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ABSTRACT PROCEEDINGS

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## PLENARY SESSIONS

### PS1: Calculation of complex chemical reaction equilibria: old and new approaches



*Ahmed Bellagi*

Dr. Ahmed Bellagi is emeritus professor of chemical and energy engineering at the Ecole Nationale d'Ingénieurs de Monastir since 1992. Prior to that, he has been a professor of chemical engineering at the Ecole Nationale d'Ingénieurs de Gabès. He received his PhD in 1979 from the Rheinisch-Westfälische Technische Hochschule at Aachen, Germany. His research interests mainly focus on Process Thermodynamics, Absorption Refrigeration and Solar Cooling, Modeling and Simulation of Unit Operations and Processes.

Recently, his pedagogical interests focus on the development of Demonstrations for chemical and energy engineers using the software Mathematica® in collaboration with Dr. H. Binous.

<http://demonstrations.wolfram.com/author.html?author=Bellagi>

### PS2: Bio-composite materials gypsum-based reinforced with natural fibers and/or cords



*Imed Miraoui*

Imed Miraoui is a Professor at the University of Gafsa, Tunisia and a member of the TEIM Laboratory (Technology, Energy and Innovative Materials). He received his B.Sc. degree in Mechanical Engineering from the University of Monastir in 1994 and his M.Sc. degree in Applied Mechanics from the University of Tunis El Manar in 1996. In 2008, he earned his Ph.D. in Mechanical Engineering from ENIT – University of Tunis El Manar, in collaboration with the School of Engineering at Virginia Commonwealth University, USA. In 2006, he joined the Higher Institute of Applied Sciences and Technology at the University of Gafsa, Tunisia, as an Assistant Professor. From 2011 to 2018, he was with the College of Engineering at Jouf University, Saudi Arabia, where he also served as Head of the Mechanical Engineering Department for four years. He is currently an Associate Professor and the Dean of the College of Applied Sciences and Technology at the University of Gafsa. His main research interests include the mechanics of materials, energy and laser machining. He is a certified Project Management Professional (PMP) and an ISO 21001 Lead Auditor. Miraoui serves as the project manager of PAQ-DGSE, a quality support program in higher education funded by the World Bank and the Ministry of Higher Education. He has participated in several national and international research projects as both a coordinator and a partner.

### PS3: Computational Fluid Dynamics (CFD) in Energy Systems: Innovations, Challenges, and Future Applications



*Mouldi Chrigui*

Professor Mouldi Chrigui is a faculty member at the Ecole Nationale d'Ingénieurs de Gabès (ENIG), where he leads the Mechanical Modeling, Energy and Materials Laboratory. Previously, he was a research associate at Darmstadt University of Technology and has supervised numerous PhD theses in chemical and mechanical engineering. A recipient of Tunisia's national scholarship, he completed his engineering (Dipl.-Ing.) and master's degrees at the Karlsruhe Institute of Technology (KIT) before earning a PhD in Mechanical Engineering from Darmstadt University of Technology. He also spent one year at Heidelberg University and undertook an extended scientific stay at South Wales University in Sydney, Australia. With extensive experience in academia and industry, Professor Chrigui has made

significant contributions to Computational Fluid Dynamics (CFD), combustion modeling and multiphase flow simulations. As a certified international expert in combustion modeling, he has played a key role in cutting-edge industrial projects and has contributed to the advancement of simulation methodologies.

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**PS4: Power energy and green hydrogen production using ceramic electrochemical technology: Issues, challenges and developments at CNR-ITAE**



*Massimiliano Lo Faro*

Dr. Massimiliano Lo Faro is a Senior Researcher at the Institute for Advanced Energy Technologies “Nicola Giordano” (CNR-ITAE), which is part of the Italian National Research Council (CNR). He earned his Ph.D. in Materials for Environment and Energy from the University of Rome “Tor Vergata” in 2008, focusing on ceramic materials for direct hydrocarbon oxidation in solid oxide fuel cells (SOFCs). Since joining CNR-ITAE in 2008, he has led research activities on SOFCs, contributing to over 100 publications. His expertise spans solid oxide electrochemical devices, including fuel cells, electrolysis cells and batteries. He has edited textbooks such as Solid Oxide-Based Electrochemical Devices and Hybrid Technologies for Power Generation and his contributions have been recognized with awards like the H2Roma award and multiple Dokiya Fund grants. Dr. Lo Faro has also served as a guest editor for journals like the International Journal of Hydrogen Energy and Electrochimica Acta.

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**PS5: Thermal Storage: the case of Solar Pond**



*Mohamed Jomaa Safi*

Professor Mohamed Jomaa Safi, currently Professor Emeritus, has had a distinguished career in physics, mathematics and energy research. He holds a State Ph.D. in Mathematics (1987) and a Ph.D. in Physics (1980) from the University Pierre et Marie Curie (Paris 6), along with a B.S. in Theoretical Physics from the University Diderot (Paris 7). He has served as Vice-President of the Tunisian Society of Physics, a Visiting Fulbright Professor at the University of Texas and M.I.T. and a Visiting Professor at the University of Ancona (Italy). He was appointed Full Professor of Heat Transfer and Energetics at the National Engineering School of Tunis (ENIT) and directed key research units, including “Mechanics and Energetics” at ENIT and “Metrology in Thermal Science and Fluid Mechanics” at the National Engineering School of Monastir. His contributions extend beyond academia, having served as Advisor to the State Secretary for Research in Energy, Water and Environment and as Coordinator of the Arab Network on Desalination Technologies and Renewable Energy Sources under the Arab Science and Technology Foundation (ASTF). He co-founded major scientific conferences, including the Euro-Med Conference on Desalination, the International Conference on Applications of Porous Media and the Maghreb Conference on Water, Energy and Climate Change. His achievements have been recognized with awards from the Arab Science and Technology Foundation (2008), the Sustainable Development Institute of the College of Menominee, Wisconsin, USA (2005) and the Italian Government, which honored him as Knight of the Order (Cavaliere dell’Ordine) in 2005.

**PS6: The Biomechanics of the Bone Remodeling after Hip Arthroplasty**

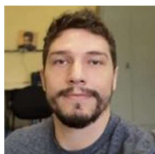


*Anas Bouguecha*

Professor Anas Bouguecha is a distinguished academic specializing in mechanical engineering. He is affiliated with the Ecole Nationale d'Ingénieurs de Gafsa (ENIGA), where he leads the Mechanical Modeling, Energy and Materials Laboratory. Professor Bouguecha earned his Ph.D. in Mechanical Engineering and has achieved habilitation (Dr.-Ing. habil.), reflecting his advanced research qualifications. His expertise encompasses finite element analysis, metal forming, biomedical engineering, materials engineering and computer engineering. Throughout his career, he has supervised numerous Ph.D. theses in both chemical and mechanical engineering, contributing significantly to the academic community. Professor Bouguecha has also collaborated on various international research projects, enhancing the global understanding of mechanical systems and materials science. In addition to his role at ENIGA, he has been associated with Leibniz Universität Hannover, further extending his academic influence. His prolific research output includes publications on topics such as formability of steel sheet sheared edges and reprocessing of aluminum chips by hot backward extrusion, underscoring his commitment to advancing mechanical engineering and materials science.

## EXPERT INTERVENTION

### EI1: AI-Driven Innovation: From Industrial Predictive Maintenance to Renewable Energy Advancements



*Marcos Vinicios Barp*

Marcos Vinicios Barp is a research fellow at the Institute for Advanced Energy Technologies (CNR ITAE) in Messina, Italy. He obtained his Bachelor's (2016), Master's (2018), and Ph.D. (2022) degrees in Physics from the Federal University of Santa Catarina, Brazil. His research focuses on developing analytical and computational models for improving fuel cell efficiency and investigating physicochemical properties of materials using Ab Initio methods. Prior to joining CNR ITAE in 2024, he worked as a Data Scientist at Dynamox, applying AI algorithms to industrial asset monitoring and developing software using Python, Pandas, FastAPI, Keras, and TensorFlow. He also contributed as a Ph.D. researcher for CNPq, specializing in Ab Initio and analytical methods in atomic and molecular physics, positron scattering simulations, and high-performance computing with CUDA, C++, and Python.

## ORAL PRESENTATIONS

### Advanced Computational Mechanics

#### **ID69: Transient-Based Characterization of Pipe Deterioration in a Single Pipeline System**

*Wejden Yaakoubi, Lazhar Ayed, Caterina Capponi, Silvia Meniconi and Bruno Brunone*

Gradual thinning of pipeline walls, often brought on by corrosion or fatigue, can be surprisingly difficult to spot but poses a real threat to both safety and reliability. In this paper, we introduce a mathematical approach that pinpoints and assesses this type of widespread weakening in a single pipeline divided into three sections: upstream, the damaged zone, and downstream while incorporating a new experimental-numerical formula. We use both steady-state and transient flow analyses, applying the method of characteristics to capture wave propagation, frictional losses, and changes in the pipeline's inner diameter. With the assumption that a single layer is uniformly thinning, we can home in on the weakened area by interpreting pressure and velocity readings. This approach then delivers straightforward estimates of how much the wall has thinned and the length of the compromised zone. In the end, our framework offers a practical, non-intrusive, and efficient method for spotting and measuring gradual, large-scale pipeline damage, ultimately ensuring safer and more cost-effective infrastructure management.

#### **ID70: Nozzle shape Optimization of an UL-PRS Crossflow Turbine Using the Adjoint based gradient Solver**

*Zaineb Touati, Khaled Souaissa, Marco Sinagra, Tullio Tucciarelli and Mouldi Chrigui*

The optimization of Crossflow turbines is crucial for enhancing energy efficiency in various power generation systems. This paper presents a study on the optimization of a Crossflow turbine using the ANSYS Adjoint Solver to maximize the target torque and improve the turbine's performance. The optimization was conducted at the turbine's optimum design point, with a head of 40 m and a flow rate of 190 L/s. The optimization approach resulted in a significant increase in torque while maintaining a rotational speed of 753 rpm. The findings demonstrate the effectiveness of the optimization approach in improving turbine performance by reducing energy losses and optimizing blade geometry. This study provides valuable insights into the enhanced utilization of Crossflow turbines in diverse applications.

#### **ID44: Performance Analysis of a Helical Savonius Hydrokinetic Turbine Using CFD Simulations**

*Mariam Elakrout, Ahmed Ayadi and Abdallah Bouabidi*

Electricity plays a crucial role in economic growth, driving the need for innovative and sustainable energy solutions. As the demand for renewable energy sources grows, hydrokinetic turbines have gained attention as a promising technology for harnessing energy from water currents, offering a reliable alternative to traditional power generation methods. Among these, the Savonius turbine stands out due to its simple design, self-starting capability, and high efficiency in low-velocity flows. This study investigates the performance of a helical Savonius hydrokinetic turbine submerged in a rectangular water channel using Computational Fluid Dynamics (CFD) simulations in ANSYS Fluent. The numerical results are carefully compared with experimental data to validate the accuracy of the simulations. Emphasis is placed on analyzing the torque and power coefficients as functions of the tip speed ratio (TSR), which are key parameters for evaluating turbine performance. Additionally, the study delves into the local flow characteristics around the helical Savonius turbine, providing a detailed understanding of the complex fluid dynamics involved. The findings contribute to optimizing

turbine design and operation, offering valuable guidance for the development of more efficient hydrokinetic energy systems that can significantly enhance sustainable power generation.

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**ID27: Numerical Simulation of Vacuum-Assisted Resin Infusion: Process Analysis**

*Houssef Cherif, Saouab Abdelghani, Khawla Essassi, Abdelkhalak El Hami, Anas Bouguecha and Mohamed Haddar*

The Vacuum-Assisted Resin Infusion (VARI) process has emerged as a pivotal technique in liquid composite moulding (LCM), enabling the efficient production of high-quality composite materials with minimal equipment investment. However, optimising the resin infusion dynamics and preform compaction remains a critical challenge due to the complex interplay of hydromechanical parameters. In this study, we employ numerical simulations based on the finite difference method to model the intricate flow behaviour and structural deformation within the VARI process. Our work systematically investigates the effects of resin viscosity, infusion pressure, and fibre compaction on the pressure distribution, resin flow kinetics, and resulting preform thickness. The findings reveal key sensitivities in the process parameters that directly influence manufacturing consistency and material performance. By integrating simulation results with analytical models, this study provides a comprehensive framework for understanding and optimising the VARI process, contributing valuable insights to enhance the reliability and efficiency of composite manufacturing technologies.

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**ID72: State estimation of Fractional Order Systems: Application to a Spring-Mass-Damper**

*Salsabil Khchim, Anissa Benaicha and Atef Khedher*

This article discusses the design and analysis of the Luenberger observer for fractional-order linear systems based on a state representation using the Caputo derivative. For FOS, the Lyapunov stability criterion is used to ensure the robustness and convergence of the observer. Global stability is guaranteed by the Mittag-Leffler criteria. We suggested the dynamic mechanical system example of a "spring-mass-damper" for numerical simulations to study the modeling and estimation states and to demonstrate the efficacy as well as the precision of the proposed methods in a variety of dynamical situations.

