. He has done some highly cited work on the design, simulation and performance evaluation of solar thermal systems. Some of his work has found a place in standard international textbooks on energy such as Principles of Solar Engineering, Third Edition, CRC Press, Taylor and Francis, 2015 and International Handbook of Energy Security, Edward Elgar Publishing Ltd, UK, 2013. He has several national and international MoUs/collaborations with faculty members/institutions from Portugal, Chile, France and the USA. His current research interests are solar photoactive and new-generation photovoltaic/energy materials, solar thermal systems performance parameters, and

renewable energy policy and management. He has contributed substantially to national and international levels as a member of the board of studies as well as committees on the energy of central universities, NITs and IITs; expert of different committees of All India Council for Technical Education (AICTE), State Electricity Regulatory Commission (SERC); State Service Commission (SSC), Ministry of New and Renewable Energy (MNRE) and international Universities/Institutions; and also as Head of the Dept of Energy, Tezpur Central University, Tezpur Assam, India. A former Governing Council member of the Solar Energy Society of India (SESI), Prof Samdarshi was the organizing secretary of the maiden ICORE 2011 (International Congress on Renewable Energy 2011) organized in North-East India. He has been a member of the Editorial Board of the Solar Energy Society of India Journal. He has visited several prestigious institutions like the National Renewable Energy Laboratory, Golden, Colorado, USA; and Nanyang Technological University, Singapore.

Title

Solar Cookers – Scope of innovation through a holistic performance parameter

Abstract

Solar cooking offers a unique opportunity to conserve conventional energy, reduce carbon footprint by replacing fossil fuel, reduce the drudgery of the rural populace, provide options for alternative use of forest/agro-fuel, empower rural women and thus contribute to gender equity, and substantially reduce the health-hazards common to closed-space conventional cooking practices. Currently, for each type of cooking method a different solar cooker design viz boiling type (solar box cooker), frying and roasting type (concentrating/Scheffler cooker) and indoor cooking (advanced heat transfer cookers) are employed. The requirement of diverse designs and their variants to cater to specific food preferences, cooking ergonomics and cooking power(temperature), storage for round-the-clock cooking, including factors like availability of conventional/clean cooking fuels, portability, and purely economic factors (capital cost), affect people's interest in solar cooking and, consequently, their propagation and acceptability. To promote and propagate solar cooking technology to common people all over the world, there is a need to develop modified, advanced, and hybridised designs of solar cookers which can address these issues and be employed for low as well as intermediate-temperature applications with scaling options. Also, new designs essentially need to be in tune with the requirements of the end users of different economic strata and for locations with diverse meteorological conditions. To have *a priori* quantified information about the design performance of any solar cooker a Holistic Performance Parameter (HPP) and a related test procedure are needed. This should be robust enough to assess the minor improvements, if any, through design/operational interventions/innovations. The thermal performance of solar cookers has been investigated all over the world with different intentions. A large number of them also study the design improvements in terms of one or more including overall thermal performance, optical performance, heat loss, cooking power, cooking time, cooking load and energy storage. Therefore, solar cooking is one of the well-documented research fields.

The scope of innovation in these designs through the existing thermal performance parameters such as figures of merit, cooking power, thermal efficiency, and specific time; and

more inclusive and holistic Cooker Optothermal Ratio (COR) and the related test procedures need to be properly understood before employing them. While most of these are derived from heating-based, COR can also be derived from cooling-based test procedures. The strengths in the evaluation, grading, and testing of existing solar cookers and their future designs and design hybrids too need in-depth analyses. As solar cooking technology advances, there is a clear need for a singular standardised testing approach for performance evaluation and comparison that is simple for consumers to understand and standards which are future-ready for maintaining and improving the quality of manufacturing. These will enable the objective performance evaluation, encourage research and development, enhance consumer confidence, and propagate adoption.

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Brief Biography

Dr. S. N. Pandey is working as a Professor in the Department of Physics, Motilal Nehru National Institute of Technology (MNNIT) Allahabad, Prayagraj, India. He has more than twenty-nine years of both teaching and research experience. He is a recipient of many awards and fellowships including the University Grants Commission (UGC) Research Award, Associateship of The Institute of Mathematical Sciences, SERC Visiting Fellowship, JNCASR Visiting Fellowship. He is the Mentor of the INSPIRE programme and Coordinator of the Madhava Mathematics Competition. He is associated with many academic bodies/ societies as a life member/ member.

The area of research of Prof. Pandey is both experimental and theoretical condensed matter physics.

A. Experimental: Nanostructured thin films, functional oxide nanomaterials, carrier transport in thin films, gas sensors, nanomaterials for energy storage, supercapacitors and device fabrications.

B. Theoretical: Dynamics of nonlinear and damped systems, symmetry and integrability, fractal and multi-fractal analysis, quantum computing: entanglement dynamics.

Prof. Pandey has published more than 60 research papers in reputed international/ national journals like Physical Review Letters, Chemical Physics Letters, Journal of Applied Physics, Journal of Power Sources, Energy, Electrochimica Acta, Journal of Mathematical Physics. He presented his research work in international/ national conferences as Plenary Speaker, Keynote Speaker, Invited Speaker. He is a reviewer and editorial board member of many international/ national journals.

Prof. Pandey has supervised six Ph.D. scholars and two post-docs (N-PDF). Currently, three Ph.D. scholars are working with him. Prof. Pandey has been appointed as Head of the Department of Physics, MNNIT Allahabad for the second time. He is also Chairman of the Senate Master's Programme Committee. Prof. Pandey visited many countries like the USA, Russia, Ukraine, South Africa, Singapore, Finland.

Title

Advanced energy storage materials for supercapacitor application

Abstract

The increase in population and depletion of both fossil fuels and non-renewable resources are going on simultaneously with time. The production of energy is important but the storage of energy is equally important. Energy storage plays a significant role in today's era and will continue to do so in the coming future. Thus, there is a vital need for flourishing in this field for now and near-future applications. It is not always easy to meet the needs of both the

storage of a large number of electric charges in small volumes and the ability to transfer charges quickly by a single energy storage device for modern portable electronic devices. However, these energy storage devices should be user-friendly and have minimal impact on the environment. The supercapacitor is an emerging topic in the field of energy storage systems that can offer higher power density than batteries and higher energy density than traditional capacitors. In other words, one can say, it fills the gap between the batteries and conventional capacitors. The supercapacitor has tremendous advantages, which include high charge/discharge current capability, very high efficiency, wide temperature range, etc. Further, fractal analysis provides a deeper understanding of the morphology of the surface. I shall discuss the supercapacitor behaviour of the oxide/ hydroxide materials. The fractal analysis will also be applied to study the influence of surface characteristics on the performance of the supercapacitor.

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Brief Biography

Giridharan Shanmugavel has 30 years of practising experience in the 'Switched Mode Power Conversion' domain. He holds a Master's degree from the Indian Institute of Science, Bangalore. He has worked at the General Electric company, in X-ray and Solar Power applications, as a Power Electronics Architect and a Technology Programs Leader. Currently, he is the Director for Product Applications at Analog Devices, focusing on Monolithic Integrated Power Products.

Title

Drivers and Challenges in High-Performance Power Conversion Systems - An Overview

Abstract

The presentation identifies applications of Switched Mode Power Converters (SMPC) across the electrical energy supply chain - between generation and consumption, including distribution and storage systems. Unique requirements specifications of high-performance SMPC systems are recognized. The underlying drivers that define the needs of the various application segments are analysed. Top challenges and the state of the art in applied technology solution trends are presented.

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Brief Biography

Prof. Sudipta De, Mechanical Engineering Department of Jadavpur University received his PhD Degree from IIT-Kharagpur. He was a guest researcher at the Lund University, Sweden. He was nominated senior scientist by the Indian National Science Academy (INSA), New Delhi to the Technical University of Munich, Germany under the international bilateral exchange program of the Academy in the field of clean energy. He was the selected faculty under the "India4EU" program and worked at the Royal Institute of Technology (KTH), Stockholm in the field of sustainable energy. He has received his research funding from different institutes including the University Grant Commission, the Department of Science and Technology of India; EU, Swedish Research Council, DFG-Germany; SIU and DIKU-Norway etc. He is an elected fellow of the West Bengal Academy of Science and Technology. He is on the editorial board of the International Springer Nature journal "Clean Technologies and Environmental Policy" (Impact Factor: 4.3). He is an Indian National Science Academy (INSA) Teacher awardee. He was the leader of the Indian Delegation in the 13th Plenary Meeting of ISO/TC 238: Solid Biofuels. He is also awarded 'Shiksha Ratna' by the higher education Department of the Government of West Bengal, India. His research interest is interdisciplinary sustainable energy including Indian energy transition.

Title

Distributed hybrid renewable energy systems for rural India: Exploring optimized sustainable solutions

Abstract

The global energy transition is moving towards low-carbon options. Simultaneously reliability and affordability of energy for all people have to be assured. A renewable share increase in the national energy mix is also desired. However, renewable resources have several limitations regarding availability (uncertainty, intermittency), cost, reliability etc. Adding renewable power to the grid without affecting the grid stability is also a big challenge. Distributed off-grid generation may not affect the central grid and its hybridization with several available resources may increase the reliability of power supply. The Indian energy sector is currently fossil fuel-dominated though it has a definite commitment to a net zero power sector. On the other hand, many Indian villages, specifically remote locations still do not have power, at least reliable power, though they have several unused renewable resources. As a feasible option, new off-grid distributed hybrid renewable energy systems may be explored for sustainable energy solutions for rural India. However, the widely varying demographic and topographic conditions of India cannot have any single sustainable solution for all locations. Overall sustainability may be improved by optimizing several criteria of sustainability including possible uncertainties for these criteria. A series of such optimisation studies using Multi-Criteria Decision Making (MCDM) processes for different remote villages

of India will be presented to show a possible path of sustainable Indian rural energy solutions. Though the objective of these solutions is the same, the obtained solutions are different depending on local resources and constraints.

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Brief Biography

Dr. Manoj Kumar Soni is a Professor in the Mechanical Engineering department and coordinator of the Centre for Renewable Energy and Environment Development (CREED) at Birla Institute of Technology and Science (BITS), Pilani. He is a B.E. (Mechanical), M.E. (Thermal Power Engineering), and Ph.D. in Energy Efficiency. He was a faculty at VNIT Nagpur before joining BITS Pilani in 2002 with more than 27 years of teaching and research experience.

His research interests include solar thermal, thermal engineering, renewable energy, and energy efficiency. He has co-authored three books, viz, Indian and International adaptations of the world-renowned book 'Fundamentals of Thermodynamics' by Claus Borgnakke, and Richard E. Sonntag. He recently published a book on 'Prime Movers and Fluid Machines'. He has published more than 35 research articles in high-impact factor international journals, two book chapters, and more than 25 papers at international conferences. He has filed three patents, two Indian and one USA. He has delivered keynote addresses at various international conferences and workshops. He has also conducted faculty development workshops. He recently was appointed as a member of the Advisory board for the ArcelorMittal Nippon Steel India-Academy for Skill Development.

As a research team member, he visited P.T. Indo Bharat Rayon, Indonesia, an Aditya Birla Group unit, in 2011. In 2015, he was awarded a Summer Scholarship under the university immersion scheme of BITS Pilani. He visited the University of South Florida, Tampa, and Columbia University, New York. He is the recipient of the 'Dr. Shirin Gadhia Sustainability Award 2019' from Eco Center ICNEER, Vadodara. He also received a 'Stifterverband Scholarship' from Institut für Werkzeugmaschinen und Fertigungstechnik, Technische Universität, Braunschweig, Germany, in 2019 for visiting TU Braunschweig for one week of his research work. He was a Jury member for the 9th Manufacturing Today Conference and Awards 2021, organized by Aditya Birla Group, Manufacturing Today, and LOCTITE. Also, a jury member of the 4th, 5^{th,} and 6th VDMA Manufacturing Excellence Award (Energy Efficiency and Conservation - Large Category), organized by Verband Deutscher Maschinen- und Anlagenbau (VDMA) India, which is the India office of The German Engineering Federation (VDMA). He has a particular interest in spirituality and has mixed the philosophies of spirituality and thermodynamics. He has delivered special lectures on 'Thermodynamics- A philosophy of life', and 'A date with entropy' at various institutes. The students, academicians, and industries greatly appreciate his coveted lecture on Spiritual thermodynamics. He delivered his Spiritual Thermodynamics talk at the University of South Florida, Tampa, USA; the University of Balearic Islands, Spain; and Universidade do Algarve, Faro, Portugal. Four of his seven PhD students in the energy and solar thermal field have graduated successfully. He has guided over 50 MTechs, and first-degree thesis. He has experimented with many pedagogical innovations, like team-based and game-based learning and evaluations, in his various courses. At BITS, he is actively involved in the Work Integrated Programs Division for industrial collaborations. He was a coordinator of various collaborative

programs: B.S. and B.Tech Power Engg (Aditya Birla Group, NTPC, NDPL, THDC, ESSAR Power, Tata Power, JSW Energy), B.S. and B.Tech Process Engg (Aditya Birla Group Cement Business UltraTech, Hindalco Industries, Birla Cellulosic, Indogulf Fertilizers, Vedanta Aluminium), B.S. Engg Design (L&TiES, Vadodara), M.S. Engineering Management (Mahindra and Mahindra), M.S. Embedded Systems (L&TiES), M.S. Pharmaceutical Operations and Management (Wockhardt), M.S. Manufacturing Management (Vedanta Aluminium), and M.S. Automotive Engg Programs (Tata Technologies).

He is a Fellow of the Institute of Engineers (FIE) and a Life Member of the International Solar Energy Society (ISES), the Indian Society for Heat and Mass Transfer (ISHMT), and the Energy and Fuels Users Association of India (ENFUSE). He is an associate member of Solar Cookers International, USA, and a Senior Member of the Universal Association of Mechanical and Aeronautical Engineers (UAMAE).

Title

Handling of alternative fuels and their mix in Indian cement plants – issues, challenges, and solutions

Abstract

To reduce its carbon impact and assist India 's goal of becoming carbon neutral by 2070, which was committed at COP26 and COP27, the Indian cement industry has found various levers to achieve it. Alternative Fuels (AFs), i.e., wastes like Municipal Solid Waste/Plastic/Agro/Hazardous Waste, etc., to replace the coal is established as one of the potential levers. However, it comes with many challenges associated with process, system design, safety, operation, logistics, economics, etc. The industry is working hard to address these issues to enhance AFs utilization. Transfer chute jamming emerged as one of the major issues but could not get due importance, and it may stop the complete AF handling system. A wide range of variations in AFs properties like moisture, particle size, particle shape, angle of repose, internal friction angle, bulk density, etc, leads to transfer chute jamming. A survey established that about 78.7 % of Indian cement plants face this issue and try to resolve it by hit and trial at the site. The conventional approach of transfer chute design and ignorance of AFs properties as input during design are the significant causes of jamming. It takes 85 to 90 minutes to clear the chute and restart the AFs feeding system, which creates various process and operational disturbances. Recently, a joint study concluded by BITS Pilani and the National Council for Cement and Building Materials, Ballabgarh, where the design parameters are established for a transfer chute that may handle various types of AFs and their mix without jamming and in case the chute is jammed, it may be cleared in 6 to 7 minutes. Discrete Element Modelling is used as a simulation tool to analyse the issues with conventional transfer chutes and develop the new transfer chute design parameters. Design is validated on an industrial-level experimental setup, where 19 types of wastes were used at the operating capacity of 8 tph to 15 tph for 261 hours. The chute performed excellently in various operating conditions. Chute design parameters are published in research papers and are being implemented by various cement plants in India. A patent is filed for a fast-cleaning mechanism for the transfer chute. This study will ease the path to achieving a high thermal substitution rate by consuming more waste as fuel in cement production.

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Brief Biography

Dr Pankaj Kumar is an energy professional with 22 years of experience in renewable energy, energy efficiency, and climate change programs, with more than 15 years working with Bilateral and Multilateral agencies i.e., GIZ, UNDP and UNIDO. He supported a project as a technical expert with MNRE, MoMSME and MOEF&CC under the GEF-funded program with UNDP and UNIDO in close cooperation with State Nodal Agencies, and technical institutions including Industrial Associations.

He has published more than 20 articles in national and international journals and reviewed more than 15 papers as an expert reviewer in the energy area. He is passionate about delivering expert guest lectures for academic and research scholars in various national and international technical institutions/universities.

In academics, he did a PhD in Energy, M. Tech in Energy Management, a Postgraduate in Business Management and an associateship from CSIR. He is a lifetime member of India Metrological, also awarded and appreciated by National and International experts.

Title

Using concentrating solar thermal technology for industrial applications to reduce the dependence on fossil fuels

Abstract

The increasing cost of fossil fuels and concerns about climate change necessitates an increasing dependence on renewable energy. Solar energy is a solution to curb the increasing energy imports and the current trade deficit. While most renewable energy sources provide energy in the form of electricity, Concentrated Solar Thermal (CST) technologies are considered as a source of thermal energy production for heating and cooling applications.

