1st National Seminar on Structural Mechanics and Materials (SNMSM'25)
October 29-30th, 2025

University Mohamed Boudiaf of M'Sila
Faculty of Technology
Mechanical Engineering Department

SNMSM

CERTIFICATE Of PARTICIPATION

This Certificate is awarded to :

Leila Bechane

For the ***ORAL*** presentation of the paper entitled : ***Effect of the HTL Layer (a-Si) on the Efficiency of the CdS/CdTe Solar Cell via Numerical Simulation***

Authors: ***Leila BECHANE, Hadda TIOUIRI and Sabrina BENABBAS***

at the 1st National Seminar on Structural Mechanics and Materials (SNMSM'25), held at M'Sila University-Algeria, on October 29-30th 2025.

Dean of the Faculty

Conference Chair

Dr. Cherif SAIB

University Mohamed BOUDIAF of M'sila, Faculty of Technology

1st National Seminar on Structural Mechanics andMaterials (SNMSM'25)

October 29-30, 2025

« 1NSSMM'25 » PROGRAM
Wednesday, October 29th, 2025

"IBN HAYTHEM" AMPHITHEATER	
08h30-09h00	Registration
	OPENING CEREMONY
09h10-10h00	Opening word of the rector Pr. Ammar BOUDALAA-University Mohamed Boudiaf of M'sila Word of the Technology Faculty Dean Dr. Abdelkader DJERAD-University of M'sila Welcome speech of SNMSM'25 Chair: Dr.Cherif SAIB.
	Chairs of the session : Pr. ZAOUI M. ; Pr. ROKBI M. ; Pr. FARSI Ch.
10h20-11h00	Plenary Session :Pr. Hocine OSMANI Title «Analyse multi instrumenté de l'endommagement des composites »
11h00- 11h20	Poster Session 1-Pause-Café/Coffee Break
	Chairs of the session : Pr. MENASRI . ; Pr. RAHMOUNI Z.E.; Pr. FARSI Ch.
11h20-12h00	Plenary Session : Pr. YounèsBENARIOUA Title «Elaboration and characterization ofcertain coatings applied in industry»
12h20-13h30	Lunch Time

University Mohamed BOUDIAF of M'sila, Faculty of Technology

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Session Poster 1/ Mercredi 29 Octobre 2025 / 1st Poster Session 10h00- 10h20		
Jury interactif des affiches/Interactive Poster Jury: Pr. BENARIOUA Y. ;Dr. MOUSSAOUI N. ;Pr. RAOUACHE E.		
2	Synthesis of ZnO/CdO Heterojunction Thin Films Nanostructure via Sol-Gel Method	**ROUABAH Mounir**
11	Etude comparative des procédés de coupage au fraisage, plasma et au oxycoupage sur la qualité des pièces découpées.	**MECHTA Ahlem**
29	Valorization of Date Palm Fibers for Sustainable Reinforcement in Geopolymer Composites	**BRIKI Leila**
4	Comportement mécanique en compression et modes de rupture des stratifiés PRFV.	**MASMOUDI Amina**
5	Detach Water into Hydrogen and Oxygen using binary Copper-Chloride, energy and exergy analysis	**BENBRIKA Omar**
66	POST-WELD HEAT TREATMENT EFFECTS ON THE MICROSTRUCTURE AND MECHANICAL BEHAVIOR OF IN-738 LC JOINTS	**GHOUSS Haoues**
8	Free Vibration Response of Cracked Composite Plates: A Comparison Between Conventional and CNT-Reinforced Structures	**MAOUDJ Samah**
46	Thermo-Economic Analysis of a Solar Power Tower Plant with Two-Tank Molten Salt Thermal Storage System for application in the Algerian arid climate	**Khaled BOUCHAREB**
21	Analysis of the Effect of Cutting Parameters on Tool Wear and Chip Morphology in Hard Machining of Ti5553 Titanium Alloy	**SAHBI MohandOUIDIR**
27	Apport de la mécanique des fluides dans l'étude des écoulement sanguins	**Imane TREA**
28	Optimisation mono et multi-objective des paramètres de coupe lors de l'usinage de l'acier AISI D2 en utilisant la lubrification MQL	**ALLAL Mohammed**
6	The use of plastic waste in building materials	**HAMMACHESoumia**
10	Numerical Investigation of Collector Diameter Effects in Solar Chimney Systems	**SEMANEAmmar**
40	STRUCTURAL STUDY OF THE INSERTION OF SILICON, IRON AND/OR BISMUTH IN THE FRAMEWORK OF AlPO4-5	**BELAYACHI Cherifa**
43	Characterization of a cross-linked polyethylene subjected to electrical discharges	**LARBA Mohammed**
59	L'impact des Systèmes D-FACTS sur les Performances du Facteur de Puissance des Réseaux de Distributions	**ZEGNOUN Si Ahmed**
57	Effect of Welding Parameters on the Microstructure and Mechanical Properties of Resistance Spot Welded AISI 430 Stainless Steel Sheets	**MAAZOUZ Morad**
77	Treatment of wastewater from the city of M'sila	**MELOUKİ Azzedine**

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Salle L29/ ROOM L29	
Présidents de la session: Dr. SAIB Ch. ; Dr. BAKHTI F.. ; Dr. BAKRI B.	
14h00- 14h40	**Plenary Session : Pr. Zergane Said Titre :«A new method for optimizing thelocation of wind turbines in theatmospheric boundary layer»**
14h40- 15h40	**Oral session 1**
15h40-16h00	**Session Poster 2 /2Poster Session 2-Pause-Café/Coffee Break**
16h00- 16h40	**Oral session 2**
17h40- 17h00	**Debate /Questions Clôture de la première journée/ Closing of the 1st day**

Salle L29/ ROOM L29			
Oral session 1/ Mercredi 29Octobre 2025/ Oral session 14h40- 15h40			
Présidents de la session: Pr. MENASERI N. ; Pr. AMROUNE S. ; Pr. ZAOUI M.			
30	STABİLİSATİON OPTİMALE DES SOLS À LA CHAUX VİVE : İMPACT DU POURCENTAGE DE CHAUX ET DU DURCİSSEMENT THERMİQUE	**Mohamed HAMDAOUI**	**14h40- 15h00**
7	Influence of Cohesive Zone Length on Crack Opening and Propagation in a Dugdale–Barenblatt Model within an Infinite Strip	**Ikram SLAMANI**	**15h00- 15h20**
26	Influence of friction angle on cutting forces in ball-end milling using a mechanistic approach	**Sif-Eddine MEKENTICHI**	**15h20- 15h40**
Oral session2/ Mercredi 29Octobre 2025/ 2 Oral session 16h00- 16h40			
Présidents de la session: Pr. ROKBI M.; Dr. ELHADI A. ; Pr. FARSI Ch.			
39	Effect of the HTL Layer (a-Si) on the Efficiency of the CdS/CdTe Solar Cell via Numerical Simulation	**Leila BECHANE**	**16h00- 16h20**
9	Buckling Analysis of Functionally Graded Plates Using a Strain-Based Higher-Order Shear Deformation Theory	**Taqiyeddine ASSAS**	**16h20- 16h40**

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14h40- 15h40	**Oral session 1**
15h40-16h00	**Session Poster 2 /2Poster Session 2-Pause-Café/Coffee Break**
16h00- 17h00	**Oral session 2**
17h00- 17h20	**Debate /Questions** **Clôture de la première journée/ Closing of the 1st day**

Salle L30/ ROOM L30			
Oral session 1/ / Mercredi 29 Octobre 2025/ 1st Oral session 14h40- 15h00			
Présidents de la session: Dr. SAIB Ch. ; Dr. BAKHTI F.; Pr. DJERAD A.			
65	Magnetic Suppression of Natural Convection in a Fin-Enhanced Annular Cavity Filled with Fe_3O_4-MWCNT/Water Nanofluid	**Dr. Souad BENKHERBACHE**	**14h40- 15h00**
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67	Elaboration des mortiers géopolymères à base de la brique rouge pour étudier le comportement mécanique et physique à la haute température	**ImenYamina OMRI**	**15h20- 15h40**
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Présidents de la session: Pr. MENASERI N. ; Pr. AMROUNE S. ; Dr. BENKHERBACHE S.			
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71	Effect of Fabric Type on the Performance of Composite Materials: A Comparative Study between Intra-Ply Woven Alfa/Jute Fabrics and Commercial Plain-Weave Jute Fabric	**Samira BOUCHAREB**	**16h20- 16h40**
72	Caractérisation mécanique et micromécanique d'un composite (fibre végétale/résine thermodurcissable)	**Moussaoui Nafissa**	**16h40-17h00**

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3	Effect of fiber orientation on the machining behavior of treated and untreated alpha fiber composites	**GRINE Madani**
18	Numerical Modelling of Ductile Damage in 3D Structures using Finite Element with rotational Dofs	**MOUSSAOUI H.E.**
20	Dielectric Analysis of Wollastonite: Effect of Frequency and Temperature on Electrical Properties	**MAALMI Mohamed**
22	Optimization of ThermophotovoltaicGaSb Cells Using COMSOL Multiphysics: Materials Integration and Thermal Management	**BELABBACI Cherifa**
31	Development and Evaluation of a Parabolic Trough Solar Collector System Using Indigenous Materials	**KHERBICHE Younes**
32	Comprehensive Analysis of the Physicochemical and Mechanical Behavior of Natural Fiber Extracted from BassiaIndica	**KOUIDRI Djamila**
42	Numerical simulation by the Eulerian–Lagrangian approach of Erosion in Cement-Mill Fan: Effects of Blade Outlet Angle and Count	**AMOURAissa**
63	Investigation expérimentale des facteurs influençant le processus d'impression 3D avec l'utilisation de filaments PLA fondus	**BOURENANE Moussa**
48	Caractérisation de bétons polymères à base de sable et de déchets plastiques et renforcés par la sciure de bois	**MEKIDECHE Salih**
60	Comparaison des viscosités de quelques types d'huiles usagées flottantes dans des récipients de différents diamètres	**DJELMID W.**
41	Enhancement of Transmittance and Strength of Sandblasted Glass by Deposition of Silica and Zirconia Thin Films	**CHEBBAH Bouzid**
50	ANOVA-Taguchi Analyses on Heat Transfer of MHD Ternary Hybrid Nanofluid MHD Jeffery–Hamel Flow.	**TALBI Nabil**
51	Comparative heat transfer analysis of γ〖Al〗_2 O_3 -H_2 O and 〖γAl〗_2 O_3 -EG in MHD flow between nonparallel a porous media channels with stretchable walls and radiation Effects	**TALBI Nabil**
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74	Estimation des besoins en eau d'irrigation à l'aide des modèles climatiques CMIP6 dans la région de la Mitidja, Algérie	**Gherbi Khadidja**

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« 1NSSMM'25 » PROGRAM
Thursday, October 30th, 2025

Salle L29/ ROOM L29	
09h30-10h00	PlenarySession:Pr.Mansour ROKBI Title :« Exploration des fibres naturelles dans la région du Hodna : Application pour composites »
Chair of the session : Pr. AMROUNE S; Pr. OSMANI H.; Dr. BENHAMADOUCHE L.	
10h00- 10h40	Oral Session 3
10h40- 11h20	Poster Session 3-Pause-Café/Coffee Break
11h20- 12h00	Oral Session 4
12h00- 13h00	Closing and certificates delivery / Clôture et remise des certificats
13h00- 14h00	Lunch Time

Salle L30/ ROOM L30	
10h00- 10h40	Oral Session 3
10h40- 11h20	Poster Session 3-Pause-Café/Coffee Break
11h20- 12h00	Oral Session 4
12h00- 13h00	Closing and certificates delivery / Clôture et remise des certificats
13h00- 14h00	Lunch Time

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Salle L29/ ROOM L29			
Oral session 3/Jeudi 30 Octobre 2025 / 3rdOral session 10h00- 12h00			
Présidents de la session: Dr. EL HADI A.; Dr.ARSLANE M.; Dr. BENKHERBACHE S.			
69	Numerical Study of Thermal and Hydraulic Behavior of Nanofluids in Perforated Pin-Fin Heat Sinks	**Dr .Fatima zohra BAKHTI**	**10h00-10h20**
70	Etude de l'efficacité inhibitrice d'un extrait d'Atractylisgummifera vis-à-vis à la corrosion de l'acier E335 dans un milieu d'acide chlorhydrique	**Mokhtar BENARIOUA**	**10h20- 10h40**
			11h20- 11h40
19	Transient Thermal Analysis of a Satellite–Launcher Separation Mechanism Using Finite Element Method	**Amine SMAHAT**	**11h40- 12h00**
Salle L30/ ROOM L30			
Présidents de la session Pr. BENYAHIA Az.; Pr. FARSI Ch.; Dr. MELOUKI Az.			
62	An experimental study on recycled polypropylene and high-density polyethylene	**Nakhla DAKHOUCHE**	**10h00- 10h20**
53	Magnetohydrodynamic Conjugate Mixed Convection Heat Transfer of a Ternary Nanofluid in Lid-Driven Triangular Cavities.	**Kamal ZITOUNI**	**10h20- 10h40**
55	Impact of Structural Defects on the Behavior of Reinforced Concrete Structures	**Djamel SEMSOUM**	**11h20- 11h40**

Session Poster 3/Jeudi 30 Octobre 2025 / 3rdSession Poster 10h40- 11h20		
Jury interactif des affiches: Pr. Dr. MELOUKIAz.; Dr.BAKRI B.;Pr. BENYAHIA A.		
14	Finite element simulation of progressive damage in composite materials	**Mohamed LATRACHE**
23	Theoretical Prediction of Protein Network-Induced Nonlocal Response in Molecular Resonator Biosensors Incorporating Hydrogen Bonding and van der Waals Interactions	**Brahim DJELLALI**
24	Evaluation of the stability of hydroxyapatite (Ca/P = 1.5) derived from sol-gel at different thermal conditions.	**Amira MOKRANE**
25	Computational Characterization of Phthalimide Derivatives: A DFT Study of Electronic Properties and Reactivity	**NabilaBENABILA**
47	Development of a Python-Based Abaqus Plugin for Random distribution of Unidirectional Fibers in Composite Materials	**Noureddine AIMEUR**
34	Influence of Applied Voltage on the Fatigue Performance of Copper-Embedded Multifunctional Composites	**Imene BACHIR BEY**
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68	The impact of incorporating marble waste on the tensile strength of composite tubes, plastic-bonded sand analysed using the Split- Disk test (SDT)	**Maria BOUCHIBA**
Jury interactif des affiches: Dr.DJAALAB AH.; Pr.KHETTAB KH.		
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79	Enhanced Diabetic Retinopathy Classification via MobileNetV3-Large Using Combined RGB and CLAHE Retinal Fundus Imagery.	**Ishaq AICHE**
49	Etude du comportement a la corrosion d'une armature en acier dans un milieu cimentaire modifie avec des fines de liege	**Hakim BENSABRA**
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73	Modeling& simulation of mechanical system for Jersey barrier	**Mohamed El Amine Moussa**
76	Optimization of alkali treatment for stipatenacissima fibers in polyester-based composites	**Farsi Chouki**
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33	Unified Jacobian–Torsor Framework for Automatic Tolerancing and Geometric Variation Analysis	**Belkacem AOUFI**
15	Bridging Biomechanics and Robotics: AI-Driven Gait Trajectories for Prosthetic Design	**NOUI Malika**
80	Enhancement of Mechanical Properties of Unsaturated Polyester Composites Reinforced with Treated Alfa Fibers and Marble Additives	**Laib N.**

SNMSM 2025

Proceedings of 1st National Seminar on Structural Mechanics and Materials

Algeria, M'Sila **29-30 October 2025**

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Contents

PREFACE

The 1st National Seminar on Mechanical Structures and Materials (SNMSM'25) was organized by Mohamed Boudiaf University in M'sila on October 29–30, 2025. This scientific event aims to strengthen collaboration between universities, industry, and public administration in order to foster investment and encourage economic development.