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**ID66: Assessment of a CFD Model for Organic Waste Pyrolysis in a Bubbling Fluidized Bed**

*Souad Aboudaoud, Souad Abderafi and Mohamed Ammar Abbassi*

The incorporation of a proper pyrolysis kinetic model is important to ensure accurate simulation of biomass waste fast pyrolysis. The aim of this work is to assess the performance of a CFD model composed of a multi-fluid model combined with two-stage, semi-global reaction mechanism for pyrolysis, which is developed to study red oak valorisation into bio-oil in a 2D bubbling fluidized bed. The simulations were conducted using Open Foam software. The yields of pyrolysis products predicted were calculated and compared with experimental yields, demonstrating successfully the performance of the kinetic model. The latter has predicted tar, char, and gas yields, with satisfactory relative errors of 2%, 8%, and 10%, respectively. Furthermore, the product yields computed by two-step, semi-global kinetic scheme proved more accurate than those provided by multicomponent-multistep and single component-single step reaction mechanisms. Therefore, two-stage, semi-global model with the appropriate kinetic constants is well convenient for predicting the pyrolysis of wood waste.

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**ID12: The effects of the thermodynamic behavior of air in the surge tank on the water hammer wave**

*Chourouk Mabrouki, Lazhar Ayed and Sami Elaoud*

The change in the flow regime of a fluid contained within a hydraulic system often leads to sudden pressure variations. The resulting pressure surges or depressions can reach significant magnitudes. These transient phenomena are known as water hammer. In the absence of protective measures, the presence of these phenomena can lead to the destruction of pipelines and pumping stations that make up the hydraulic installation. Various control devices and procedures are being considered to eliminate or mitigate the undesirable effects of hydraulic transients. These control devices are generally expensive, and no universal solution exists that is suitable for all applications. As such, the search for an effective and economical protection method remains a key focus for researchers. The alternative that provides a globally cost-effective system depends on its response and operational flexibility. An acceptable system response includes meeting specified limits on maximum and minimum pressures, maximum turbine or pump speed, prevention of liquid column separation, drainage of the balance tank or air chamber, etc. The objective of this work is consisting on both the numerical simulation of transient flows in simple and complex hydraulic systems, and the numerical solution method known as the method of characteristics to analyze the effects of different protective measures on the pressure waves generated by the water hammer phenomenon.

**Renewable Energy Systems**

**ID3: Optimization of food cooking time and temperature in a closed, concave, elliptical solar cooker of revolution exposed only in front of a paraboloidal reflector concentrator.**

*Abdelmoumen Hidouri, Kamel Rabhi and Slimen Attyaoui*

In this paper, we propose to analytically calculate, based on the dimensional characteristics of a cooker and those of a paraboloidal concentrator reflector, the heat quantities involved in a solar cooking system. This system is, essentially, composed of a glass cooker, shaped like a semi-ellipse of revolution around a vertical axis, placed at the focal zone of a paraboloidal concentrator reflector, and a pot of food installed in this cooker. The reflector reflects the incident solar rays towards the cooker. This cooker transmits the quantity of heat thus produced to the pot. This amount of heat received by the pot helps to cook the food at the final temperature  $T_f$ . Finally, for certain geometric parameters of the cooker, we plot the evolution of the final temperature  $T_f$  as a function of the reflector surface area, then its evolution as a function of the pot surface area, and its evolution as a function of the cooking duration.

**ID5: The Libyan Green Energy Belt: Bridging Renewable Energy and Sustainable Agriculture in Arid Climates**

*Mohamed Misbah and Ahmed Sawi Sharif*

This paper presents an in-depth analysis of the Libyan Green Energy Belt. A groundbreaking project that is designed to tackle current climate change issues and promote long term growth in Libya by combining renewable energy generation with sustainable farming projects and intelligent city planning to build a robust and diverse economy that can withstand shifting climate change conditions.

The study focuses on the project's second phase, which spans from Ajdabiya - Alwihat district along to Kufra district through a newly high speed transportation route that links north libya to its south. It involves jobba farming and cutting edge sustainable energy technologies such as solar panels (PV)

concentrated solar power systems and hydroelectricity using GMR extensions. Additionally it focuses on producing biofuels and green hydrogen as well as building climate resilient smart urban areas.

The paper examines the initiative's potential of capturing around 25 million tons of CO<sub>2</sub> annually and producing significant clean energy. It investigates the water management strategy in dry areas implemented by the project as well as its efforts to combat desertification and promote economic variety. Moreover the analysis covers the societal impacts such as employment opportunities, advancements in food security and enhanced quality of life for local communities.

This study contributes to the current global discourse on climate change mitigation by proposing a comprehensive approach to sustainable development in dry areas like the Libyan Sahara region through the Green Energy Belt findings and recommendations for policymakers and professionals striving for lasting solutions, in climate sensitive regions globally.

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### **ID15: Experimental and Numerical Study of The Aerodynamic Characteristics of Helical Darrieus Rotor**

*Dorra Ghodhbane, Ahmed Ayadi and Zied Driss*

As the world increasingly shifts toward renewable energy sources to reduce dependence on fossil fuels and combat climate change, wind power, particularly from Darrieus wind turbines, plays a pivotal role in meeting global energy needs sustainably. This study focuses on enhancing the aerodynamic performance of the Darrieus wind turbine rotor to increase its efficiency and maximize power capture from the wind. A detailed numerical simulation was performed using a three-dimensional model, considering both steady and unsteady flow conditions to investigate the impact of several key factors: mesh structure, turbulence models, and discretization criteria. The computational domain was divided into two sub-domains using ANSYS Design Modeler: one representing the steady-state test vein region and the other a rotating cylindrical domain encompassing the helical rotor. In terms of boundary conditions, a uniform wind velocity of 9 m/s was applied at the inlet upstream of the rotor, while atmospheric pressure was set as the outlet downstream. The study demonstrated that the mesh structure and size, as well as the turbulence model and the rotating domain's size, significantly influence the accuracy of computational results. After comparing several turbulence models, For the turbulence model the SST was selected due to its proven effectiveness in similar studies and its strong agreement with experimental wind tunnel results

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### **ID25: Experimental Analysis of the Thermoelectric Performance of an Air-Based Photovoltaic-Thermal (PVT) Solar Collector On-Site**

*Hatem Oueslati and Kamel Sahlaoui*

The objective of this study was to investigate the impact of different parameters on the thermoelectric performance of an air PVT system with a finned absorber. For this purpose, an experimental setup was built with a well-defined geometric design. The system performance and main parameters were analyzed and discussed under two operating modes, active and passive mode. The results were performed in two consecutive days of similar metrological conditions at the Borj Cedria site, Tunisia. The results showed an improvement in electrical efficiency from 13% in passive (without ventilation) mode to 14% in active mode (with ventilation) and overall thermal efficiency from 40% to 55%. In addition, the PV/T system offers higher profitability in terms of costs and revenues according to an economic study compared to other photovoltaic (PV) and thermal (ST) systems.

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**ID61: Experimental and numerical analysis of solar water heater with and without Phase Change Materials**

*Sami Missaoui, Eya Missaoui and Zied Driss*

This study explores the potential of phase change materials (PCMs) for solar energystorage via latent heat in solar water heaters. Its primary focus is to investigate the thermal performance of solar water heaters incorporating PCM. The mathematical model of a new composite material (Paraffin/Expanded Perlite) was simulated using ANSYS Fluent. To validate the proposed model, numerical predictions were compared with analytical solutions. The results illustrate the capacity of the PCM to store solar energy effectively.

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**ID64: An innovative solar heating device for a standalone solar dryer powered by solar energy**

*Sara Baddadi and Salwa Bouadila*

Food drying, as a means of post-harvest preservation, has been widely adopted in many industries and storage facilities. However, the drying process requires a tremendous amount of thermal energy in the form of high latent heat for water evaporation. This substantial energy demand accounts for 20–25% of the energy used in the food processing supply chain and 7–15% of the total global industrial energy consumption. Therefore, leveraging technological advancements with renewable energy sources is a more efficient approach to addressing the food waste crisis while preserving the environment. Among these sustainable sources, solar energy is a highly accessible and sustainable energy source that is widely used for heating, refrigeration, water distillation, desalination, and drying due to its environmentally friendly nature and low cost.

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**ID78: Study of the Performance of a Capillary Exchanger Coupled with a Hybrid PV/T system**

*Mariam Zaghdoudi and Majdi Lahzami*

The photovoltaic (PV) conversion of solar energy into electricity typically occurs under elevated temperature conditions. However, it is well-documented that high temperatures adversely affect the efficiency of PV cells. To mitigate this issue and improve overall energy efficiency, PV conversion can be integrated with thermal (T) systems, resulting in hybrid PV/T systems. This paper presents an experimental and theoretical analysis, used previously by several authors, to study the electrical and thermal performance of a novel PV/T hybrid concept, which combines a PV panel with a heat exchanger. The heat exchanger, facilitating forced water circulation, serves dual purposes: cooling the PV panel and heating water for domestic applications. The experimental investigation compares the performance of the proposed PV/T hybrid system with that of standalone PV and water heater panels. The numerical study delves into the mathematical equations governing the operational principles of the PV/T system, which are formulated and solved using TRNSYS software to conduct a numerical analysis of the hybrid PV/T system's efficiency.

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<b>Materials Science and Engineering</b>
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**ID4: Synthesis of metallic nanoparticle coatings on TiO<sub>2</sub> nanotubes: physicochemical and tribological characterization**

*Abid Boubakri, Firas Bensliman, Hafedh Dhiflaoui, Jabeur Ghozlani and Anouar Hajjaji*

In this work, we decorated biocompatible titanium (TiO<sub>2</sub>) nanoscale films on platinum Pt, by anodization and photoreduction, which is an efficient process for the synthesis of coatings, by setting the anodization potential at 70 V, the temperature of 25 to 27 °C with the anodization time of 120 min. Morphological characterizations showed a highly ordered TiO<sub>2</sub> nanotubular structure with 72.99 nm

in length, 33.10 nm in diameter and 11.73 nm in wall thickness using scanning electron microscopy (SEM) and transmission electron microscopy (TEM) techniques.

We focused our study on a physicochemical and tribological characterization of the coatings by scratch tests. The results obtained show a dense and uniform morphology coupled with significant interfacial properties. The TiO<sub>2</sub> coatings showed a measure of adhesion by scratch tests. The TiO<sub>2</sub> layers showed with a critical adhesion load LC<sub>3</sub> for 3 hours of photo-reduction equal to 7.0575. The tribological properties were studied, using a multi-pass Scratch test at constant load 1,2 and 3N which allowed to determine the friction coefficient and the energy wear rate. The friction coefficients decrease if the load is increased. It is observed that the energy increases with increasing load, and shows that the number of hours of decoration of Pt NPs deposited by the photoreduction method reduces the energy dissipated during wear. The specific wear energy equals 1.354, 3.984 and 8.082J for 1.2 and 3N e. TiO<sub>2</sub> thin film, known for its biocompatibility and biological performance, has shown tribological properties that allow it to be used in hip and knee implants.

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#### **ID54: Thermomechanical Characterization of a Composite Material based on Plaster and Wood Powder**

*Nahed Soussi, Marwa Ammar, Ameni Mokni and Hatem Mhiri*

This work is realized in the context of valorizing natural waste, in particular wood powder. This type of waste was incorporated into a plaster matrix to produce new construction material. An experimental study was carried out to characterize the thermo-physical and mechanical properties of a composite material made from gypsum and wood powder. Mechanical tests such as compressive strength and flexural strength were carried out to assess the impact of wood powder on the material strength. To analyze thermal behavior, thermal conductivity tests were carried out. These tests showed that the addition of wood powder improves thermal insulation while affecting the mechanical strength of the material. However, the minimum requirements for flexural and compressive strength are satisfied. The results show that incorporating wood powder into gypsum creates a composite material that is both lightweight and thermally efficient, with an acceptable compromise between mechanical and thermal properties. This research contributes to the sustainability and optimization of materials used in construction by natural waste recovery.

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#### **ID62: The Effect of Normal Load on Friction in Glass Fiber-Reinforced Polyamide 66 Composites**

*Sami Missaoui, Riadh Autay and Zied Driss*

An experimental investigation was conducted to examine the influence of normal load on the contact surface of polyamide 66 reinforced with varying weight percentages of short glass fibers. Tests were performed under two distinct sliding loads, 25.58 N and 55.58 N, at a constant sliding velocity of 0.056 m/s. The results indicated that elevating the normal load on the specimen's contact surface during reciprocating dry sliding significantly increased the coefficient of friction. This behavior is attributed to changes in surface interaction mechanisms, such as enhanced asperity engagement and the formation of a transfer layer under higher loads.

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#### **ID26: Experimental Measurements and modeling of CO<sub>2</sub> adsorption on various zeolites**

*Hedi Jedli, Abdessalem Jbara, Mohamed Mbarek and Khalifa Slimi*

This study investigated the CO<sub>2</sub> adsorption on the zeolites Y and 13X. The both samples was characterized with Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and N<sub>2</sub> adsorption-desorption isotherm. The CO<sub>2</sub> adsorption equilibrium isotherms were investigated at 303,

313 and 323 K and modeled with Langmuir and Freundlich model. The obtained results showed that the zeolite 13X showed a high BET surface area of 786 m<sup>2</sup>/g with higher micropore volume (0.370 cm<sup>3</sup>/g) in comparison to the other sample. Isothermic heat of adsorption on the two zeolites shows that the heat of adsorption for 13 X is greater than Y, with values of 35 and 28 kJ mol<sup>-1</sup> respectively. The CO<sub>2</sub> adsorption capacity confirms that zeolites have the potential for efficient CO<sub>2</sub> capture and separation.