Industries such as pharmaceutical, chemical & dyes, surface coating for electroplating, automotive, paper and pulp, textile manufacturing, food and beverage, dairy and leather industries require a minimum process for heating, as the energy is not being converted into power, these systems usually have higher efficiency can meet thermal i.e., heating demands of different sectors for temperatures up to 200 °C. The majority of the heating needs in the commercial sectors come from the industries. The most suitable CST technologies for meeting the heating needs in the pharmaceutical industry are identified under the UNIDO project through their cost-benefit analysis provision and availability of shadow-free space.

The paper aims to be concerned with the market potential and intervention of Concentrated Solar Thermal (CST) technology in industries to reduce the dependence on fossil fuels and make it easy to integrate with existing boilers and also highlights the successful case study using CST to generate hot water for the process heat application or wastewater treatment.

The report on CST Road Map for India developed under the GEF-funded UNIDO's solar project estimated that the actual market potential of CST technologies for process heating and cooling applications is 6.45 GW^{th} and the solar radiation (DNI/GHI) available in all the climate zones (N-S & E-W) in INDIA are suitable for the CST for industrial applications including the wastewater treatment.

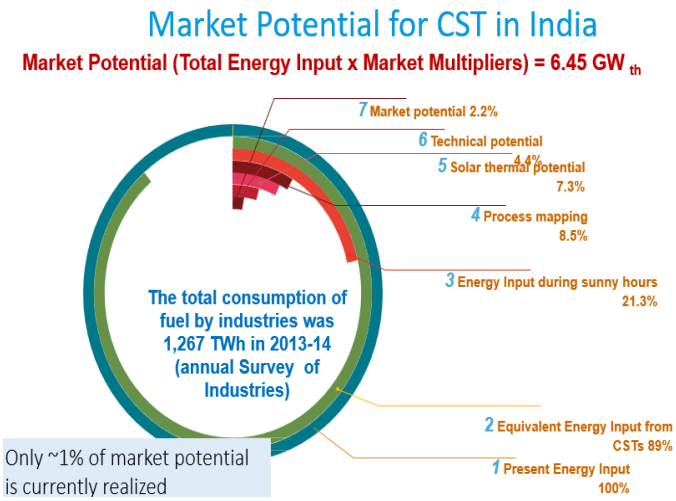

Figure. CST Market Potential in India

(Source: UNIDO report available on FIC-ISID website)

The market potential of CST takes into consideration the sum of three factors. These three factors are the willingness of the industry to implement the system, the availability of suitable space for CST and the financial returns of the system in comparison to the fuel and system that the industry is presently using. The report indicates that India has a strong opportunity to become a global market leader for CSTs for process heating and cooling due to the high irradiance and availability of local manufacturers with competitive manpower costs.

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Brief Biography

Jiten Prajapati is an Architect, Academician and GRIHA - CP based in Mumbai. He has been involved in a range of architectural and research projects pertaining to sustainability since 1994. The focus of his consultancy is on design innovation, client satisfaction and research.

He has authored and co-authored of several books, articles, papers and software tools for sustainable architecture; notably 'Handbook on Energy Conscious Buildings (at IIT-Bombay)'. He has designed a Zero Energy School Campus in the hottest region of India, that has been featured in the TERI Journal. He has designed the PDEC towers and other solar passive techniques for the first public building in India, i.e., the Police headquarters at Gulbarga, that got a LEED Gold rating from USGBC. He has developed a software namely 'CAT – Ver. 2.0' for providing pre-design climate analysis and design recommendations for various cities of India.

He has been a member of review committee for the proposed master plan of IIT-Dharwad. He has recently been a divisional grand jury member for Solar Decathlon India. He has also been a member of the review panel for M. Arch. Dissertation at IIT-Roorkee and part of technical review committee for an International conference called Energise 2023.

Title

Climate responsive design and case studies

Abstract

Climate responsive architecture is the need of the hour to conserve finite resources, reduce pollution, provide good health and, mitigate climate change. Climate analysis is an essential part of sustainable or green building design. The comfort criteria, design considerations and guidelines for solar passive architecture can be derived from the climate analysis. The methodology includes (a) Collection of data, (b) Analyse macro-climate and site (c) Establish design objectives (d) Micro-climate analysis (e) Site zoning (f) Orientation and built form. It is important to consider the physical attributes of the site and the context of design. The context refers to social, cultural, economic, topographical and technological.

A number of simple tools such as the bio-climatic chart, sun path diagrams and wind roses can be used to evaluate comfort and techniques such as designing windows and shading devices. Software tools such as Climate Consultant and CAT – Ver. 2.0 of MihirOS provide useful charts and design guidelines for a particular climate.

The microclimate analysis can help to modulate the environment of the site and its surroundings. Features such as landscaping, slope of site, surrounding structures, can among other things help to reduce ambient temperature, and, provide dust and noise control. The microclimate analysis and related zoning of facilities can help to enhance and upgrade the site. Solar passive architecture can further optimise comfort and conserve energy. Simple techniques such as orientation and shape of building, window and shading devices, colour, courtyards, perforated parapet wall, etc. can be easily incorporated in the design.

A few case studies are presented to illustrate the climate responsive architecture. It can be seen that the architecture responds to the climate and has a new design language. Thus, the climate should be considered as a resource, giving us an opportunity to design better.

Abstracts

Paper No. 009

Transient thermal behaviour of sensible energy storage system

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Abstract
Thermal energy storage observes the transient temperature variation within the system. The present study explores the transient thermal characteristics of a concrete-based storage system by varying the heat transfer fluid (HTF) inlet temperature varying from 45 to 75 °C at a fixed mass flow rate of 0.022 kg/s. The maximum energy utilization by the storage is found at 55 °C HTF inlet temperature.

Paper No. 010

Evaluation of building energy efficiency measures using statistical simulation

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Abstract
The research work in this article estimates the potential energy savings of a typical office building located in Bengaluru, India by implementing 3 ECMs (Energy Conservative Measures): AHU Economiser, Window film application, and lighting control. Since cooling and lighting account for major part of building energy consumption, the ECMs here are focused to reduce these demands. A simulation model was developed by modelling building envelope, HVAC, and lighting system using EnergyPlus and the ECM savings were obtained from this building energy model. The savings obtained from typical deterministic simulation model are for nominal conditions and the same cannot be guaranteed at site level due to uncertainty involved in modelling inputs. Hence examining the effect of uncertainty in modelling inputs would be of major focus in this work. Uncertainty in parameters like building construction, weather, occupancy, plug loads, and infiltration were examined which are expected to play vital role in building energy consumption. Energy savings obtained by implementing ECMs were obtained from simulation model and uncertainty analysis quantified the probability of such savings. Two ECM i.e., application of window film and implementation of linear lighting control showed good probability of saving site energy. Implementation of air side economizer in AHU showed probability of increase in energy consumption instead. Considering uncertainties in the input parameters and analysing their impact on the energy savings would help building owners to choose appropriate ECMs.

Paper No. 013

Numerical analysis to optimize the corrugation angle of pentagonal corrugated absorber plate of solar air collector in an indirect solar dryer for enhanced heat transfer characteristics

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Abstract
A two-dimensional numerical analysis was conducted to optimize the corrugation angle of a pentagonal corrugated absorber plate in the solar air collector of an indirect solar dryer for maximizing thermo-hydraulic performance parameter (T_{hpp}) to obtain enhanced heat transfer characteristics. A total of 60 simulations were performed in ANSYS FLUENT 2023 R1 using the SIMPLE algorithm and RNG k-ϵ model for evaluating the governing equations. Design parameters considered for the analysis were corrugation angle (α), height (e), pitch (p), and Reynolds number (Re). The corrugation angle (α) was varied from 10° – 37.5° with an interval of 2.5° for a fixed corrugation pitch, p = 150 mm and corrugation height, e = 10 mm. Reynolds number (Re) was varied from 1800 – 15000 for all values of α and performance parameters such as Nusselt number (Nu), friction factor (f), Nusselt number ratio (Nu ratio), friction factor ratio (f ratio) and thermo-hydraulic performance parameter (T_{hpp}) were estimated and an optimum value of α was proposed for the specified range of Re. It was found that the Nu ratio varied from 1.997 to 3.126 which implies that the heat transfer was enhanced up to 3.126 times as compared to flat absorber plate. Maximum T_{hpp} was found for α = 35° (T_{hpp} = 1.827) at Re = 1800, however, the maximum T_{hpp} occurred at α = 35° only for Re = 1800 and 4440, whereas for Re = 7080, 12360 and 15000 maximum T_{hpp} was found at α = 15°. Wind speed varies significantly in everyday use, and thus an α that provides maximum T_{hpp} for a wider range of Re would be more beneficial. Hence the optimum corrugation angle (α) is proposed as α = 15° as it provides better overall performance for the ISD.

Paper No. 015

Wind power potential assessment using reanalysis data-case study of Indian offshore site

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Abstract
The offshore wind industry is expanding quickly as a result of techno-logical developments and falling prices. The most crucial information for constructing wind farms is having reliable predictions about the wind resources at a particular location and using appropriate models to estimate the distribution of wind speeds at that site. This research proposes a strategy estimating India's off-shore wind resource using reanalysis data. The wind characteristics are estimated using the Weibull probability distribution, and the distribution shape (k) and scale (A) parameters are derived using three different numerical approaches at a height of 50 m to determine the wind power density using the MERRA-2 data of 22 years. The goodness of fit test, RMSE, and R^2 are used to evaluate the performance of all three selected methods. The findings show that all approaches utilized for parameter estimate are appropriate. But when it comes to determining wind potential, the Maximum Likelihood Method (MLM) stands out as the most precise. The analysed data offers useful early information on the wind potential, which is crucial for converting wind energy and figuring out whether or not wind energy generation is indeed feasible at a certain location.

Paper No. 016

Economic viability analysis of rooftop solar and vertically mounted BAPV on a multi-storied commercial building in Kolkata

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Abstract
This paper aims to study the cost-benefit analysis of a project of 883 kWp having a combination of rooftop solar plant along with vertically mounted solar modules on building façades at a multi-storied commercial building located at Newtown, Kolkata. Both operational energy consumption and renewable energy generation are simulated. The building energy consumption profile is assessed through whole building energy simulation using eQUEST as the simulation tool. PVsyst is used to design and simulate the rooftop solar plant along with vertically mounted BAPV on building walls. The study showed that 40% of the annual energy requirement for the building could be met through on-site renewable generation. Based on the different cost parameters the economic feasibility of the study is checked for an operational tenure of 27 years. The cost-benefit analysis showed the project to be economically profitable beyond 11 years of operation.

Paper No. 017

Batteries by algorithm: unleashing the potential of machine learning in RUL prediction

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Abstract
For a battery to operate effectively and reliably, a battery management system (BMS) is essential. BMS Remaining Useful Life (RUL) is predicted using machine learning. In order to accomplish this, this article investigates numerous machine learning techniques, including Logistic Regression (LR), Naive Bayes (NB), Decision Trees, and Support Vector Machines (SVM). For model training and testing, a sizable dataset comprising important variables is used, and data visualization techniques boost prediction precision. This study shows how well machine learning performs BMS RUL estimation, potentially improving battery maintenance and system performance.

Paper No. 018

Synthesis, characterization, and solar cell properties of polyaniline nanocomposites

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Abstract
Polyaniline and nanocomposite are synthesized via chemical oxidative polymerization technique. Hydrothermal method is opted for the synthesis of Zinc Oxide nanoflowers and reinforced into polymer via in-situ technique. Right shift observed in XRD peaks and morphology Changes in SEM and TEM images indicate the formation of composite. Enhanced UV absorption is observed in Polyaniline-Zinc Oxide nanocomposites compared to polymer matrix and metal oxide filler. Solar cell device fabricated by coating PANI layer showed a power conversion efficiency 0.34 %. It is increased to 3.021 % in the case of composite deposited device.

Paper No. 019

Enhanced electrochemical performance of polyaniline/chitosan/titanium carbide nanocomposite

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Abstract
In this study, the chemical oxidative technique is used to create binary and ternary nanocomposites. Specifically, polyaniline/titanium carbide (P/TiC) and polyaniline/chitosan/titanium carbide (P/CN/TiC) are the nanomaterials being combined. In XRD analysis, the formation of binary and ternary nanocomposites and their crystallization are analyzed. The fillers were added to a PANI matrix and showed strong peaks in XRD measurements. Once it is confirmed that nanocomposites have been formed, electrochemical tests are carried out using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and Tafel plots. Consequently, the ternary nanocomposite was better at electrochemical interaction than the binary nanocomposite. Future energy storage technology development may take advantage of the study's findings.

Paper No. 020

Multi-objective optimization of envelope retrofits for improved energy performance in an educational building

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Abstract
With the advent of global warming, coupled with building sector accounting for 40% of total annual energy consumption and leading contributor to carbon emissions, energy efficiency in buildings turns essential. While upcoming building stock can facilitate the energy saving approaches since design stage, for the existing buildings, retrofitting remains the sole alternative. The current study investigates the impact of retrofitting design variables on energy consumption for an educational building in tropical Mumbai. A sequential process was implemented in this study involving field visit and data collection, model development, generation of iterated scenarios followed by energy simulations and multi-objective optimization. While Python was used for generating iterations and optimizing scenarios, energy performance was done using Rhino/ Grasshopper plugins LadyBug and HonyeBee and further, validated using electricity bills. The energy performance was investigated for 40 scenarios generated by varying conductivity of wall and roof, thickness, shading angle and solar absorptance. The findings show that increase in insulation thickness while decreasing solar absorptance can reduce energy consumption. The multi-objective optimization results derived at a set of optimal scenarios with maximum energy savings and minimum cost incurred. This study paves way towards formulating energy-efficient built-environment design guidelines in future.

Paper No. 022

Comparative analysis of sunshine models for estimation of monthly global solar radiation at Bhopal, India

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Abstract
A key hurdle to properly using solar energy in India has been found as a lack of accurate solar data and an erroneous calculation of the availability of solar radiation at a location. This paper presents the analysis and estimation of the monthly average global solar irradiation for the geographical location of Bhopal, India situated at 23.16°N and 77.36°E using different regression models. The models are based on the Ratio of monthly average daily global solar radiation (H) to the extra-terrestrial radiation (H0). Each categorized model is examined, verified, and compared separately. The objective of this study is to estimate the monthly average daily global solar radiation for Bhopal, India using regression models and to validate these models by comparing the results with data from the Ministry of New and Renewable Energy (MNRE) using Python (SolarPy) and Microsoft Excel Advanced. It was evident from the study that the Angstrom- Prescott model outperforms the other linear models in terms of accuracy. Akinoglu, Ogleman and Armstrong-Prescott models are suggested for assessing the GSR for the Bhopal region while taking into account all the considerations. The relevant model discussed in this paper may be used to estimate solar radiation relatively accurately for an area of Bhopal and the surrounding area, as well as possibly for any locations with a comparable climate. Further this study would help in selection and designing of adequate solar photovoltaic and thermal technologies for the climatic conditions of Bhopal.

Paper No. 024

An empirical study on factors influencing energy efficiency in metal industry cluster

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Abstract
Micro, Small and Medium Enterprises (MSMEs) are crucial to the Indian economy. The majority of the metal manufacturing industries exist in clusters. In the contemporary globalized world, such clusters' survival and expansion depend on three critical sustainability characteristics: economic, environmental, and social. The first two dimensions of energy-intensive metal industries depend on the efficient use of energy, which is a critical input in their operations. Improved Energy-Efficiency (EE) contributes to increased competitiveness through cost reduction and reduced environmental damage. However, understanding the elements that influence EE is critical for its advancement. This research investigates these aspects in metal sector clusters that use energy. Cobb-Douglas production function based on source data from 80 metal industries is used to determine the relevance of energy input. The energy efficiency level is calculated in terms of Specific Energy Consumption, and the Principal Component Analysis (PCA) approach is used to identify variables impacting energy efficiency. These variables are also examined and analysed using multiple regression models.

Paper No. 025

Assessment of lung loading of nanoparticle emissions from conventional diesel and methanol diesel-RCCI engine

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Abstract
This study investigates the mass deposition of nanoparticles in the human lungs caused by emissions from conventional diesel (CDC) and methanol diesel reactivity-controlled compression ignition (MD-RCCI) engines. The lung compartment model is used to estimate the deposition of nanoparticles in the lung. A single-cylinder automotive diesel engine is modified to be run in RCCI combustion mode. Methanol is used as low reactive fuel to explore the RCCI strategy. The nanoparticles emitted are used as input for the compartment model to calculate the lung's regional and total particle loading. The effect of engine load and fuel pre-mixing ratio on regional and total lung load is explored. The calculation for the lung loading is performed with exposure time and particle diameter. The findings indicate that the alveolar region exhibits the highest lung loading, while the head region demonstrates the lowest deposition of nanoparticles under all the tested conditions. The net mass deposition in the lungs depends on the deposition and clearance rate. With an increase in engine load, the lung loading of nanoparticles increases for CDC and decreases for MD-RCCI. The MD-RCCI emitted nano-particles show the lowest lung loading under all the test conditions. The MD-RCCI engine has a lower potential to load lungs as compared to CDC.