The seminar provided an open platform for researchers, academics, and professionals to exchange knowledge and expertise by presenting the latest advancements and innovations in the field of mechanical structures and materials. It also served as an opportunity to discuss ideas, establish scientific partnerships, and develop possibilities for technical and research collaboration.

The program of the seminar included keynote lectures, oral presentations, and poster sessions, all related to the following main topics:

** **Topic 1: Materials characterization, composites, polymers and smart materials, biomaterials, material recycling, and environmental assessment.*

** **Topic 2: Manufacturing, dynamics and modeling of structures, robotics, and diagnosis of machining machines.*

** **Topic 3: Renewable energies, sustainable development, and energy storage technologies.*

The scientific committee received a significant number of contributions from various universities and research centers across the country. A selected set of the best works were accepted to enrich discussions and broaden collaboration prospects in support of scientific research and industrial development in Algeria.

1sh National Seminar on Structural Mechanics and Materials
(SNMSM 2025).
29-30 October 2025: M'sila, Algeria
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Bridging Biomechanics and Robotics: AI-Driven Gait Trajectories for Prosthetic Design

Malika Noui*[1]

[1] *University Setif1*

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Abstract **–** This paper presents a reproducible and scalable framework for generating physiologically plausible gait trajectories using deep learning, with direct application to intelligent prosthesis design. Starting from raw biomechanical datasets, we implement a robust preprocessing pipeline to extract and normalize multi-joint motion sequences. These sequences are modeled using recurrent neural networks to capture temporal dependencies and intersegmental coordination. The predicted trajectories are then injected into a MuJoCo-based simulation environment to evaluate their biomechanical feasibility and dynamic stability. Through visual and quantitative validation, we demonstrate that the simulated movements align with clinical gait norms and offer actionable insights for prosthetic control strategies. This approach bridges the gap between data-driven modeling and robotic execution, laying the groundwork for adaptive, patient-specific prosthetic systems.

Keywords **–** *Gait trajectory modeling; Intelligent prosthesis design; Biomechanical; Deep learning MuJoCo;*

I. INTRODUCTION

The development of intelligent prosthetic systems demands accurate modeling of human gait that is both physiologically plausible and mechanically executable. Traditional approaches often struggle to generalize across diverse users and walking conditions, limiting their adaptability in real-world scenarios. In this work, we present a novel deep learning framework that leverages sequential neural architectures,specifically Long Short-Term Memory (LSTM) networks, to generate robust joint trajectories from both simulated and real gait datasets. These trajectories are deployed within robotic platforms such as MuJoCo and ROS, enabling seamless integration between biomechanical simulation and physical execution.

Our framework is designed to support scalable, personalized prosthetic control for clinical rehabilitation and industrial applications. By validating the generated movements across varied subject profiles and dynamic environments, we demonstrate strong generalization and biomechanical fidelity. This approach not only enhances the realism of gait synthesis but also lays the foundation for adaptive, data-driven prosthetic systems capable of responding to individual needs in real time.

This research work provides the following major contributions:

- **Realistic Gait Generation :** Our model uses LSTM networks to learn from both real and simulated gait data, producing joint trajectories that are physiologically accurate and executable. These trajectories are validated in MuJoCo and ROS, ensuring that the movements are suitable for robotic prosthetic control.
- **Adaptive Prosthetic Control :** Our model generalizes across various subject profiles and walking environments. This adaptability allows our system to deliver personalized prosthetic control without manual tuning, making it scalable for clinical and industrial applications.

The rest of this paper is organized as follows: First, we provide brief review of related works. In section 3 we describe the dataset used in our model. Section 4 is devoted to background concepts. In section 4, we present experiments and evaluation processes. A conclusion is presented in the last section

II. Related works

Recent advances in deep learning have significantly influenced prosthetic gait modeling, particularly through the use of recurrent neural networks (RNNs) and reinforcement learning. Wen et al. (2019)**[1]** introduced an online reinforcement learning framework for robotic knee prostheses, enabling real-time personalization of gait patterns based on user feedback. Similarly, Li et al. (2021)**[2]** demonstrated how reinforcement learning could expedite impedance tuning for prosthetic limbs, allowing for more natural and adaptive movement. These approaches highlight the growing emphasis on data-driven control strategies that respond dynamically to individual biomechanical profiles.

Trajectory generation has also benefited from deep learning innovations. Zhu et al. (2023, 2024**)[3]** proposed diffusion-based models like Difftraj and Controltraj to synthesize structured motion trajectories, which, although originally applied to GPS data, offer transferable insights for biomechanical motion synthesis. In parallel, Ma et al. (2020) and Zou et al. (2024)**[4]** explored dynamic movement primitives and spatial quantization techniques for exoskeleton gait generation, emphasizing the importance of physiologically grounded models. Together, these studies underscore the potential of combining temporal modeling, simulation environments, and clinical validation to create intelligent, patient-specific prosthetic systems.

III. Dataset

The dataset **BothLegsWalk.mot[5]** is a sample motion file used in OpenSim, a biomechanics simulation platformThe dataset represents a biomechanical time-series that records joint angles throughout a walking cycle. It was likely obtained through motion capture or simulation software such as OpenSim. Each row corresponds to a specific moment in time, while each column reflects the angular position of a particular joint, measured in degrees. We selected the flow data :

- **Hip flexion :** increases during the swing phase when the leg moves forward.
- **Knee flexion :** peaks during mid-swing to allow foot clearance.
- **Ankle angle :**shifts from dorsiflexion (heel strike) to plantarflexion (toe-off).
- **MTP angles** : reflect toe bending, especially during push-off.

IV. BASICS CONCEPTS

IV.1 DEEP LEARNING

Deep learning is a subset of machine learning that uses artificial neural networks with multiple layers to learn complex patterns from large amounts of data. It excels in tasks like image recognition, natural language processing, and time-series prediction by automatically extracting features without manual intervention.

IV.2 LSTM (LONG SHORT-TERM MEMORY)

LSTM is a specialized type of Recurrent Neural Network (RNN) designed to model sequential data and capture long-term dependencies. Unlike traditional RNNs, LSTMs solve the problem of vanishing gradients by using memory cells and gates that control the flow of information.

- Forget gate: decides what information to discard
- Input gate: decides what new information to store
- Output gate: controls what information is passed to the next step

LSTMs are widely used in:

- Speech recognition
- Language modeling
- Time-series forecasting
- Event detection in NLP

V.3 EVALUATION METRICS

- **Mean Absolute Error (MAE)** is a metric used to evaluate the accuracy of a regression model. It measures the average magnitude of errors between predicted values and actual (true) values, without considering their direction (positive or negative).
- **Mean Squared Error (MSE)** is a common metric used to evaluate the accuracy of a regression model. It measures the average of the squared differences between predicted values and actual values.
- **Root Mean Squared Error (RMSE)** is a standard metric used to evaluate the accuracy of a regression model. It measures the square root of the average of the squared differences between predicted values and actual values.
- **R^2, or the coefficient of determination**, is a statistical measure that indicates how well a regression model explains the variance in the target variable. It shows the proportion of the variation in the actual data that is captured by the model's predictions.

V.4 WHAT IS MUJOCO?

MuJoCo stands for Multi-Joint dynamics with Contact. It is a physics engine designed for accurate and efficient simulation of complex systems, especially in robotics, biomechanics, and reinforcement learning. The key features are :

- **Realistic physics:** Simulates rigid body dynamics, soft contacts, friction, and constraints.
- **Fast and efficient:** Optimized for speed, making it ideal for training AI agents in simulation.
- Differentiable: Supports gradient-based optimization, useful for control and learning tasks.

- **Flexible modeling:** Can simulate humanoid robots, prosthetic limbs, animal locomotion, and more.

The Common Use Cases are :

- **Reinforcement learning:** Used in environments like OpenAI Gym and DeepMind Control Suite.
- **Robotics:** Simulates robot arms, quadrupeds, and manipulators.
- **Biomechanics:** Models human movement and prosthetic interactions.
- **Control systems:** Tests controllers in simulated physics environments.

File Format :

MuJoCo uses XML-based model files (typically) that define:

- Body structure
- Joints and actuators
- Contact surfaces
- Sensors and constraints

III. EXPERIMENTS AND EVALUATION

V.1 TASK 1: GENERATION OF GAIT TRAJECTORIES

V.1.1 PSEUDOCODE: LSTM MODEL FOR JOINT ANGLE PREDICTION

1. IMPORT required libraries:

2. LOAD joint angle data from BothLegsWalk.mot file:

- Read the .mot file into a DataFrame
- SELECT only the following columns: ['hip', 'knee', 'ankle', 'pelvis', 'foot']
- STORE the result in df_selected

3. NORMALIZE joint angle values

4. CREATE input sequences

5. CREATE output labels for prediction

6. BUILD LSTM model:

- INITIALIZE Sequential model
- ADD LSTM layer with 64 units, input shape = (window_size, number of joints)
- ADD Dense layer with output size equal to number of joints
- COMPILE model using Adam optimizer and mean squared error loss

7. TRAIN the model

8. EVALUATE the model

V.1.2 RESULTS AND ANALYSE

TABLE I. MODEL PERFORMANCE METRICS FOR GAIT TRAJECTORY PREDICTION

Metric	Value	Meaning
MAE (Mean Absolute Error)	**0.0093**	On average, predictions deviate from actual values by 0.0093 units. Lower is better.
MSE (Mean Squared Error)	**0.0002**	Measures the average squared difference between predicted and actual values. Very low, indicating high accuracy.
RMSE (Root Mean Squared Error)	**0.0130**	Square root of MSE. Gives error magnitude in original units.
R^2 (Coefficient of Determination)	**0.997**	Indicates that 99.7% of the variance in the data is explained by the model. This is excellent.

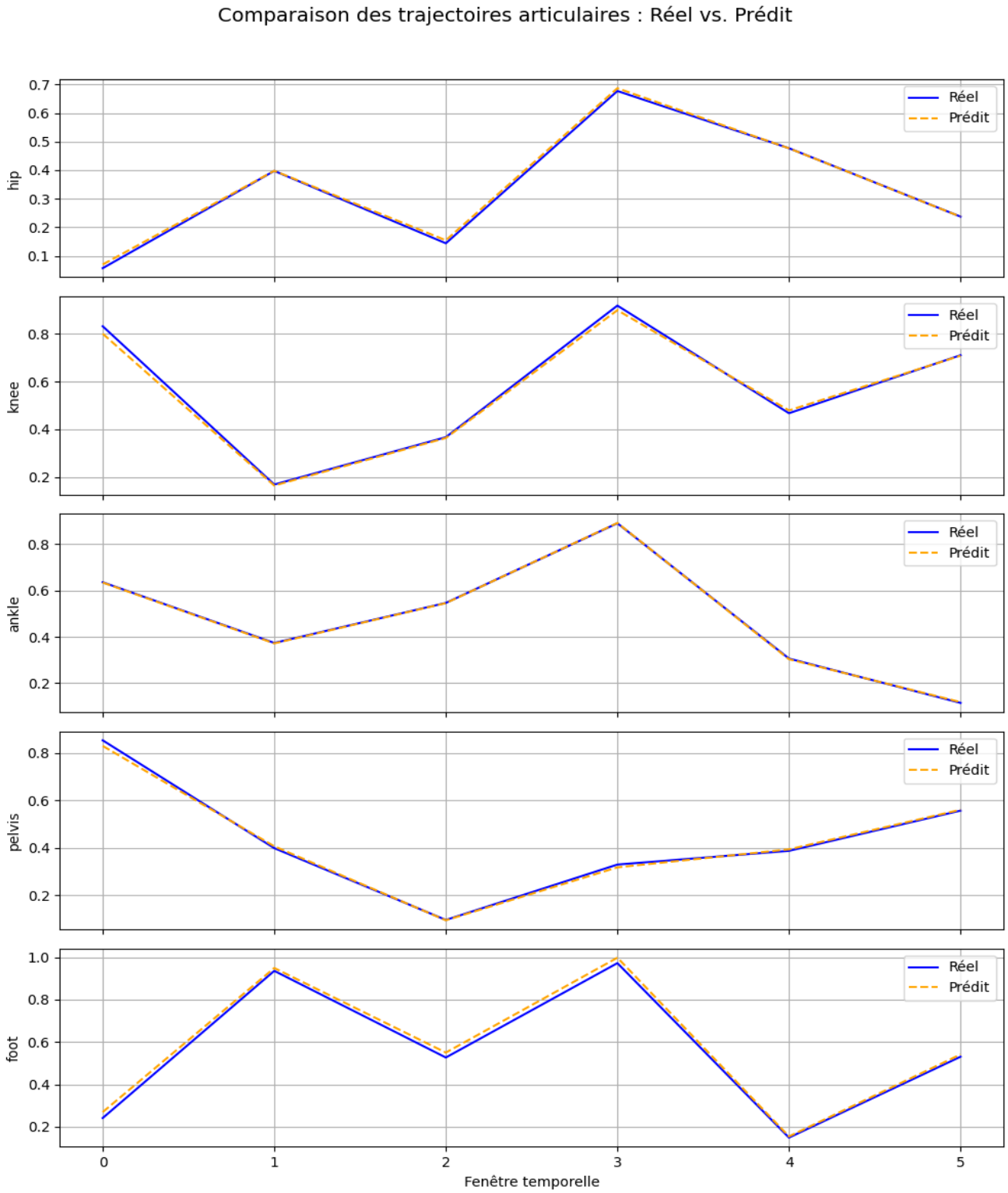
- **High Precision**: An R^2 of 0.997 shows your model captures nearly all the variability in the data.
- **Minimal Error**: Extremely low MAE, MSE, and RMSE values suggest your predictions are very close to the actual values.
- **Well-Trained Model**: These results imply strong performance and good generalization.