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**ID43: Experimental Investigation of PLA Rigidity in Fused Deposition Modeling**

*Manel Dhouioui, Boutheina Ben Fraj, Wissem Zghal, Hamdi Hentati and Mohamed Haddar*

This study investigates the rigidity properties of polylactic acid (PLA) polymers fabricated using fused deposition modeling (FDM). Experimental tensile tests are performed to assess the influence of key FDM parameters, which are layer thickness, printing speed, and printing orientation, on the mechanical behavior of 3D-printed PLA samples, with a particular focus on Young's modulus (E). A systematic variation of these parameters enables a comprehensive characterization of PLA's stiffness, providing insights into its structural integrity and potential applications in engineering and manufacturing. The results contribute to the optimization of FDM process settings to enhance the mechanical performance of PLA components, ensuring improved reliability in functional applications.

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**ID49: Characterization of Viscoelastic Behavior in creep and Evolution of the Schapery Model for Mirror Resin**

*Mohsen Dardouri, Ali Fellah, Fethi Gmir and Abdessattar Aloui*

This paper sheds light on the nonlinear viscoelastic creep behavior of mirror epoxy, recently applied on coating in the construction and civil engineering sector. The "3D epoxy" technology gives the interior a modern personalized look based on mirror epoxy, a two-component thermosetting liquid polymer. The ratio of hardener to resin is an essential factor with regard to the mechanical characteristics, and consequently reflects on the quality of the material in service. In this context, this study is concerned with the long-term viscoelastic behavior and the evolution of the Schapery model of pure mirror epoxy at 100:50 resin / hardener ratio. Five creep tests at constant stresses and at ambient temperature are carried out in order to numerically determine the static nonlinearity factors  $g$  and  $g_0$  formulated in the Schapery model. A remarkable consistency between the variations of the experimental and numerical values of the model programmed on MATLAB allows to say that the Schapery model describes well and in a satisfactory way the real behavior of the epoxy mirror.

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**ID39: Study of the influence of ball-end milling process parameters on the roughness of slightly inclined surfaces**

*Lotfi Dahmani, Boujemaa Hadj Brahim, Slimen Attyaoui and Mohamed Nasser*

This study examines the impact of ball-end milling process parameters on the arithmetic surface roughness (Ra) when milling slightly inclined surfaces in AISI 321 steel. This steel is widely used in many sectors due to its high mechanical properties and corrosion resistance. However, due to its low thermal conductivity and high ductility, it is considered a grade of low machinability. Two machining strategies were employed: unidirectional and bidirectional machining. The cutting speed (Vc), feed rate (fz), depth of cut (ap), and overhang length of the milling cutter (L) were the factors studied. The ball end milling process was optimized using Taguchi methodology (L16). ANOVA analyses were used to extract optimal process conditions based on surface performance. The study revealed linear regression models and the influence of each parameter on surface roughness (Ra). The feed rate (fz) was found to be the most significant parameter for surface roughness (Ra) in both unidirectional and bidirectional milling strategies. Using Taguchi's optimization method, we concluded that  $V_c = 97,37$

m/min,  $f_z = 0.05$  mm/rev,  $a_p = 0.5$  mm and  $L = 93$  mm were the optimized levels to improve the finished surface roughness in both cases. Overall, this study provides valuable insights into the effects of cutting parameters on surface finish during ball end milling of AISI 321 grade steel, which can be used to optimize machining processes in various sectors.

**ID73: Effect of fiber length and fiber load on the stiffness of Juncus acutus/LDPE composites**

*M. Essaleh, A. Khanfir, M. Yengui, M. Khlif, A. Bouguecha and M. Haddar*

In this study, a novel composite material based on Juncus acutus fibers and low-density polyethylene (LDPE) was developed and characterized. The natural fibers underwent an alkaline treatment process, followed by grinding and sieving to obtain two particle size fractions (0.5 mm and 1 mm), optimizing fiber dispersion within the polymer matrix. The treated fibers were then incorporated into LDPE at two reinforcement levels (5% and 10%) and extruded using a MEGDS32-1A single-screw extruder. Specimens were molded via injection molding following ISO 527-2 standards. A full factorial 22 design was conducted to evaluate the effect of fiber length and fiber load on the Young's Modulus of the composite. The results revealed that fiber length significantly improves stiffness, while fiber load showed no significant main effect. However, a strong interaction effect between fiber length and fiber load was observed. The interaction and contour plots analysis revealed a significant increase in stiffness with increasing fiber length and decreasing fiber load.

**Energy Storage and Batteries**

**ID47: Impact of Roof Shape on Thermal Comfort in Buildings with Integrated Phase Change Materials**

*Mohamed Habib Haddad, Sana Dardouri and Jalila Sghaier*

Building shape plays a critical role in energy efficiency and is a major factor in new construction. This approach can also be applied to buildings to explore potential energy savings through innovative roof designs. This study compares three roof shapes flat, gable, and domed regarding thermal comfort parameters (PMV, PPD, and indoor temperature) with and without the integration of phase change materials (PCM). Two key days were selected to represent extreme weather conditions: the coldest day in winter and the hottest day in summer. On these days, thermal factors often exceed comfort levels, as the average thermal comfort index reflects conditions during building occupancy, leading to deviations in indoor air temperature when heating and cooling systems are inactive. The results demonstrate that integrating PCM significantly improves indoor conditions. Specifically, on July 21, the internal temperature decreased by an average of 1.5°C, while on January 21, it increased by 1.5°C. Furthermore, the internal comfort zone improved, with a rise in PMV and a reduction in PPD, particularly for flat roofs. For gable and domed roofs, the inclusion of PCM resulted in only minor fluctuations in PMV and PPD values. However, for flat roofs, the integration of PCM notably enhanced these thermal comfort parameters, especially in winter, where the PMV index ranged from -1.34 to -1.03 without PCM, compared to -1.15 to -0.7 with PCM.

**ID48: Advanced control of electrolyzers powered by hybrid photovoltaic/thermal (PV/T) system for hydrogen and domestic hot water production in residential buildings**

*Mohamed Hamdi and Souheil Elalimi*

One of the key challenges in hydrogen production is the intermittent nature of renewable energy sources. To address this issue, enhancing grid flexibility and implementing advanced energy storage

solutions are critical for ensuring the reliable production of hydrogen. The electrolysis system used in this study is based on photovoltaic/thermal (PV/T) technology and is intended to produce hydrogen fuel and domestic hot water (DHW) simultaneously, offering a sustainable solution to the growing global emissions problem. Our results show that adding the dynamic control mechanism greatly improves the system's flexibility and efficiency, enabling it to maximize energy generation and storage in response to changing solar conditions. In order to keep pressure below the critical upper limit for safety, the system controlled the electrolyzer's operation based on hydrogen storage levels and efficiently managed extra PV/T power, which varied between 100 and 900W in Tunisian climatic conditions with a collector area of 9 m<sup>2</sup>. The results show that hydrogen production follows a seasonal pattern, peaking in July at 3.32 kg, and reaching its lowest in winter months at 1.9 kg. Thermal and electrical outputs also follow this trend, with maximum values in summer. The economic analysis highlights that the cost of hydrogen is \$5.159/ kg, while the cost of domestic hot water (DHW) is \$0.069/ kWh, confirming the system's viability and potential as a sustainable energy production in Tunisian conditions.

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**ID59: Experimental investigation of a trays inclined solar still with enhanced condensation process**

*Sahar Grine, Fatma Ouled Saad, Fatma Ezzahra Lakhel, Amira Akrouti, Jamel Madiouli and Ammar Hidouri*

To guarantee ecosystem safety, solar stills offer a sustainable and attractive solution, gaining attention for their eco-friendly solar energy potential to produce value-added products with minimal environmental impact, especially in arid areas as well as southern Tunisia, with abundant sunshine. In this present study, an experimental incorporation of stepped passive solar still design (SS) is suggested to optimize the thermal performance of the conventional solar still (CSS) due to its poor output of fresh water at climate conditions of Gafsa, City-Tunisia (34° 25' 104'' Nord; 8° 46' 362'' Est), including different parameters like solar intensity, glass, basin water, and ambient temperature, as well as water output collected. Findings reveal the effectiveness of using an external fan installed at the top on condensing glass (SSF) generates roughly 61% more than the standard one (4.70L vs. 2.88L) per m<sup>2</sup> of basin water with an identical water depth of 2cm, for a comparatively minor increase in cost of about 15.5%. This increased yield lessens the environmental effect per liter of water generated by spreading material and energy expenses across a greater output. The CPL for the modified trays solar still obtained \$0.021/liter. Its energy and economic period payback are estimated to be 800 and 36 days, respectively, at the ideal flow rate.

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**ID53: Sliding mode control-based MPPT for high-power wind energy: design and performance analysis**

*Nadia Gasmi, Radhia Garraoui, Bassem Omri, Mouna Ben Hamed and Lassaad Sbita*

This paper presents an advanced Sliding Mode Control (SMC)-based Maximum Power Point Tracking (MPPT) strategy for wind energy systems. The proposed approach is designed to enhance the efficiency and robustness of wind power extraction under varying wind speed conditions. Traditional MPPT techniques often suffer from slow convergence and high oscillations, especially in rapidly changing environments. In contrast, the SMC-based MPPT method ensures fast tracking, reduced chattering, and improved stability through a well-designed sliding surface and adaptive control parameters. The system is modeled and simulated in MATLAB/Simulink, where the efficiency of both the wind generator and the MPPT is assessed. Performance evaluation focuses on tracking speed, power conversion efficiency, and robustness to wind fluctuations. The results demonstrate that the

proposed SMC-MPPT significantly improves energy harvesting efficiency, making it a promising solution for large-scale wind energy applications.

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**ID13: Thermal Effects of PCM Melting Process in Salt Gradient Solar Ponds: an Experimental and Numerical Approach**

*Daniele Colarossi, Yasmine Rghif, Belkacem Zeghmati and Paolo Principi*

The integration of Phase Change Materials (PCMs) in Salt Gradient Solar Ponds (SGSPs) is a promising solution for enhancing their storage capacity. PCMs allow to store a large amount of thermal energy, exploiting their high latent heat during the solid-liquid phase change. The choice of the melting temperature and PCM mass is crucial to maximizing its storage efficiency. This work investigates the effects of two operating conditions on the thermal behavior of the SGSP. First, the indoor test, under controlled conditions, proves the effectiveness of the PCM compared to a traditional SGSP. Secondly, the outdoor tests, under natural climatic conditions, compare different melting temperatures. This experimental study is completed by a numerical investigation to predict temperatures in the SGSP under weather data of Ancona (Italy) under different melting temperatures and mass ratios of PCMs. According to results, under controlled conditions the PCM integrated SGSP turns out to have a temperature around 3 °C lower than the traditional case. Results show a positive correlation between melting temperature and climatic conditions, such as air temperatures and solar irradiance. Numerical results show that higher mass ratios, like 28 % and 49 %, or too high melting temperatures do not allow to complete the melting process and accordingly maximize the thermal benefits. Lower mass ratios (14 % and 19 %) better exploit the melting process and the latent heat of the PCMs.

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**ID37: Dater Approach for the Modeling and Analysis of a PV Cell-Battery System modeled by Hybrid Petri Nets**

*Khouloud Soltani, Hajer Mlayeh and Atef Khedher*

This study proposes a novel method to model and study the dynamic behavior of an energy system based on the photovoltaic (PV) cell-battery using Hybrid Petri Nets (HPN). A proposal for an algebraic linear model is presented, formulated in the form  $Ax \leq b$ , in order to illustrate the dynamics of HPN. This mathematical modeling provides the ability to predict the system's trajectory over time, offering important insights regarding energy production, battery charging/discharging, and the overall system efficiency. Furthermore, an observer, designed in a comparable form, is employed in order to evaluate the state of the HPN. We evaluate the effectiveness of the suggested models and the accuracy of the estimation by contrasting the simulation results with those of the state estimation. To confirm the approach The suggested method is implemented within the framework of a university case study on a PV-battery system, illustrating its robustness in examining energy flow and improving system performance. This research helps advance green energy systems by providing a comprehensive framework for analysis using HPNs.

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**ID36: Investigation of Heat Transfer Mechanisms in a Composite Wall Incorporating BioPCM Materials**

*Khmais Hidouri, Sana Dardouri and Jalila Sghaier*

The building integrated with a phase change material (PCM) creates a significant thermal barrier between the indoor environment and the outside, resulting in a better thermal insulation system. The insulation system using laminated walls based on the integration of bioPCM in the form of a layer within a composite material to form a multilayer wall in order to achieve an insulation system with thermal energy storage. A theoretical model is constructed, based on the phase transition of the

bioPCM and the heat transfer between the indoor and outdoor environments through the layers of the composite wall. The result indicates that the thermal stability of the indoor environment is related to the thermal properties of the layers of the construction wall and that the thermal energy storage time by the PCM is related to the thermal conductivity of each layer of this composite wall, and that modifying the thermal conductivity of the bioPCM helps to increase the temperature gradient between the two faces of the wall. In the case of impregnating bioPCM within a composite material with dimensions smaller than those of this material, the imposed temperature is applied at three positions of their boundaries, which affect the rate of change from solid to liquid state, resulting in a short duration to obtain this bioPCM. In conclusion, the impregnation of bioPCM in composite materials in buildings improves thermal insulation performance for walls and minimizes energy consumption in heating and cooling by reducing energy losses at the wall level and regenerating stored energy in winter.