Paper No. 026

Characterizations of cyclic combustion variations in RCCI engine using multifractal detrended fluctuations analysis

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Abstract
This study experimentally investigated the cyclic variations and partial burn in reactivity-controlled compression ignition (RCCI) engine. Multifractal Detrended Fluctuations Analysis (MFDFA) is used to characterize the cyclic variations and partial burn. The experiments are carried out on a modified single-cylinder diesel with the development ECU (electronic control unit). The RCCI combustion is achieved by injecting gasoline (as low-reactivity fuel) into the intake manifold through the port-injection system while diesel (as high-reactivity fuel) is directly injected into the cylinder. This study explores the effect of the gasoline/diesel premixing ratio (r_p) on combustion stability and partial burn. It is found that the variations in CA10, CA50, and COVIMEP increased with r_p. Results indicate that the percentage of misfiring cycles increased from 36.4 % to 83.1 %, when r_p increased from 40 % to 50 %. MFDFA analysis shows that total heat release (THR) becomes anti-persistent and its degree of multifractality decreases when r_p is increased. The Multifractal analysis also shows that THR, CA10 and CA50 have large fluctuations at smaller scales, and these fluctuations are persistent in nature and smaller fluctuations at large scales are anti-persistent in nature.

Paper No. 027

Exergy analysis of single-stage metal hydride hydrogen compressor

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Abstract
This work reports an exergy analysis of a single-stage metal hydride hydrogen compressor. The performance of the metal hydride (MH) hydrogen compressor is determined from the exergy viewpoint. Further, the effect of alloy composition used in the compressor on exergy efficiency is studied. The performance analysis is done for $LaNi_5$-xAl_x were x = 0.1, 0.2, 0.3 and 0.4 at a supply pressure of 3 bar and desorption temperature of 100, 120 and 140 °C. Exergy efficiency decreased with an increase in Al concentration and increased with an increase in desorption temperature. A maximum exergy efficiency of 70.1 % and desorption pressure of 41 bar is obtained at 140 °C for $LaNi_{4.9}Al_{0.1}$.

Paper No. 028

Effect of transverse fin configuration on the performance of adsorption cooling system

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Abstract
In this work Three dimensional and 2D axisymmetric models are developed for 0.5 kg longitudinal fin and transverse fin configuration reactor. The simulations are performed to study the adsorption/desorption characteristics of ammonia in Calcium Chloride composite. The simulation results of Transverse fin reactor are used for validation and maximum deviation found to be ±3 %. Further simulations are carried out on transverse finned reactor by varying the fin thickness and these results were used to find the performance of simple adsorption cooling system and it is found that these systems effective with finned reactor. The variation of average bed temperature, ammonia concentration in sorption bed and cooling power are also presented for different fin configured reactor. The maximum COP of cooling system obtained is 0.63 with transvers fin configuration of thickness 1.5 mm.

Paper No. 030

Computational workflow for investigating hydrogen permeation in novel hydrogen storage materials

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Abstract
The United States Department of Energy (DOE) has set ambitious targets for hydrogen storage materials for onboard light-duty cars which are to be achieved by 2027. One of the major problems in solid hydrogen storage materials is the sluggish uptake/release kinetics. Much attention has been focused on understanding kinetics. Hydrogen solid-state diffusion is a rate-controlling step in the majority of metal hydrides. Here we discuss computational workflow which can be used to estimate hydrogen diffusivity. A detailed study of hydrogen concentration, hydrogen neighbours is performed on nickel hydride (NiH) fcc materials to understand their effect on H diffusion. The nudged elastic band (NEB) method is used to determine hydrogen diffusion barrier with various hydrogen concentrations in presence of hydrogen neighbours. The energy barriers for hydrogen hopping were calculated for few million different configurations with various local chemical environments. Two paths for H hopping from one octahedral site to a vacant neighbour octahedral site are identified: one path is straight, and the other is curved via tetrahedral site. The curved path shows diffusion faster than the straight path. This study demonstrates H diffusion is faster at higher hydrogen concentration, as the concomitant volume expansion lowers the energy barrier.

Paper No. 032

Analysis of evaporative cooling characteristics in variable cross-section clay pipes with staggered and aligned orientations

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Abstract

Human comfort difficulties are being brought on by global warming and industrialization. For developing countries with low per capita incomes, evaporative cooling is a cost-effective and environmentally benign option. In order to reduce their environmental impact and help regional farmers and craftsperson's, researchers are looking at using natural materials like clay jars and cooling pads made of natural fibers. The direct evaporative cooling system was experimentally investigated by utilizing porous variable cross-section spheroidal clay pipes (SCP). The experimentally controlled parameter was inlet air velocity in the range of 2-9 m/s for both aligned and staggered configurations of SCP. The thermosyphon concept was used to ensure that water would flow through SCP. The investigated parameters were exit air and water temperature, pressure, humidity, and velocity. The water side temperature and water level were monitored to assess mass consumption. Performance metrics, including temperature drop, increase in relative humidity, saturation efficiency, and coefficient of performance, were assessed. Comparisons were made between the experimental outcomes for aligned and staggered orientation. This study examines how air velocity affects the temperature decrease and humidity of air using SCP. Results showed that staggered positions have a 21.2 % higher temperature drop and 9.5 % higher humidity compared to aligned positions. Also, there was a 20.6 % rise in saturation efficiency and a 0.17 kW increase in cooling effectiveness for staggered positions. Thermosyphon water circulation reduces pump energy consumption, resulting in an increase of COP by 1.66. The maximum pressure drops were 2.5 mm and 3 mm of water for aligned and staggered positions, respectively. The experimental investigations conclude that the use of SCP in direct evaporative cooling systems is a promising material for high performance and energy savings.

Paper No. 034

Modeling and analysis of gas turbine fog cooling system

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Abstract
Fog cooling is one of the most efficient and economical methods to cool the inlet air of the gas turbine to improve its performance. In this paper, firstly, a model has been developed to estimate the cooling of ambient air by the fog cooling method. The model is based on basic thermodynamics and psychrometric processes and analyses the effect of ambient conditions (temperature and relative humidity) on inlet air cooling. Fog cooling is one of the most efficient and economical methods to cool the inlet air of the gas turbine to improve its performance. Secondly, based on the characteristics curve of heavy-duty and aerodynamic gas turbines, power and heat rate models are developed. In order to comprehensively understand the effects of fogging, a sensitivity study by varying the ambient conditions was conducted. For each gas turbine, five values of ambient inlet air temperature (25 °C, 30 °C, 35 °C, 40 °C and 45 °C) and relative humidity (20 %, 30 %, 40 %, 50 %, and 60 %), were examined. For all cases analysed, the maximum cooling and power augmentation is achieved at high ambient temperature and low relative humidity at 45 °C and 20 % relative humidity. The aero-derivative gas turbine is more sensitive to ambient conditions, and up to 21.417 % power augmentation is achieved, as compared to the heavy-duty gas turbine (18.807 %) for the same ambient condition (45 °C and 20 % relative humidity). The paper is intended to provide a simple method to evaluate the potential of power augmentation by using the air-cooling potential of the fog cooling technique which can be useful for gas turbine users.

Paper No. 035

Multi-objective optimization for visual, thermal, and energy performance of glazing and shading assemblies in the temperate climate zone of India

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Abstract
With rapid urbanization and higher energy demand, high-performance building design has drawn attention to the challenges for a sustainable built environment. Climate-adaptive envelope parameters have a significant interactive impact on building social, environmental, and economic performance. This research proposed a multi-objective optimization (MOO) approach to evaluate building performance, including visual comfort, thermal comfort, and energy demand simultaneously. A residential apartment building situated in a temperate climatic zone (Köppen climate classification: Bsh) of Bangalore (India) was chosen as a case study. The optimization was initiated with Rhinoceros tools and Grasshopper in order to maximize the Useful Daylight Illuminance (UDI) and minimize the Thermal Discomfort Percentage (TDP) and the Energy Use Intensity (EUI). The Octopus plugin of Grasshopper was used to explore the building envelope parameters such as wall window ratio (WWR), window height, window sill height, external louvers depth, external louvers count, louvers angle, vertical fins depth, vertical fins count, glazing conductivity (U-value), solar heat gain coefficient (SHGC), and visible light transmittance (VLT) to achieve the good balance (trade-off solution) be-tween building performance objectives. The trade-off solution improves the UDI, TDP, and EUI by 46.19 %, 30.44 %, and 22.65 %, respectively, from the initially generated optimal solution. The outcome of this research illustrates how optimization methodology can be useful for building professionals in the early design stage of building envelopes to ensure a healthy and comfortable indoor environment with minimum energy demand.

Paper No. 036

A multi-objective optimization approach for envelope design in naturally ventilated building of Jaipur city: A case study of residential building

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Abstract
This paper investigates the socioeconomic performance of a commonly constructed envelope design in Jaipur City (India). A multi-objective optimization approach was used to investigate thermal and visual performance and construction cost by evaluating various envelope possibilities. A residential apartment building in a semi-arid composite climate (Köppen Climate Classification: Bsh) of Jaipur, India, is selected for the purposed methodology investigation. Various scenarios of walls, roofs, glazing assemblies, window-to-wall ratio (WWR), and orientation were optimized with the genetic algorithm (GA) coupled with the Design-Builder tool. The present optimization was conducted in two phases: In the first phase, unmet hours (thermal uncomfortable hours) and initial construction cost were assessed across 99,792 different energy efficiency measures, and eight Pareto solutions were identified. The second phase assesses the reliability of Pareto solutions in terms of visual comfort using Rhinoceros tools coupled with Grasshopper software. Furthermore, the author also investigated the individual effect of walling and roofing assemblies on thermal comfort. Moreover, identify the indoor operative temperature boundaries and plot the psychrometric chart on which occupants feel thermal comfortable in a naturally ventilated building. This research reveals that a robust optimal Pareto solution reduces unmet hours and initial cost by 12.40 and 38.62 %, respectively, and enhances visual comfort compared to worst-case design solutions.

Paper No. 037

Sustainable development in India: Evolution of green building assessment systems and roadmap for improving occupant efficiency and working leniency

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Abstract
This research paper investigates different parameters that contribute to enhancing the rating in green building assessments, with a primary focus on occupant efficiency and working leniency. The study emphasizes the significance of low U-values in reducing energy consumption and improving environmental performance in green buildings, Furthermore, the research explores waste reduction strategies, promoting the use of sustainable materials and design practices to minimize construction waste. The study also underscores the importance of indoor air quality in green buildings, discussing ventilation, material selection, and pollutant generation. By creating a healthier and more comfortable indoor environment, green buildings aim to improve occupant well-being and productivity. The research design outlines the methodology used to assess occupant efficiency and working leniency in both certified green and non-rated buildings. Measurements of indoor air quality parameters are conducted through various instruments and methods, complemented by subjective measurements obtained through occupant interviews and surveys. Through a comprehensive evaluation of green and non-rated buildings, this research provides valuable insights and a roadmap for stakeholders to implement occupant-centric design principles and sustainable practices. The ultimate goal is to create green buildings that prioritise occupant comfort, productivity, and environmental responsibility.

Paper No. 038

Optimization of roughness parameter of artificially roughed solar air heater

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Abstract
Solar air heaters are simple and cost-effective devices that harness freely available energy from the sun. However, their efficiency is limited by the low coefficient of heat of air. To improve their performance, many techniques have been applied, with one common approach being the use of artificially rough absorber plates. Nonetheless, designing the artificial roughness and selecting appropriate operating parameters to achieve higher heat transfer rates and lower friction factors can be quite challenging. In this study, the researchers aimed to optimize the roughness parameters and operating parameters to enhance the thermal performance of a solar air heater duct with artificially roughened surfaces. The Taguchi methodology was employed for this purpose. Through this approach, the researchers successfully identified the optimal roughness and operating parameters that lead to the desired performance levels. The operating parameter considered in the study was the Reynolds number, while the roughness parameters included Relative roughness height and Relative roughness pitch.

Paper No. 040

Combustion, performance, and vibrations of dual fuel engine modified with hydrogen reactor

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Abstract
The depletion of fossil resources and escalating environmental problems present difficulties for the transportation sector. The primary goal of employing hydrogen gas in the engine as opposed to pure diesel and biodiesel is to reduce vibrations through improved combustion. However, testing is only conducted with stationary engines employing conveniently accessible hydrogen cylinders and some hydrogen generation methods. As a result, by combining with a hydrogen reactor, the VCR diesel engine may operate as a dual-fuel engine. The hydrogen gas was delivered at 0 lpm (pure diesel), 10 lpm, and 15 lpm into the manifold of the dual fuel engine during tests utilizing various loads from 0 to 12 kg with an interval of 3 kg, using a hydrogen reactor and flow meter. The addition of hydrogen and diesel to a modified diesel engine enhances combustion, performance and reduces vibrations. When compared to pure diesel and biodiesel, these experiments, which are limited to stationary engines, show rather optimistic results.

Paper No. 041

The future of energy transition in India: A comprehensive study of the legislative & policy framework

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Abstract
This article focuses on the future of energy transition in India by comprehensively evaluating the contribution of the legislative and policy framework. The policy and the legislative framework must complement each other to achieve the ultimate goal of a low-carbon economy. However, there exists a significant disparity between them, particularly in India. The study delves into energy law's fundamental principles and its potential to address the energy transition challenge. The contribution of legal scholarship to the energy transition is distorted, primarily because of its lack of integration into the mainstream legal academic discipline, which poses a significant challenge in mitigating and adapting to the adverse effects of climate change. The article examines the impact of key environmental legislation and subordinate legislative frameworks on energy transition efforts. The article gives prominence to recent amending Acts, analysing their drafting tone and evaluating their alignment with each aspect of the energy trilemma. It emphasizes the necessity of harmonizing law and policy for successful energy transition by reviewing decisions made by constitutional courts. Ultimately, the article concludes with an overview of the implications of energy law's role in energy transition and research.

Paper No. 043

A comparative study of the performance and emissions of SI engine fuelled with isopropyl acetate, n-butyl acetate, and premium-gasoline

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Abstract
The rising demand for fossil fuels is rapidly depleting the limited sources of crude oil, leading to harmful emissions upon combustion. Consequently, developing sustainable and eco-friendly alternatives to fossil fuels has become imperative. This study investigated the performance and emission characteristics of blending isopropyl acetate and n-butyl acetate with premium gasoline (PG) at various engine speeds. Biofuels-PG blends were prepared by mixing biofuels and PG in volume ratios of 10 %, 20 %, and 30 %. For instance, a combination of isopropyl acetate and PG with 10 % isopropyl acetate and 90 % PG is denoted as IPAG10, while other blends such as IPAG20, IPAG30, BAG10, BAG20, and BAG30 also named accordingly. The performance and emission characteristics of these blends were also compared with PG and ethanol-PG blends. The results showed that the brake thermal efficiencies of BAG10, IPAG10, and EG10 were close to that of PG, with values of 30.29 %, 29.87 %, and 29.19 %, respectively. However, the brake-specific energy consumption of the blends is higher than PG. Specifically, at 2500 rpm, the brake-specific energy consumption increased by 1.16 %, 2.56 %, and 4.98 % for BAG10, IPAG10, and EG10 blends, respectively. In addition, these blends result in reduced carbon monoxide (CO), nitrogen oxide (NOx), and hydrocarbon (HC) emissions when compared to PG. Notably, the maximum reduction in emissions occurred at 2500 rpm for both BAG30 and IPAG30. The results of this study suggest that blending isopropyl acetate and n-butyl acetate with premium gasoline is a promising way to reduce emissions and improve the performance of SI engines.

Paper No. 045

Experimental evaluation of a falling film liquid desiccant cooling system with solar assistance

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Abstract
The need to maintain human thermal comfort and the current air-conditioning systems' high-power consumption has led researchers to search for an alternate dehumidification solution. The liquid desiccant dehumidification system has emerged as one of the promising alternatives as a long-term renewable and power-efficient technology because of its effective humidity-controlling capacity. The dehumidifier and regenerator are the primary components of the liquid desiccant cooling system. The current study performs the experimental analysis on a solar-assisted falling film liquid desiccant cooling system using $CaCl_2$ solution as a liquid desiccant. The regenerator of the current study uses hot water from the marquise-shaped flat plate collector to regenerate the diluted solution. The performance parameters for the current system are dehumidification rate and cooling capacity, and performance is evaluated by altering the solution volume flow rate and solution concentration. According to experimental results, the dehumidification rate and cooling capacity are shown to rise with increasing solution volume flow rate and solution concentration, and the maximum dehumidification rate and cooling capacity are achieved at 12.5 LPM solution volume flow rate and 37 % solution concentration.