Table II. Joint-by-Joint Analysis

JOINT	TRAJECTORY MUTCH	OBSERVATIONS
HIP	EXCELENT	Predicted line closely follows the real trajectory, with a smooth peak around frame 2 and consistent descent.
KNEE	VERY GOOD	Slight variation in amplitude, but the overall shape and timing of peaks are well captured.
Ankle	STRONG	Predicted trajectory mirrors the real one with good phase alignment and amplitude consistency.
PELVIS	VERY CLOSE	More dynamic fluctuations; predicted line captures the general pattern but with small timing offsets at peaks and troughs.
FOOT	Slightly noisier	More dynamic fluctuations; predicted line captures the general pattern but with small timing offsets at peaks and troughs.

- **Model Performance:** The LSTM model demonstrates high fidelity in reproducing joint trajectories, especially for hip, pelvis, and knee.
- **Temporal Consistency:** Predicted curves maintain temporal alignment with real data, which is crucial for biomechanical modeling and motion prediction.

- **Foot Dynamics:** Slightly more erratic behavior in the foot graph may suggest higher variability or complexity in that joint's movement.



V.2 TASK 2: TRAJECTORY INJECTION INTO MUJOCO

This part of MY project focuses on evaluating the predicted gait trajectories using a physics-based simulation (MuJoCo) to check if the movements are biomechanically realistic and dynamically stable.

Simplified Pseudocode Explanation :

1. Load predicted joint trajectories (e.g., angles or positions over time)

2. Initialize the MuJoCo simulation environment with a human or prosthetic model

3. Inject the predicted trajectories into the simulation

4. Run the simulation to animate the movement

5. Record outputs: joint stability, ground reaction forces, balance metrics

6. Compare simulated movement to clinical gait standards

7. Visualize results (e.g., trajectory plots, stability graphs)

8. Extract insights for prosthetic control strategies

IV. CONCLUSION

This study presents a reproducible framework for generating physiologically plausible gait trajectories using deep learning, with direct application to intelligent prosthesis design. By preprocessing raw biomechanical data and modeling multi-joint motion sequences through recurrent neural networks, we achieved high predictive accuracy, as evidenced by strong performance metrics (e.g., MAE = 0.0093, R^2 = 0.997). The predicted trajectories are intended to be injected into a MuJoCo-based simulation environment to evaluate their biomechanical feasibility and dynamic stability. While this study proposes a detailed pseudocode outlining the simulation workflow, the actual implementation and experimental validation remain part of future work. This planned simulation will help bridge the gap between data-driven modeling and robotic execution, laying the groundwork for adaptive, patient-specific prosthetic systems.

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Influence of Friction Angle on Cutting Forces in Ball-End Milling Using a Mechanistic Approach

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Abstract – This study investigates the influence of friction angle on cutting force generation during ball-end milling of aluminum alloy Al 7075, using a mechanistic modeling approach. The research aims to understand how variations in the friction angle (β = 45°, 60°, 75°) affect the cutting force components F_x, F_y, F_z, and the resultant force Fr under consistent cutting parameters.
A detailed mechanistic model was developed, incorporating the geometry of the ball end tool, material properties, and dynamic interactions during milling. The model discretizes the cutting edge and integrates tangential, normal, and axial forces based on chip thickness and tool engagement, while also integrating the effect of friction angle into the cutting force coefficients.
Simulation results reveal that increasing the friction angle leads to a systematic rise in all force components, with significant increases in normal (F_y), indicating stronger tool material interaction. A bar chart and force time plots confirm the predictive capacity of the model.
This research highlights the critical role of the friction angle in tool design and machining strategy. The model serves as a powerful tool for optimizing cutting parameters and improving machining performance in complex milling processes involving aluminum alloys.

Keywords – *Friction angle; Cutting force; Aluminum alloy; Mechanistic approach; Machining strategy;*

I. INTRODUCTION

Ball end milling is one of the most versatile machining operations in modern manufacturing, widely applied in the production of molds, dies, aerospace structures, and automotive components. Its spherical tool tip enables the machining of complex three-dimensional surfaces and precise finishing in multi-axis operations. However, the curved geometry complicates tool–workpiece engagement and makes accurate prediction of cutting forces more challenging, since chip thickness and contact conditions vary continuously along the edge [1].

Cutting forces strongly influence machining performance, affecting material removal rate, dimensional accuracy, surface integrity, tool wear, and overall stability. Incorrect force estimation can cause chatter, tool failure, poor surface finish, or thermal damage. For this reason, reliable force prediction remains a central objective in machining science and process optimization [2].

Among existing modeling strategies, the mechanistic approach is particularly effective. It establishes semi-empirical relationships between chip load and force response by discretizing the tool into slices and applying force coefficients derived from experiments or material behavior. This

method balances accuracy and computational efficiency, making it suitable for industrial applications [3], [4].

An important factor in force generation, though often simplified, is the friction angle (β) at the tool chip interface. This angle reflects the interaction between normal and frictional forces and directly affects the balance between tangential and axial components. A small β indicates efficient shearing with low resistance, while larger values imply increased ploughing or rubbing [5], [6].

This study examines the influence of different friction angles (β = 45°, 60°, 75°) on cutting forces in the ball end milling of Aluminum 7075, a material valued for its strength-to-weight ratio, machinability, and industrial relevance. Simulation results are presented using time-domain force plots and comparative charts, providing insight into how friction modifies cutting behavior. These findings help identify optimal cutting conditions and strategies to minimize frictional effects.

II. MECHANISTIC MODELING OF CUTTING FORCES AND INTEGRATION OF FRICTION ANGLE

A. Overview of the Mechanistic Cutting Force Model

The mechanistic approach predicts milling forces by dividing cutter engagement into elements and summing their force contributions using empirical coefficients. It is particularly effective for ball-end milling, where tool edge geometry varies continuously [7], [10]. Each elemental cutting force $d\vec{F}$ at a point on the tool edge can be resolved from local elemental chip load h and cutting edge width db. The basic formulation for force components in the local tool coordinate system is:

$$\begin{aligned} dF_t &= K_t \cdot h \cdot db \\ dF_n &= K_n \cdot h \cdot db \\ dF_a &= K_a \cdot h \cdot db \end{aligned} \quad (1)$$

Where:

- K_t ,K_n ,K_a : Cutting force coefficients (N/m²),
- h: Uncut chip thickness (m),
- db: Width of the elemental cut (m).

These elemental forces are transformed into the global coordinate system (F_x, F_y, F_z) through coordinate transformations based on the angular position ϕ, helix angle γ, and tool radius geometry.

B. Chip Thickness and Engagement Zone Calculation

For each tool rotation step and axial level z, the local chip thickness $h(\phi,z)$ is computed as:

$$h(\phi, z) = [\, ft \cdot sin(\phi) + s(\phi, z) - n(\phi, z)] \cdot sin(\kappa p(z)) \quad (2)$$

Where:

- f_t : Feed per tooth (m),
- ϕ: Angular position of tooth (deg),
- $s(\phi,z)$: Accumulated chip load from previous engagements (surface memory),
- $n(\phi,z)$: Instantaneous surface height due to tool vibration or previous pass,
- $\kappa p\ (z)$: Local projection angle, which depends on whether the point lies on the spherical tip or cylindrical body:

C. Friction angle and its effect on cutting coefficients

The friction angle β is defined as the angle between the resultant force vector and the normal to the tool rake face. It is mathematically related to the friction coefficient μ at the tool chip interface:

$$\mu = tan(\beta) \quad (3)$$

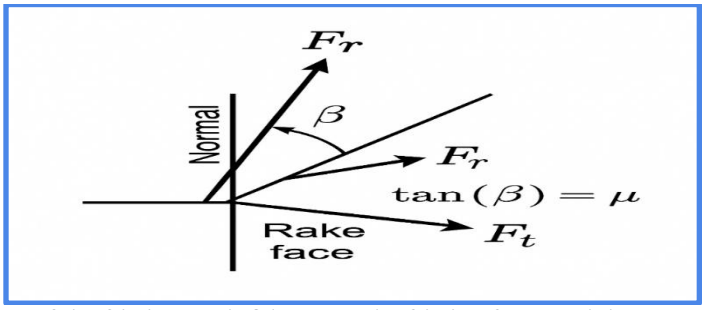

Fig.1 representation of the friction angle β between the friction force and the normal to the rake face

The friction angle shifts the balance between shear and normal forces, altering force distribution. For Al 7075-T6, the specific cutting pressure (K_s) is 850 N/mm², from which cutting coefficients (K_t, K_n, K_a) as reported in the literature [8], [9].

$$K_t = K_s \cdot sin(\beta)$$
$$K_n = K_s \cdot cos(\beta) \quad (4)$$
$$K_a = K_n$$

The corresponding values of cutting coefficients are summarized in Table 1.

Table 1. Values of cutting coefficients for: β = 45°, 60°, and 75°

Friction Angle (β)	K_t(N/mm²)	K_n(N/mm²)	K_a(N/mm²)
45°	601	601	601
60°	737	425	425
75°	821	220	220

D. Cutting Force Accumulation

The total cutting force components in the X, Y, and Z directions are calculated by numerically summing all the elemental forces over all engaged teeth and slices:

$$F_x = \sum_{\varphi,z} (dF_t \cdot cos(\varphi) + dF_n \cdot sin(\varphi) \cdot sin(\kappa p) - dF_a \cdot sin(\varphi) \cdot cos(\kappa p))$$
$$F_y = \sum_{\varphi,z} (dF_t \cdot sin(\varphi) - dF_n \cdot cos(\varphi) \cdot sin(\kappa p) + dF_a \cdot cos(\varphi) \cdot cos(\kappa p)) \quad (5)$$
$$F_z = \sum_{\varphi,z} (dF_n \cdot cos(\kappa p) - dF_a \cdot sin(\kappa p))$$

And the resultant force is:

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \quad (6)$$

III. SIMULATION RESULTS AND ANALYSIS

A. Cutting Forces Results

- ***X-Direction Force (F_x) Comparison***

Figure 2 compares the F_x forces for all three friction angles.

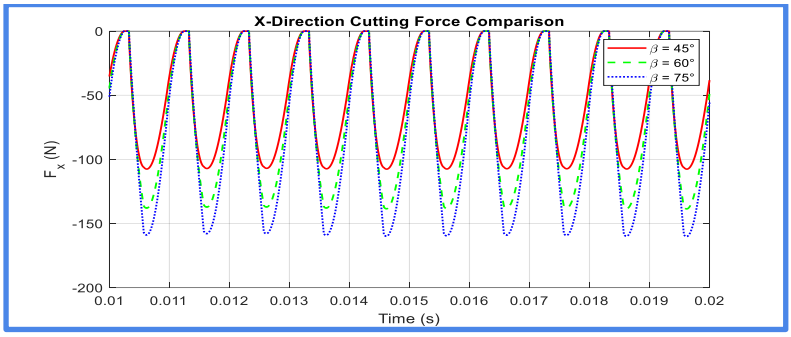

Fig. 2 Comparison of X-direction cutting forces for different friction angles

F_x increases with friction angle, peaking at $\beta = 75°$ and reaching its lowest at $\beta = 45°$. Higher angles also make force peaks more pronounced, showing the strong effect of friction on cutting dynamics.

Y-Direction Force (F_y) Comparison

Figure 3 compares the F_y forces for all three friction angles.

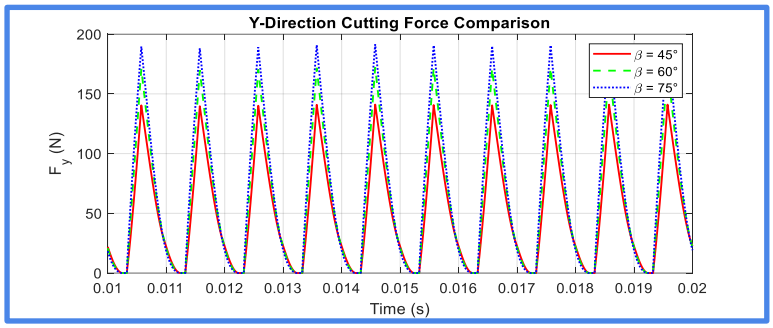

Fig. 3 Comparison of Y-direction cutting forces for different friction angles

F_y shows the greatest variation with friction angle, with amplitudes increasing as resistance grows. At $\beta = 75°$, cutting is most aggressive due to higher tangential force influence.

Z-Direction Force (F_z) Comparison

Figure 4 compares the F_z forces for all three friction angles.

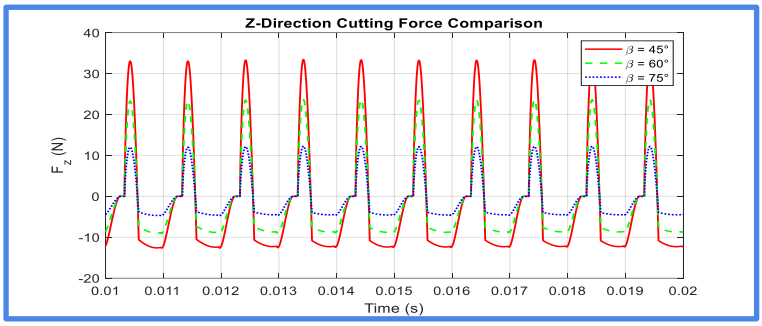

Fig.4 Comparison of Z-direction cutting forces for different friction angles

F_z decreases with increasing friction angle due to reduced normal coefficient (kn). The highest axial force occurs at $\beta = 45°$, while $\beta = 75°$ shows the lowest values.

Figure 5 illustrates that all components (F_x, F_y, F_z) and the resultant force (F_r) rise as friction angle increases.

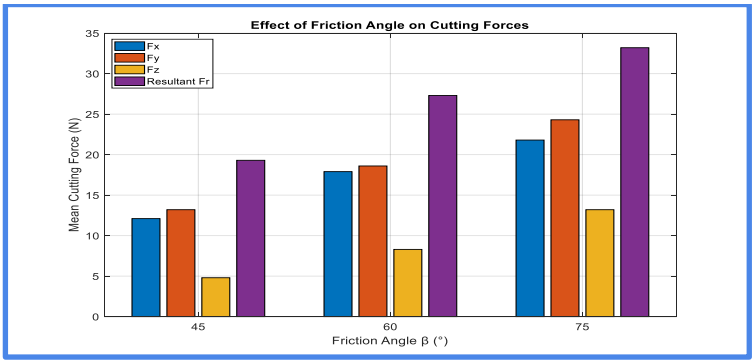

Fig. 5 bar chart of the influence of friction angle (β = 45°, 60°, and 75°) on mean cutting force.