### Robotics, Automation and AI

#### **ID56: A comparative analysis of innovative control techniques for PEMFCS: Hybrid adaptive PI sliding mode and perturb & observe strategies**

*Radhia Garraoui, Bassem Omri, Mouna ban Hamed and Lassaad Sbita*

To enhance robustness against parameter variations and external disturbances, this study introduces an innovative hybrid control strategy that integrates the Perturb & Observe (P&O) method with Adaptive Proportional-Integral (PI) Sliding Mode Control. This novel approach contributes significantly to the advancement of control techniques for Proton Exchange Membrane Fuel Cells (PEMFCs). The proposed controller leverages an adaptive PI regulator, where the sliding surface is determined by the error, ensuring precise tracking of the maximum power point. To evaluate its effectiveness, the hybrid strategy is compared with conventional Adaptive PI and P&O methods, analyzing key performance indicators such as response time and energy efficiency. The results demonstrate notable enhancements in system performance, making this approach a promising solution for optimizing PEMFC operations under varying conditions. The entire control framework is developed and simulated in Simulink MATLAB, providing a comprehensive platform for testing and analysis.

#### **ID83: Artificial Intelligence and Dynamic Vehicle Scheduling: PPO-Driven Optimization**

*Nouha Alyaoui, Om Kolthoum Elhajjej, Wafa Akermi and Karim Chabir*

Efficient vehicle scheduling is a major issue in modern transportation systems, impacting traffic flow, travel times, and overall urban mobility. The advent of autonomous vehicles and intelligent transportation systems (ITS) offers new prospects for developing dynamic and adaptive scheduling solutions. This paper explores the application of Proximal Policy Optimization (PPO), a reinforcement learning algorithm, for optimizing vehicle routing and scheduling in complex traffic scenarios. We compare PPO's performance against other state-of-the-art algorithms, including traditional methods like Dijkstra's algorithm and more recent approaches such as Deep Q-Networks (DQN). Our results demonstrate that PPO performs better than other methods at reducing average travel times and improving traffic flow efficiency. Furthermore, we investigate the robustness of PPO to handle dynamic traffic conditions, such as sudden congestion or road closures. This research highlights the potential of reinforcement learning, particularly PPO, for developing intelligent and adaptive vehicle scheduling systems that can contribute to smarter and more sustainable urban transportation.

## **ID21: ANN-Driven Trajectory Optimization and Collision Avoidance for Robotic Manipulators in Cluttered Workspaces**

*Hani Nasri and Hatem Tlijani and Khaled Nouri*

The robotic arm operating in dynamic, cluttered environment have challenges in real-time adaptability and computational efficiency, our challenge is to develop a system capable of planning optimal paths and avoiding in both static and dynamic obstacles in real time simulation. We use a Artificial Neural Network (ANN) to learn and predict optimal paths for robotic arms when we include obstacles. We train the ANN using a diverse dataset of environment, obstacles, and optimal paths to enable generalization to new scenarios. We using the RoboDk simulator to generate our data set with UR5 arm-robot universal Robots. Our ANN-based method approach aims to improve computational efficiency, adaptability, and robustness compared to traditional methods.

Our methodology follow a process as follows:

- Data Collection :
  - To generate the dataset of UR5 robotic arm trajectories in various environments with static and dynamic obstacles we use simulation by RoboDk simulator
  - We include diverse scenarios to ensure robustness and generalization.
- ANN Architecture :
  - We design architecture is specifically designed for this task, combining Convolutional Neural Networks (CNNs) for spatial feature extraction and Recurrent Neural Networks (RNNs) for temporal data processing.
  - Inputs: Environment state ( obstacle positions, target position, current joint angles).
  - Outputs: Optimal path(Joint angle) or trajectory for the robotic arm.
- Training : The training method include a supervised learning with labelled optimal paths and reinforcement learning with reward-based feedback, this to improve the system's ability to plan paths and avoid obstacles.
- Validation : We validate our model by using real time simulation in workspace environment's RoboDk, evaluating the performance metric such as path length, the obstacles prediction and success rate.

Our results demonstrate significant improvements in computational efficiency, adaptability, and robustness when compared to traditional methods.

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## **ID71: Prediction of Brake Power in Pelton Turbine Using Machine Learning Algorithms**

*Lachhel Belhassen, Ichraf Hammadi, Lazhar Ayed and Abdallah Bouabidi*

Accurate prediction of brake power in Pelton turbines is essential for optimizing efficiency and improving overall performance. This study explores the application of machine learning algorithms to estimate brake power based on key operational parameters, including opening jet section and flow rate. Several models, including Support Vector Regression (SVR), Polynomial Regression (PR), Random Forest (RF), and Multilayer Perceptron Regression (MLP), are developed and optimized using hyperparameter tuning to enhance their predictive capabilities. The dataset undergoes preprocessing, and cross-validation is applied to ensure model robustness and prevent overfitting. To evaluate model performance, statistical metrics such as  $R^2$ , coefficient of determination, is employed, providing insights into the accuracy and reliability of each approach. The results indicate that hyperparameter tuning significantly improves model performance, reducing prediction errors and enhancing generalization. Among the tested models, RF demonstrate superior accuracy in predicting

brake power, making it valuable tools for real-time applications, ultimately contributing to the advancement of hydroelectric power generation through real-time monitoring and optimization.

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#### **ID6: Dynamic Modeling and PID Control of a UAV: Stability and Performance Analysis**

*Chabir Amal, Abid Aicha and Ben Hamed Mouna*

The main objective of this paper is the synthesis of robust stabilizing control laws in terms of Quadrotor orientation. The difficulty of its control is mainly due to its complex, non-linear, multi-variable dynamics, especially when it is under actuation. All stabilizer controls are designed to ensure the continuation of the desired trajectories along the three angles ( $\phi$ ,  $\theta$ ,  $\psi$ ). We will create a mathematical model of a quadcopter using the laws of the dynamics of the drone. Autonomous air vehicle modeling is relatively complex, and the complexities are filling for miniature drones because of the number of physical effects that come into play, namely aerodynamic effects, gravity, gyroscopic effects, friction, and moment of inertia. This complexity results from the difference in these effects between each flight mode. This model makes it possible to link the physical quantities of the drone that interest us and that we observe (its position and orientation) to the speeds of rotation of the engines. This will allow us to establish control laws based on the model we have established. Then we briefly presented the operating principle of a PID regulator. We presented the simulation results obtained and then carried out a series of tests thanks to a simulation we carried out on Matlab-Simulink; we were thus able to observe the behavior of the controlled system during the continuation of delivery for the control and resistance against instantaneous disturbances for the study of regulation.

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#### **ID7: Optimizing Handover Decisions in 5G Vehicular Networks Using Deep Q-Networks**

*Amina Gharsallah, Faouzi Zarai and Mahmoud Neji*

The rapid evolution of 5G vehicular networks has transformed Vehicle-to-Everything (V2X) communications, enabling real-time applications such as autonomous driving and traffic management. However, the high mobility of vehicles and dynamic network conditions complicate handover management, often resulting in connection disruptions and latency spikes. Traditional methods, like fuzzy logic or static thresholds, struggle to adapt to these challenges, prompting the need for intelligent, predictive solutions. This paper proposes a novel approach to handover management in 5G vehicular networks using Deep Q-Networks (DQN), a deep reinforcement learning technique. By integrating DQN with a Software-Defined Networking (SDN) framework, our method dynamically selects optimal handover targets based on real-time inputs, including signal strength, network load, and vehicle mobility patterns. Extensive simulations conducted, demonstrate that our approach reduces handover failure rates by up to 35% and latency by 30% compared to baseline fuzzy logic and rule-based methods. These improvements stem from DQN's ability to anticipate network changes and adapt decisions proactively. This work underscores the potential of deep reinforcement learning in enhancing automation and connectivity in next-generation vehicular systems, paving the way for more robust ITS solutions.

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#### **ID40: Artificial intelligence application in electric vehicle battery charging**

*Mabrouka Romdhane, Maria Amaidi, Mohamed Naoui and Ali Mansouri*

Artificial intelligence (AI) has become a key pillar in many fields worldwide, due to its ability to optimize performance and improve the efficiency of complex systems. The rise of electric vehicles (EVs) is no exception to this trend. Indeed, the integration of AI in this sector is proving particularly promising, particularly in the areas of control, security, and energy storage management. In the context of electric vehicle battery charging, AI plays a crucial role in enabling the development of intelligent and adaptive management strategies. This article explores the latest trends and recent advances in the

application of artificial intelligence for electric vehicle charging management, with a particular focus on charging process optimization and bidirectional energy management (V2G and G2V).

### Energy Efficiency and Conservation

#### **ID51: Impact of Climatic Conditions on the Thermal Performance of Solar Air Dryer: A Numerical Study**

*Mouna Belhadj Ltaief, Walid Ben Amara and Abdallah Bouabidi*

Solar drying is an efficient and eco-friendly method for preserving agricultural products. This study presents a numerical simulation of a solar air dryer using ANSYS Fluent to analyze heat and mass transfer under natural convection. The governing equations of mass, momentum, and energy are solved using the finite volume method. The Discrete Ordinates (DO) radiation model is employed to account for radiative heat transfer. The numerical model is validated against experimental data. Key performance parameters, including temperature distribution, airflow patterns, and drying efficiency, are evaluated. The results show good agreement, with a maximum deviation of less than 5% between simulations and experiments. Additionally, the maximum temperature reaches 70.39°C under a solar radiation intensity of 1109 W/m<sup>2</sup>.

#### **ID57: Combustion and Performance Analysis of a Diesel Engine Operating with Hydrogen-Enriched CNG in Dual-Fuel Mode**

*Rafaa Saaidia, Mideni Krotli, Imed Miraoui and Abdallah Bouabidi*

Diesel engines are extensively used due to their high thermal efficiency and low emissions of hydrocarbons (HC) and carbon monoxide (CO). However, their substantial production of nitrogen oxides (NO<sub>x</sub>) and particulate matter (PM) necessitates alternative combustion strategies to enhance performance and mitigate emissions. One promising approach is dual-fuel combustion, particularly with natural gas (NG) and hydrogen enrichment, which has shown potential in improving engine operation. While prior studies have largely concentrated on performance and emissions, the direct influence of combustion characteristics on engine efficiency has received limited attention. This research addresses this gap by examining the combustion behavior of a diesel engine operating in dual-fuel mode with hydrogen-enriched compressed natural gas (CNG). A key focus is the relationship between hydrogen addition and engine performance, an area not comprehensively explored in the literature. Experiments were conducted with hydrogen fractions of 20% and 30% (by volume) in CNG, analyzing combustion parameters such as in-cylinder peak pressure and the Coefficient of Variation of Indicated Mean Effective Pressure (COVIMEP), alongside energy conversion efficiency across varying engine speeds and loads. The results demonstrated notable improvements in combustion efficiency, particularly in the premixed phase, with in-cylinder peak pressure reaching 4.1 bar at 20% load. Enhanced combustion stability was observed, with COVIMEP remaining below 10% for all hydrogen blends. Performance enhancements included a maximum thermal efficiency of 10.2% and a minimum fuel consumption of 236 g/kWh, comparable to conventional diesel operation. These findings underscore the viability of hydrogen-enriched CNG as a cleaner and more efficient alternative to standard diesel engines. This study provides valuable insights into dual-fuel combustion behavior, highlighting the role of hydrogen enrichment in improving both stability and overall engine performance.

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**ID50: Performance enhancement of a Building Integrated Photovoltaic system using wavy fins with slots**

*Monia Chaabane, Salma Benzarti and Hatem Mhiri*

In this study, the performance of a Building Integrated Photovoltaic system is evaluated using CFD simulations. As this system main drawback is related to its limited efficiency for high solar cell temperatures, a cooling technique is proposed. It consists of the application of fins which are directly attached to the BIPV system, in the backside of its PV cell. Wavy fins with slots are proposed and the corresponding effect on the BIPV system overall performance is evaluated. The results clearly show that all the proposed cooling technique was found to be effective in reducing of the solar cell temperature and thereby increasing the electrical conversion efficiency of the BIPV system. A temperature reduction achieving 17 °C was noted, which allowed an increase of the electrical efficiency achieving 8 %. In addition to its effects on the BIPV system electrical performance, the proposed cooling system provides a better heat exchange, which allows an important thermal output and increases the BIPV system thermal efficiency.