Paper No. 047

Microwave assisted mechanochemical synthesis of $Na_{0.67}CoO_2$ as potential cathode material application in sodium-ion batteries

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Abstract
Herein, we report the synthesis of layer-structured P_2-$Na_{0.67}CoO_2$ using a facile mechanochemical approach assisted by microwave heating. This modification, to the conventional synthesis route has enabled in obtaining a pure phase material at a significantly lower temperature and time than currently existing methods. Structural characterization reveals a P2-type structure, which is an electrochemically favourable structure for cathode material application. X-ray diffraction (XRD) data confirms the phase purity along with crystallite size (D) of 67.6 nm. SEM images reveal a polyhedral structure with stacking of flake-like morphology. Energy dispersive spectroscopy (EDS) data indicate that the synthesized material matches the expected stoichiometry with homogenously distributed elemental composition as seen from EDS mapping. The average particle size was measured to be 5.65 µm from DLS measurements. The specific surface area was found to be 0.7 m^2g^{-1} by BET method using N_2 adsorption-desorption isotherm, with the average pore size being 75.82 nm.

Paper No. 048

Comparative analysis of two different storage modules for techno-economically optimum and environmentally benign decentralized hybrid energy systems

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Abstract
Ever-increasing passenger and freight traffic increases the global demand for transportation systems. It is projected to double by 2050. Such growth in the transportation sector represents the economic and environmental development of society. It increases energy consumption and environmental emissions that need to be addressed. To meet the Sustainable Development Goal (SDG 7) transportation sector must follow the emerging energy generation systems trajectory. The increased EV demand increases energy consumption which may create disturbances in the centralized grid system's stability. It also increases the electricity cost. To reduce this critical challenge developing overall sustainable decentralized hybrid energy system-based EV charging stations is the global need. This study aims to analyse the techno-economic and environmental performance aspects of different energy combinations integrated with two different emerging storage modules for developing overall sustainable energy solutions. The analysis result shows that the combination of photovoltaic-wind-DG-Lithium-ion is techno-economically optimal (cost of electricity-$0.204/kWh) with the least environmental impact.

Paper No. 050

An approach to improve the computational accuracy of power factor in thermoelectric energy conversion

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Abstract
Thermoelectric technology is emerging as a novel technique and has become very popular in the field of energy harvesting, especially waste heat energy. The performance of any material for thermoelectric application can be analysed using the first principle technique significantly. The thermoelectric transport parameters are extracted by using the Boltzmann transport equations within the constant scattering time approximation. However, this approach leads to the erroneous estimation of thermoelectric properties as it is a crude assumption of scattering time approximation. In the present work, for silicene and germanene, the scattering time of charge carriers is obtained as a function of temperature by investigating electron-phonon interactions from the first principles. Our calculations incorporate the interaction of the charge carriers with all the possible phonon modes, which gives access to the highly precise scattering times. Incorporating the scattering times in-formation in Onsager transport coefficients, thermoelectric transport properties are calculated based on the electronic band structure using HSE06 functional. To quantify the degree of inaccuracy occurring within constant scattering time approximation, the thermoelectric power factor is estimated using our proposed method and compared with constant scattering time.

Paper No. 051

Designing and application of MATLAB app designer for conducting techno-economic analysis of grid-tied rooftop solar PV system

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Abstract

This paper focuses on a techno-economic analysis of a grid-tied Rooftop Solar PV System (RTSPVS), which is conducted using MATLAB app designer R2022a. The techno-economic analysis is done on a grid-tied RTSPVS for a system of the capacity of 5 kWp (kilo watt peak), in Nagpur, India. The system capacity can be designed as per users' requirements due to the customizable nature of the developed app. The technical analysis includes the calculation of critical parameters like the performance ratio (PR) and 10 other technical parameters, which are depicted through graphs on MATLAB app designer. The economic analysis includes the calculation of critical parameters such as present worth factor, capital recovery factor, and levelised cost of electricity for a lifetime, which comes out to be 14.09, 0.07, and 0.28 INR/kWh, respectively by considering that the maximum debt to equity ratio as 70:30 with loan on 8 % of interest. The EMI comes out to be 319.4 INR/month by using the App. The cash flow analysis for a case study has been carried out where 70% of generated units (GU) are exported while the rest are imported to the grid using a gross metering scheme. The payback period, internal rate of return, and net present values for the gross metering case came out to be 9 years, 11.11 % and 50,912.49 INR respectively. This paper suggests that the user to analyse the techno-economic analysis done by MATLAB app designer, which creates more awareness about the solar PV system before installing it.

Paper No. 053

Study of performance ratio of newly developed high-performance airfoil with respect to the airborne wind energy system

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Abstract
The harvesting and storage of renewable energy, particularly wind energy, has become crucial for the development of both developed and developing countries. Wind energy, harnessed through turbines, has proven its potential as a reliable and non-polluting energy source for the future; while wind energy offers significant advantages, a major drawback is the complex and challenging installation process. To address this issue, an airborne wind energy system has emerged as a promising alternative technology that uses a system that captures the energy from wind at higher altitudes and has a reduced number of parts. In this context, this study focuses on increasing the efficiency of the Airborne Wind Energy System (AWES), namely ground-gen, by generating new airfoils from Clark-Y, a base airfoil which have higher performance characteristics. Several airfoils are formed using the XFLR software by changing the camber and thickness of the Clark-Y airfoil, and the airfoils with the best modification based on the performance ratio, which is a ratio of the coefficient of lift to a coefficient of drag (Cl/Cd) were selected. A further attempt is made to generate a new airfoil series, the CITI series, from the result obtained by modification. The performance was tested based on parameters like the Cl/Cd ratio of the airfoils. Results revealed that the performance of the CITI series airfoil increased by almost 26.92 %.

Paper No. 055

Characterization of heat generation and its impact with cell ageing in a lithium ion cell using coupled electrochemical-thermal model

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Abstract
Effective thermal management is crucial for safe battery operation, requiring an accurate prediction of heat generation within the batteries. This work models a Panasonic NCR18650PF cell using a coupled electrochemical with the thermal model in COMSOL Multiphysics. Heat generation in the cell and the different components contributing to the total heat were analysed. The study was done for current rates from 0.5 to 2, characterizing the domain-wise (cathode, anode, separator) and component-wise (reversible, irreversible and mixing heat) contributions to the total heat generation. Reversible heat was found to dominate at lower current rates, and as the C-rate increased to 2, the irreversible component gained prominence. Electrolyte resistance was found to be the major player in the irreversible component. The total heat generation curve was observed to follow the trend of heat generation contribution from the negative electrode. The study was extended to investigate the effect of cycle ageing on cell heat generation by incorporating additional film resistance due to the solid electrolyte interface (SEI) layer growth at the anode. The maximum temperature rise almost doubled at 2000 cycles of operation for the same current rates compared to a new cell.

Paper No. 056

Backward dynamic programming approach to solve the unit commitment problem based on a day load curve

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Abstract
Unit commitment is generally used to schedule the units to minimize the production cost for the total system across the scheduled time horizon under generator operational constraints. The unit commitment problem is nonlinear and a mixed integer type combinatorial optimization problem. We can obtain the global optimal solution by complete listing, which is impossible for large power systems due to its requirements for excessive computational time. Unit commitment presents a methodology to reduce costs and improve the system reliability. Unit commitment is a dynamic process, and power production planning changes as per loads and topologies of the network. The problem is solved by the backward dynamic programming approach, which solves the dynamic problem in 12 stages. This paper deals with a unit commitment problem that is solved using backward dynamic programming without time constraints, and outcomes show minimum cumulative total cost for operating 4 units in 12 stages for a 24-hour horizon based on a load curve of a day.

Paper No. 058

A comparison of battery thermal management systems for Li-ion batteries in electric vehicles

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Abstract

Thermal management of electric vehicle batteries is essential for the performance and safety of the overall system. Maintaining the required battery temperature and its uniformity must be the target of the battery management system. The present study aims to analyse different methods of battery thermal management based on their effectiveness in attaining the desired conditions. A battery module of 20 cells was designed with a cell discharge rate of 2C. Simulation and experimental analysis were performed on the model by maintaining the ambient temperature at around 27 °C - 30 °C. The system was analysed (i) without cooling, (ii) with water cooling through an integrated aluminium channel on either side of the battery pack and (iii) cooled by using PCM encapsulated around the cells. Paraffin wax was used as the PCM for the current analysis. From the simulation results, the temperature was found to be lowered by 13.27 °C when PCM was incorporated into the cell arrangement, whereas the temperature was lowered by 14.42 °C with the usage of an aluminium cooling channel of U-type cross-section, inlet velocity of water being 0.1 m/s. In the experimental analysis of the PCM embedded system, it was observed to have reasonable temperature uniformity. Both cooling methods effectively bring down the system's temperature, which is crucial for maintaining the optimal conditions for Li-ion battery packs to work effectively in the long run.

Paper No. 059

Performance analysis of a microbial fuel cell using solid waste as substrate in terms of various parameters

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Abstract
Solid organic waste is a substantial environmental concern nowadays and is at catastrophic levels worldwide. The composting technique, a type of natural decomposition, is currently utilized extensively to handle organic waste. This study investigated the impact of cellulose-based substrates, including wheat and rice straw, on a solid microbial fuel cell (SMFC). Furthermore, the operating parameters, such as pH, moisture content, etc., were examined to check their influence on the power performance. According to the results, the substrate and moisture content had the most significant effects on SMFC. A superior SMFC power output would be attained if the rice straw had a moisture level of 60 %, a pH value of 6-8, and these factors combined. These results would offer helpful information about the use of solid organic waste in SMFC.

Paper No. 060

A multi-mode energy analysis of direct expansion heat pump

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Abstract
Heat pumps are energy-efficient and can produce more heat than the required work input. The DX-SAHP system integrates the solar collector-evaporator into the heat pump, allowing the refrigerant to expand directly and absorb heat from solar and ambient air. This work aims to study the thermal performance of the DX-SAHP water heater, theoretically and experimentally. The system proposed a finned evaporator with a surface area of 0.42 m^2 and was tested under three modes - solar, air, and solar-air hybrid mode. The COP for heating was used to evaluate the performance of the DX-SAHP water heater, with an average variation of less than 12 % between theoretical and experimental results. The average COP of the DX-SAHP for all modes was found to be 1.15, with an average solar radiation of 250 W. The water temperature could reach up to 55 °C in an hour. The DX-SAHP water heater is efficient for domestic hot water and drying applications.

Paper No. 062

Phosphonated Poly (2,5-Benzimidazole)/zirconium phosphate nanocomposite membranes for vanadium redox flow battery application

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Abstract
Among the large-scale energy storage systems, vanadium redox flow battery (VRFB) has gained a lot of interest due to its flexible design, high discharge capability, increased cycle life, and safe operation. In a VRFB, the ion exchange membrane (IEM) is a crucial component which separates two electrolyte solutions while enabling ionic conduction through it. The most often utilised membrane materials are Nafion-based membranes with long-term cycle stability and excellent proton conductivity, but further commercialization is inhibited by their higher price and lower ion selectivity. So, for the latest membrane materials, a key objective is to achieve significant cost reduction while simultaneously enhancing the cell performance. Hence, Zirconium Phosphate (ZrP) nanoparticles based ABPBI (Poly 2,5 benzimidazole) polymer nanocomposite is taken into consideration to construct a high-performance and low-cost IEM for VRFB application. The ZrP nanoparticles were prepared by the reflux method. The prepared powders were characterized by X-Ray diffraction (XRD), dynamic light scattering (DLS), and scanning electron microscopy (SEM). Then, the ABPBI-ZrP nanocomposite was prepared using the solution blending and casting method. Then, the proton conductivity of the membranes was enhanced by doping them in a phosphoric acid solution. The ABPBI-ZrP composite holds immense promise for enhancing cell performance in vanadium flow batteries. Its unique properties offer great potential for elevating the overall efficiency and effectiveness of these batteries. With this composite, we can expect significant advancements in the realm of vanadium flow battery technology, leading to more reliable and efficient energy storage solutions.

Paper No. 066

CO_2 hydrate formation kinetics in the presence of TBAB

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Abstract
The objective of the present work was to investigate the effect of TBAB concentration on the CO_2 hydrate formation kinetics. All the experiments were carried out at 280 K temperature, 3.0 MPa pressure, and 300 RPM. Four different TBAB concentrations (5.0, 10.0, 19.0, and 32.0 wt %) were used to evaluate the performance of the TBAB promoter during hydrate formation. Reactor temperature profile, induction time, and gas consumption were studied for the different TBAB concentrations. The reactor temperature increased with an increase in the TBAB concentration and reached its maximum temperature (285.8 K) at 32.0 wt % TBAB concentration. The induction time follows an inversely proportional relationship with TBAB concentration. The lowest induction time was reported at the highest TBAB concentration. The gas consumption rises with the increasing TBAB concentration up to 10.0 wt %. However, a further increase in TBAB concentration resulted in a decrease in gas consumption. The hydrate slurry was formed in a less concentrated TBAB solution, whereas the highly concentrated TBAB solution formed a solid hydrate.

Paper No. 067

The impact of training algorithms and transfer functions on the accuracy of neural network-based temperature prediction of 3S4P battery module

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Abstract

The accurate prediction of lithium-ion battery temperature is of utmost importance for efficient battery thermal management systems. Artificial Neural Network (ANN) offers a powerful tool to assess battery module behaviour under varying operating conditions. In this study, experimental data is generated by charging a 3S4P battery module with 0.5 C-rates at ambient temperatures of 30 °C and 35 °C. This data is then utilized to train, validate, and test 54 ANN models with different transfer functions and training algorithms. The input parameters to the ANN models include State of Charge (SOC), current, ambient temperature, and voltage, while the battery module's maximum temperature serves as the output parameter. Our findings reveal that the Feed Forward Back Propagation ANN structure, employing Levenberg-Marquardt (LM) as the training algorithm, with 40 neurons in the first hidden layer using Logistic sigmoid (LOG) function and 1 neuron in the outer layer using the linear function, yields the lowest mean absolute relative deviation (MARD) value (0.027002 %) and the highest Regression Coefficient (R^2=0.99998). The ANN-LM structure with LOG transfer function demonstrates accuracy in predicting experimentally collected data for battery module under charging and varying ambient temperature.

Paper No. 068

A numerical analysis to investigate the impact of the throat-to-diameter ratio on the performance of a gasifier

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Abstract
Environmental pollution and the depletion of conventional energy resources have resulted in an increasing number of individuals worldwide embracing alternative methods to meet their residential and commercial energy needs. Gasification refers to the process of converting waste materials into energy that can be effectively utilized. Additional theoretical and experimental investigations are necessary prior to the successful implementation of gasification technology in remote areas. The ongoing study pertains to the creation of a numerical model that exhibits the characteristics of being steady-state and 2-D axisymmetric. The model has been specifically developed to accurately depict a waste gasification process within an Imbert downdraft gasifier that incorporates a fixed bed configuration. The model is used to assess the performance of a gasifier design across a range of throat-to-diameter ratios (0.22-0.44) in relation to the temperature distribution and percent composition of individual gases in the producer gas. The study's findings demonstrated that the model displayed enhanced concurrence with the empirical data reported in other scholarly works.

Paper No. 075

Degradation assessment through prediction approaches for solar PV system in south India

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Abstract
An essential element that directly affects the economic viability and financial sustainability of solar photovoltaic (PV) systems throughout their operational lifetime is the rate of degradation of these systems. The performance of PV systems has traditionally been believed to degrade linearly over time, declining at a fixed rate. The degradation rate, however, is frequently nonlinear, as observed from the operational nature of the PV system. The considered system for the present objective includes a section of 380 kWp PV system evaluated for a period of 10 months. Three prediction-based approaches for evaluating degradation rate have been formulated which include Feed Forward Neural Network, Radial Bias (Exact-Fit), and Radial Bias (fewer neurons). The RMSE found for these methods were 8.755E-8, 0.00181, and 0.00169 respectively. Amongst the developed model, feedforward backpropagation predicts a close match with the experimental/actual degradation rate factor (Rd). PV system owners and investors may experience financial instability if this non-linearity in the degradation rate is ignored.

Paper No. 087

Carbon dioxide storage using gas hydrates and kinetics modelling in a large-scale reactor

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Abstract
Modern energy requirements are driving carbon dioxide emissions to cause cli-mate change. Carbon dioxide capture and storage is the key to continual development. CO_2 capture through hydrate technology is a promising solution among several methods. The current work has attempted to store carbon dioxide in the hydrate form at a large-scale 25 L reactor. The hydrate is formed in pure and saline water conditions to demonstrate the hydrate-based gas storage can be achieved without the need of purified water. Further, tetrahydrofuran (THF), a thermodynamic promoter, is also used in combination with kinetic promoter sodium dodecyl sulphate to explore the hydrate-based storage at lower pressure requirements. The experiments are conducted after preparing the reactor bed at an initial pressure 35 bar and 275.15 K. The reactor is also connected to various other components, including recirculating bath to maintain a constant temperature and a gas booster for charging the gas in the reactor. Chemical affinity-based hydrate growth modelling is used to analyse the hydrate formation process. The experimental results demonstrate that carbon dioxide can be successfully captured in both saline and pure water. The affinity rate constant decreased with an increase in the hydrate growth kinetics, indicating lesser mass transfer resistance to the hydrate growth. Further, carbon dioxide storage based on the hydrate technology can be successfully implemented using carefully selected thermodynamic and kinetic promoters.