These results demonstrate that friction angle is a critical parameter in ball-end milling force prediction and must be considered for accurate mechanistic modeling.

IV. CONCLUSION

- The friction angle (β) has a significant impact on the cutting force components in ball end milling operations, as demonstrated through a mechanistic simulation approach.
- Higher friction angles result in stronger tool material interactions, causing greater resistance and thus higher cutting forces.
- The mechanistic model accurately captures this trend, proving its suitability for predictive simulations in milling operations.
- These results highlight the importance of optimizing the friction angle (through coatings, lubrication, or tool material) to reduce force magnitudes, improve machining efficiency, and extend tool life.

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A new method for optimizing the location of wind turbines in the atmospheric boundary layer

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Abstract **–** The prediction of wind farm power output is strongly dependent on how the turbines are spatially arranged. A simplistic model that assumes a uniform and unidirectional wind field is not sufficient to determine the optimal turbine placement with accuracy. To address this limitation, the present work introduces a more refined methodology for optimizing turbine micro-siting within a wind farm, making use of the random number generation technique. In particular, a more advanced and realistic wake model is developed, one that incorporates the influence of the atmospheric boundary layer, ground surface roughness, and turbulence. These additions enable a better assessment of turbine interference and contribute to reducing wake losses. For the simulations, data from NREL's Phase VI wind turbines were employed. The results obtained with this improved model were then compared to those derived from the simplified approach, demonstrating notable enhancements in prediction accuracy.

Keywords **–** *Ishihara Wake model; wind energy; Wind farm; Optimization; Generation of pseudo-random numbers;*

1. Introduction

The excessive reliance on fossil fuels such as oil and natural gas in recent decades, along with the resulting large-scale carbon dioxide emissions, has driven a global transition toward renewable energy sources. Among these, wind energy stands out as a clean, sustainable, and environmentally friendly option that produces no greenhouse gases. Its worldwide expansion continues, supported by the installation of turbines in increasingly windy regions to enhance electricity generation. Nevertheless, the efficiency of wind farms is strongly influenced by the spatial arrangement of turbines. The wake effect, which causes a noticeable reduction in wind speed, can significantly lower the power output of downstream turbines.

This study focuses on reducing the wake effect within wind farms and improving overall energy production through the optimal micro-siting of turbines. The proposed approach relies on an advanced wake model developed by Ishihara, combined with random number generation as an optimization technique. The optimization program, implemented in MATLAB, integrates the characteristics of NREL wind turbines to achieve reliable performance predictions.

Ishihara wake model

The prediction of wake behavior within wind farms is essential for accurately estimating power losses and optimizing turbine placement. In this context, Ishihara proposed a comprehensive analytical wake model derived from experimental data obtained through wind tunnel tests conducted on a reduced-scale wind turbine. Unlike simpler approaches, this model provides a more realistic representation of wake dynamics by incorporating not only the influence of natural atmospheric turbulence but also the additional turbulence generated by the wake of upstream turbines.

This dual consideration is particularly important, as the interaction between ambient turbulence and wake-induced turbulence significantly affects the velocity deficit and the overall structure of the wake. By capturing these effects, the Ishihara model enhances the accuracy of performance predictions across an entire wind farm, especially in configurations where multiple turbines are positioned in close proximity. Consequently, it offers a valuable tool for micro-siting studies aimed at minimizing wake interference and maximizing overall energy production. A schematic illustration of the model is presented in **Figure 1**, highlighting its ability to represent the combined impact of external atmospheric conditions and turbine-induced flow disturbances on downstream performance [1].

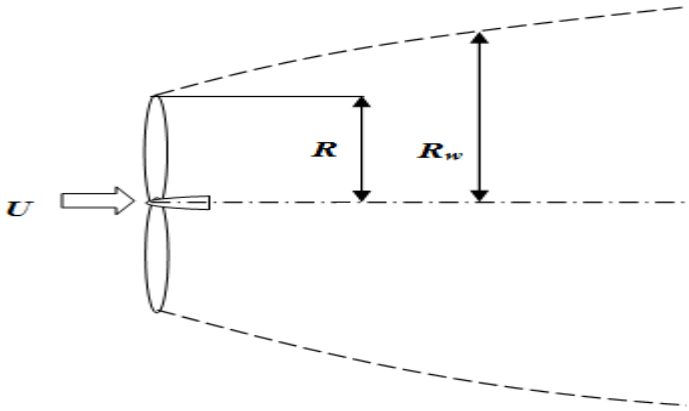

Figure 1. Ishihara wake model

The velocity in Ishihara's model [1] is given by the following equation:

$$U_w = U\left(1 - \frac{\sqrt{C_t}}{32}\left(\frac{1.66}{K_1}\right)^2 \left(\frac{x}{D}\right)^{-p} exp\left(\frac{r^2}{D_w^2}\right)\right) \quad (1)$$

Where D_w denotes the wake diameter, defined as follows:

$$D_w = 2R_w = \frac{K_1 C_t^{0.25}}{0.833} D^{1-\frac{p}{2}} x^{\frac{p}{2}} \quad (2)$$

The parameter p depends on both ambient and generated turbulence::

$$p = K_2(I_a + I_w) \quad (3)$$

The *random number generation is* essentially mathematical approch. What is actually required is a procedure capable of producing a sequence of numbers that gives the appearance of randomness—or more precisely, *pseudo-randomness*. Pseudo-random number generators typically rely on congruential recurrences [3], which take the form:

$$X(n+1)=aX(n)+bmod[m] \qquad (6)$$

For a wind farm divided into N cells, this approach consists of calculating the remainder obtained by dividing a natural number by $m=N+1$. The sequence $X(n)$, constructed using (6), lies between 0 and 100 for a single iteration. The objective function f, which represents this sequence, is then evaluated at this point.

Applied to a wind farm, this technique generates multiple turbine layout configurations. The total power output is calculated for each configuration, and the optimal micro-siting arrangement is the one that achieves the maximum power.

3.2. Atmospheric Boundary Layer

Applied to wind farms, this method produces various turbine layouts, each evaluated by its total power output. The optimal micro-siting configuration is the one that maximizes this power.

$$\frac{U}{U_{ref}} = \left(\frac{Z}{Z_{ref}}\right)^{\alpha} \qquad (7)$$

The wind speed downstream of each turbine exhibits an exponential deficit based on height (see Figure 2).

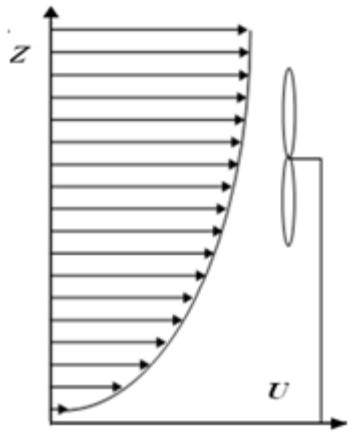

Figure. 2 Wind speed profil in Atmospheric Boundary Layer

this speed profile is applied to all the turbines on the site. Thus, the wind speed downstream of each turbine exhibits an exponential deficit based on height (see Figure 2).

Table 1 NREL Turbine Characteristics

Rotation speed	72 r/min
Blade length (R)	5.03 m
Rotor height (Z)	17 m
Number of blades	3

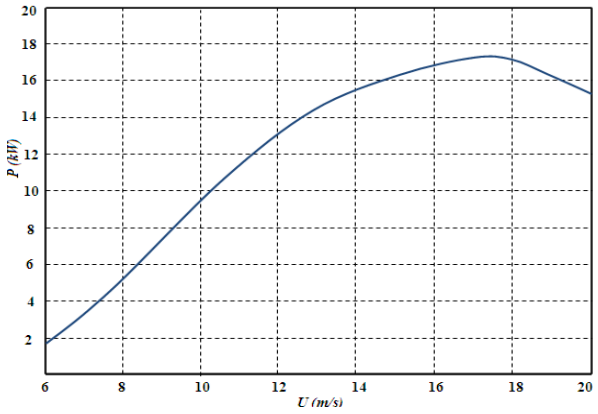

Fig. 3. Power curve of NREL turine

1. Results and discussions

4.1. Power calculation

For the simulations, data from the NREL wind turbine were used. The characteristics of this wind turbine are shown in Table 1 [7]. The characteristic power curve of the wind turbine used is illustrated in Figure 3 [8].

In the proposed wind speed profile, the power generated by a wind turbine depends on the reference speed Z_{ref}, the reference height Href, and the hub height Z. To achieve this, the swept area of the blades (actuator disk) is divided into several surface elements Δs_i, with each element corresponding to a velocity $U_i(z)$, as shown in Figure 4.

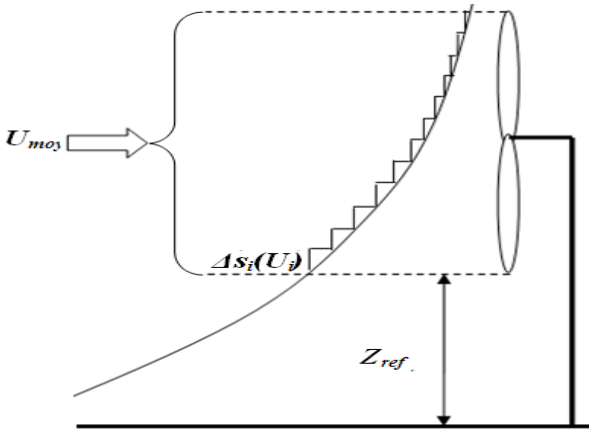

Fig. 4. Actautor disk Discrtization

The elemental power P_i is calculated for each surface element. The total power of the turbine can then be expressed as follows:

$$P = \sum_{i=1}^{n} \frac{P_i \Delta si}{S} \qquad (8)$$

S : Is the air passing through the turbine's actuator disk

At a reference height of 10 m above the ground and with a reference speed of 12 m/s, the results obtained regarding the effect of discretization M of the actuator disk on the total power of a single turbine are presented in Table 2.

Tableau 2 Effect of discretization

M	2	4	6	10	16
P(kW)	14.30	14.35	14.35	14.36	14.36

As shown in Table 2, the power produced by a wind turbine, accounting for the boundary layer, appears to stabilize around 14.35 kW for a discretization number M = 4. This result has been selected for our optimization procedure.

4.2. Optimal arrangement

We consider a square wind farm divided into 100 identical cells, each measuring 8Rx10R (where R is the length of the blade). Thirty NREL-type wind turbines are to be installed at the centers of these cells. The random number generation method will be used to propose several random arrangements of the turbines within the farm. The calculation program, developed in MATLAB, calculates the power output for each arrangement, with the optimal micro-siting corresponding to the configuration that provides the maximum power from the 30 turbines. At 10 meters above the ground, with a reference wind speed of 12 m/s, the simulation results indicate that the arrangement offering the maximum power of 418.85 kW corresponds to the optimal configuration. Figure 4a shows the optimal arrangement for this configuration. Compared to the results from the simplified model (Figure 4b), the current model proves to be more effective, resulting in a more even and extensive distribution of the turbines. Table 3 lists the characteristics and simulation conditions adopted for the two models.

		X	X		X				
X	X							X	X
						X	X		
			X	X	X				

	X	X							X
X							X	X	
				X	X	X			
		X	X						
X	X							X	X
					X	X	X		

(a)

X	X		X	X		X			
X		X					X	X	
	X						X		
		X	X					X	
			X	X					
	X							X	
	X	X	X			X	X		
					X				X
X							X	X	
					X				X

(b)

Fig. 4. Optimal arrangement: (a) current study, (b) previous study [8]

The power of a single wind turbine without wake effect is 14.1246 kW, which results in a total power of 423.7396 kW for the 30 turbines in the farm. Comparing the results with and without wake effect shows a power difference of 1.15%. In contrast, in the simplified model, differences can exceed 2.5% [8].

Table 3 Characteristics and conditions adopted

Simplified model	Detailed model
- Without boundary layer - V = 12 m/s - Absence of generated turbulence - Jansen wake model [9]	- With boundary layer - V_{ref} = 12 m/s - Presence of generated turbulence - Ischihara wake model [1]

It is also important to note that the generation of random numbers in the optimization program of the previous study was based on the Rand function [10], whereas the present study relies on the programming of equation (6).

2. Conclusion

In this work, we presented a new method for optimizing wind turbines at a specific site, based on a mathematical approach using random number generation, a detailed description of the wake, and the integration of the boundary layer profile. The optimization results obtained through simulation show significant improvements compared to the simplified model; the observed power deficit is markedly reduced, suggesting that the wake effect can be considerably mitigated by choosing an appropriate turbine arrangement. The inclusion of the boundary layer, ground roughness, and both ambient and generated turbulence in the power calculation program demonstrates that the model can accurately describe the real effects encountered by the turbines. Further investigation is needed to assess the impact of extreme climatic conditions (temperature, sand storms) on the performance of wind farms.

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ANOVA-Taguchi Analyses on Heat Transfer of MHD Ternary Hybrid Nanofluid MHD Jeffery–Hamel Flow.

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Abstract – This study investigates heat transfer in MHD Jeffery–Hamel ternary hybrid nanofluid flow influenced by thermal radiation, variable thermal conductivity, wall stretching/shrinking, and temperature jump effects, using ZrO_2 and MoS_2 nanoparticles. Nonlinear PDEs are reduced to ODEs via similarity transformations and solved numerically with the Explicit Runge-Kutta Method, while statistical tools (Regression, ANOVA, Taguchi L_{18}) optimize results. Findings show that skin friction and heat transfer strongly depend on flow parameters, with maximum heat transfer achieved in convergent channels at high Reynolds number, Hartmann number, wall stretching/shrinking, radiation effects, thermal conductivity variation, jump parameter, and nanoparticle concentration.

Keywords – *J-H flow; ternary hybrid nanofluid; variable thermal conductivity; temperature jump; optimization, Regression, ANOVA; Taguchi analyses (L_18);*

I. INTRODUCTION

This paper investigates boundary layer flow and heat transfer in wedge-shaped geometries, which are important in aerospace, energy, and chemical industries. Building on the classical Falkner–Skan model, recent studies have expanded to nanofluid (NF) and hybrid nanofluid (HNF) flows, which improve thermal conductivity and heat transfer efficiency. Applications of MHD nanofluids span from medical treatments to energy systems, with researchers analyzing effects of radiation, chemical reactions, slip conditions, Joule heating, and complex geometries such as curved or porous channels. The Sutterby fluid model also receives attention for its practical relevance in non-Newtonian fluids [1].