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**ID46: New numerical study for predicting the behavior of an energy system Based on the Galerkin method**

*Marwa Ben Boubaker and Rached Ben Younes*

In this work, we propose a mathematical and numerical method which relies on the combination of Duhamel's theorem and Galerkin's method to predict the intrinsic behavior of an energy system in continuous operation. To do this, Duhamel's theorem states that by knowing perfectly the intrinsic response of an energy system to a onestep load unit, one could predict its behavior for any solicitation without to make use of prior experiments. We then determined based on this method that we have developed, the coefficients constituting this intrinsic response of the energy system and we have formulated that response. This method has been tested and validated for different forms of stress on a system to determine its behavior. This method could thus be applied, in particular, in cooling of a nuclear reactor or in the case of cooling a turbine in a thermal power plant.

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**ID67: Performance Enhancement of Air-Coal Ash Fluidized Bed Reactor in Bubbling Regime**

*Souad Aboudaoud, Sara Touzani, Souad Abderafi, Abdelkhalek Cheddadi and Mohamed Ammar Abbassi*

Bubbling fluidized bed reactors, common in industrial applications, exhibit efficient gas-solid mixing for enhanced mass and heat transfer. However, their performance is influenced by various design and operational factors. This study focuses on analyzing reactor's diameter and superficial gas velocity, which impact various reactor performance metrics, including fluidization behavior, bubbles formation, pressure drop, bed expansion, gas residence time, and overall gas-solid flow hydrodynamics. Eulerian-based CFD model in OpenFoam software was used to simulate the process in an air-coal ash fluidized bed reactor, and validated by comparing obtained results values with those found experimentally in literature. Large reactors with big diameters transitioned quickly to bubbling regime, at low bubbling velocity (0.49 m/s), indicating a recommended fluidization index of 1.48, in contrast to narrow reactors with small diameters, which promote the slugging regime appearance. A reactor with a diameter of 0.4 m was found to be the most optimal since it led to a good air coal mixing. Bubbling fluidization performance was also enhanced for inlet gas velocity of 0.64 m/s and a consistent distribution of gas-solid flow throughout the reactor was observed. Bed expansion was improved significantly by 40% for a gas residence time in the bed of 0.92s.

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**ID38: Numerical Simulation of Iron Particle Injection into a Spherical Reactor**

*Kodes Hamda, Khaled Souaissa, Léo Courty and Mouldi Chrigui*

This study investigates the injection of iron particles into a closed spherical reactor to enhance energy efficiency and reduce dependence on fossil fuels. The reactor, with a capacity of 20 L and equipped with internal baffles to induce turbulent flow, is designed to optimize particle dispersion. Simulations were conducted using ANSYS Fluent and the Discrete Phase Model (DPM) to examine the behavior of the injected particles, focusing on their suspension, velocity distribution, size, and density. The objective is to study the density of the particles, specifically where they remain suspended and concentrated within the spherical chamber, as this will be crucial for future combustion processes. The findings reveal that the highest air velocity occurs near the baffles, aiding in particle dispersion, while other areas exhibit lower velocities, which could lead to stagnation. The study emphasizes the importance of controlling flow conditions and turbulence to ensure uniform particle distribution, enhance reactor performance, and optimize the combustion process.

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**ID82: Strategic Carbon Footprint Evaluation and Emission Reduction Approaches for the Mdhilla Industrial Site: Insights from the Tunisian Chemical Industry**

*Oussama Hajji, Sana Dardouri, Nejib Hidouri and Jalila Sghaier*

The chemical industry is a significant contributor to global greenhouse gas (GHG) emissions, underscoring the critical need for comprehensive carbon footprint assessments to advance sustainable industrial development. This study examines the carbon footprint of the Mdhilla industrial site, a key facility within the Tunisian Chemical Group, focusing on triple superphosphate (TSP) production. Using the Bilan Carbone tool, emissions from direct and indirect sources including energy consumption, raw material processing, transportation, and waste management were quantified.

The total emissions were calculated at 392256 t CO<sub>2</sub>e, with phosphogypsum waste management representing the largest source (45%), highlighting substantial environmental challenges such as soil and water contamination. Freight-related emissions (18%) reflect the transportation demands of raw materials and product distribution, emphasizing the importance of optimizing logistics, local sourcing, and transitioning to efficient transport modes. Emissions from goods and materials inputs (16%) highlight the need to engage low-carbon suppliers, while energy consumption (14%) and chimney emissions (6%) call for energy efficiency improvements and low-carbon energy adoption.

The study identifies critical emission hotspots and proposes targeted mitigation strategies, offering a replicable framework for reducing emissions in similar industrial facilities and fostering sustainable operations.

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**ID42: AI-powered Energy Efficiency: Prediction and Anomaly Detection**

*Moujahed Maha, Hamdi Mohamed, El Ouederni Ridha and ElAlimi Souheil*

The transition toward sustainable energy systems necessitates innovative methodologies to enhance their adaptability, efficiency, and reliability. This study investigates the application of advanced Artificial Intelligence (AI) techniques, including Machine Learning (ML), optimization algorithms, and predictive analytics, to address critical challenges in contemporary energy management. The research proposes AI-driven frameworks designed to accurately forecast energy loads, optimize demand response strategies, and detect anomalies through dynamic thresholding mechanisms. Additionally, it conducts a thorough sensitivity analysis of the employed machine learning models, emphasizing the significance of feature selection and evaluation. These frameworks aim to enhance operational efficiency, ensure dependable demand response mechanisms, and facilitate the

development of intelligent and sustainable energy infrastructures. The findings offer practical and actionable insights, underscoring the transformative potential of AI in advancing energy systems while contributing significantly to the broader objectives of energy management and sustainability.

### Biomechanics, Bioengineering and Manufacturing

#### **ID32: Prediction and Optimization of Mechanical Performance of short Alfa Fiber-Reinforced Polypropylene Biocomposites for Automotive Applications: A Taguchi Design Approach**

*Iskander Jellid, Rawdha Kessentini, Olga Klinkova, Anas Bouguecha, Imad Tawfiq and Mohamed Haddar*

This study investigates the mechanical properties of Alfa fiber-reinforced polypropylene (PP) biocomposites, utilizing maleic anhydride-grafted polypropylene (MAPP) as a coupling agent to enhance fiber-matrix adhesion. The mechanical characteristics of these biocomposites were predicted and optimized by examining the effects of varying short Alfa fiber content (0%, 15%, and 30%) and the influence of MAPP (0%, 3%, and 6%) on tensile strength and Young's modulus. A combination of extrusion and injection molding processes was employed. The experimental results were analyzed using the Taguchi method for the design of experiments (DOE), specifically with an L9 matrix, to systematically examine and predict the impact of fiber content on the biocomposite properties. It was found that the optimal mechanical properties were achieved with 17.5 % Alfa fiber and 6 % MAPP. Empirical equations were developed to predict the behavior of the biocomposite based on fiber content and matrix composition. These findings provide valuable insights for the development of biocomposites suitable for automotive applications, where both mechanical performance and sustainability are essential.

#### **ID58: Thermomechanical Behavior of Phosphogypsum Composites Reinforced with Olive and Eucalyptus Wood Chips**

*Rafaa Saaidia, Houcem Itaeif, Abdallah Bouabidi, Lazhar ayed and Imed Miraoui*

The increasing demand for sustainable and high-performance construction materials has driven research into innovative composite formulations utilizing industrial by-products and renewable resources. This study investigates the thermomechanical behavior of phosphogypsum (PG) composites reinforced with olive and eucalyptus wood chips, aiming to enhance their mechanical strength and thermal insulation properties. A comprehensive experimental and numerical analysis was conducted to assess the impact of fiber reinforcement on flexural strength, water absorption, and thermal conductivity. The results indicate that fiber reinforcement significantly improves mechanical performance, with optimal flexural strength observed at 15% fiber content. Beyond this threshold, excessive fiber addition led to structural inhomogeneities and decreased mechanical efficiency. Thermal conductivity measurements revealed a progressive reduction in  $\lambda$  with increasing fiber content, reaching a minimum value of 0.60 W/m·K at 20% reinforcement, demonstrating the material's excellent insulating potential. Comparative analysis between olive and eucalyptus fibers showed that olive-reinforced composites exhibited slightly lower thermal conductivity, attributed to variations in fiber morphology and porosity. Computational Fluid Dynamics (CFD) simulations further validated experimental findings, confirming the enhanced thermal performance of fiber-reinforced PG composites. These results highlight the strong potential of phosphogypsum-based composites as eco-friendly alternatives to conventional insulation materials, promoting waste valorization and energy-efficient construction. Future work will focus on fiber surface treatments, hybrid reinforcement strategies, and long-term durability assessments to further optimize performance and broaden industrial applications.

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**ID24: Chip Breaker Geometry Effect on Cutting Forces in Orthogonal Cutting**

*Hassen Khelifi, Wahid Tarhouni, Lefi Abdellaoui and Wassila Bouzid*

In this paper, a new analytical model of cutting forces prediction in orthogonal cutting is developed while considering the chip breaker geometry. Based on the equilibrium of the applied moments on the chip at the tool-tip, a new shear angle is defined. The found results have depicted that the tool-chip contact length has been restricted and the shear angle is increased by using an insert with a small land of the chip breaker. It is also underlined that the amount of cutting forces exerted by the tool is decreased.

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**ID22: Modeling of Mass and Heat Transfer in a Granular Medium: Case of Convective Drying of Agri-Food Products**

*Hasna Arfaoui, Hatem Oueslati and Sami Kooli*

This study shows that heat and mass transfers in porous media are phenomena encountered in many physical, chemical and microbiological situations, corresponding to wide areas of applications concerning the rational use of energy, soil pollution, management of household waste landfills.

In the case of granular products dispersed jointly on racks, the heat and mass transfers are carried out mainly on the upper side subjected to the air current. The study is done in one-dimensional and the medium is assumed homogeneous and isotropic. The results are developed for a convective drying operation on the agricultural product potato.

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**ID86: Segmentation of Initial Mechanical Events in the Bileaflet ON-X Heart Valve Using Structured HMM and Impulse-Guided Viterbi Decoding**

*Radhia Akermi and Rached Ben Younes*

In this work, we propose an approach based on a structured Hidden Markov Model (HMM) combined with an impulse-guided probabilistic Viterbi decoding strategy to segment the cardiac cycle of phonocardiographic (PCG) signals. This approach focuses on the initial mechanical segment of an ON-X bileaflet mechanical valve implanted in the mitral position. The cardiac cycle begins with a mechanical segment (SM) composed of the acoustic sub-components S1 and S'1, which correspond to the asynchronous closure of the valve leaflets. This SM is modeled as an autonomous macro-state within the HMM, with predefined transitions between its sub-states and the global functional states. The segmentation relies on an adaptive transition matrix, adjusted around impulse-like peaks to accurately capture the mechanical events. Impulse-guided probabilistic Viterbi decoding is employed to determine the most probable sequence of states, ensuring precise detection of the different cardiac phases. The model's performance is evaluated using several metrics: An F1 score of 0.97, an Area Under the Curve (AUC) of 0.95, and a False Positive Rate (FPR) below 0.04. The model also achieves a precision of 0.97, a recall exceeding 0.95, and low localization error, with a Root Mean Square Error (RMSE) of 0.09. The detection time remains under 0.1 seconds per cycle, enabling real-time application. Even under noisy conditions, the model maintains a score of 0.90, ensuring robustness and reliability. Our approach presents an excellent solution for the real-time segmentation of the internal dynamic states of mechanical valves, thereby optimizing clinical monitoring.

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## Smart Grids and Energy Management

### **ID65: Fault Detection and Classification in Photovoltaic Systems Using AI and Machine Learning Techniques**

*Sarah Jaffali, Aicha Abid and Mouna Ben Hamed*

Photovoltaic (PV) systems are exposed to various faults that can impact their efficiency and durability. This paper presents an approach combining mathematical modeling and artificial intelligence to detect and diagnose faults in a grid-connected PV system. The effectiveness of the proposed method is validated through simulation and experimentation.

### **ID76: A review of cybersecurity measures for an enhanced IoT-based PV Pumping System**

*Malek Belouda, Tlili Messai, Chayma Azouz and Mami Abdelkader*

IoT based systems has reformed several industrial sectors particularly irrigation systems. Their integration in such a systems has contributed to make agricultural production more efficient and more connected. Nevertheless, the use of these smart solutions presents growing threats related to vulnerabilities in IoT devices. These problems include several issues such as unauthorized Access and Data Breaches, Malware and Ransomware, Denial of Service (DoS) and Distributed Denial of Service (DDoS) Attacks, Data Manipulation, Insecure APIs and Communication Channels and Inadequate Logging and Monitoring. Due to the increasing interdependence of IoT applications, the risks and dangers carried by the safety of people can threaten public safety.. The aim of this study is the review of different cybersecurity threats that can attack an IOT based Photovoltaic Pumping system (PVPS) and the measures that can be adopted to prevent these risks will be highlighted.

### **ID23: The influence of the integration of digital technology on CO2 emissions and energy in the European Countries**

*Hasna Khemili*

The replacement of manual labor with machines stimulated economic growth, with energy being the crucial factor in sustaining industrial operations. However, industrialization has led to an increase in carbon emissions, causing environmental degradation. Consequently, the substantial increase in CO2 emissions has far-reaching implications for the economy, society and human well-being.