Paper No. 090

Concept of solar thermal energy utilization in cement plants

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Abstract
Indian cement industry has been at the forefront of the adoption of technological interventions and innovative techniques to integrate sustainability within its growth aspirations. Indian Cement Industry has shown its commitment on various fronts like energy, quality, environment, and sustainability. India is among the very few countries that are planning and taking action for the national targets set to settle climate change's adverse effects as per the Paris Agreement. The contribution of the Indian Cement Industry in this regard is noteworthy and over the years, has received global acknowledgment for being environment-friendly business operations. The Indian cement industry is counted under core industries and it confirms a significant role in the country's economic growth and development. The cement industry is well-linked with other sectors such as housing, public constructions, infrastructure, coal, transportation, power, etc. The annual installed capacity of the cement industry in India was 594 million tons (2022-23), with production of ~ 360 million tons. India is well-positioned to lead globally in renewable energy applications. India's journey towards low-carbon development needs the support of the international community. The cement industry is aware of the significant threat posed by climate change and is focusing on developing its own renewable energy technology. This supports the vision of strengthening existing strategies with investment that achieve better results through green energy, efficient energy planning growth of power. Huge energy savings can be achieved in the cement sector through the use of renewable energy, especially Waste Heat Recovery (WHR) and solar power plants which can reduce operating costs and improve the environment. There are many applications in the cement manufacturing process that need thermal energy sources. Calcination of raw material, drying of raw material, and hot air requirement are some of the examples that force demand for thermal energy to the tune of 80 % of the total energy requirement. The transition from conventional thermal energy sources to green energy would be a great breakthrough for the Indian cement industry. This will not only make the cement industry sustainable in terms of energy availability but use waste/by-products of other industries as Supplementary Cementitious Material (SCM) through thermal conditioning. A feasibility concept of using Solar Thermal Energy is discussed in this paper. A successful demonstration of using solar Concentrated Solar Power (CSP) technology is also briefed here towards thermal conditioning of phosphogypsum to concert impurities in inert form, making the material competent to replace mineral gypsum in cement plants.

Paper No. 091

Design of low-cost hybrid electric bicycle

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Abstract
Nowadays, the cost of fuel, particularly petrol is increasing and also the amount of pollution contributed by the vehicles in urban and major cities is constantly rising. Research studies are being conducted for additional alternate sources of energy for vehicles in an effort to solve these issues. Again, purchasing vehicles (such as mopeds, scooters, or motorbikes) for every class in society is not financially feasible. This has led to the development of an alternate method of providing for these socially and economically disadvantage people as well as a remedy for environmental contamination. In this study, a low cost solar-assisted bicycle is designed that is propelled by a BLDC motor installed in the rear axle housing. The BLDC motor is powered by a battery that is charged by the solar panels positioned on the bicycle carriage. When bicycle is stationary, the solar panel will be recharging the battery. The solar-assisted bicycle is equipped with a 250 W BLDC motor, allowing it to move at a speed of about 24-30 kmph. It is equipped with two 7.5 Ah lead acid batteries, a 50 W photovoltaic panel, a 250 W, 24 V, 21 voltage regulator, and a 24 V, 21 A accelerator and motor controller. Additionally, there is a facility for charging the battery using a 220-230 V AC power outlet supply in the event that the solar supply is inadequate due to gloomy weather.

Paper No. 093

Experimental studies on the gasification potential of sawdust and high-ash Indian coal blends in a fluidized bed gasifier

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Abstract
The fluidization of solids with the use of particle suspension in flu-id media is essential to achieving a constant bed temperature and a quick rate of heat transmission. Indian high-ash coal and sawdust were selected as the study's biomass materials while keeping in mind the Indian setting. Coal and sawdust work synergistically to enhance the process and its yield when mixed and gasified. Coal was pulverized or grinded to the specific size range needed for sus-pension in a fluid condition. Samples of sawdust were combined in weight ratios of 10 %, 20 %, and 40 % with coal. The gasification process was successfully finished at temperatures between 850 °C and 960 °C without encountering any operational issues. The carbon conversion efficiency (CCE), calorific value of the product gas (CV), cold gas efficiency (CGE), and syngas production per kilo-gram of feed were evaluated for each scenario of the mix. It was demonstrated that the output of syngas per kilogram of feed in-creases for all biomass blends as the gasification temperature rises from 850 °C to 960 °C. Additionally, it was discovered that as reactor temperature and mixed biomass content increase, so do the concentrations of CCE, CV, CGE, and CO-H_2 in the product gas.

Paper No. 094

Environmentally extended MRIO-SDA analysis on India's CO_2 emissions during 2005-2014

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Abstract
To understand and combat global environmental issues, there is a rapidly growing interest in using Multi-Regional Input–Output Analysis (MRIO) and Structural Decomposition Analysis (SDA). However, the methodology tends to be rigorous, creating a significant barrier to using such techniques by researchers in the field. This paper aims to provide a detailed framework which can be used to conduct an environmentally extended MRIO-SDA analysis while employing open-source data and packages. This foundation enables an examination of the trends in and the drivers of India's total change in CO_2 emissions for 2005-2014. The results are consistent with the existing literature - India is a net exporter of CO_2 emissions with sectors like manufacturing, electricity, commercial and public services and construction engendering considerable change in emissions embodied in trade. Moreover, the demand effect is the most significant contributor to the rise in India's total emissions. Replication material is available in the supplementary section.

Paper No. 098

Representative days for the calculation of annual optical efficiency of solar power tower systems

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Abstract
An SPT system primarily consists of a collector field of heliostat mirrors and a heat collection unit called the receiver. The ability of the heliostat mirrors to concentrate the solar radiation on the receiver is termed the optical performance. It is necessary to predict the optical performance of an SPT system as accurately as possible. The optical performance of the SPT system depends on the position of the sun primarily, which varies with the time of day. Considering many time instants from each day for multiple days of the year for the prediction of annual optical performance is computationally expensive. For this reason, a set of dates may be used to represent an entire year, and discrete time points at regular intervals can be chosen within the sunshine hours. Therefore, the accuracy of the predicted optical efficiency may depend on the choice of the dates selected to represent the entire year. In this study, multiple sets of dates and discrete time intervals have been considered. The annual optical efficiency predicted based on the calculation at each 1 min time interval for 365 days is considered to be the standard for comparison. It was observed that annual optical efficiency can be predicted with sufficient accuracy when only 4 days of the year are chosen as the representative days, thus reducing the computational burden.

Paper No. 099

Performance of bifacial lead-free all-perovskite tandem solar cell for indoor applications

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Abstract
The concept of bifacial tandem solar cell (BTSC) design, allowing light to penetrate the device from both its front and back surfaces, has proven to be a potent strategy for enhancing power conversion efficiency (PCE). In this study, we present the performance evaluation of a novel $MAGeI_3$ - 2D/3D $FASnI_3$ BTSC configuration. The BTSC was concurrently illuminated with AM1.5G solar spectrum from the front surface, while being exposed to various artificial light sources from the back surface. Comprehensive combinations of these artificial lighting conditions were also employed to explore their influence on BTSC performance. Using Silvaco TCAD software, the device architecture was thoroughly optimized. At optimized thicknesses of 130 nm for $MAGeI_3$ and 620 nm for 2D/3D $FASnI_3$, the lead-free all perovskite BTSC (LPBTSC) displayed an impressive peak PCE of 30.29 %. This PCE was obtained under simultaneous AM1.5G solar spectrum and halogen lighting illumination. In addition, the LPBTSC was able to achieve an impressive optimum PCE of 58.28 % by utilizing an innovative strategy. This remarkable result was observed when blue and white LED sources simultaneously illuminated the device's front and rear surfaces. The output power density of the LPBTSC falls within the range of 1 to 29 mW cm^{-2}, which is sufficient for serving as an effective energy harvester for Internet of Things (IoT) and indoor applications, all while maintaining low fabrication costs. This study underscores the immense potential of bifacial tandem solar cells in effectively harnessing a diverse array of lighting conditions, offering promising prospects for various practical applications.

Paper No. 100

Performance evaluation of parabolic trough collector with internal longitudinal hybrid -fins receiver tube

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Abstract
The present study aims to examine the performance of LS-2 parabolic trough collector (PTC) when operated with gaseous working fluid namely carbon dioxide, methane, and air, along with the combination of two different fin profiles (hybrid-fins) such as case-1 (T-shaped and rectangular), case-2 (V-shaped and rectangular), and case-3 (T-shaped and V-shaped), respectively, attached inside the absorber tube. The objective of the current study is to analyze the enhancement of this newly proposed receiver tube based on the performance enhancement factor index, thermal and exergy efficiency, and compare it with a smooth tube. The design and simulation are performed using commercial software Ansys Fluent 2020 R2, and results obtained from the present numerical study are validated with available literature and found in good agreement. Case-3 finned-tube shows a maximum heat transfer coefficient value of 256.125 Wm^2K^{-1}, 207.546 Wm^2K^{-1}, and 464.384 Wm^2K^{-1} for air, carbon dioxide, and methane gas respectively. And, maximum performance index factor values of 76.8 %, 82.1 %, and 66.4 %, were obtained for air, carbon dioxide, and methane gas, respectively, from all other examined cases. For each gas, the use of fins leads to an increment in both the thermal and exergy efficiency concerning to non-fin case.

Paper No. 102

Net zero energy assessment of multi-storied residential buildings integrated with onsite solar rooftop PV System: A case study

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Abstract
India has established ambitious goals to attain net zero emissions by 2070 and to meet half of its electricity demands from renewable energy sources by 2030. Residential building energy consumption plays a pivotal role in this energy transition. The increasing prevalence of multi-story buildings in urban areas, coupled with the growing adoption of room-based air conditioning systems, exerts additional pressure on the energy demands of residential buildings. The objective of this paper is to investigate the possibility of achieving net zero energy status for a multi-storied residential building by incorporating a rooftop solar system as a source of onsite generation. The study involved examining the energy consumption and performance of ten residential apartment buildings in Kolkata, India. This examination was conducted using whole-building energy simulation for both the base case and the energy-efficient design case for annual energy consumption. The energy-efficient case was developed by replacing the conventional brick wall construction with Aerated autoclaved concrete (AAC) blocks and integrating the high-performance residential cooling option. The building models were developed and energy consumption analyses were carried out using the e-QUEST energy simulation tool. The results revealed that the increased degree of energy efficiency measures helped to reduce base case energy consumption by a range of 34 to 37 %. This study also explored three solar generation scenarios, including building façade integrated photovoltaic, and assessed their outcomes, yielding average generation rates of 16.16 % for scenario A, 26.96 % for scenario B, and 49.25 % for scenario C. Net zero energy assessment confirmed more integration of energy efficiency measures and alternate on-site renewable energy generation sources.

Paper No. 103

Energy efficient field emission characteristics of graphene-wrapped zinc oxide rods

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Abstract
In this article, the cold emission properties of pure and graphene-wrapped zinc oxide rods (ZR) have been reported. ZRs were grown on both the silicon as well as on glass substrate via a simple wet chemical method using KMnO4 assisted seeding technique as wrapped by graphene sheet using a simple spin coating technique. The pure and wrapped samples were characterized by X-ray diffraction (XRD), field emission scanning electron microscope (FESEM), and Fourier-transformed infrared (FTIR) spectrophotometer. XRD confirms the proper phase formation whereas FESEM shows the uniform wrapping of the ZRs with the graphene sheets. FTIR spectra show considerable changes in bond formation after the sample gets wrapped by graphene. Both the samples show promises towards possibilities for being used as cold emitters when the field emission characteristics of the sample were measured in the laboratory-assembled field emission setup. Unlike the previous report, the wrapped sample shows almost the same emission features except little betterment in turn on field and enhancement factor compared to pure ZnO. This is believed to be due to the local destruction of field enhancement in the hybrid sample and thus it is concluded to get desirable emission characteristics further modification is necessary.

Paper No. 104

Effect of PCM embedding on indoor temperature through building wall

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Abstract
This study addresses the growing energy consumption in the building sector due to the increasing demand for thermal comfort, primarily driven by heating and ventilation needs. Phase Change Materials (PCMs) offer a promising solution as they can store significant heat energy during their phase change process, based on latent heat principles. The selection of the appropriate PCM depends on the region's climate, with a focus here on the hot climate of central India where temperatures can soar up to 48-50 °C in summers. The research investigates PCM's role in enhancing thermal comfort for building occupants and compares its performance with traditional building materials. Two experiments were conducted on building wall structures: one to determine the optimal PCM layer placement and the other to compare PCM with materials like concrete bricks, sand, and an air gap individually. The experiments were conducted during the daytime with temperatures ranging from 35-39 °C. The results indicate that placing the PCM layer closer to the heat source provides better thermal comfort. Compared to traditional materials, PCM showed minimal temperature rise in a cold water bath, demonstrating reduced temperature fluctuations and prolonged cooling. This research highlights the potential of PCMs to enhance energy efficiency and occupant comfort in hot climates.

Paper No. 105

Molybdenum disulfide flake functionalized defect-rich carbon nanotubes as effective cold emitter: A possible low energy solution for efficient electron gun

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Abstract
This article reports the successful synthesis of carbon nanotubes in amorphous form (a-CNTs) through a low-temperature solid-state reaction. The as-synthesized a-CNTs were functionalized uniformly by flake-like MoS_2 nanostructure. XRD study confirms the amorphousness of the pure a-CNTs whereas functionalized sample shows the proper phase formation of MoS_2. Electron microscopic images confirm the tubular morphology of the pure a-CNTs as well as the uniform functionalization of the same by MoS_2 flakes. Elemental analysis done with the EDX study denied showing the presence of any impurities confirming again the proper phase formation. FTIR study enlightens about the presence of different bonding in the sample. When field emission characteristics of both the sample were taken it was seen that the functionalized sample shows much better results compared to the pure a-CNT. The turn-on field showed a decrease from 8.99 to 4.86 V/µm whereas a three-time increment in the enhancement factor from 930 to 2742 was obtained in the case of functionalized sample. The possible reasons behind the enhancement are the concentration of field lines at the sharp edges of MoS_2 flakes, a lesser work function of the foreign element as well greater electron transport through the favourable band bending.

Paper No. 108

Global estimates of energy efficiency savings in electricity supply

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Abstract
Global primary energy supply for electricity generation increased at a CAGR of 3.3 % and electricity generation grew 4.1 % during 1990-2020. Higher electricity generation for the same primary energy supply was achieved due to changes in the fuels used, and improvements in the efficiency of the electricity system. This study shows how these factors contributed to the change in the primary energy supply for electricity generation globally during 1990-2020. Using the log-mean divisia index, the changes in electricity generation energy use are decomposed into three main effects - demand, fuel mix, and efficiency. The energy efficiency improvements contributed to three-fourths of the savings and the remaining one-fourth was due to the changes in fuels in the primary energy supply for electricity generation.

Paper No. 109

Thermohydraulic performance due turbulators of multiple hemi-circular geometries in solar thermal collector

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Abstract
The use of solar energy, a substantial and environmentally sustainable form of renewable energy, is advantageous for a variety of purposes, encompassing heating, cooling, electricity production, and drying techniques. Solar air heaters (SAHs) have demonstrated significant efficiency in harnessing solar energy for various thermal applications, such as heating and drying processes. Despite the promise of solar air heaters (SAHs), their actual use is typically limited due to restricted convective heat transfer produced by the smooth absorber walls. The primary aim of this study is to enhance the thermal efficiency of a solar air heater (SAH) by including a set of carefully designed hemispherical turbulators in a strategic manner. The turbulators were built with meticulous attention to dimensional parameters, encompassing a range of width ratios (w/e) from 1.0 to 2.0. The relative height (e/H) was determined to be 0.5, and the relative pitch (p/e) was systematically defined at 10. A comprehensive series of experimental experiments was done, encompassing a wide range of Reynolds numbers, spanning from 2000 to 16000. The primary focus of this comprehensive assessment was on key performance metrics, specifically the Nusselt number, friction factor, and overall thermohydraulic efficiency. Significant enhancements were noted in the Nusselt number and the friction factor, with peak values of 2.85 and 5.75, respectively, observed under specific parametric conditions of w/e = 1.6, e/H = 0.5, and p/e = 10, as well as w/e = 1.2, e/H = 0.5, and p/e = 10.

Paper No. 111

Optimal battery control and performance enhancement with fuzzy logic maximum power point tracking in solar-PV system

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Abstract
The electric power produced from a solar photovoltaic system is contingent upon several interdependent parameters, including solar irradiance levels and cell operating temperature. Consequently, the implementation of Maximum Power Point Tracking Controllers (MPPT) is essential to attain the highest PV system power output, independent of environmental variations. This research suggests a fuzzy charge controller based on a maximum power point tracker (MPPT) for power harvesting from a solar photovoltaic (PV) to efficiently charge a battery storage system. The study explores a photovoltaic system with solar panels, MPPT technology, and a DC-DC buck power converter, utilizing the Fuzzy Logic Control (FLC) algorithm to charge a 48-volt battery. The research involves a comparative analysis between two MPPT approaches, P&O (Perturb and Observe) and FLC along with battery charge controllers. Simulation results reveal that the FLC algorithm exhibits the fastest response time during standard and variable test conditions, minimal start-up fluctuations, and the highest overall efficiency.