The current work presents a new analysis of MHD Jeffery–Hamel ternary hybrid nanofluids influenced by external magnetic fields, thermal radiation, variable thermal conductivity, and stretching/shrinking walls. Governing equations are reduced to nonlinear ODEs using similarity transformations and solved numerically. A Taguchi optimization approach identifies parameter

combinations that maximize heat transfer while reducing skin friction, offering insights for improved performance in engineering and industrial processes [2].

II. PROBLEMATIC

1. The study examines the steady, incompressible flow of nanofluid between nonparallel channels under effects of multiple variables (**Figure 1**):

- The nanoparticles exhibit a uniform size distribution and a spherical form.
- External magnetic field
- Ternary hybrid nanofluids (i.e. $Fe_3O_4 - ZnO - UO_2$)
- Radiation source.
- Stretching ($\tau > 0$)/shrinking ($\tau < 0$) walls
- Variable thermal conductivity $\dot{k}_{thnf}(T) = k_{thnf}(1 + \varepsilon \frac{T}{T_w})$
- Temperature jump

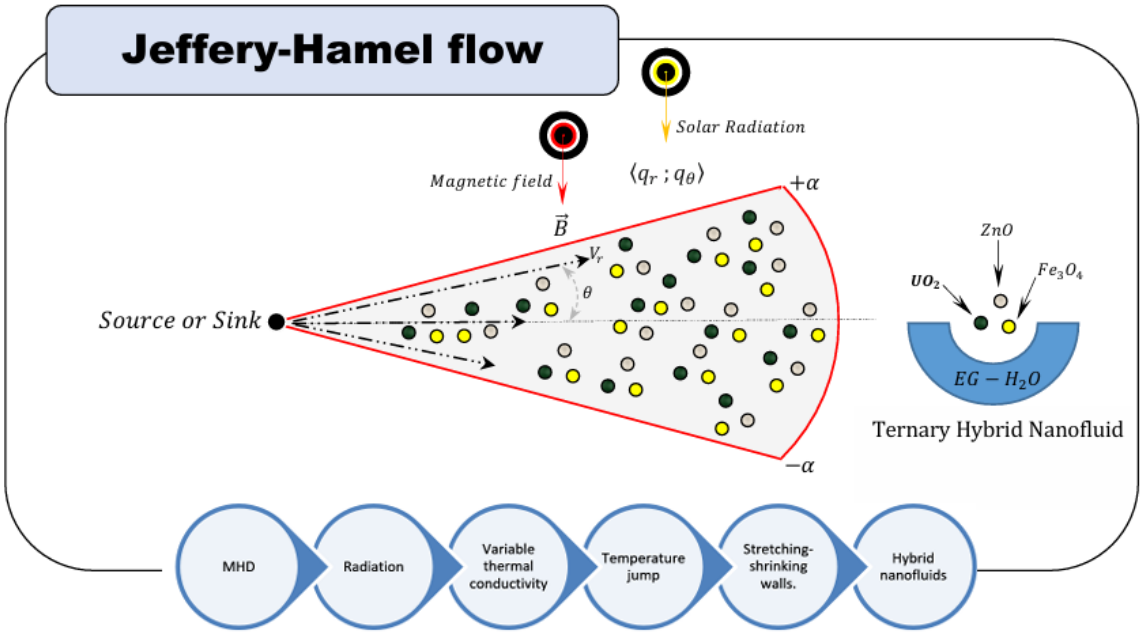


Fig. 1. Flow chart of the case study

III. PROBLEM FORMULATION

This section establishes the theoretical framework for analyzing MHD hybrid nanofluid flow in nonparallel channels under magnetic fields. It introduces the governing equations—continuity, Navier–Stokes, and energy equations—under the assumptions of incompressibility and Newtonian fluid behavior. Key factors such as variable thermal conductivity, temperature jump boundaries, and radiation effects are incorporated to provide a comprehensive model. The formulation in cylindrical coordinates (r, θ, z) sets the basis for investigating parameter influences and optimizing flow and heat transfer dynamics.

$$\frac{1}{r}\frac{\partial}{\partial r}(rV_r) = 0 \tag{1}$$

$$V_r\frac{\partial V_r}{\partial r} = -\frac{1}{\rho_{thnf}}\frac{\partial \mathrm{P}}{\partial r} + \nu_{thnf}\left[\frac{\partial^2 V_r}{\partial r^2} + \frac{1}{r}\frac{\partial V_r}{\partial r} + \frac{1}{r^2}\frac{\partial^2 V_r}{\partial \Theta^2} - \frac{V_r}{r^2}\right] - \frac{\sigma_{thnf}}{\rho_{thnf}r^2}(B^2 V_r) \tag{2}$$

$$-\frac{1}{\rho_{thnf}}\frac{\partial \mathrm{P}}{r\,\partial \Theta} + \frac{2\nu_{thnf}}{r^2}\frac{\partial V_r}{\partial \Theta} = 0 \tag{3}$$

2.

3. $\left(\rho c_p\right)_{thnf} V_r\frac{\partial T}{\partial r} = \left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\dot{k}_{thnf}(T)\frac{\partial T}{\partial r}\right) + +\frac{1}{r^2}\frac{\partial}{\partial \Theta}\left(\dot{k}_{thnf}(T)\frac{\partial T}{\partial \Theta}\right)\right] +$

$\mu_{thnf}\left[2.\left(\left(\frac{\partial V_r}{\partial r}\right)^2 + \left(\frac{V_r}{r}\right)^2\right) + \left(\frac{1}{r}\frac{\partial V_r}{\partial r}\right)^2\right] - \left(\frac{1}{r^2}\frac{\partial q_\theta}{\partial \theta} + \frac{1}{r}\frac{\partial r q_r}{\partial r}\right) + \frac{\sigma_{thnf}B^2}{r^2}{V_r}^2$ **4.** (4)

5. The boundary conditions are as follows in Table 1:

6. Table 1. The boundary conditions

7.	**8.** For velocity	**9.** The temperature
10. $\theta = 0$	**11.** $V_r = \frac{V_c}{r}$ and $\frac{\partial V_r}{\partial \Theta} = 0$	**12.** $\frac{\partial T}{\partial \Theta} = 0$
13. $\theta = \pm\alpha$	**14.** $V_r = \frac{s}{r}$	**15.** $T = \frac{T_w}{r^2}$

16. Introduce non-dimensional terms in the form:

17. $$\begin{cases} \eta = \frac{\Theta}{\alpha} \\ F(\eta) = \frac{f(\Theta)}{f_{max}} \\ \theta(\eta) = r^2\frac{T}{T_w} \\ \dot{k}_{thnf}(T) = k_{thnf}(1 + \varepsilon\frac{T}{T_w}) \end{cases}$$ **18.** (6)

19. Using Eq (6) into $(1-4)$ gives

20. $F''' + 2Re\alpha A_0 A_1 FF' + (4 - A_0 A_2 Ha)\alpha^2 F' = 0$ **21.** (7)

22. $(1 + Rd + \epsilon\theta)\theta'' + 2\epsilon\theta'^2 + 2\alpha^2\left(2Rd + 2 + Pr\frac{A_3}{A_4}F\right)\theta + \frac{PrEc}{ReA_0A_4}(4\alpha^2F^2 +$

$F'^2) + \frac{Pr.Ec A_2 Ha}{ReA_4}\alpha^2F^2 = 0$ **23.** (8)

24. The boundary conditions are as follows in Table 2:

25. Table 2. The boundary conditions

26.	**27.** For velocity	**28.** The temperature
29. $\eta = 0$	**30.** $F = 1$ and $F' = 0$	**31.** $\theta' = 0$
32. $\eta = \pm 1$	**33.** $F = \tau$	**34.** $\theta = 1 + \lambda\theta'$

From Eqns. (7-8), the quantities A_0, A_1, A_2, A_3, A_4 and dimensionless numbers are as follows:

$$\begin{cases} A_0 = \frac{\mu_{thnf}}{\mu_f}; \mathrm{A}_1 = \frac{\rho_{thnf}}{\rho_f}; \mathrm{A}_2 = \frac{\sigma_{thnf}}{\sigma_f}; \mathrm{A}_3 = \frac{(\rho C_p)_{thnf}}{(\rho C_p)_f}; \mathrm{A}_4 = \frac{k_{thnf}}{k_f} \\ Ec = \frac{\alpha . f_{max}^2}{C_{pf} . T_w}; \mathrm{Ha} = \sqrt{\frac{\sigma_f r^2 \mathrm{B}_0^2}{\mu_f}}; Pr = \frac{\rho_f . C_{Pf} . f_{max}}{k_f}; Rd = \frac{16\sigma^* T_w^3}{3K^* k_f} \end{cases}$$

The skin friction coefficient and Nusselt number are:

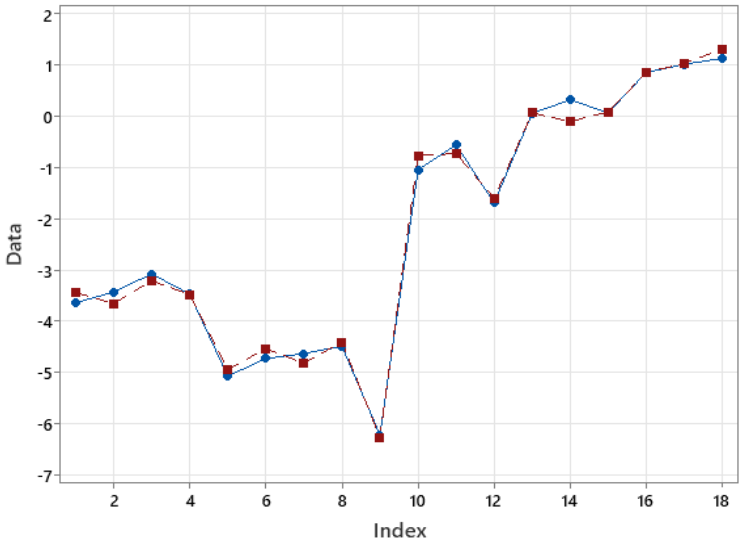
$$C_f{}^{\blacksquare} = \frac{1}{A_0} F' \rfloor_{\eta=1} \quad \textbf{35.}\ (9)$$

$$Nu^{\blacksquare} = -(\mathrm{A}_4 + \mathrm{Rd})\theta' \rfloor_{\eta=1} \quad \textbf{36.}\ (10)$$

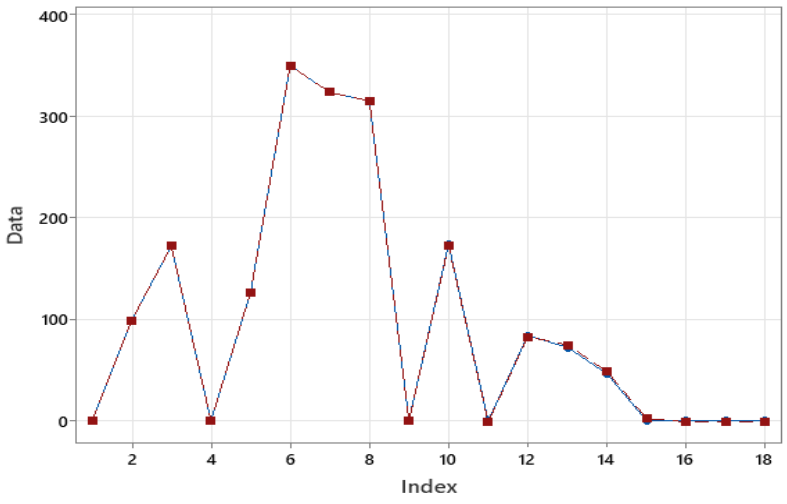
The properties of ternary hybrid nanofluid $(\blacksquare_{thnf})$ are defined in Appendix A.

IV. Results and Discussion

IV.1 Validation and Comparison



a. Skin friction coefficient



b. Heat transfer rate

Fig 2. Comparison between statistical and mathematical models for both responses (– statistical – mathematical)

Finality, from Tables 3 and 4 compare current results with those in Refs. for velocity values $F''(0)$ in both channels (α= - 5° and α= + 5°). . In fact, The Statistical Analyse (Taguchi Analyses) was chosen for its efficiency in solving nonlinear ordinary equations of ternary hybrid nanofluid flow through convergent and divergent channels.

Table 3. Comparison between current and literature results for $-F''(0)$ in converging channel when $\alpha = -5°$.

Re	$-F''(0)$ [47]	$-F''(0)$ [48]	$-F''(0)$ [49]	$-F''(0)$ models
10	1.784547	1.784546	1.784546771	1.784546764
30	1.413692	1.413692	1.413692093	1.413692090
50	1.121989	1.121989	1.121989151	1.219891952

Table 4. Comparison between current and literature results for $-F''(0)$ in a diverging channel when $\alpha = +5°$.

Re	$-F''(0)$ [47]	$-F''(0)$ [48]	$-F''(0)$ [49]	$-F''(0)$ models
10	2.527192	2.527192	2.5271922	2.52719211
30	3.942140	3.942140	3.9421402	3.94214014
50	5.869165	5.869165	5.8691651	5.869165251

V. CONCLUSIONS

This study demonstrates that MHD hybrid nanofluid flow in convergent and divergent channels is strongly influenced by flow parameters, nanoparticle concentration, and magnetic effects. Higher Reynolds numbers increase skin friction due to stronger inertial forces, while greater Hartmann numbers stabilize the flow and reduce resistance. Enhanced nanoparticle concentrations significantly improve heat transfer performance, a trend further supported by ANOVA results, which highlight the dominant role of the interaction (α × Re) on C_f and the combined effects of (α × Re) and (α × Ha) on Nu. Optimization reveals that a Reynolds number of 210 and a nanoparticle concentration of 6% yield optimal outcomes. Radiation further enhances heat transfer, particularly in regions with higher φ_thnf and lower ϵ, while stretching/shrinking effects (τ) modulate skin friction through wall–fluid interaction. Comparative assessments of statistical and mathematical models confirm their predictive accuracy, and future research should extend this work by exploring varied nanoparticle types and loadings to optimize MHD hybrid nanofluid applications.

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Comparative heat transfer analysis of $\gamma Al_2O_3 - H_2O$ and $\gamma Al_2O_3 - EG$ in MHD flow between nonparallel a porous media channels with stretchable walls and radiation Effects

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Abstract – The present work concentrates on comparative heat transfer analysis in the MHD flow of γ-nanoparticles between nonparallel flow for both base fluid (i.e ethylene glycol and water). with considering the radiation, stretchable walls and porous media. The modeling based on nonlinear PDEs such as continuity, momentum and heat equations, these equations transformed to a system of nonlinear ODEs using similarity transformations. To address this, then solved numerically and analytically, the analytical solution has been constructed using by Daftardar-Jafari method (DJM), the present results in particular cases are compared to results obtained by the HAM-based Mathematica package and by the Runge- Kutta Fehlberg 4th–5th order (RKF-45) for validation. The effects of active parameters such as the effective Prandtl number, nanofluid volume fraction, base fluid, Darcy number, stretchable walls parameter and thermal radiation parameter are investigated on the velocity and temperature, skin friction and Nusselt numbers.