The necessity to examine whether digital technology innovations (DTI) contribute to sustainability is highlighted by their advancement and adoption in socioeconomic domains. This study focuses on how important DT is in decreasing emissions in 27 EU countries, along with other important aspects. DT considerably decreased CO2 emissions, according to estimates from Generalized Least Squares (GLS). Using a different statistical methods of Panel data such as RE model, OLS and GLS models, for the period between 2017 and 2022, we explore the impact of digital technology and its components (digital intensity, digital technologies for business and e-commerce), on CO2 emissions and air pollution.

The results show that the digital technologies innovation components are statistically significant and negative, except digital intensity which has a positive impact on CO2 emissions. Thus, digital technology for business (Artificial intelligence, big data, IoT, cloud, electronic informations, social media), e-commerce (selling on line, e-commerce turnover...) decrease air pollution. However, Digital intensity increases CO2 emissions due to the massive use of digitalization in EU countries.

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**ID8: PEG-Based Shape-Stabilized PCM with a Natural and Sustainable Resource: Thermal Properties and Applications**

*Amira Akrouti, Sahar Grine, Abdelwaheb Trigui and Ammar Hidouri*

This study explores the development of a novel shape-stabilized phase change material (ssPCM) using pinecone powder—a natural and sustainable resource—as a supporting structure, combined with polyethylene glycol (PEG 6000) as the phase change material (PCM) due to its excellent Thermal Energy Storage (TES) properties. Graphite was incorporated to enhance thermal conductivity, reduce leakage, and improve shape stability. The resulting ssPCMs demonstrate enhanced thermal properties and significant potential for green energy applications. This work aims to develop a convenient and efficient method to prepare a form stable bio-composites with low-cost and eco-friendly materials. Thermal performance was evaluated using advanced characterization techniques. The Laser Flash Analysis (LFA) method was utilized to determine thermal diffusivity and calculate thermal conductivity, while the Thermomechanical Analysis (TMA) determine density measurements. A T-history setup was employed to determine the melting enthalpy of the ssPCM. This approach allows for the use of larger sample sizes—several orders of magnitude greater than typical calorimetric techniques—ensuring additionally the representativeness of the results. This ssPCM not only addresses environmental concerns by leveraging natural materials but also achieves high thermal efficiency, offering a sustainable and reliable option for applications for energy storage. The findings highlight the potential of incorporating additives into PCM systems to enhance both thermal and structural performance.

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**ID28: Comparative Analysis of ANN-Based and P&O MPPT Algorithms for Photovoltaic Systems**

*Imed Faza, Taoufik Brahim, Riadh Abdelati and Abdelmajid Jemni*

Maximum Power Point Tracking (MPPT) techniques are essential for optimizing the efficiency of photovoltaic (PV) systems by ensuring operation at the maximum power point (MPP). This study presents a comparative performance evaluation of two MPPT algorithms: an Artificial Neural Network (ANN)-based MPPT and the conventional Perturb and Observe (P&O) method. The comparison is based on key performance metrics, including tracking speed, steady-state oscillations, efficiency, and robustness under dynamic irradiance and temperature conditions. Simulation results demonstrate that the ANN-based MPPT achieves faster convergence to the MPP, reduces power fluctuations, and enhances overall efficiency, particularly in rapidly changing environments. However, its increased computational complexity and implementation challenges may limit its practical deployment. This study provides valuable insights into the strengths and limitations of both methods, guiding their selection for various PV applications.

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**ID31: Scheduling support system based on the Yamazumi chart and Activity-on-Arrow (AoA) technique for optimizing manufacturing process**

*Ines Ajmi, Imed Miraoui and Jihene Almastouri*

This paper addresses the resolution of a flow-shop scheduling problem of a cable manufacturing process in the tension mode for an automobile manufacturing production line. The aim is to provide an appropriate solution based on modeling, optimization and implementing of improvement aid system. The yEd Graph Editor software was used in process modeling in order to detect chain malfunctions. A dynamic approach based on a combination of YAMAZUMI CHART and task-potential methods was used to minimize the chain delay. Application and numerical analyzes have shown that this approach is efficient and is able to provide a better solution to optimize chain stoppage time. Results show that

the combination of these two methods was very effective and produces better solutions. The line downtime was reduced and the productivity was increased.

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**ID55: Industrial Anomaly Detection in Metal Components Using Autoencoder-Based Inspection Systems**

*Boufares Oussema and Imed Miraoui*

Quality control is essential in manufacturing industries to ensure that products meet the required standards. In this paper, we present an anomaly detection system for multi-component inspection using an autoencoder-based approach. The system extracts meaningful features from images, applies normalization techniques, and trains an autoencoder to identify defective samples. Anomalies are detected by measuring the reconstruction error and applying an adaptive thresholding technique. Our method is evaluated on a dataset of metal nuts, bottles, and transistors, demonstrating high accuracy and fast inference, making it well-suited for real-time industrial applications.

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**ID60: Optimization of Production Scheduling in Factories Using Genetic Algorithms and Petri Nets**

*Sameh Affi, Atef Khdher and Khaoula Bouazzi*

The optimization of production scheduling in factories is a critical challenge in modern industry, where efficient resource management and adherence to deadlines are essential. Traditional scheduling methods, often based on fixed rules or simple heuristics, quickly reach their limits when faced with the increasing complexity of industrial processes. In this study, we propose a hybrid approach that combines Genetic Algorithms (GA) and Petri Nets (PN) to optimize task scheduling and machine assignment. The objective of this work is to integrate these two approaches to develop a robust and adaptable method for production scheduling, minimizing delays, improving resource utilization, and ensuring compliance with operational constraints. Results show that the Genetic Algorithm efficiently optimizes real-time task scheduling. The improvement is fast at the beginning and stabilizes over time, showing that GA is effective but could be improved further with mutation control or hybrid approaches.

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**Structural Dynamics and Vibrations**

**ID80: Early Detection of Rotor Bar Breakage in Induction Machines Using Infrared Thermography and Thermal Image Processing**

*Rabii Hajji, Mohamed Salah, Ghazoi Hamza and Hatem Tlijani*

Infrared thermography (IRT) is a cutting-edge technique characterized by its ability to monitor objects in real time, without requiring to halt the inspected system. This feature allows for fast, accurate, and secure diagnostics, essential in industrial environments where production shutdowns can be costly. In addition, IRT is a non-destructive technique that does not damage the inspected equipment, making it ideal for regular checks and preventive maintenance. In addition, its telemetric measurement nature offers the advantage of ensuring operator safety. In this paper, we focus on the application of this technique for the detection of an early defect marking the beginning of the breakage of a rotor bar of an induction machine. The proposed method is based on the preprocessing of thermal images to extract regions of interest to allow an analysis of the thermal map of the average temperature deviations, the extraction of statistics of the temporal evolution of the maximum temperature, and the analysis of histograms by decomposition into Gaussian modes. Furthermore, we discuss the impact of

the defect on the spatial temperature profile. The experimental results obtained on a laboratory test bench demonstrate the effectiveness of the proposed IRT-based approach, outperforming conventional diagnostic techniques that rely on electrical signal analysis and vibration monitoring.

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**ID34: Investigation of the structural, vibrational and dielectric properties of the half-doped spinel chromite Ni<sub>0.5</sub>Cd<sub>0.5</sub>Cr<sub>2</sub>O<sub>4</sub>**

*Kais Omri and Jabeur Khlifi*

The Ni<sub>0.5</sub>Cd<sub>0.5</sub>Cr<sub>2</sub>O<sub>4</sub> spinel chromite was prepared through the sol-gel process. The X-ray diffraction analysis indicates that the present sample is well crystallized in the cubic structure with the Fd-3m space group. The average crystallite size was estimated to be in the range of 38 – 55 nm, the FTIR analysis confirmed the formation of this spinel chromite by the appearance of the two absorption bands around 600 cm<sup>-1</sup>, characterizing the spinel structure. The structural and mechanical properties were investigated. It was noted that the studied composition has a good resistance to tensile and shearing stresses as well as thermal stress. The dielectric properties of the chromite were studied in the frequency range 40 Hz – 1 MHz and in the temperature range 300–600K. According to the Jonscher-law analysis, conductivity is shown to increase with increasing frequency and temperature, which confirms a semi-conductor behavior in our sample. On the other side, the conduction process follows the CBH model at relatively low temperatures and changes to the NSPT model at high temperatures. Impedance analysis has indicated that the relaxation phenomenon is strongly dependent on temperature and frequency and is described by a relaxation time distribution. In addition. All these results confirmed that the prepared sample can be considered a good candidate for the low- frequency energy storage application of the applied electric field.

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**ID17: Study of structural, elastic, optical, dielectric and magnetic properties of sol-gel synthesized Li<sub>0.2</sub>Co<sub>0.3</sub>Zn<sub>0.3</sub>Fe<sub>2.2</sub>O<sub>4</sub> ferrite for optoelectronic and electrical applications**

*Fakher Hcini, Sobhi Hcini and Mohamed Lamjed Bouazizi*

This work presents a detailed investigation of the structural, elastic, optical, dielectric, and magnetic properties of Li<sub>0.2</sub>Co<sub>0.3</sub>Zn<sub>0.3</sub>Fe<sub>2.2</sub>O<sub>4</sub> ferrite synthesized through the sol-gel process. The structural parameters deduced from the refinement of the XRD pattern closely match the theoretical values, confirming the proposed cation distribution of the prepared sample. From the FTIR spectrum, we assessed the elastic properties using the ultrasonic pulse transmission method, revealing that the sample exhibits brittle mechanical behavior. According to UV-Vis optical absorbance analyses and based on Tauc's law, the sample exhibits a direct optical transition, with the band gap energy (E<sub>g</sub>) determined to be 2.51 eV. The study of electrical conductivity showed that our sample exhibited a reduced activation energy (E<sub>a</sub>= 0.154 eV) and remarkable electrical resistivity at room temperature (ρ<sub>dc</sub> ~ 10<sup>4</sup> Ω.m), indicating the material's potential for microwave device applications. The conduction process of the sample aligns with the NSPT model. Additionally, the temperature coefficient of resistance (TCR) suggests that the sample is a promising candidate for infrared radiation detection. A low coercive field was also derived from the hysteresis loops, confirming the soft nature of the sample operating within a microwave frequency range of 8–9 GHz. Overall, the findings indicate that the substitution of Co and Zn leads to lower band gap and activation energy values, as well as higher electrical resistivity compared to those reported for Li<sub>0.5</sub>Fe<sub>2.5</sub>O<sub>4</sub> lithium ferrites, thereby expanding the electrical and optoelectronic performances of these ferrites.

### **ID81: Numerical Modeling and Structural Analysis of High-Pressure Hydrogen Storage Tanks for Industrial Applications**

*Leila Khalifa, Fatma Majdoub, Mohamed Elbouzidi and Zied Driss*

Hydrogen is a promising energy carrier for the energy transition, offering high energy density and significant potential for reducing carbon emissions. However, storing hydrogen as a compressed gas remains a significant challenge, requiring pressure vessels capable of withstanding high pressures while minimizing material weight and cost. This study, part of an industrial project with Tunisian chemical groups, presents a numerical simulation using COMSOL Multiphysics to evaluate three types of pressure vessels: Type I (metallic, made of AISI 4130 steel), Type II (AISI 4130 steel reinforced with carbon fibers in the cylindrical section), and Type III (aluminum 6061 fully reinforced with carbon fibers). The mechanical analysis focuses on von Mises stress, principal stresses, and maximum displacement under an internal pressure of 20 MPa. The results demonstrate that composite tanks (Types II and III) offer improved specific strength and substantial weight reduction compared to the metallic tank (Type I), with superior performance in terms of mechanical stresses and deformations. This study underscores the critical role of material selection in developing safe, efficient, and cost-effective hydrogen storage solutions for industrial applications and hydrogen mobility.

## **Thermal Energy and Heat Transfer**

### **ID18: Mixed convection of CNTs nanoliquid through a channel with periodic heated cavities**

*Mohamed Ghazali Belhaj and Mohamed Ammar Abbassi*

The current paper investigates numerically the mixed convection in a channel with multiple heated cavities. The governing equation treated via FEM as method of discretization to examine meticulously the heat transfer problem in various size of element. The numerical results show the effect of different parameters, noticing the Richardson number  $0.01 \leq Ri \leq 20$  with Reynolds number  $Re=200$ , and volume fraction of CNTs nanoparticles  $0 \leq \phi \leq 0.04$ . The results describe the enhancement of heat transfer with the augmentation of the percentage of nanoparticles in the base fluid (water) to reach its maximum at  $\phi=0.04$ , on the other hand, the heat transfer decreases slightly with the increase of Ri number. Concluding that the enhancement of natural convection in that case plays a negative role in heat transfer, and the nanoparticles of CNTs being a suitable parameter to improve heat transfer

### **ID75: Second law analysis of magneto-hydrodynamics (MHD) natural convection heat transfer**

*Mohamed Ammar Abbassi and Bouchmel Mliki*

The paper presents a numerical study of MHD natural convection heat transfer of a heated block situated on the bottom wall of an enclosure filled with nanofluids. The transport equations for a Newtonian fluid are solved numerically using the Lattice Boltzmann Method (LBM). The effective thermal conductivity and viscosity of the nanofluid are calculated by KKL (Koo-Kleinstreuer-Li) correlation. The influence of pertinent parameters such as Rayleigh number, solid volume fraction, Hartmann number, magnetic field inclination angle, nanoparticle volume concentration and aspect ratio of the rectangular heated block on the flow, heat transfer characteristics and entropy generation has been investigated. It is found that the total entropy generation is an increasing function of Rayleigh number while it is a decreasing function of Hartmann number. Moreover, the numerical results demonstrate that the average Nusselt number increases steadily but non-linearly by the augmentation of the nanoparticles volume fraction. Also, the results demonstrate that the Magnetic field with an inclination angle of  $\gamma = \pi/2$ , has the maximum heat transfer coefficient and the total entropy generation.