Paper No. 113

Effect of ionic salt in synthesized biopolymer for electrochemical applications

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Abstract
In this communication, the creation of an electrolyte system composed of pectin biopolymer and an ionic salt (KI)-incorporated biopolymer composite is disclosed. The composite electrolyte films of synthesized pectin biopolymer with KI salt at various concentrations have been made using the solution cast process. The conductivity for pectin biopolymer-based electrolyte sheets can reach orders of 7.8×10^{-6} S/cm, a three-order increase above the conductivity of pure pectin (2.7×10^{-9} S/cm). The current communication describes electrical, structural, and optical analyses of the biopolymer electrolyte films. The POM pictures, which highlight the amorphous nature of the electrolyte films, serve as a representation of the optical properties. The ionic makeup of biopolymer electrolyte films is shown by the maximal cationic transference number. UV-visible optical absorption spectroscopy in the wavelength range of 300-800 nm was used to examine the optical characteristics.

Paper No. 114

An effective model for performance prediction of a centrifugal pump with nose caps using CNN

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Abstract
The centrifugal pump is to be cost-effective, efficient, reliable and ensures safe operation at or near Best Efficiency Point [BEP] and is heavily used in various day-to-day applications. Flow instabilities emerge in a centrifugal pump while operating outside of its design parameters. To reduce the flow instability, the conventional fastener for the impeller of a centrifugal pump is modified with the addition of nose caps. The authors created 12 different design profiles to minimize the flow randomness over-suction region and have witnessed a reduction in instability. While the experimentation can be done with different other design profiles also, it consumes considerable time and resources. Computer programs based on Machine Learning (ML) have proven to employ algorithms to autonomously develop cost-effective solutions while saving a substantial amount of time and enhancing the systems' effectiveness, adaptability, and quality. The paper proposes an effective CNN [Convolutional Neural Network] based network to predict the output parameters of centrifugal pumps for different nose caps and operating conditions. The model is trained using a dataset taken from the readings through experimentation and is validated using a test dataset. The performance of the model is validated using standard metrics like RMSE and R^2.

Paper No. 116

Fabrication and thermal characterization of carbon-based composite phase change material for latent heat thermal energy storage applications

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Abstract
This study describes a comprehensive exploration into the fabrication and thermal analysis of composite phase change materials (PCMs) that have been enriched with carbon nanoparticles such as Graphene nanoparticles (GNPs) and Multiwalled carbon nanotubes (MWCNTs). The primary objective of this research is to augment the thermal properties of these composite PCMs. The study employs a systematic experimental methodology encompassing the selection of base materials and additives, composite PCM preparation, and characterization of their material properties. The investigation reports the improvement in the cooling rate of Paraffin-based PCMs because of the integration of the selected nanoparticles. The enhancements in cooling rate are marked, with an increase of 13.719 %, 8.841 %, 5.792 %, and 1.829 % for 1 wt % Paraffin/GNPs, 1 wt % Paraffin/MWCNT, 2 wt % Paraffin/MWCNT, and 2 wt % Paraffin/GNPs composite PCM respectively. However, future investigations are needed to exercise discretion in determining the optimal size and concentration of nanoparticles to extract the maximum benefits of the cooling rate. In addition, the incorporation of nanoparticles was found to modify the phase transition of the base PCM resulting in the preservation of high energy storage capacity. Further scrutiny of thermal analysis demonstrated that the fabricated nano-enhanced phase change materials (NePCMs) exhibit good thermal stability. The fabricated NePCMs should be promising contenders for applications pertaining to solar energy storage.

Paper No. 121

Optimal model parameter estimation of PEM fuel cell using mountaineering team based optimization

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Abstract
In this paper, a recently developed meta-heuristic (MH) algorithm, namely mountaineering team-based optimization (MTBO), has been applied to estimate seven unknown model parameters of proton exchange membrane (PEM) fuel cells. The mathematical model of the PEM fuel cell is considered to be complex and non-linear and it contains several unknown parameters. Identification of these parameters is difficult using classical approaches. MH approaches are capable of solving complex problems. Therefore, MTBO has been used to identify the values of these parameters. A sum of squared error (SSE) based objective function is considered and minimized in this study. The error is the difference between the experimental and estimated value of voltages. The polarization characteristics, such as I-V and P-V curves have been used to evaluate the accuracy of the algorithm. Results obtained using MTBO have been compared with four competitive algorithms namely, grey wolf optimization (GWO), Harris Hawk Optimization (HHO), differential evolution (DE) and whale optimization algorithm (WOA). The great closeness between the experimental and estimated polarization characteristics reveals that MTBO is a good identifier. Moreover, convergence curves and box plot studies have been used to check the speed and reliability of the algorithm. From the convergence curve it is observed that MTBO converges easily as compared to other algorithms. Also, from the box plot study, it is seen that with the lowest median and small interquartile range, MTBO outperforms other algorithms. Moreover, a statistical study including mean, standard deviation, best and worst values is also performed to check the robustness of MTBO. It is concluded that MTBO performs better than other competitive algorithms in solving the problem of parameter estimation of PEM fuel cells.

Paper No. 122

Evaluation of optimal weibull parameter for wind resource assessment at coastal terrain by metaheuristic optimization algorithms using reanalysis data

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Abstract
This study focuses on evaluating wind resources at a coastal terrain in India by optimizing the parameters of the Weibull distribution. The research utilizes a 22-year dataset from NASA MERRA-2 reanalysis to analyse wind characteristics. The Weibull probability distribution is used, and the shape (k) and scale (A) parameters are determined through three different numerical techniques (Modified Maximum Likelihood Method (MMLM), Empirical method of Lysen (EML) and Method of Moment (MOM)) along with two metaheuristic optimization algorithms (Particle Swarm Optimization (PSO) and Genetic Algorithm (GA)) at a height of 50 meters. The accuracy of the methods is assessed using goodness of fit tests, RMSE, and R2. The results indicate that all parameter estimation methods are suitable, but the MMLM is the most accurate for evaluating wind potential. PSO was shown to be more efficient than the GA. These findings are anticipated to contribute to existing knowledge on probabilistic modeling of wind resources and the usefulness of MERRA-2 in assessing wind resources.

Paper No. 126

Emission assessment from the energy sector of Tumuyon Khullen village of Manipur in India

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Abstract
Stabilising greenhouse gas (GHG) emissions from the energy sector is crucial for global sustainability. This paper presents an in-depth analysis and quantification of GHG emissions from the energy sector in Tumuyon Khullen village in North-East India. The study captured emissions from commercial, institutional, residential, agricultural & forestry activities and road transportation. The total average GHG emissions from the energy sector were estimated to be 1307.4 T CO_2e per annum. Residential energy use emerges as the most significant contributor producing 986.6 T CO_2e, accounting for nearly 75.5 % of total emissions. Road transportation, institutional & commercial sectors and agricultural & forestry account for 267.8 T CO_2e (20.5 %), 20.9 T CO_2e (1.6 %) and 8.8 T CO_2e (2.4 %) of the total emissions, respectively.
The research findings underscore the IPCC conclusion that residential energy use can lead to significant GHG emissions, primarily when encompassing traditional energy sources like firewood. Emissions from agricultural & forestry reflect the impact of diesel-based mechanised practices. The diverse emission landscape emphasises the importance of sector-specific initiatives to reduce GHG emissions. Given the significant share of residential emissions, the transition to cleaner energy sources for domestic usage could have a substantial impact. For transportation, strategies could include promoting electric or hybrid vehicles or enhancing public transport and non-motorized transit options. Research findings could contribute to a deeper understanding of GHG emissions in rural Indian contexts and underlines the urgency and opportunities for targeted interventions to mitigate local GHG emissions.

Paper No. 127

Assessment of extent of crystallisation of $CuCl_2$ (from quaternary system of CuCl, $CuCl_2$, HCl, water) and its limiting conditions in crystallisation step of thermochemical Cu-Cl cycle

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Abstract
Cu-Cl thermochemical cycle is a process for generation of hydrogen without emission of greenhouse gases. It involves four steps viz. electrolysis, crystallisation, hydrolysis and thermolysis to achieve overall splitting of water into hydrogen and oxygen in a closed loop. In the electrolysis step of the cycle, electrolyser produces hydrogen gas and its effluent (spent electrolyser solution) consists of a quaternary system comprising $CuCl_2$, CuCl, HCl and water. The composition of the electrolyser effluent may vary based on electrolyser operating conditions. This effluent is fed to the crystallizer to separate $CuCl_2$ crystals which are utilised in hydrolysis step, while the remaining liquid is recycled back as part of the feed to the electrolyser. Thus, the crystallisation step is essential for sustained cyclic operation. Owing to the narrow range of conditions under which this crystallisation occurs, every electrolyser effluent may not yield crystals on cooling. This makes investigations on the extent of crystallisation and its limiting conditions for processing electrolyser effluent of varying composition important. Experiments are conducted for different electrolytic conversion, acidity, crystallisation temperature, residence time considering 2M CuCl as the electrolyser feed. Few experiments have also been done for different feed concentration of CuCl keeping conversion same. The experiments have been conducted with simulated electrolyser effluent. The crystallisation is found to produce needle-shaped bright green coloured crystals of different sizes with varying yield based on experimental conditions. XRD analysis of product samples show $CuCl_2$/$CuCl_2.2H_2O$ crystals. This study throws light on crystallisation operations for varying electrolyser effluent compositions and operating conditions of interest.

Paper No. 128

Model parameter extraction of solar PV cell using gold rush optimizer

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Abstract
In this article, a recently developed metaheuristic optimization algorithm, Gold Rush Optimizer (GRO) is applied to extract five model parameters of a solar photo-voltaic (PV) cell. The mathematical model of a PV cell is considered to be highly complex and non-linear and extraction of model parameters is found to be a multivariate and multimodal problem. It is difficult to solve this problem by conventional methods. Metaheuristic algorithms have the advantages of solving this problem of parameter extraction. Therefore, in this paper, GRO has been used to extract the parameters and is compared with five state-of-art algorithms such as grey wolf optimization (GWO), differential evolution (DE), bald eagle search (BES), harris hawk optimization (HHO), and whale optimization algorithm (WOA). Parameter extraction problem is characterised by an objective function which is defined as the root mean squared error (RMSE). Two case studies have been considered in order to evaluate the effectiveness of GRO. Also, the accuracy of the algorithm has been checked through the closeness between estimated and experimental I-V characteristics for both the case studies. Moreover, convergence curves have been plotted to evaluate the convergence speed and the effectiveness is evaluated using statistical study including min, standard deviation and mean of RMSE value. It is observed that GRO extracted model parameters of solar PV cells accurately and statistical study reveals that GRO outperforms among other algorithms.

Paper No. 130

Structural analysis and optimization of a shell and tube condenser employed in the low-temperature thermal desalination (LTTD) process

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Abstract
Though India is surrounded by water from three sides, potable water is scarce. NIOT has been actively utilising ocean water to generate drinking quality water for island communities in India. This technology, called the low-temperature thermal desalination (LTTD), is an offshoot of the ocean thermal energy conversion (OTEC) cycle based on the Rankine cycle. The condenser is one of the key components in the LTTD plant which is responsible for producing drinking quality water. While the condenser should be capable of condensing the incoming vapour efficiently, the structural integrity of the component also needs to be looked at, owing to the huge pressure difference on both sides of the shell, weight of the component plus water weight acting on the supports, and the buckling strength. For this, the condenser was modelled in ANSYS Design Modeler and AUTODESK Inventor. Subsequently, the condenser was analysed in ANSYS Workbench for its structural and buckling strength, corresponding to various load cases. The design was modified accordingly and was optimised.

Paper No. 137

Gas hydrate-based post-combustion carbon dioxide capture and separation from flue gas

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Abstract
Gas hydrates are crystalline, non-stoichiometric inclusion compounds formed by host water molecules, which encase the guest molecules through hydrogen bonding. There exist several applications of gas hydrates including energy (methane/natural gas) storage, gas separation, CO_2 capture, desalination etc. Considerable research efforts are put forth globally on CO_2 capture, utilisation, and sequestration to battle global warming and climate change. Post-combustion carbon dioxide capture encompasses a method of removing CO_2 from exhaust flue gas. The development of such a technology can retrofit the existing direct flue gas emissions points. In this study, we examine the kinetics of hydrate formation using a simulated flue gas mixture (75 % N_2/25 % CO_2) in the presence of Tetra n-butyl ammonium chloride (TBAC) and L-methionine. Experiments were conducted between the temperature range 273.2-283.2 K and 8-8.8 MPa pressure. It was found that 0.5 wt % L-methionine effectively promoted the hydrate formation resulting in a high separation factor for CO_2. For different concentrations of the TBAC and L-methionine, various kinetic parameters including the gas uptake, separation factor, and t90 were calculated. Morphology observations during the formation are also presented.

Paper No. 152

Preparation and characterization of CuO nanoparticles dopped paraffin wax composite for solar thermal energy storage in the solar drying application

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Abstract
Thermal energy storage (TES) systems for solar dryers receive wide attraction as the TES system enhances the performance of dryers. The most promising phase change material (PCM) for TES in solar drying applications is thought to be paraffin wax. However, the performance of the TES is hindered by the low thermal conductivity of paraffin wax. In the present study, composite PCMs comprised of pure paraffin wax and copper oxide (CuO) nanoparticles have been developed with various weight percentages (1 %, 2 %, 3 %, and 4 % CuO), and their thermo-physical characteristics were investigated with Field Emission Scanning Electron Microscope (FESEM), Energy Dispersive X-ray analysis (EDAX), Differential Scanning calorimetry (DSC), and Thermogravimetric Analysis (TGA), Fourier-transform infrared spectroscopy (FTIR) and Thermal conductivity analyzer. The FESEM images of 1% and 2 % CuO nano-composite revealed that nano-particles diffused equally in paraffin wax and formed a sound network, enabling for improved heat transfer within the paraffin wax. However, sample with 3 % and 4 % CuO nano-particles suffers from more agglomeration. No foreign molecules were detected in the samples other than the constituents of the CuO in the EDAX analysis. DSC heat flow curves for all samples follow a similar pattern, and there are no noticeable alterations at the crest, revealing that the influence of CuO nanoparticle addition on phase change temperature is insignificant. TGA results demonstrate that the dispersion of CuO nano-particles specifically delays the thermal breakdown of Nano-CuO paraffin composites and improves thermal stability. FTIR spectrum has proved that the dispersion of CuO nanoparticles has no effect on chemical bonding with the paraffin. This ensures that nano-CuO–paraffin composites are chemically stable. According to theoretical model calculations, increasing the weight percentage of CuO nanoparticles in pure paraffin wax raises the sample's thermal conductivity in both the liquid and solid stages. However, except for thermal conductivity, the results were not satisfactory when adding nanoparticles above 2 % weight fraction due to the localized agglomeration and higher cost of nano-particles.

Paper No. 153

Doped graphitic carbon nitride: An efficient supercapacitor material

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Abstract

Synthesis of graphitic carbon nitride (GCN) has been done by simply solid-state heating of urea at a moderate temperature of 550 °C. The synthesized GCN was further doped by transition metal like nickel using nickel nitrate as a precursor. The X-ray diffraction shows that after doping the sample loses its crystallinity considerably whereas the FESEM micrograph shows after doping the chips-like structure of pure GCN gets profound elongation around a specific direction. XPS spectrum confirms the doping of the sample with a profound 2p peak of nickel. When FTIR spectra were taken it was seen that the spectra contained a profound FTIR pattern that is characteristic of pure GCN whereas after doping the spectra also show profound shifting from its initial pattern. All these collectively suggest that doping causes considerable changes in the internal crystal structure of GCN. Both the pure and doped GCN showed promise as charge storage material when a cyclic voltammetry study was performed with two different scan rates. However, the doped sample shows the value of specific capacitance as high as 90 F/g much higher compared to that of the pure sample. The charge-discharge characteristic of the doped sample also shows a marked change in pattern compared to the pure one. The EIS spectra of both the samples show a capacitive nature showing the promises of the system to wards super-capacitor applications.

Paper No. 154

Design and development of a compound parabolic concentrator (CPC) solar water heating system: A case study

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Abstract
Design, installing, commissioning, and testing of Compound Parabolic Concentrator (CPC) based fully automatic Programmable Logical Control (PLC) controlled solar water heating plant is carried out at ACG Capsule Pvt Ltd Pithampur, Indore (22.61 °N, 75.67 °E) to cater to the demand of 60,000 litres of hot water at 80 °C per day. A total 1152 m^2 aperture area of CPC collector is installed in four different interconnected sites. An average quantity of 48,500 litres of hot water is achieved after testing the plant. The installed Compound parabolic concentrating (CPC) collector technology system can save 1,56,000 litres/year of High-speed diesel which emits 6315 tons of CO_2 in 15 years and needs 320 acres of forest to absorb it.