Keywords *– γ-nanoparticles; mixture base fluid; stretchable walls parameter; effective Prandtl number; DJM; RKF 45 order; Shooting technique;*

I. INTRODUCTION

Nanofluids and hybrid nanofluids have emerged as advanced working fluids due to their superior thermal conductivity and viscosity, making them valuable in applications such as cooling, lubrication, energy systems, and microfluidics. By dispersing nanoparticles like oxides, carbides, or carbon nanotubes into base fluids (water, oils, glycol), their thermo-physical properties are significantly enhanced, leading to improved heat and mass transfer. Recent studies also emphasize the role of **MHD effects** in controlling flow and heat transport in electrically conducting fluids, particularly under porous and radiative conditions. Modern computational approaches, including ANN, RSM, and Python-based

models, are increasingly employed to optimize nanofluid performance for industrial and engineering applications [1], [2].

II. GOVERNING EQUATIONS

He flow configuration of MHD γ −nanofluid incompressible flowing in nonparallel porous media channels is demonstrated in **Figure 1.**

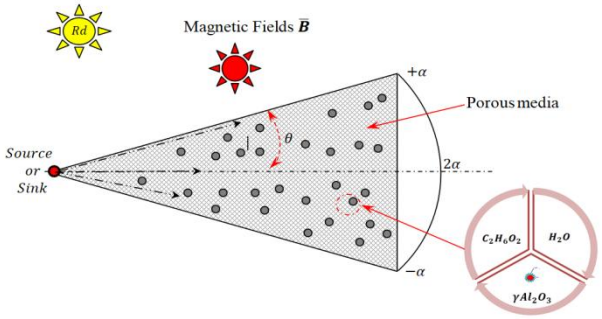


Figure 1. Geometric paradigm of the flowing system.

Assumptions:

- Steady, incompressible, laminar flow.
- Flow inside nonparallel walls creates a convergent or divergent channel.
- Porous medium follows the Darcy-law.
- Thermal radiation arises from the Rosseland approximation.
- No-slip boundary constraints at walls
- Hybrid nanofluid composed of γ-Al_2O_3 and base fluids (H_2O, EG).

The continuity, Navier-Stokes, and energy formulas the regarded as MHD γ −nanofluid incompressible flowing in divergence-convergence porous channels with the rapidity elements ($V = V_r(r,\Theta), V_\theta = 0, V_Z = 0$) given as [36-38]

$$\frac{1}{r}\frac{\partial}{\partial r}(rV_r) = 0, \tag{1}$$

$$V_r\frac{\partial V_r}{\partial r} = -\frac{1}{\rho_{nf}}\frac{\partial p}{\partial r} + \nu_{nf}\left[\frac{\partial^2 V_r}{\partial r^2} + \frac{1}{r}\frac{\partial V_r}{\partial r} + \frac{1}{r^2}\frac{\partial^2 V_r}{\partial \Theta^2} - \frac{V_r}{r^2}\right] - \frac{\sigma_{nf}}{\rho_{nf}}(B^2V_r) - \frac{\mu_{nf}}{k_p}V_r \tag{2}$$

$$-\frac{1}{\rho_{nf}}\frac{\partial p}{r\,\partial\Theta} + \frac{2\nu_{nf}}{r^2}\frac{\partial V_r}{\partial\Theta} = 0 \tag{3}$$

$$(\rho c_p)_{nf}V_r\frac{\partial T}{\partial r} = k_{nf}\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 T}{\partial\Theta^2}\right] + \mu_{nf}\left[2.\left(\left(\frac{\partial V_r}{\partial r}\right)^2 + \left(\frac{V_r}{r}\right)^2\right) + \left(\frac{1}{r}\frac{\partial V_r}{\partial r}\right)^2\right] - \frac{\partial q_r}{\partial r} - \left(\frac{1}{r^2}\frac{\partial q_\theta}{\partial r} + \frac{1}{r}\frac{\partial rq_r}{\partial r}\right) + \sigma_{nf}B^2V_r \tag{4}$$

With boundary condition introduced as:

- At $\boldsymbol{\theta = 0}$:

$$\boldsymbol{V_r = \frac{V_c}{r},\ \frac{\partial V_r}{\partial\theta} = 0,\ \frac{\partial T}{\partial\theta} = 0,} \tag{5}$$

- At $\boldsymbol{\theta = \pm\alpha}$:

$$\boldsymbol{V_r = \frac{\partial V_r}{\partial r},\ T = \frac{T_w}{r},} \tag{6}$$

For further understanding and clarification regarding the boundary conditions, at the channel walls, the velocity matches the expansion and contraction rates assumed by the surfaces taken so that both the temperature and concentration remain constant, while the free stream meets the asymptotic rate of

decrease. These boundary conditions represent realistic flow configurations through the movement of the nanofluid across the walls. Rosseland approximation gives:

$$q_r = -\frac{16}{3}\frac{\sigma^* T_w^3}{k^*}\left(\frac{\partial T}{\partial r}\right) \quad (7)$$
$$q_\theta = -\frac{16}{3}\frac{\sigma^* T_w^3}{k^*}\left(\frac{\partial T}{\partial \theta}\right)$$

where $T^4 \cong 4T_\infty^3 T - 3T_\infty^4$ is expressed by Taylor series approximations, k^* is the mean absorbing factor and σ^* is Stefan–Boltzmann fixed values, accordingly:

$$\frac{\partial q_r}{\partial y} \approx -\frac{16\sigma^* T_w^3}{3k^*}\left(\frac{\partial^2 T}{\partial y^2}\right) \quad (8)$$

The properties of γ −nanofluid and the thermo-physical characteristics of conventional liquid (ethylene glycol-water) and nanomolecules are expressed in Tables 1 and 2, respectively:

Table 1. A characteristic is made between the physical features of nanofluids [39].

For $\gamma Al_2O_3 - water$	For $\gamma Al_2O_3 - EG$
$(1-\varphi_{\gamma Al_2O_3})\rho_{H_2O} + \varphi_{\gamma Al_2O_3}\rho_{\gamma Al_2O_3}$	$(1-\varphi_{\gamma Al_2O_3})\rho_{EG} + \varphi_{\gamma Al_2O_3}\rho_{\gamma Al_2O_3}$
$(1-\varphi_{\gamma Al_2O_3})(\rho C_p)_{H_2O} + \varphi_{\gamma Al_2O_3}(\rho C_p)_{\gamma Al_2O_3}$	$(1-\varphi_{\gamma Al_2O_3})(\rho C_p)_{EG} + \varphi_{\gamma Al_2O_3}(\rho C_p)_{\gamma Al_2O_3}$
$\frac{\mu_{nf}}{\mu_{H_2O}} = 123\varphi_{\gamma Al_2O_3}^2 + 7.3\varphi_{\gamma Al_2O_3} + 1$	$\frac{\mu_{nf}}{\mu_{EG}} = 306\varphi_{\gamma Al_2O_3}^2 - 0.19\varphi_{\gamma Al_2O_3} + 1$
$\frac{k_{nf}}{k_{H_2O}} = 4.97\varphi_{\gamma Al_2O_3}^2 + 2.72\varphi_{\gamma Al_2O_3} + 1$	$\frac{k_{nf}}{k_{EG}} = 28.905\varphi_{\gamma Al_2O_3}^2 + 2.8273\varphi_{\gamma Al_2O_3} + 1$
$\frac{\sigma_{nf}}{\sigma_{H_2O}} = 1 + \frac{3(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{H_2O}} - 1)\varphi_{\gamma Al_2O_3}}{\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{H_2O}} + 2\right) - \varphi_{\gamma Al_2O_3}\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{H_2O}} - 1\right)}$	$\frac{\sigma_{nf}}{\sigma_{EG}} = 1 + \frac{3(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{EG}} - 1)\varphi_{\gamma Al_2O_3}}{\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{EG}} + 2\right) - \varphi_{\gamma Al_2O_3}\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{EG}} - 1\right)}$
$\frac{Pr_{nf}}{Pr_{H_2O}} = 82.1\varphi_{\gamma Al_2O_3}^2 + 3.9\varphi_{\gamma Al_2O_3} + 1$	$\frac{Pr_{nf}}{Pr_{EG}} = 254.3\varphi_{\gamma Al_2O_3}^2 - 3\varphi_{\gamma Al_2O_3} + 1$

Table 2. Thermophysical characteristics of a liquid based on $C_2H_6O_2$ and H_2O as well as nanomaterials.

Physical properties	$\rho\ (kg/m^3)$	$C_p(J/kg.°K)$	$k(W/m.°K)$	$\sigma(S/m)$	Pr
$C_2H_6O_2$	1116.6	2382	0.249	0.05	206
H_2O	998.3	4182	0.60	1.7×10^{-8}	6.96
γAl_2O_3	3970	765	40	10^{-10}	–

Considering the following transformations:

$$\eta = \frac{\Theta}{\alpha}, \quad F(\eta) = \frac{f(\Theta)}{f_{max}}, \quad \theta(\eta) = r^2.\frac{T}{T_w}, \quad (9)$$

The use of the similarity transformation, which is represented by Eq. (9), provides us with the coupling formulas for the speed and temperature outlines as:

- For $\gamma Al_2O_3 - Water$

$$F''' + 2Re\ \alpha\frac{A_1}{A_0}FF' + \left[4 - \frac{A_2}{A_0}Ha\right]\alpha^2F' - \frac{1}{Da}\alpha^2F' = 0 \quad (10)$$

$$(1+Rd)\theta'' + 4\alpha^2Rd\theta + 4\alpha^2\theta + \frac{A_3}{A_4}2\alpha^2Pr_{H_2O}F\theta + \frac{A_0}{Re.A_4.}Pr_{H_2O}.Ec(4\alpha^2F^2 + F'^2) + \frac{A_2}{A_4}Pr_{H_2O}Ec\ HaF^2 = 0 \quad (11)$$

- For $\gamma Al_2O_3 - EG$

$$F''' + 2Re\ \alpha\frac{A_1}{A_0}FF' + \left[4 - \frac{A_2}{A_0}Ha\right]\alpha^2F' - \frac{1}{Da}\alpha^2F' = 0 \quad (12)$$

$$(1+Rd)\theta'' + 4\alpha^2Rd\theta + 4\alpha^2\theta + \frac{A_3}{A_4}2\alpha^2Pr_{EG}F\theta + \frac{A_0}{Re.A_4.}Pr_{EG}.Ec(4\alpha^2F^2 + F'^2) + \frac{A_2}{A_4}Pr_{EG}Ec\ HaF^2 = 0 \quad (13)$$

From Eqs. (10-13), the quantities A_0, A_1, A_2, A_3, A_4 and A_5 are as follows in Table 3.

Table 3. Explanation of the quantities control constraints [39].

Symbol		Formula
A_0	For $\gamma Al_2O_3 - Water$	$123\varphi_{\gamma Al_2O_3}^2 + 7.3\varphi_{\gamma Al_2O_3} + 1$
	For $\gamma Al_2O_3 - EG$	$306\varphi_{\gamma Al_2O_3}^2 - 0.19\varphi_{\gamma Al_2O_3} + 1$
A_1	For $\gamma Al_2O_3 - Water$	$\left(1-\varphi_{\gamma Al_2O_3}\right) + \varphi_{\gamma Al_2O_3}\frac{\rho_{\gamma Al_2O_3}}{\rho_{H_2O}}$
	For $\gamma Al_2O_3 - EG$	$\left(1-\varphi_{\gamma Al_2O_3}\right) + \varphi_{\gamma Al_2O_3}\frac{\rho_{\gamma Al_2O_3}}{\rho_{EG}}$
A_2	For $\gamma Al_2O_3 - Water$	$\left(1 + \frac{3(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{H_2O}} - 1)\varphi_{\gamma Al_2O_3}}{\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{H_2O}} + 2\right) - \varphi_{\gamma Al_2O_3}\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{H_2O}} - 1\right)}\right)$
	For $\gamma Al_2O_3 - EG$	$\left(1 + \frac{3(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{EG}} - 1)\varphi_{\gamma Al_2O_3}}{\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{EG}} + 2\right) - \varphi_{\gamma Al_2O_3}\left(\frac{\sigma_{\gamma Al_2O_3}}{\sigma_{EG}} - 1\right)}\right)$
A_3	For $\gamma Al_2O_3 - Water$	$\left(1-\varphi_{\gamma Al_2O_3}\right) + \varphi_{\gamma Al_2O_3}\frac{\left(\rho C_p\right)_{\gamma Al_2O_3}}{\left(\rho C_p\right)_{H_2O}}$
	For $\gamma Al_2O_3 - EG$	$\left(1-\varphi_{\gamma Al_2O_3}\right) + \varphi_{\gamma Al_2O_3}\frac{\left(\rho C_p\right)_{\gamma Al_2O_3}}{\left(\rho C_p\right)_{EG}}$
A_4	For $\gamma Al_2O_3 - Water$	$4.97\varphi_{\gamma Al_2O_3}^2 + 2.72\varphi_{\gamma Al_2O_3} + 1$
	For $\gamma Al_2O_3 - EG$	$28.905\varphi_{\gamma Al_2O_3}^2 + 2.8273\varphi_{\gamma Al_2O_3} + 1$
Pr	For $\gamma Al_2O_3 - Water$	$Pr_{H_2O}\left(82.1\varphi_{\gamma Al_2O_3}^2 + 3.9\varphi_{\gamma Al_2O_3} + 1\right)$
	For $\gamma Al_2O_3 - EG$	$Pr_{EG}\left(254.3\varphi_{\gamma Al_2O_3}^2 - 3\varphi_{\gamma Al_2O_3} + 1\right)$

Thus, the constraints converted according to the above are as follows:

- At the middle line of the channel:

$$F(0) = 1,\ F'(0) = 0 \ \text{ and } \theta'(0) = 0, \quad (14)$$

- At the body of the channel:

$$\boldsymbol{F}(\mathbf{1}) = \boldsymbol{\tau} \text{ and } \boldsymbol{\theta}(\mathbf{1}) = \mathbf{1}. \tag{15}$$

The parametric values were defined in Table 4.

Table 4. Explanation of the parameter control constraints [36-38].