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**ID10: MHD natural convection of nanofluid due to an inner rotating cylinder in a 2D cavity with a non-Newtonian**

*Baraa Mnasri and Mohamed Ammar Abbassi*

The purpose of this study is to numerically two-dimensional steady state MHD natural convection in a cooled square cavity with a hot inner rotating cylinder. The gap between the cylinder and the enclosure walls is filled with power law non-newtonian nanofluid. The moving boundary condition was defined for the cylinder wall located within the enclosure where the wall is insulated. The continuity, motion and energy equations are solved by applying COMSOL Multiphysics. This study concentrated on the Rayleigh number ( $Ra = 103-106$ ), power-law index ( $n = 0.6-1.8$ ), Hartmann number ( $Ha = 0-25$ ), volume fraction ( $\phi = 0$  to  $0.06$ ) and angular rotational velocity ( $\Omega$ ) from counterclockwise at  $Pr (6.2)$ . This research project examines the impact of inner cylinder rotation on heat transmission and fluid flow at various above parameters  $Ra$ ,  $\phi$ ,  $Ha$  and  $n$  where the outcomes are reported in terms of streamlines, isotherms, average Nusselt number of the heated wall.

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## POSTER & VIDEO PRESENTATIONS

### Advanced Computational Mechanics

#### **ID1: Influence of Grid Density on Buoyancy-Driven Flow Dynamics in a 2D Cavity: A Parametric Investigation**

*Abdelhak Bahlouli and Adel Lalaoua*

The accurate simulation of buoyancy-driven flow in a two-dimensional (2D) cavity is highly sensitive to grid resolution, as it directly impacts the representation of thermal gradients, velocity fields, and overall flow dynamics. This study conducts a parametric investigation into the influence of grid density on the numerical modeling of natural convection within a 2D cavity, driven by temperature-induced density variations. A series of simulations are performed using progressively refined grid resolutions, ranging from coarse to fine meshes, to evaluate their effects on key flow characteristics such as velocity profiles, temperature distributions, and heat transfer rates. The Rayleigh number, a dimensionless parameter governing the strength of buoyancy forces, is varied across a broad range to examine its interplay with grid resolution. Results reveal that coarse grids often fail to capture critical flow features, such as secondary vortices and sharp thermal boundary layers, leading to significant inaccuracies in predicted Nusselt numbers and flow patterns. In contrast, finer grids improve solution fidelity but at the cost of increased computational expense. A grid-independent solution is achieved for sufficiently high grid densities, providing a benchmark for optimal mesh design. This work underscores the importance of grid sensitivity analysis in ensuring reliable and efficient simulations of buoyancy-driven flows. The findings offer practical insights for researchers and engineers seeking to balance accuracy and computational efficiency in modeling natural convection phenomena within confined geometries.

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#### **ID2: Comparative Study of Numerical Methods for Internal Flow: Implicit-Explicit Finite Differences and Lattice Boltzmann Method with Varying Lattice Node Arrangements**

*Abdelhak Bahlouli and Idir Lasloudji*

The accurate simulation of internal flows, such as the lid-driven cavity problem, remains a cornerstone in computational fluid dynamics (CFD) due to its relevance in engineering and scientific applications. This study presents a comparative analysis of numerical methods for modeling internal flows, focusing on implicit and explicit finite difference schemes alongside the Lattice Boltzmann Method (LBM). The investigation explores the performance of these methods under varying lattice node configurations, including structured grids like D2Q9 and more complex arrangements such as D3Q15 or adaptive meshes. Implicit finite difference methods are highlighted for their unconditional stability, enabling larger time steps at the cost of increased computational complexity. In contrast, explicit finite difference schemes offer simplicity and ease of implementation but are constrained by strict stability criteria. The LBM, with its mesoscopic approach, demonstrates superior flexibility in handling complex boundary conditions and unsteady flow phenomena, particularly in confined geometries like the lid-driven cavity. Benchmark comparisons reveal that LBM achieves high accuracy and efficiency, especially when paired with higher-order lattice node arrangements. However, trade-offs between computational cost, stability, and accuracy are critically examined across all methods. Results from this study underscore the importance of selecting an appropriate numerical method based on flow characteristics, grid resolution, and desired fidelity. By bridging traditional finite difference techniques with modern LBM approaches, this work provides valuable insights for optimizing simulations of internal flows in diverse applications ranging from microfluidics to industrial-scale systems.

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**ID41: Optimizing the Thermal Performance of Double Skin Façades under hot climatic condition**

*Maha Fguiri, Ali Fguiri, Zouhaier Mehrez and Mohamed-Razak Jeday*

Net-Zero-energy buildings are a sustainable solution to the growing demand for energy and environmental concerns in the construction sector. The key to achieving near-zero energy consumption is the ability of walls to adapt to changing weather conditions. To meet this challenge, double skin facades (DSF) have been introduced. A DSF is composed of two layers of glazing separated by a ventilated air cavity, with openings located at the top and bottom of the facade, as well as shading systems integrated inside. This research validates numerical simulations based on experimental data and a grid-sensitivity analysis. The main objective of this study is to present a two-dimensional CFD model capable of predicting the thermal performance of the DSF during the summer season. CFD modelling aims to analyze the influence of shading devices within the cavity, air flow and heat transfer through the DSF. Four different opening sizes 10 cm, 20 cm, 24 cm and 30 cm are considered as design parameters. The opening of 10 cm causes the maximum temperature in the cavity, indicating limited air circulation and heat accumulation. Conversely, the 30 cm opening has the lowest temperature, suggesting more efficient ventilation and better heat dissipation.

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**Materials Science and Engineering**

**ID20: Mechanical Properties of HfO<sub>2</sub> and ZrO<sub>2</sub> Investigated via Ab Initio Calculations Using CRYSTAL17**

*Hanen Ferhi, Othmen Khaldi and Rached Ben Younes*

Hafnia (HfO<sub>2</sub>) and zirconia (ZrO<sub>2</sub>) are widely studied transition metal oxides due to their remarkable mechanical, electronic, and thermal properties, making them essential in various technological applications. Here, we report on the mechanical properties of HfO<sub>2</sub> and ZrO<sub>2</sub> using density functional theory (DFT) as implemented in the CRYSTAL17 code. The structural optimization and elastic tensor calculations are performed within the generalized gradient approximation (GGA) and hybrid functionals to accurately describe the electronic structure and interatomic interactions. The computed elastic constants are used to derive key mechanical parameters such as bulk modulus, shear modulus, Young's modulus, and Poisson's ratio, providing insight into their mechanical stability and anisotropic behavior. The results are analyzed in comparison with experimental data and previous theoretical studies, highlighting the impact of electronic structure effects on the mechanical performance of these oxides. Our findings contribute to a deeper understanding of HfO<sub>2</sub> and ZrO<sub>2</sub>, offering valuable insights for their potential applications in coatings, microelectronics, and structural ceramics.

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**ID11: Modeling using numerical and the Taguchi methods for the orthogonal cutting of AISI 4140 steel**

*Boujemaa Hadj Brahim, Lotfi Dahmeni, Slimen Attyaoui and Mohamed Nasser*

The machining with cutting tools remains the most widely used mechanical manufacturing process, despite the emergence of other methods such as additive manufacturing and laser cutting. This requires special attention to the process, despite its complexity related to the numerous physicochemical and thermomechanical phenomena involved in chip formation. Material removal influences friction, shear, wear, as well as the metallurgical and micromechanical transformations of finished surfaces. The resultants of the tool/material interactions through the shear and chip removal plane are evaluated by the profiles of the cutting forces, machining stress and temperature stresses required at the cut. The

aim of this study is to analyze the influence of cutting conditions, specifically cutting speed and feed rate, on the thermal and mechanical stresses applied to the tool, in order to better understand the impact of these parameters on the machinability of the AISI 4140 material. A numerical thermomechanical model using a 2D Finite Element approach for orthogonal cutting has thus been developed with Abaqus/Explicit©. The results obtained from numerical simulation were then modeled using the Taguchi method. These results indicate that the increase in cutting speed and feed rate causes a rise in temperature at the tool-chip interface, while the maximum stress on the tool decreases at high cutting speeds. It is also established optimization of the parameters and that the impact of interactions between factors often ignored in similar works should be reviewed with curiosity.

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**ID84: Inverse identification for multi-criteria optimization 3D elastic properties of cross-ply Elium 150®-reinforced flax fiber composites**

*Ameny Ketata*

In real-world applications, composite material manufacturers often provide only partial data. This limitation makes it challenging to conduct 3D finite element simulations, as only a subset of material properties can be directly derived from standardized static tests. To overcome this constraint, an inverse method was employed to identify the optimal mechanical properties of cross-ply laminate Elium® composites reinforced with flax fibers. This approach builds on a method previously validated for unidirectional UD-0° materials. This method combines the use of a Design of Experiments (DoE) and the Response Surface Methodology (RSM) to generate meta-models describing the numerical estimated frequencies as functions of the material's mechanical constants. These meta-models were then integrated into an optimization framework using the Non-Dominated Sorting Genetic Algorithm (NSGA). The objective function aimed to minimize the differences between experimental and numerical frequencies for each vibration mode. Throughout this process, key genetic algorithm hyperparameters, such as population size, number of generations, and convergence error, were carefully adjusted since they directly influence the genetic operators (selection, crossover, and mutation), which are the fundamental mechanisms that drive the evolution of the algorithm toward optimal solutions. Specifically, these hyperparameters were modified from those used for UD optimization, which is expected to account for the increased complexity of cross-ply laminate architectures, where interactions between layers and fiber orientations introduce additional challenges.

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**ID29: Mathematical Modeling and Optimization of Sisal and Cactus Fiber-Reinforced Plaster Composites**

*Imed Miraoui and Samir Zidi*

In response to the growing need for sustainable materials, this study synthesizes findings on sisal and cactus fiber-reinforced gypsum composites with an emphasis on mathematical modeling. Three models - the Rule of Mixtures (ROM), the Inverse Rule of Mixtures (IROM), and the Hirsch model - were used to analyze and predict composite behavior based on chemical treatments and fiber properties. Alkali (NaOH) and paraffin oil treatments improved fiber tensile strength, reaching up to 490 MPa for sisal and a 42% improvement for cactus (from 36.6 MPa to 52 MPa). Sisal cords composed of twisted fibers outperformed single fibers, increasing the flexural strength of the composite by up to 40%. Optimal fiber mass fractions of 3.75% for cactus and 1.25% for sisal, combined with a fiber length of 120 mm, further improved composite performance until saturation reduced properties. Gypsum mixes containing 50% water provided the optimum balance of workability and strength. The effectiveness of each model in predicting composite behavior based on these parameters was carefully evaluated.

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**ID79: Numerical simulation of the Erichsen test of thin DP600 steel sheets and Aluminium alloy using SolidWorks**

*Said Mlik, Slimen Attyaoui and Mohamed Nasser*

This research aims to present the basics of one of the most widely used methods of stretch forming, namely the Erichsen test. It is used to show the formability of metal sheets and is a useful measure, showing the ductility of materials intended for further use. In addition, the finite element analysis FEA was carried out using the SOLIDWORKS 2016 software and the main aim of this paper is to compare Von-Misses strain and stress for structural steel and aluminum alloys with thicknesses of 2 and 3 mm. The hypothesis of this article is to obtain results that will confirm that aluminum alloys are more ductile than DP600 steels and that with the increase in the drawing depth of the sheets, this increases similarly.

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<b>Structural Dynamics and Vibrations</b>
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**ID77: Experimental Analysis of Gear Tooth Breakage Impacts on Vibration and SEIG Current Signatures in Wind Turbines**

*Mohamed Belgacem, Mohamed Salah, Soufien Essahbi and Hatem Tlijani*

Gear transmission systems play a crucial role in many industrial applications requiring the adaptation of speed and torque between the drive motor and the driven load. Wind turbines are a perfect illustration of this issue: their speed multiplier, an expensive and frequently faulty component, ensures the conversion between the slow rotation of the blades and the speed required by the electric generator. This paper focuses on the diagnosis of defects affecting this critical component. We analyze the impact of a tooth breakage on a spur gear through: Time and frequency vibration characterization, and analysis of the stator currents of a self-excited induction generator supplying a resistive load. The tests were conducted on an experimental wind farm reproducing isolated site conditions. Comparative analysis of the signals (healthy vs. defective) reveals characteristic signatures allowing us to propose a reliable, economical monitoring method adapted to preventive maintenance constraints. The results obtained are promising in terms of detection efficiency at low cost.