Paper No. 156

Experimental investigation of effect of a transverse crack on Wind Turbine Blade using vibration based method for the development of SHM

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Abstract
This study attempts to implement the methodology of analysing the health condition of a wind turbine blade under the influence of a transverse crack using a vibration-based technique. A commercially available wind turbine is used to study the effect of transverse crack on the blade using Fast Fourier Transform (FFT) Analyzer. Initially, a frequency spectrum of wind turbines with intact blades is recorded as an indication of healthy condition. A transverse crack is induced on one of the blades to record the frequency spectrum of the wind turbine considering the occurrence of damage. For various locations of cracks at different depths, the frequency spectrum was recorded. It was observed that due to the presence of a crack, an imbalance in the system is generated. It was found that as the crack approaches to free end of blade frequency was decreased indicating a reduction in stiffness. The introduction of the crack reduced frequency considerably however for an increase in the depth of the crack hardly any reduction in frequency was observed. To predict the location of a crack, a program in Python language was constructed using a database prepared from experimentation. Various machine learning algorithms were used in the program to form a basis for structural health monitoring (SHM) systems. Out of the algorithms used, K Nearest Neighbour (KNN) showed promising results. It is concluded that the constructed program is able to identify the occurrence of cracks at a particular location.

Paper No. 157

A novel explore - Harvest Monte Carlo algorithm for dynamic reconfiguring PV array based electric vehicles

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Abstract
The globe is currently experiencing a serious energy crisis in all sectors, but the energy constraint is most acute in the automobility sector for fossil fuel-powered automobiles. This energy problem will be significantly alleviated by the current trend of electric vehicle reintroductions to the market, which will also assist in cutting carbon emissions. There is a lot of research being done to increase the efficiency and mileage of electric vehicles, and mounting a photovoltaic array to a moving vehicle may be a practical way to both assist in propulsion and completely utilize solar energy while driving throughout the day. This technique will work best when applied to larger vehicles with more surface area, including buses, trams, cruise ships, low-altitude aircraft, etc. The dynamic reconfiguration of such a photovoltaic array mounted to a moving vehicle under partial shading conditions using a fast and highly efficient novel algorithm is proposed

Paper No. 162

Opto-thermal design and analysis of a 1 MW panel solar central receiver for small-scale applications

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Abstract
This paper discusses the design and analysis of a panel receiver for the solar tower, with the objective of designing a suitable receiver for a small-scale solar tower plant. The plant is intended to have a high temperature (> 400 °C) thermal power output of 1 MW to be used for charging thermal storage for various applications like backup for a thermal power plant or metallurgical applications. The heat flux distribution obtained on the panel receiver has been obtained using a radial staggered heliostat field. This design and analysis of the panel receiver has been done for Bikaner, India on spring equinox, solar noon. The thermal efficiency of this designed receiver comes out to be 85.9 %.

Paper No. 165

Investigation of cooling performance of hybrid battery thermal management system using nanoparticle enhanced composite PCM and nanofluid charged pulsating heat pipe for electric vehicles

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Abstract
Electric vehicles (EVs) are becoming a popular choice for consumers. Battery thermal management system (BTMS) is an active research area as battery overheating leads to lower battery life and fire hazards. In this work, a hybrid BTMS is proposed using a composite PCM (Paraffin 1 wt. % Fe_3O_4 nanoparticle) and a nanofluid (2 wt. % $CuO+Fe_3O_4$-water) charged pulsating heat pipe. An experimental investigation is conducted to investigate the performance of this hybrid BTMS. A module of 6 substitute batteries is considered as a heat source, which generates equivalent heat generated by 18650 lithium-ion battery cells operating at a 3 C discharge rate. The findings indicate that when utilizing natural convection cooling at the PHP condenser, the PCM reduces 28.21 °C in cell sur-face temperature. On the other hand, when employing forced convection cooling, the reduction is 16.43 °C compared to baseline results without the hybrid BTMS.

Paper No. 166

Experimental investigation of biogas and Karanja biodiesel blend on the effect of performance and emissions of dual fuel C.I engine

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Abstract

In the evolving global energy landscape, environmental concerns and depleting fossil fuels drive interest in sustainable alternatives like biogas and biodiesel. This study focuses on the performance and emissions of a karanja biodiesel-biogas dual-fuel engine, bridging gaps in existing research. It explores engine dynamics considering factors like blends, compression ratios and loads. Increasing load correlates with higher brake thermal efficiency, while B25 and B50 biodiesel blends exhibit lower BTE, highlighting fuel composition's role. Smoke emissions decrease with higher biodiesel blend percentages and increase with lower compression ratios. Biogas-biodiesel fuel demonstrates reduced smoke and NO_x emissions compared to pure biodiesel. Elevated compression ratios lead to higher NO_x levels, except for B50 biogas-biodiesel blend, showing lower emissions. The study concludes that biogas-biodiesel mode offers advantages in emissions control and sustainable fuel choice, contributing to a comprehensive understanding of alternative fuel engine behaviour. In the context of energy's vital role in economic progress and the environment, this research guides future exploration for greener energy options.

Paper No. 167

Investigation of effectiveness of economizer arrangement with screw compressor to provide subcooling to enhance COP in various Natural refrigerant based cascade freezer in warm ambient

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Abstract

In this study, two natural refrigerant based cascade refrigeration system (CRS) configurations having a single low temperature evaporator maintained at –45 °C are investigated for a cooling load of 60 kW operating in warm ambient of 45 °C. Both the CRSs employ IHX in LTC to ensure suction super heat and a de-super heater to reduce the cascade heat load. One of the configurations, termed as IDI employs an IHX at the condenser exit to provide subcooling effect while the other configuration termed IDE has an economizer arrangement with screw compressor to provide the subcooling effect. R744 is used as refrigerant in the low-temperature circuit (LTC). While four different natural refrigerants, namely R717, R290, R1270 and R600a are explored for the high temperature circuit. The energetic and exergetic performance for both the configurations are evaluated and compared. Among the configurations, the overall COP is found maximum for IDE system for all refrigerant pairs while refrigerants pair R744/R600a outperform others for both IDI and IDE configurations. The highest overall COP for R744/R600a pair is found to be 1.21, while the same is found 1.29 for IDE which is a 6.6 % improvement.

Paper No. 168

Effect of the sediment sizes on the CO_2 hydrate formation: Applicable to carbon capture and sequestration

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Abstract
One of the potential carbon capture and sequestration techniques for mitigating global warming is capturing CO_2 from industrial sources and delivering it below the oceanic floor (depth>300 m), where CO_2 capsulizes in the gas hydrate lattice. Gas hydrate is the crystalline compound that forms when guest molecules (CO_2, CH_4, etc.) are encapsulated by water molecules at high-pressure and low-temperature conditions. At such depth, the viability of storing CO_2 using hydrate depends on the kinetics of CO_2 hydrate formation in the presence of varying sizes of oceanic sediment. So, in this study, a real-world scenario is mimicked where CO_2 was delivered using a pipeline inside the different sizes of sediments [smaller size sand (Diameter = 0.5-1.5 mm) and larger size sand (Diameter = 1.5-3.0 mm)] and CO_2 hydrate formation kinetics and morphological changes were studied. The results show that CO_2 uptake per mol of water is higher in the presence of smaller-size sediments (0.11 mol/mol) than larger-size sediments (0.09 mol/mol). The experimental outcomes of the study offer valuable insight of CO_2 hydrate formation in oceanic sediments and would help in the advancement of carbon capture and sequestration technology via hydrates.

Paper No. 169

Natural water cooler: An innovative, energy-efficient and low-cost solution for cooling water

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Abstract
In the scorching heat of the Indian summer, access to cool and clean drinking water is of utmost importance. However, rural areas often face the challenge of erratic power supply, making traditional water-cooling solutions ineffective. Existing water coolers in the market are expensive, electricity-dependent, and use harmful refrigerants for cooling. To address these issues a Natural Water Cooler (NWC) was developed which is a low-cost, energy-efficient, and eco-friendly solution based on the principle of heat exchange. This present study describes the design, operation, and advantages of a natural water cooling system (NWC) that uses solar PV technology, copper coils covered with viscose fabric, and a DC fan. The NWC lowers water temperature by 6 to 10 °C by using copper coils encased in viscose fabric and operated by a solar powered fan. The maximum efficiency of about 65 % is reported for a dry bulb temperature of around 41 °C and RH of 17 % for the considered time duration. Incorporating a water filtration system into the natural water cooler ensures the delivery of clean and safe drinking water, solving public health issues sometimes connected to improperly maintained cooling systems. The use of copper coil in the system also brings additional health benefits due to its antimicrobial properties.

Paper No. 171

Evaluating HHV prediction equations using proximate and ultimate analyses

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Abstract
Biomass, in rural areas, is obtained through variety of crops and biomass residues from forestry, agriculture and the agro-industry, is an abundantly available fuel source. Usage of biomass residue as a solid fuel result in air pollution, which affect both indoor and outdoor environments. Considering the pollution problem and many more, gasification emerges as an environmentally and economically fit alternative to conventional biomass combustion. The current study evaluates the potential of various biomass resources as fuel source by analysing their calorific values, proximate and ultimate values. Wheat straw, paddy straw (PB-370, PR-1121, PR-44 and PR-126), maize and bajra were chosen for analysis due to their abundance in Punjab. Thermo-chemical properties, chemical properties and calorific values are investigated in the present research. Proximate and ultimate analysis values are used to predict Higher Heating Value (HHV) from twelve different equations (six from proximate values and six from ultimate values). The investigation conducted in this study delved into a comprehensive analysis of predicted HHV calculations derived from various equations, which provide significant insights into the energy potential of the examined biomass. The research encompassed a meticulous examination of both proximate and ultimate values, thereby elucidating the intricate relationships governing the biomass's composition and its energetic attributes.

Paper No. 175

Experimental investigation on performance analysis of air source heat pump system

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Abstract
As a solution to the need for clean heating, a low-temperature air-source heat pump heating system with great efficiency and little impact on the surrounding environment has been proposed and put into operation. The heat pump is a device that makes effective use of energy. Heat pumps are very versatile and may be used in a wide range of settings. Some of these settings include the refrigeration sector, industrial operations, the heating and cooling of buildings, and the heating and cooling of water. Heat pumps can also be used to refrigerate food. Air-source heat pumps are used far more often than geothermal heat pumps for the purpose of providing household heating. The principal reason for this is that air-source heat pumps have lower expenses associated with their installation. The R-410A refrigerant is utilised because it does not contribute to the depletion of the ozone layer and has a modest contribution to the warming of the planet. Observations indicate that the performance coefficient, on average, is 3.5. When compared to an electric heater, the energy consumption of a heat pump is much lower at 74.66 %.

Paper No. 176

Energy and exergy analysis of evacuated tube solar air heater for air heating applications

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Abstract
In today's world, it is very necessary to make use of solar energy in a variety of contexts in order to keep the environment clean and reduce dependency on fossil fuels. The primary objective of this research is to assess the efficiency of solar air heating systems that make use of evacuated tube collectors and combine these systems with inherent sensible heat storage capacities. In the course of this research, a maximum hot air temperature of up to 80 °C was reached. According to the findings of the research, it is possible for the system to function normally for air heating between the hours of 8:00 and 18:00. When there is low radiation, such as during evening hours, the stored heat is utilized to heat the air. The hot air that is produced by the evacuated tube solar air collector is used for a variety of purposes such as space heating, food processing, dairy production, sun drying, and desalination of water.

Paper No. 178

Thermal degradation behavior, thermal stability, and kinetic analysis of solid wastes for their valorization

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Abstract
The management of municipal solid wastes is one of the major problems for many years. As a result, it has a fatal contribution to the circumstances of hazardous effects such as a critical role in the pollution of major water bodies, fire hazards, health issues, etc. This work deals with providing solutions to such kinds of problems. The outcomes of this study will provide a roadmap to analyse the pyrolysis potential, heat recovery potential, pollution potential, etc. This study can explore the optimized utilization of municipal solid wastes thoroughly. Several thermal analysis techniques such as proximate analysis, calorific value analysis, thermogravimetric analysis, and differential thermogravimetry are adopted to analyse selected samples in a sophisticated manner. Non – isothermal TGA experiments were performed under heating rates of 5, 10, and, 20 °C /min from room temperature to 900 °C. With a purge flow of nitrogen at the rate of 100 mL/min. The kinetic analysis was performed using model-free integral isoconversional models such as Kissinger–Akahira–Sunose (KAS), Flynn – Wall – Ozawa (FWO), Starink (STK), and Tang (TM) respectively, and the reaction mechanisms for the active pyrolysis stage of devolatilization were predicted using the model-fitting method of the Coats–Redfern method. This stage for three samples represented Avrami–Erofeev (A2), Ginstling Brounchestein (D4), and 2–D Diffusion (D2) models respectively. The findings of this study will play a major role in the selection of the most appropriate samples for higher oil yield via the pyrolysis technique, and in designing, modifying, and optimising the pyrolysis reactor.

Paper No. 180

Application of EV trucks: An emerging future in Indian cement industry

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Abstract
The cement industry in INDIA, the second largest in the world in terms of installed capacity, is an important partner to the Government for realizing the dreams of "New INDIA" Presently, the industry is heavily reliant on road infrastructure to transport cement from plant to end user using conventional diesel trucks. Apart from being economically expensive, using diesel trucks also leads to harmful emissions like CO_2, CO, NO_x, and particulate matter in the atmosphere. The present study compares the usage of electric trucks with conventional diesel trucks and finds it as an economically lucrative and environmentally beneficial solution for addressing the logistical woes of the Indian cement industry.

Paper No. 182

Insights into biomass gasification: A statistical analysis

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Abstract
Biomass gasification stands as a critical route for sustainable energy generation. In this study, we perform a comprehensive analysis by harnessing the combination of principal component analysis (PCA) and multivariable regression analysis. Our study attempts to work out the entangled relationship between the different variables involved in the gasification process through a literature-derived dataset, finally leading to the formulation of predictive equations with implications for the field of biomass gasification. The biomass gasification process has a number of factors, i.e., independent variables, that can vary the output, i.e., dependent variables. Data was collected from various scholarly articles. The data set involved the values of independent variables, viz., proximate analysis, ultimate analysis, gross calorific values, gasification conditions (equivalence ratio (ER), gasification temperature), and dependent variables, viz., output gas vol % and gas LHV. Two PCAs were performed, first for all variables and then only for independent variables. A total of 6 principal components (PC) and 4 PCs were generated for all variables and for only independent variables, respectively. The PCA of all variables with 6 PCs covered 80.32 % of the variance, while 4 PCs of independent variables covered 74.10 % of the variance. The four PC independent variables were regressed with the dependent variables to obtain the final regression equation. This study's findings provide valuable insights into the biomass gasification process through the combination of PCA and multivariable regression and the correlation between the different independent and dependent variables.

Paper No. 189

Assessing the impact of integrating triangular grooves on the performance of a double pass solar air heater

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Abstract

An extensive literature survey on a double-pass solar air heater (DPSAH) contributed to the idea that the inclusion of fins, grooves, ribs, etc. on the absorber plate increased their performance. So, a numerical study for the enhancement of thermal and hydraulic performance of a DPSAH has been done. Equilateral triangular-shaped grooves of 15 mm length were placed at 50 mm from each other. The length, breadth and height of the solar air heater are 1014 mm, 350 mm and 72 mm respectively with a relative height ratio i.e. e/H value of 0.4. A constant and continuous heat flux of 880 W/m^2 was supplied on the roughened absorber plate. The entire computational work was carried out using ANSYS 23.0 software and the RNG k-Ɛ turbulence model was used for the simulation. By performing the grid test, a 2mm grid size was considered for further analysis. And with the Reynolds number (Re) ranging between 3000-15000 different values of the Nusselt number (Nu) and friction factor (f) were obtained. The Nu and f of the DPSAH with a triangular grooved absorber plate are compared with that of a flat absorber plate to obtain the thermo-hydraulic performance parameter (THPP). The maximum THPP obtained is 3.29 at Re 3000 which is higher than the contemporary models.

Paper No. 190

Compressed biogas with biodiesel as pilot fuel performance on novel variable compression ratio mechanism assisted DI diesel engine

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Abstract
In this paper the effect of renewable fuels like blending of Mahua bio- diesels up to 20 % and compressed biogas fuel performance in duel fuel mode using single cylinder direct injection diesel engine has been evaluated. The engine utilizing non-conventional fuels with lower calorific value increases the harmful emissions and reduces power output. To overcome this drawback, the engine accompanied with the variable compression ratio (VCR) mechanism. If VCR is adjustable as per load and speed of the engine during the operation, the fuel under consideration will perform to better achieving higher efficiency. In this study, the compression ratio 12,14,16 and 18 has been analysed and predicted the optimum condition of the engine for the particular fuel under consideration. The unique feature of the testing is that the automatic variation in compression ratio as per load and speed of the engine using novel mechanism incorporate the variable injector location also. This mechanism utilizes the auxiliary piston that reciprocates inside the main combustion chamber increasing or decreasing the effective clearance volume achieving the compression ratio variation. This mechanism facilitates this alteration in compression ratio without intervention of human being. The smooth variation in compression ratio causes the compete combustion of the charge and hence higher efficiency could be achieved.