Symbol	Name	Formula
Re	Reynolds number	$\frac{rV_{max}\alpha}{\nu_f} = \frac{f_{max}\alpha}{\nu_f}$
Ec	Eckert number	$\frac{\alpha f_{max}^2}{C_{pf}T_w}$
Ha	Hartmann number	$\sqrt{\frac{\sigma_f r^2 B_0^2}{\mu_f}}$
Pr	Prandtl number	$\frac{\rho_f C_{pf} f_{max}}{k_f}$
Da	Darcy number	$\frac{k_p}{r^2}$
Rd	Radiation parameter	$\frac{16T_w^3\sigma^*}{kK^*}$

The skin friction coefficient C_f is given by:

For $\gamma Al_2O_3 - Water$ $$C_f^{\blacksquare} = \left(123\varphi_{\gamma Al_2O_3}^2 + 7.3\varphi_{\gamma Al_2O_3} + 1\right)F'\rfloor_{\eta=1}, \tag{16}$$

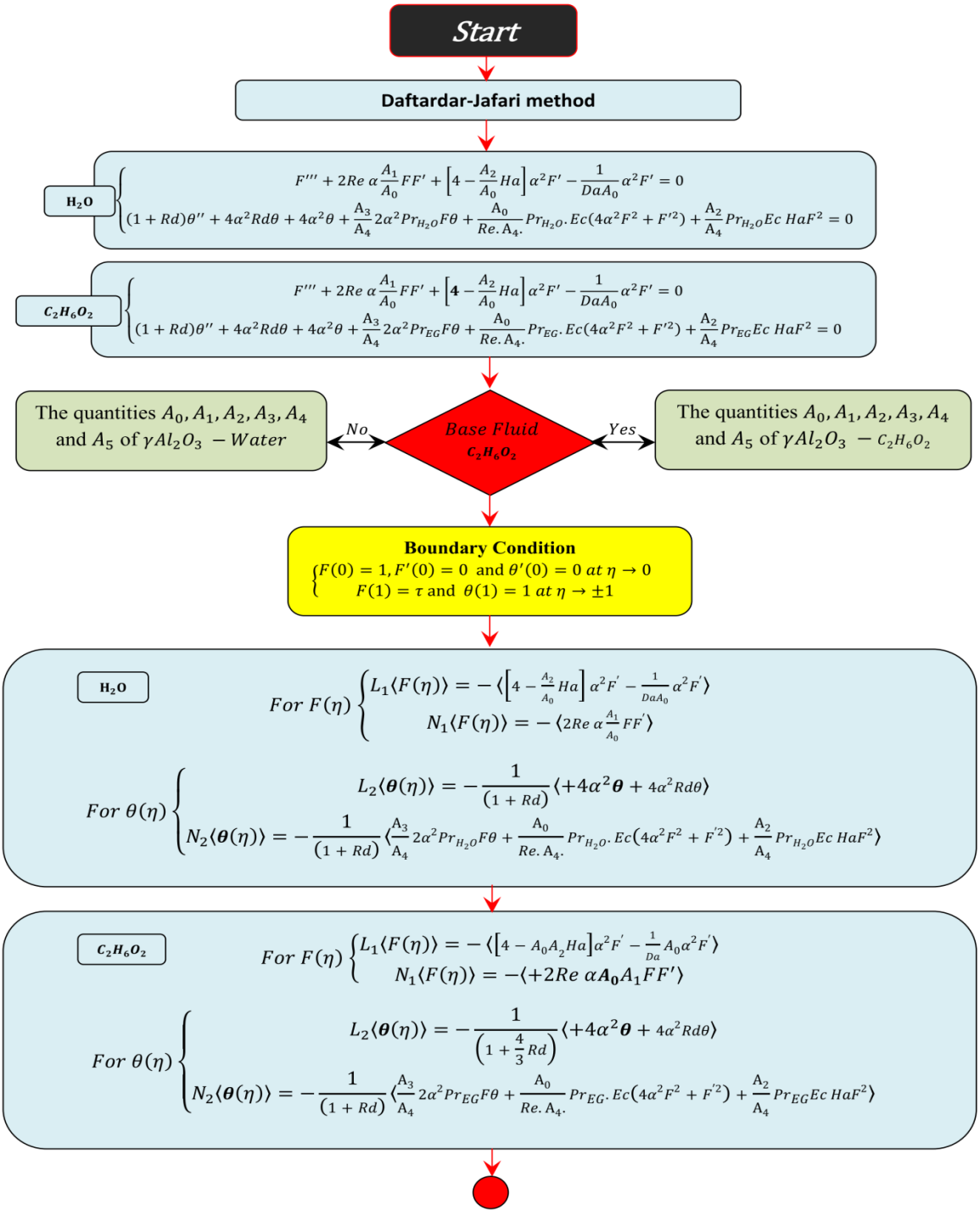
For $\gamma Al_2O_3 - EG$ $$C_f^{\blacksquare} = \left(306\varphi_{\gamma Al_2O_3}^2 - 0.19\varphi_{\gamma Al_2O_3} + 1\right)F'\rfloor_{\eta=1}, \tag{17}$$

The Nusselt number Nu is defined as:

For $\gamma Al_2O_3 - Water$ $$Nu^{\blacksquare} = \left(4.97\varphi_{\gamma Al_2O_3}^2 + 2.72\varphi_{\gamma Al_2O_3} + 1\right)\theta'\rfloor_{\eta=1}, \tag{18}$$

For $\gamma Al_2O_3 - EG$ $$Nu^{\blacksquare} = \left(28.905\varphi_{\gamma Al_2O_3}^2 + 2.8273\varphi_{\gamma Al_2O_3} + 1\right)\theta'\rfloor_{\eta=1}, \tag{19}$$

III. DJM PROCEDURE



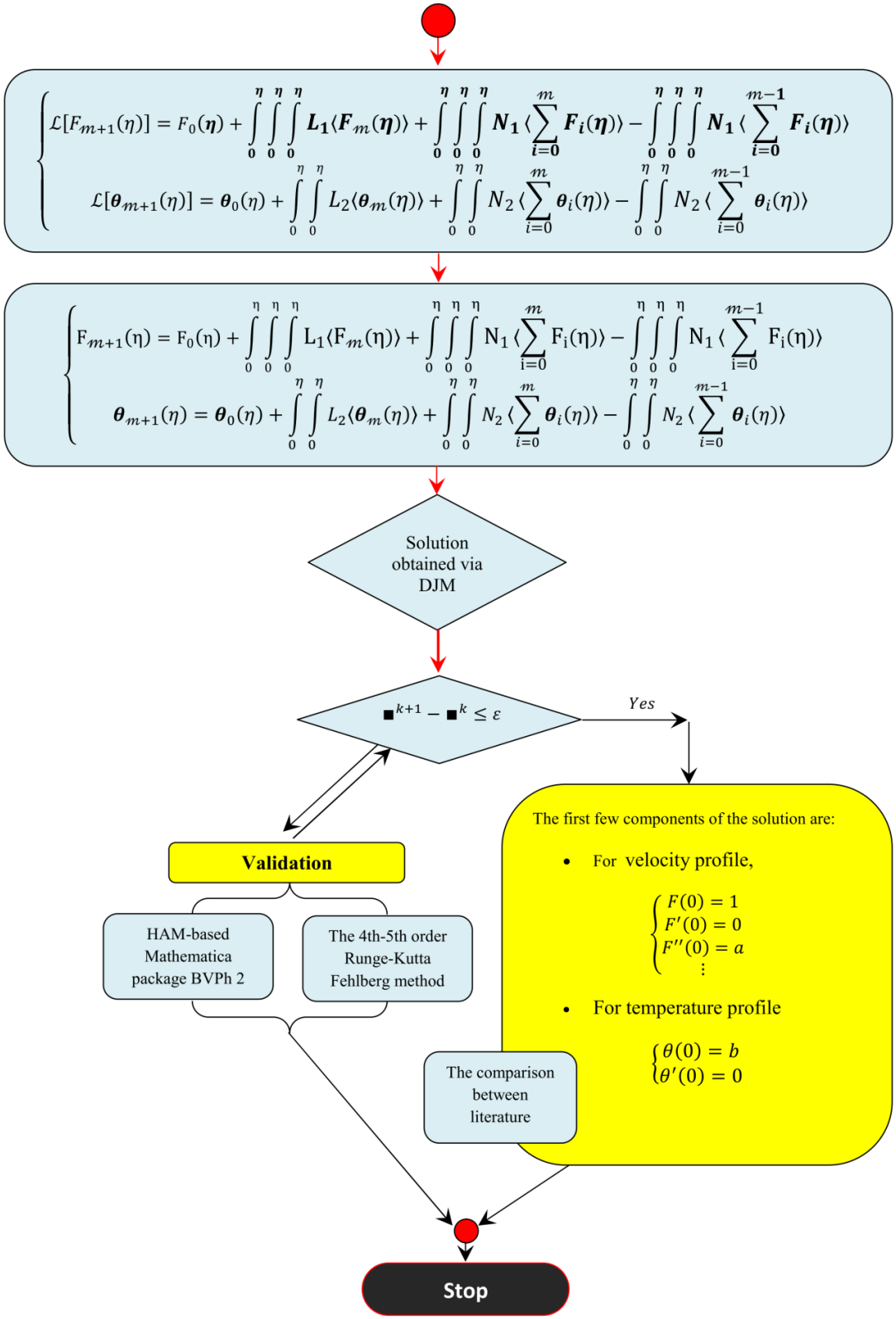


Figure 2. DJM procedure

IV. Results and Discussion

Table 5. Comparison relating DJM findings and those accessible in the previous works for $F''(0)$ in a converging channel at $\alpha = -5°, Ro = 0, \varphi = 0,$ and $Ha = 0$.

Re	$F''(0)$ Ref. [44]	$F''(0)$ Ref. [45]	$F''(0)$ Ref. [46]	$F''(0)$ Ref. [47]	$F''(0)$ Ref. [48]	Present result
10	1.784546	1.784546	1.784547	1.784547	1.784546	1.78454676647832
30	1.413692	1.413692	1.413692	1.413692	1.413692	1.41369209136734
50	1.121989	1.121989	1.121989	1.121989	1.121989	1.2198919535123

Table 6. Comparison concerning DJM outcomes and those accessible in the previous works for $F''(0)$ in a diverging channel at $\alpha = +5°, Ro = 0, \varphi = 0,$ and $Ha = 0$.

Re	$F''(0)$ Ref. [44]	$F''(0)$ Ref. [45]	$F''(0)$ Ref. [46]	$F''(0)$ Ref. [47]	$F''(0)$ Ref. [48]	Present result
20	2.527192	2.527192	2.527192	2.527192	2.527192	2.5271921099653
60	3.942140	3.942140	3.942140	3.942140	3.942140	3.9421401298651
100	5.869165	5.869165	5.869165	5.869165	5.869165	5.8691652309431

Table 7. Comparison of recent findings with the previously published outcomes for $F'(1)$ and $-\theta'(1)$ at $F(1) + \lambda F'(1) = \tau, Re = 50, Da = 0, Rd = 0$ and $\varphi = 0$.

λ	α	Ref. [47]		Ref. [49]		Ref. [50]		Present results	
		$F'(1)$	$-\theta'(1)$	$F'(1)$	$-\theta'(1)$	$F'(1)$	$-\theta'(1)$	$F'(1)$	$-\theta'(1)$
-2	-5	- 5.130921689	0.03157845854	- 5.1309222926	0.0315761821	- 5.1309318671	0.0315752477	- 5.1309315674	0.0315754598
-1	-5	- 4.652183982	0.03734696604	- 4.6521591354	0.0373226368	- 4.6521592892	0.0373210205	- 4.6521592315	0.0373212094
0	-5	- 2.833915413	0.04214811723	- 2.8339514330	0.0421517243	- 2.8338418752	0.0421520009	- 2.8338416854	0.0421520076
2	-5	3.654305033	0.05052578617	3.6697111853	0.0502423154	3.5697079349	0.0502430863	3.56970788949	0.0502432786
-1	5	- 3.508090102	0.03475109986	- 3.5081031667	0.0347758169	- 3.5080681268	0.0347755158	- 3.5080680873	0.0347758732
0	5	- 1.109360533	0.03999321083	- 1.1093265266	0.0399820121	- 1.1092617837	0.0399841412	- 1.1092615783	0.0399841096
1	5	0	0.04640127099	0	0.0464015106	0	0.0464037895	0	0.0464037985

V. Concluding Remarks

This study shows that converging channels yield higher velocities and temperatures than diverging ones in MHD γ-Al_2O_3 nanofluid flow. Nanofluids with EG as the base fluid exhibit greater temperatures, while higher Darcy numbers reduce velocity, enhance surface friction, and lower heat transfer. Nanoparticle concentration has opposite effects in converging and diverging channels, and γ-Al_2O_3–H_2O nanofluid outperforms γ-Al_2O_3–EG in divergent flow. Finally, even small increases in thermal radiation significantly reduce temperatures in both nanofluids.

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Synthesis of ZnO/CdO Heterojunction Thin Films Nanostructure via Sol-Gel Method

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Abstract – This study focuses one the synthesis and characterization of nanostructured ZnO/CdO thin films, and nanoparticles using Sol-gel approach for advanced photovoltaic applications. The study explores how nanoengineering these materials can enhance the performance of heterojunction solar cells. The sol-gel method was employed to produce uniform nanoscale films with precise control over morphology and composition advanced.
Characterization techniques XRD, TEM, SEM confirmed the formation of crystalline ZnO and CdO nanostructures with controlled particle size 18 -38 nm, optical studies revealed enhanced light trapping I, the nanostructured films, while electronics measurements demoted improved carrier mobility compared to bulk materials.
The developed ZnO/CdO nano-heterojunction showed exceptional promise for next-generation solar cells, offering improved efficiency through nanoscale engineering of interfaces and band alignment, future work will focus on optimizing nanoparticle size and interfacial properties.

Keywords *– Sol-gel; nanoparticles; ZnO/CdO; heterojunction; thin films; nanoscale;*

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Effect of fiber orientation on the machining behavior of treated and untreated alpha fiber composites

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Abstract – This study provides a comprehensive analysis of the milling behavior of epoxy composites reinforced with untreated and NaOH-treated alfa fibers, considering two fiber orientations (0° and 90°) and using both up milling and down milling techniques. A cubic regression model was applied to the experimental data, yielding high correlation coefficients of 0.90 and 0.91 for up milling at 0° and down milling at 90°, respectively, in untreated samples. Similar model performance was observed in the NaOH-treated composites. Although slightly lower correlation values were obtained for other milling conditions and fiber orientations, the regression models remained statistically significant, as evidenced by Fisher statistics exceeding the critical value at the 5% significance level. The findings highlight feed rate as the most influential parameter, significantly affecting both normal and axial cutting forces, while cutting speed showed minimal impact in this regard. In contrast, cutting speed exhibited a more substantial influence on feed force compared to feed rate, with the interaction between cutting speed and feed rate emerging as the most statistically significant factor.