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**ID19: Preliminary Structural Design for vibration analysis of drone's blade**

*Ghazoi Hamza, Waad Chraiti, Mohamed Salah and Mohamed Haddar*

Aerial manipulators have many important application scenarios, such as maintenance, inspection search and rescue. The unmanned Aerial Vehicle or drone is a mechatronics device consisting of mechanical and electronic components. It has wide range of applications in engineering and in daily routine. This research work deal with the conceptual design of the drone taken into account the vibration aspect. Body frame and other electronics component of the drone are subjected to vibration during flight. The present study focuses on the modelling and vibration analysis of the drone blade based on analytical approach. In fact, the main source of the blade vibration is the rotation of the rotor. The blade, in this investigation is considered as an elastic structure. An object-oriented modeling approach will be used with the Modelica language. Through a simple modeling technique in Dymola environment, this novel method enables us to create a model for calculating the vibration response of the drone structure during the preliminary phase of the design process.

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## Robotics, Automation and AI

### **ID52: A Deep Learning method for MS Lesion Quantification on MRIs**

*Mouna Sahnoun, Fathi Kallel, Salma Sakka and Mariem Dammak*

Multiple Sclerosis (MS) is marked by a demyelination process that results in brain lesions, which can be detected and visualized using Magnetic Resonance Imaging (MRI). To address the challenges of this task, various MS lesion segmentation methods have been developed. In this work, we present a segmentation approach based on 3D U-Net model, specifically designed for detecting MS lesions in MRI scans. To accurately segment MS lesion and measure its volume, image preprocessing is essential. Hence, we introduce a method for volumetric lesion quantification on MRIs of MS patients, leveraging automatic lesion segmentation using FLAIR modalities from the public ISBI Dataset.

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## Renewable Energy Systems

### **ID68: Dynamic regime study of a solar-powered phosphate drying prototype**

*Wael Manai, Kamel Rabhi and Slimen Attyaoui*

Solar-powered phosphate drying integrates solar energy, chemistry, geology, and engineering to enhance efficiency and sustainability. With over 3,000 hours of sunshine annually, regions like Tunisia offer ideal conditions for this method, which significantly reduces CO<sub>2</sub> emissions compared to traditional drying techniques. The process optimizes thermodynamic and kinetic factors, such as temperature and drying duration, while research focuses on improving solar system engineering, energy modeling, and storage. Economic assessments ensure profitability without compromising phosphate quality. Innovation efforts aim to enhance sustainability and lower costs, making this technology a viable and eco-friendly industrial solution.

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### **ID9: Comparative Analysis of Radial and Longitudinal Internal Fins for Enhancing the Performance of Parabolic Trough Solar Collectors**

*Anissa Ghomrassi, Hatem Mhiri and Philippe Bournot*

In this paper, the impact of inserts with various shapes on the thermal performance of a cylindro-parabolic collector is studied numerically. Radial and longitudinal fins are tested and their insertion effects on thermal performance of parabolic trough solar collector. Various longitudinal fins number are tested numerically and the best configuration are chosen. To thoroughly execute this research, the methodology is structured into two key stages. First, the concentrated solar heat flux densities within the focal region are computed using SOLTRACE software. Next, computational fluid dynamics (CFD) simulations are employed to assess and improve the thermal performance of the receiver tube. The heat flux densities derived from SOLTRACE serve as the thermal boundary conditions for the receiver tube. A set of numerical simulations was conducted across five different absorber tubes to complete the analysis. The analysis demonstrates that the Nusselt number is significantly higher in tubes with inserts compared to plain tubes. This increase is primarily due to improved heat transfer mechanisms, including the generation of vortices, faster fluid exchange, and enhanced mixing within the flow. All enhanced models display a more even temperature distribution compared to the smooth absorber tube, with radial fins demonstrating superior performance over longitudinal fins. This design improvement promotes efficient mixing of heat flux between the heated wall (which absorbs concentrated solar energy) and the cooler fluid region (upper wall directly exposed to solar radiation).

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**ID74: Optimizing Natural Ventilation with Double-Pass Inclined Solar Chimneys: A Sustainable Solution for Energy-Efficient Buildings**

*Akermi Faouzi, Dib Amar, Aissaoui Faris, Touafek Khaled and Bouaraour Kamel*

Double-pass inclined solar chimneys are innovative structures designed to harness solar energy for natural ventilation in habitats. Unlike traditional chimneys, which rely solely on the buoyancy of warm air for ventilation, double-pass inclined solar chimneys incorporate solar heat to enhance airflow. These chimneys consist of two passageways: an outer transparent cover and an inner absorber plate. The transparent cover allows sunlight to penetrate and heat the absorber plate, which in turn heats the air within the chimney. As the air warms, it rises due to buoyancy, creating a draft that draws cooler air from the habitat below. This process creates a continuous airflow within the chimney, facilitating natural ventilation. The inclined design of these chimneys maximizes solar exposure throughout the day, optimizing heat absorption and airflow. Additionally, the double-pass configuration enhances thermal efficiency by trapping and utilizing solar heat effectively. By harnessing renewable solar energy, double-pass inclined solar chimneys offer a sustainable solution for ventilating habitats, reducing reliance on mechanical ventilation systems and lowering energy consumption. They provide a cost-effective and eco-friendly alternative for maintaining indoor air quality and comfort in various living spaces.

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**Thermal Energy and Heat Transfer**

**ID30: Estimation of the Coefficient of Convective Heat Transfer of a Wall by Inverse Approach**

*Imen Lassioued, Ali Fguiri and Mohamed-Razak Jeday*

This study focuses on the identification of convection heat transfer coefficients (inside and outside) of a building wall, using the iterative method of Levenberg-Marquardt. The main steps include validating a numerical code by precise temperature measurements, analyzing the temperature distribution across the wall, and comparing thermal behavior between an insulating material and a conductive material. The results show a significant heat transfer between wall surfaces and a gradual dissipation of heat inside. A sensitivity study reveals that the influence of convection coefficients varies depending on the position of the measuring points, and that the effect is localized for each coefficient. The feasibility of identifying a single coefficient (assuming the other known) has also been tested successfully. The study shows a reliable convergence of the method, even with initial values far from the exact solution.

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**ID35: Mixed Convection Study of Hybrid Nanofluid Flow in a Trapezoidal Cavity with a Hot Cylinder Inside**

*Kamel Bouaraour, Amel Trabelsi, Djemoui Lalmi and Mohamed Salem Sidi Mohamed*

This study aims to examine heat transfer and fluid flow around a heated solid cylinder in a lid-driven trapezoidal cavity filled with a hybrid TiO<sub>2</sub>-Cu/water nanofluid. The upper wall is maintained at uniform temperature and moves at a constant velocity  $U_0$ . The solid cylinder located in the center of cavity is kept at a higher temperature than the top wall, while the remaining walls are kept insulated. The hybrid nanofluid flow is considered to be Newtonian, laminar, and incompressible. The Richardson number's impact is analyzed by keeping the Reynolds number constant at 20 and adjusting the Richardson number between 0.1 and 10. The volume fractions of each nanoparticles range from 0% to 6%. The results are presented in terms of streamlines, isotherms, and profiles of the average Nusselt number. Numerical data indicates that clockwise rotating cells are formed inside the trapezoidal container as a result of the combined influence of natural and forced convection. The presence of Copper and TiO<sub>2</sub> hybrid nanoparticles in the receiving fluid enhances heat transfer by increasing the total thermal conductivity of the hybrid nanofluids. Higher Richardson values

correspond to more significant changes in heat transfer and Nusselt number. Increasing the Richardson number from 0.1 to 10, due to heightened buoyancy effect, results in a 35.25% increase in the Nusselt number.

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### Energy Efficiency and Conservation

#### **ID33: Impact of the Surface Energy Potential and collisional transitions $\Delta k = \pm 3$ on line widths of $\text{PH}_3$ perturbed by Ar in the $\nu_2$ and $\nu_4$ bands**

*Jamel Salem and Siwar Barhoumi*

The three-dimensional surface energy potential (3D-PES) of the Argon of Phosphine ( $\text{PH}_3\text{-Ar}$ ) Van der Waals complex has been displayed along the intermonomer coordinates using a method clearly correlated with related clusters. The analytical representation of this 3D-PES has been obtained. This surface accurately characterizes the intermolecular interaction between  $\text{PH}_3$  and Ar. The extension of the spectral system of phosphine under the influence of argon at room temperature was then calculated using this 3D-PES. We first modified this surface with the help of a new function "fractional" to integrate it into software to extend computing during collisions. We then used a semi-classic modified model of Robert and Bonamy, which was improved by the concept of exact trajectory. This theoretical model is supported by the consideration of collisional transitions  $\Delta K = \pm 3$  alongside those of  $\Delta K = 0$ . Room temperature data were obtained for various branches of rovibrational bands  $\nu_2$  and  $\nu_4$  of  $\text{PH}_3$  and showed appropriate consent for experimental measurements. Comparing our calculations to others performed previously shows the impact of our surface energy potential and the consideration of collisional transitions  $\Delta K = \pm 3$  on the best prediction of the measured line widths. The results presented here should significantly improve the precise determination of the abundances of  $\text{PH}_3$  and Ar in the planet's atmospheric spectrum.

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#### **ID16: Environment and economic analysis of an industrial waste heat**

*Douha Alaya, Ali Fguiri and Mohamed-Razak Jeday*

Industrial activities are typically generated with large amount of waste, including solid, liquid or gas which often contain significant amounts of unused energy dissipated to the environment, this may be attributed, firstly to the technical, economic and environment difficulties associated with the conventional heat recovery methods and secondly, to the temporal or geographical disparity between the energy produced and the heat required. This work reports in an environmental and economic analysis of 59.15 MW as an industrial waste heat at low temperature for heating 1 ha of an agriculture greenhouse near an industrial plant in southern Tunisia. The environment analysis aims to quantify the overall amount of greenhouse gas emission, however the economic analysis of the viability of the industrial waste heat is essential, because it determines the final adoption of energy efficiency measures. This study was carried out using RETscreen software taking, as a reference case, a greenhouse located in the region of Gabes in southern of Tunisia using natural gas as a heating source.

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#### **ID45: Innovative Application of TIM-PS in Natural Convection Flat Plate Solar Air Collectors for Improved Thermal Efficiency**

*Marwa Ammar, Nahed Soussi, Ameni Mokni, Hatem Mhiri and Hervé Bournot*

Recognizing the high efficiency of solar energy as a renewable resource and the potential of solar air collectors for its utilization, this study investigates heat transfer within such systems. An unsteady, three-dimensional Computational Fluid Dynamics (CFD) analysis was used for this purpose. A key outcome of this CFD study is the identification of a highly optimized and cost-effective design for a vertically mounted collector featuring seven perforated,  $+45^\circ$  inclined Transparent Insulation Material

Parallel Slats (TIM-PS) elements. This innovative facade collector achieves a thermal efficiency of around 60%, while remaining lightweight and cost-effective. The unique combination of perforation and tilting in the TIM-PS, investigated in this research, drives this performance. This leads to a new solar air heater design, leveraging natural convection, that offers adaptability across diverse geographical locations and sunlight conditions.

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### **Biomechanics, Bioengineering and Manufacturing**

#### **ID63: Simulation of PLA Biocomposite Reinforced with kenaf Fibers as a Sustainable Alternative to Aluminum for Car Body Manufacturing**

*Samir Zidi and Imed Miaraoui*

This chapter explores the feasibility of using a PLA (polylactic acid) biocomposite reinforced with kenaf fibers as a sustainable alternative to aluminum in car body manufacturing. The car body design was developed using Solidworks, and the mechanical performance evaluations were performed through simulations in Ansys. The primary objective of the study is to compare the mechanical properties of the PLA/kenaf biocomposite with those of aluminum, a conventional material widely used in car body manufacturing. Simulation results show that the PLA/Kenaf biocomposite exhibits mechanical properties that are competitive with aluminum. While the stiffness and strength of the biocomposite are slightly lower than those of aluminum, it exhibits superior toughness and impact resistance. In addition, the PLA/Kenaf biocomposite is significantly lighter and more environmentally friendly compared to aluminum. These results suggest that the PLA/Kenaf biocomposite holds great promise as a material for car body manufacturing. The results of the study may appeal to automotive manufacturers seeking sustainable alternatives to traditional materials. The use of a biodegradable and environmentally friendly material such as the PLA/Kenaf biocomposite could provide significant environmental and economic benefits.

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### **Smart Grids and Energy Management**

#### **ID14: Performances of an agricultural greenhouse using different materials**

*Djemoui Lalmi, Kamel Bouarour, Abdelouahab Benseddik, Ahmed Badji, Hocine Bensaha and Hadeef Redjem*

This study investigates the implementation of an evaporative cooling system in agricultural greenhouse utilizing three locally available materials: straw, palm leaves, and wool pads. The objective is to develop a cost-effective and sustainable cooling solution for maintaining optimal temperature conditions within the greenhouse environment. The cooling system integrates a photovoltaic (PV) generator to power a fan, with excess energy store in batteries for night time operation. The effectiveness of each material as a cooling pad is evaluate based on their ability to humidity and cool the greenhouse space. Results from the experiment demonstrates the efficiency of the cooling system in reducing temperature fluctuations within the greenhouse. The findings highlight the potential of utilizing locally sourced materials in designing eco-friendly cooling solutions for agricultural applications. Future research directions may focus on optimizing the system parameters and exploring additional materials to enhance cooling efficiency and sustainability in greenhouse environments.

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