Paper No. 191

Effect of chord radius on performance of hydrokinetic turbine

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Abstract
The energy flow rate per unit flow area of water flow is quite high compared to airflow. This is because of the high density of water compared to that of air. Hence, a hydrokinetic turbine has the potential to extract more power compared to a wind turbine for the same size of a turbine. The Darrius turbine is one of the best options that can be used as a hydrokinetic turbine due to its high coefficient of power. In the present work, the experimental investigations are carried out to study the hydrodynamic performance of three bladed Darrieus turbine with NACA0012. The effect of five different chord radius are investigated with numerical simulations, as a basic profile of the Darrieus turbine vanes. The result indicates that the optimum performance of the turbine is obtained for CRR = 2 (chord radius = 500 mm) which is 12.5 % higher than that of the conventional NACA 0018 profile of turbine vanes. The maximum torque of the turbine is obtained for CRR = 3 (chord radius = 750 mm) which is 6.41 % higher than that of the conventional NACA 0018 profile of turbine vanes.

Paper No. 193

Effect of inner arc extension on the performance of vertical axis wind turbine

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Abstract
Wind power is widely accessible and widely recognized as one of the cleanest and most sustainable kinds of electricity. In the present investigation, the vertical axis wind turbine with modified Savonius turbine vanes is explored. The modified Savonius vane shape suggested by Kerikous et al. for hydro- dynamic application, is further analysed for wind turbine application in the pre- sent investigation. The domain size optimization, grid independence study, and validation of the used methodology are carried out before going to the detailed investigation of the present investigation. The outcome of the results is analysed using velocity and pressure contours, variation of coefficient of torque, and coefficient of power with different tip speed ratios. The results indicate that the zero vane extension provides the best power coefficient among all the cases of vane extensions investigated in the present study.

Paper No. 195

Development and performance evaluation of a desiccant-aided evaporative cooling system with solar regeneration for dry regions: Comparative analysis and feasibility study

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Abstract
This research aims to create a Desiccant-Aided Evaporative Cooling (DAEC) unit tailored for dry regions, using silica gel for desiccation and solar thermal regeneration. The study combines theoretical analysis and practical tests in Jodhpur, Rajasthan, to control indoor temperature and humidity for improved comfort. Parametric studies explore performance factors, and a comparison with prior research highlights the system's effectiveness, which ranged from 80 % to 85 % over multiple days. A feasibility index 20.7 is demonstrated, emphasizing the simplicity and efficiency of this model for dry regions, unlike previous research focused on high-humidity areas.

Paper No. 196

Experimental Investigation for Drying Solanum Tuberosum (Potatoes) in Solar Air Dryer

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Abstract
Most developing countries are unable to solve their food problems due to increase in the population that have a direct impact on food balance. Because of poor processing techniques, storage facilities and quantity of food deterioration. To maintain this balance, drying of crop is important to preserve the fruits and other fresh food from spoilage, harmful bacteria. Drying of crop can be done in many ways either by using artificial mechanical dryer or under the open sun. but the first method uses fossil fuel which is very costly, going to deplete in future and harmful for environment. The second method is totally depending upon the weather condition. By the contrast, use of solar dryer is cheaper and more efficient that includes protection from flies, pets, rain or dust. In developing countries solar dryer is used to fulfil the demand of good quality and low-cost food by using sustainable source of energy. A direct solar dryer was used in the present work and potatoes were dried. The moisture content of potatoes from 75 % to 15.6 %. the results show that the most effective factor on drying rate is temperature of sir and velocity of air inside the dryer. pre-treatment plays very important role in drying process that increase drying rate and reduce drying time. The pre-treated product dried earlier as well as has less effect on the colour of product than untreated product.

Paper No. 201

Optimization of biodiesel synthesis parameters of waste cooking oil through response surface methodology

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Abstract

As increase of cost of crude oil and exhaust emission. The research is focused on production of biomass blended fuel having similar combustion property of diesel. It achieves the required energy demand and also reduces the exhaust emission formation. In the present study waste cooking oil (WCO) is use for making of bio fuel through response surface methodology (RSM) based transesterification process. The Box-Behnken design is used to explore the impacts of the primary operating factors including methanol, catalyst concentration, and reaction time on the production of biodiesel. The results revealed that the most crucial parameter is the catalyst concentration. The maximum bio- diesel yield under optimal condition is 98.75 wt %. An empirical quadratic equation has also been developed to demonstrate the relationship between biodiesel conversion with its viscosity.

Paper No. 202

Forecasting model for the consumption of naptha and deisel using deep learning

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Abstract
The country's energy policy is highly dependent on petroleum products as it is considered one of the significant energy resources. With increasing growth in energy demand, a well-built forecasting model is critical to effectively monitor energy policies by offering energy miscellany and energy needs that conform to the country's diverse structure. Decision-makers, regulating authorities, and energy providers will benefit from the accurate predictions of petroleum products and their usage. This paper develops a deep learning framework consisting of a Long Short Term Memory (LSTM) model and deep feedforward layers. The pro- posed model is termed Deep Long Short Term Memory (DLSTM). The developed model is utilized via training through the monthly consumption data of two major petroleum products (Naptha and Diesel) from the fiscal year 1998 to 2019 and predict the consumption of these products for the next three years

Paper No. 203

Electronic and optical features of halide perovskite CsGeBr3 using modified Becke Johnson potential within DFT

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Abstract
Cubic perovskite halides are considered as potential materials for photovoltaic applications. In this paper, electronic and optical properties of halide perovskite CsGeBr3 using full potential augmented plane wave (FP-LAPW) method are presented. An accurate exchange-correlation potential namely modified Becke Johnson (mBJ) as embodied in Wein2k code (FP-LAPW scheme) is employed in present computations. For a more realistic work, we have used the available experimental lattice parameters. The direct band gap at Z point (0.591 eV) arises due to valence band maximum of Ge(4s) and conduction band minimum of Ge (4p) states, which is close to available experimental band gap. Optical properties namely real and imaginary dielectric constants, reflectivity, absorption coefficients show its usefulness in solar cells. Further, the absorption coefficient in the energy range 10 to 20 eV unambiguously depicts its applicability in the ultraviolet rays detectors. Moreover, the present optical and electronic properties are compared with available isovalent halides in bulk and thin film phases.

Paper No. 205

Tariff structures for residential electricity consumption in India: An analysis of disparities and effect on consumption

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Abstract
Residential electricity consumption in India constitutes about 25 % of the total electricity consumption and is poised to grow significantly in the coming decades. Electricity tariff is a significant factor affecting residential electricity consumption. This paper examines the process of setting the residential tariff structures in different states of India by respective agencies. Data from regulatory bodies are used to compare the tariff structures of different states and bring out significant differences. Further, the affordability of electricity in different states is compared using the metric of cost of electricity for a lifeline consumption of 100 kWh/month. Further, the effect of tariffs on electricity consumption is analysed. The results indicate that tariff paradigms in India vary widely, often without sufficient justification. While telescopic multi-scale tariffs are used by most states, Jharkhand is the only state that uses a single slab system. Analysis of the cost of electricity shows that states like Rajasthan have very high electricity tariffs, which hampers the affordability of electricity, especially for the lower social strata. Twenty states fall into the category of high tariff, and low consumption which shows that rationalizing tariffs may support increased electricity use.

Paper No. 206

Analyzing trends in appliance ownership and the residential electricity consumption in rural India: A case study of Maharashtra state

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Abstract
Residential electricity consumption in India contributes to nearly one-fourth of the total electricity consumption. Electrification has a key role in rural development; however, the translation of electrification into appliance ownership and rural development remains understudied across time. This study aims to understand the appliance ownership and electricity consumption trends in rural Maharashtra using household-level data. The study presents an analysis of appliance ownership and usage hours of fans, televisions (TV), air conditioners, refrigerators, washing machines, and air coolers. The data reveals significant disparities between urban and rural areas, with an overall increase in appliance ownership over time. Light and fan ownership have high ownership levels followed by televisions. Air conditioners and washing machines were observed to be the least owned appliances. The spatial distribution of appliance ownership and electricity consumption revealed various disparities amongst northern and southern states of India. In Maharashtra, Vidarbha region is observed to have more cooling appliances especially air coolers as compared to the rest of Maharashtra, while refrigerator and washing machines are observed to be highly owned in the western region of Maharashtra. The findings of this study offer valuable insights into the dynamics of electricity consumption and appliance ownership.

Paper No. 208

Systemic approach for sustainability assessment of mini-grids: A review and some causalities

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Abstract
Mini-grids are considered to be a promising solution for providing a reliable electricity supply, especially in remote and rural areas. However, there are various challenges faced by the mini-grids - technical, social, economic, environmental, and organisational. Past efforts to assess the sustainability of mini-grids have used cross-sectional studies (static approaches). The assessments are focused on the impact assessment of the projects where the sustainability of the projects may not be reflected. This study attempts to adopt a dynamic approach to the sustainability assessment of mini-grids. The recent literature on sustainability assessment and systemic approaches in the area of mini-grids has been reviewed and summarized. The paper proposes a causal loop diagram for mini-grids, considering different techno-economic variables. There is a scope to expand this work to include various dimensions of sustainability assessment.

Paper No. 211

Implications of time of day tariff policy on residential consumers with grid-connected rooftop solar PV systems in Ahmedabad, India

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Abstract
In June 2023, the Government of INDIA announced that a Time of Day (ToD) tariff policy would be implemented for electricity consumers by April 2025. The notification proposes time-differentiated billing based on three periods: peak period, normal tariff period, and solar hours. This paper examines the implications of the proposed ToD tariff policy on the electricity bills of residential consumers having grid-connected rooftop photovoltaic (PV) systems by analyzing the changes in their energy charges. The hourly residential electricity consumption data for the year 2018 is collected from the National Energy End-use Monitoring (NEEM) dashboard. A grid-connected rooftop PV system is simulated with the help of System Advisor Model (SAM) software to get the hourly generation data. The energy charges are calculated for four households to understand the potential impact of implementing the ToD tariff policy. The study concludes that the design of ToD tariff (charges/rebates) has the potential to influence the projected savings of the consumers having grid-connected rooftop PV systems. The impact can be neutralized by providing additional incentives for surplus exported electricity. If consumers with grid-connected rooftop PV systems are penalized more than other consumers because of the ToD tariff, it may jeopardize the ongoing efforts of the central and state governments to accelerate the deployment of the grid-connected solar PV systems.

Paper No. 212

Adsorption of light oil on rock surfaces: A molecular dynamics study

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Abstract

In enhanced oil recovery, the extraction efficiency of injecting fluids heavily relies on the adsorption behavior of crude oil on the rock surface. Thus, a detailed molecular-level understanding of crude oil-rock interactions is crucial when designing novel injecting fluids. Using molecular dynamics simulations, we investigated the structure and energetics of light oil (dodecane) near calcite, mica, and silica surfaces representing commonly observed carbonate, clay-type, and sandstone reservoirs, respectively. We observed several layers of light oil adjacent to the rock surface with a strong bound layer on the calcite surface. We found epitaxial adsorption of light oil on the calcite surface, whereas less structured adsorption was observed on the mica and silica surfaces. We found that the distinctive adsorption pattern observed on each rock surface is governed by a specific surface atom (calcium on calcite, potassium on mica, and hydroxylated oxygen on silica). Hence, to delaminate the oil from the surface, the effect of such an influencing ion should be compensated with another ion or solvent that weakens the structuring.

Paper No. 214

Comparative analysis on performance of solar air heater by using nanomaterial-black paint coating on absorber plate

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Abstract

Heat is more effectively absorbed by absorber plates that include graphene, copper oxide, and cerium oxide nanoparticles mixed into the black paint. The Reynolds number fluctuates depending on the mass flow rate and fixed selective coating on the absorber plate. According to the experimental findings, graphene/CuO-black paint has an average thermal efficiency improvement of 3.58 %. Entropy generation ranges from 0.1557 to 0.8447, and it is higher for black paint and lowest for black paint that contains graphene/ CuO. According to the study of entropy generation, entropy production rises as the mass flow rate rises. With regard to other coating materials, the energy efficiency increase for graphene/CuO-black paint was found to be 4.39 %. Bejan's number, which goes all the way to unity (0.999), highlights enhanced thermal performance.

Paper No. 215

Standalone on-wheel solar milk pasteurization

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Abstract
Many conventional pasteurization equipment utilizes the thermal energy of steam. The combustible process of fuel creates this heat energy. Milk undergoes pasteurization by heating it to 63 ^{0}C while maintaining it there for a period of thirty minutes. In general, the pasteurization process is done on a large scale at a centralized location. There are only a few distributed milk pasteurization systems. The present article focuses on a study of onboard solar pasteurization system development. The solar energy may be employed to pasteurize milk. The pasteurization is carried out during milk transportation to the centralized location. One of the key parts of this system is the solar air heater. The effective rate of solar air heaters is influenced by several factors. These parameters, such as air mass flow rate, solar radiation wind velocity, and atmospheric temperature, are adjusted in this work to examine air variation in outlet temperature. For the air flow rate from 0.01 kg/s to 0.1 kg/s, air outlet temperature varies from 89.20 ˚C to 61.23 ˚C for 40 ˚C and for airflow rates from 0.1 to 0.19 kg/s, there is negligible impact on air outlet temperature. Further at the lowest air flow rate of 0.01 kg/s the variation in the outlet air temperature is 86.67 °C to 109.78 °C for the variation in the solar radiation is 700 W/m^2 to 1150 W/m^2. At 1110 W/m^2 and 4 m/s, the air outlet temperature is 110.05 °C which is sufficient for the milk pasteurization process.

Paper No. 217

An experimental investigation to determine the optimal nanomaterial for coating a solar thermal absorber panel

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Abstract
Most solar thermal systems use dull black absorber plates that absorb sun energy. Nanoparticles' enormous surface area and increased thermal conductivity promote heat transmission, thermal stability, heating, and cooling. This research identifies the best nanoparticle kind and proportion for dull black absorber plate paint to increase thermal performance. This exploration employs 10 %, 20 %, 30 %, 40 %, and 50 % aluminium, copper, and titanium oxide nanoparticles. Dull black paint with 30 % aluminium oxide nanoparticles had the highest average temperature of 55.3 °C in the open environment. This plate also had the largest radiation heat transfer (15 W) and average absorber plate-atmosphere temperature differential (20.9 °C). This study found that dull black paint with 30 % aluminium oxide nanoparticles is best for solar thermal device absorber plates. This experimental research advises using 30 % aluminium oxide mixed with dull black paint to boost the thermal performance of the absorber plate of solar stills, dryers, cookers, and air heaters.

Paper No. 218

Economic and emissions analysis of behind-the-meter energy storage with rooftop solar: A case study for Indian residential consumers

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Abstract
The global carbon dioxide emissions from fossil fuels continue to rise, driven by rising energy use. Rooftop photovoltaic (RTPV) systems are an effective way to reduce emissions and, consequently, the carbon footprint for residential consumers. The use of behind-the-meter (BTM) energy storage with RTPV is a flexible and dependable method for generating electricity as it provides power to the customer even if there is an outage from the utility grid. It also reduces reliance on the utility through savings in the electricity bill and reducing CO_2 emissions. In this paper, we analyse the economics and emissions along with the sizing of BTM battery storage co-located with RTPV for residential customers in India. Based on the power flow interactions between RTPV, grid, and battery storage, a techno-economic framework is built to compute the system's life cycle cost. The life cycle cost of energy for BTM battery storage with RTPV to meet a 14-kWh energy demand is INR 11/kWh. We observe a 75 % decrease in utility costs and a 58 % reduction in CO_2 emissions for the same system. The findings of this study can help policymakers, utilities, and homeowners make informed decisions regarding the adoption and integration of energy storage systems with residential solar PV installations.

Paper No. 219

Tuning the solvothermal method for the synthesis of nanostructured free-standing supercapacitor electrodes

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Abstract
The development of robust energy-storage technologies is necessary due to the continuously growing global energy demand. Supercapacitors exhibit high power densities, and further enhancement of their energy densities makes them suitable candidates for reliable energy storage applications. In this study, we have synthesized NiMn Layered Double Hydroxides (NMLs) deposited on activated carbon cloth (CC) as the electrode material for high-performance supercapacitors. The NML@CCs are synthesized using a one-step solvothermal method by varying the composition of the reaction medium, using different combinations of de-ionized water and ethanol. Various structure characterization techniques are employed to study the synthesized NML@CC nanostructures for phase and morphological information. The effect of reaction media on the electrochemical performance in a 3-electrode setup is investigated comprehensively. The observed results indicate that the maximum electrochemical performance is exhibited by the electrode fabricated using pure ethanol as a reaction medium, with a specific capacitance of 3675 F g^{-1} @ 2 mA cm^{-2}. This study paves the way to tune synthesis routes to achieve high performance supercapacitor electrodes.

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