Keywords – *Milling; NaOH treatment; Alpha fibers; composite; fiber orientation;*

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Comportement Mécanique En Compression Et Modes De Rupture Des Stratifies Prfv

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Résumé **-** I Cette étude propose une investigation expérimentale du comportement en compression dans le plan et des mécanismes de rupture des stratifiés en polymère renforcé de fibres de verre (PRFV). Un dispositif de compression spécialement conçu, développé conformément à la norme ASTM D695-15, a été utilisé pour appliquer une charge le long de l'axe longitudinal des éprouvettes de stratifiés en PRFV, garantissant ainsi des conditions de contrainte dans le plan précises. L'objectif du protocole expérimental était de caractériser la réponse mécanique et de suivre l'évolution des endommagements jusqu'à la rupture. Afin d'obtenir des informations détaillées sur le champ de déformations, la Corrélation d'Images Numériques a été mise en œuvre sur la surface latérale des éprouvettes. Cette méthode optique sans contact a permis d'effectuer des mesures plein champ de déformations avec une haute résolution et d'observer en temps réel la localisation des contraintes et des zones de déformation. Les courbes contrainte–déformation ont montré une réponse homogène entre les différents essais, caractérisée par une phase linéaire élastique bien définie suivie d'une déformation non linéaire liée à l'initiation des endommagements. La rupture s'est systématiquement localisée dans la zone centrale des éprouvettes et a impliqué plusieurs mécanismes, tels que la fissuration longitudinale, la fissuration interlaminaire en cisaillement, la rupture des fibres et la formation de bandes de flambage, accompagnées de signes visibles de micro-flambage des fibres. Les résultats issus de la Corrélation d'Images Numériques ont montré une excellente corrélation avec les mesures expérimentales, validant ainsi le dispositif d'essai et apportant un éclairage précis sur l'initiation et la propagation de la rupture.

Keywords *– PRFV; Stratifiés; Polymère; Fibre; MEB; Compression; Comportement mécanique :*

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Detach Water into Hydrogen and Oxygen using binary Copper-Chloride, energy and exergy analysis

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Abstract **–** In this article, an in-depth thermodynamic study of a new thermochemical cycle for hydrogen production is carried out. This cycle includes three chemical reactions based on Copper and Chlorine (Cu-Cl) for the dissociation of the water molecule into hydrogen and oxygen. The new configuration of the stages and reactions of the cycle presented in this work has not yet been considered in the literature. The first two reactions are recycling stages, they produce O2 as well as hydrochloric acid HCl. The third reaction is the main one, it produces hydrogen. The maximum temperature of the cycle is around 450°C-500°C. This cycle can use solar energy or any available thermal source, such as heat from transportation exhaust or gas turbines to produce H2. Other transformations are proposed to the proposed Cu-Cl cycle in order to overcome the problems encountered and subsequently improve its efficiency. Various evaluations are performed using several thermodynamic modeling tools, such as heat, enthalpy, entropy, and destroyed exergy. The efficiency of the hydrogen production reaction is estimated at around 88%. Which is a very positive result. These models are carried out by the EES energy simulation software.

Keywords **–** *Hydrogen production; water dissociate; thermochemical process; Copper-Chlorine cycle; exergy and energy analyses:*

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The Use of Plastic Waste in Building Materials

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Abstract **–** Plastic waste is considered one of the most serious environmental pollutants due to its persistence and resistance to degradation.in the field of civil engineering, a growing trend has emerged that focuses on utilizing this waste as partial replacements or additives in construction materials, with the dual objective of reducing environmental pollution and decreasing reliance on traditional Natural resources. research has shown that incorporating recycled plastic particles into concrete can improve certain properties, such as impact resistance and reduced overall density, thereby producing lightweight concrete with enhanced thermal insulation efficiency. similarly, plastic fibers have been used to increase the durability of concrete and to limit cracking caused by shrinkage.in Clay brick production, the addition of specific proportions of plastic waste has been found to reduce water absorption and improve insultation capacity, while also contributing to the development of low-cost building units.
Other applications include the incorporation of recycled plastic in asphalt mixtures to improve road resistance to thermal deformation.
Despite these advantages, the main challenge lies in determining the optimal proportions of plastic to ensure a balance between improving mechanical properties and maintaining structural safety requirements. furthermore, scaling up these practices requires the development of standardized engineering guidelines that guarantee the quality and safety of the resulting materials. consequently, the integration of plastic waste in civil engineering represents a promising approach that not only contributes to sustainable construction practices but also supports the principles of circular economy and environmental protection.

Keywords *– plastic waste; durability; mechanical properties; concrete; construction Materials;*

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Influence of Cohesive Zone Length on Crack Opening and Propagation in a Dugdale–Barenblatt Model within an Infinite Strip

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Abstract **–** This work treats the case of a Dugdale–Barenblatt crack within an infinite strip through the resolution of a hyper singular integral equation. The crack is perpendicular to the strip boundaries and located at its center. The solution approach is based on second order Chebyshev polynomials and requires meticulous treatment of the jump discontinuities within the loading distribution along the crack faces. The analysis establishes the relationship between strip width and cohesive zone length, and further examines the evolution of the crack opening with the cohesive zone length. In addition, the study investigates the variation of applied load with increasing crack length for different ratios of initial crack length to strip width, and presents a simulation of crack propagation. Validation of our approach is achieved through comparison with both the infinite medium case and the work of H. Tada et al. ''The Stress Analysis of Cracks Handbook, Del Research Corporation, Hellertown, Pennsylvania. 1973''.

Keywords **–** *Dugdale-Barenblatt ; Crack opening ;Propagation ; Infinite strip ;Cohesive zone;*

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Free Vibration Response of Cracked Composite Plates: A Comparison Between Conventional and CNT-Reinforced Structures

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Abstract – This study investigates the free vibration behavior of functionally graded carbon nanotube-reinforced composite (FG-CNTRC) plates using extended finite element method (XFEM), considering both un-cracked and cracked configurations. The CNTs are distributed in uniform (UD) and functionally graded (FG-X) patterns, with the effective elastic modulus calculated using the modified Halpin-Tsai model. Governing equations are based on first-order shear deformation theory to account for transverse shear. The primary goal is to determine the required fiber volume fraction in a conventional composite plate (carbon/epoxy) to achieve comparable stiffness to the FG-CNTRC plates. Results are presented for un-cracked plates and plates with crack lengths of 0.4 and 0.8 units, highlighting the influence of CNT reinforcement and crack length on natural frequencies. This research provides insights into optimizing composite design by comparing the vibration performance of traditional and nanocomposite.

Keywords – *Carbon nanotubes; free vibration; cracks; XFEM;*

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Buckling Analysis of Functionally Graded Plates Using a Strain-Based Higher-Order Shear Deformation Theory

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Abstract **–** The buckling behavior of functionally graded quadrilateral plates subjected to mechanical and thermal loads is analyzed using a four-node finite element based on a strain-based high-order shear deformation theory (HSDT). Unlike conventional HSDTs that involve numerous unknowns, this approach reduces complexity by enforcing zero transverse shear stress on the plate's top and bottom surfaces and by assuming a sinusoidal distribution of transverse shear strains through the thickness. As a result, shear correction factors are not required. The material properties of the functionally graded material (FGM) plates are defined using a simple power-law distribution based on the volume fractions of the constituent materials.

The developed finite element model incorporates five degrees of freedom (DOFs) per node, derived from the integration of two strain-based components: a membrane element with two DOFs and a Reissner-Mindlin plate element with three DOFs. The displacement fields are formulated using higher-order terms that adhere to compatibility conditions and rigid body motions. The stiffness and geometric matrices are derived using the principle of total potential energy. To decouple membrane and bending effects, the concept of the physical neutral surface is introduced.

Convergence and validation studies confirm the stability and accuracy of the proposed finite element in predicting the critical buckling loads and thermal thresholds for both isotropic and functionally graded plates. Additionally, the influence of key parameters—such as the volume fraction exponent, side-to-thickness ratio, and loading conditions—on the buckling response is thoroughly examined.

Keywords **–** *Functionally graded; Finite element; Buckling behavior; strain-based; membrane;*

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Numerical Investigation of Collector Diameter Effects in Solar Chimney Systems

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Abstract – The solar chimney is an innovative renewable energy system that harnesses solar radiation to generate an upward airflow inside a tower. Heated air beneath a large glass collector rises naturally and drives turbines connected to generators, producing clean electricity. This simple and sustainable technology is based on thermodynamic and aerodynamic principles, and represents a promising alternative to meet energy demands while reducing environmental impact

This study focuses on modeling a solar chimney through numerical simulations using Ansys Fluent 2019R3. The results were validated by an experimental study conducted at the University of M'sila. The research also investigated the influence of the collector radius on the dynamic behavior of the fluid within the chimney. Increasing the collector diameter enhances both the air temperature beneath the collector and the airflow velocity inside the chimney, leading to an overall improvement in efficiency. The findings confirm that optimizing the collector dimensions plays a crucial role in improving the energy efficiency and electricity generation capacity of solar chimney power plants.

Keywords – *Solar chimney; Collector temperature; Solar radiation; Ambient temperature; Ansys; simulation;*

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Comparative Analysis of Milling, Plasma Cutting, and Oxy-Fuel Cutting Processes on the Quality of Machined Components.

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Abstract – The objective of this research is to experimentally investigate the influence of CNC plasma cutting, CNC oxy-fuel cutting, and milling parameters on mild steel sheets E24-2 (S235JR), as well as to optimize these parameters in order to achieve optimal cutting quality. The analysis also focused on the phenomenon of the heat-affected zone (HAZ) in the different machined areas. In parallel, the mechanical effects were evaluated through tensile tests, along with Brinell and Vickers hardness measurements.

Keywords – *CNC plasma cutting; CNC oxy-fuel cutting; Milling; Mild steel (S235JR / E24-2); Hardness and tensile testing;*

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Elaboration and characterization of certain coatings applied in industry

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Abstract **–** Surface treatments for materials are increasingly used. They allow the modification of the surface characteristics of these materials to optimize their applications. These treatments also enable parts to fulfill opposing functions, such as core ductility and good resistance to wear and corrosion. Among these surface treatments, we can distinguish between surface treatments by structural transformation of mechanical or thermal origin, thermochemical treatments, and the deposition of thin films and coatings. The surface treatment of metallic materials, polymers, glass, and ceramics is therefore largely a service used by many industrial sectors, including automotive, heavy industry, light industry, eyewear, decoration, currency, clothing, telecommunications, renewable energy, construction, medical, aerospace, aeronautics, and nuclear energy. Our purpose is to present various surface treatments applied to certain materials to enhance their surface properties. Regarding the treatments discussed, we will then present some research work that addresses the development and characterization of thin films and metallic coatings deposited on certain materials to improve their mechanical behavior, particularly hardness and adhesion.

Keywords **–** *Coating ; thin films ; surface treatment ; hardness ; adhesion;*

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Finite Element Analysis of Progressive Damage in Composite Materials through ANSYS

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Abstract **–** Progressive damage in composite materials is a complex phenomenon that directly affects the service life and reliability of structures. This article presents a numerical approach to simulating this process using ANSYS software, combining ACP (ANSYS Composite PrePost) for laminate definition and Mechanical for stress analysis and failure modes. Failure models (such as Hashin, Tsai-Wu, or Puck) are integrated to predict fiber breakage, matrix cracking, and delamination. A parametric study highlights the evolution of stresses, strains, and damage as a function of the applied loading, up to final failure. The numerical results are compared with experimental data, confirming ANSYS's capability to reliably reproduce the progressive behavior of composites. The article concludes by emphasizing the importance of simulation in optimizing the design and durability of composite structures.

Keywords **–** *Composite materials; Finite element; ANSYS; Damage;*

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Numerical Modelling of Ductile Damage in 3D Structures using Finite Element with rotational Dofs

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Abstract **–** The type of elements and mesh size are crucial in ductile damage simulations, especially in cracking zones were strong nonlinearities impact accuracy. Challenges include rising computational costs with more elements or advanced techniques like remeshing, as well as issues such as numerical locking. To address these, first-order solid elements with improved accuracy have been developed to reduce computational effort while preserving precision. This work presents an extension of the SFR8 element to handle material nonlinearities, enabling the analysis of elastoplastic behavior and damage in ductile materials. The SFR8 element is based on the concept of spatial fiber rotation (SFR) , which improves the approximation of the displacement field by incorporating the virtual rotations of a nodal fiber within the element. The Lemaitre damage model and the SFR8 element are implemented in a Fortran code. The performance of the SFR8 element is evaluated through a series of numerical problems, with a particular focus on studying the development of critical zones. The accuracy of the results is assessed by comparing them with reference solutions.

Keywords **–** *3D finite elements; Space Fiber Rotation; Ductile damage;*

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Transient Thermal Analysis of a Satellite–Launcher Separation Mechanism Using Finite Element Method

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Abstract – This paper investigates the transient thermal behavior of a launcher–satellite separation mechanism. The finite element model couple's conduction, time-dependent convection inside the payload fairing, radiation, and contact resistances at the launcher–payload interfaces. Load profiles are derived from standard practices in spacecraft thermal engineering (ECSS, NASA) and from aerodynamic/fairing heating analyses during ascent. Validation relies on thermal test philosophies, standard margins, and sensitivity studies on emissivity, contact conductance, and heat transfer coefficients. Results highlight critical transients at the interfaces and provide guidelines for thermal design of the mechanism up to the separation event.

Keywords – *Finite element; Transient thermal; separation mechanism; ANSYS; ECSS; NASA;*

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Dielectric Analysis of Wollastonite: Effect of Frequency and Temperature on Electrical Properties

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Abstract **–** Dielectric analysis is a valuable and versatile method used to examine the electrical behavior of materials through measurement of their response to alternating electric fields at a wide variety of frequencies. The subject of this research is wollastonite (CaSiO3), a calcium silicate ceramic with extensive application as a biomaterial because of its very good biocompatibility and bioactivity. The research evaluates the frequency and temperature dependence of wollastonite's dielectric properties since they are two of the most important parameters that characterize the material's reaction to electrical stimulus in biomedical applications. Furthermore, the current research examines the influence of various solvents used for synthesizing wollastonite on its crystalline phases, which are the decisive factors for its dielectric behavior. Dielectric constant (permittivity) and dielectric loss measurements were collected to reveal structural and phase evolution related to processing conditions and treatment temperatures. Results show the typical decrease of permittivity with increasing frequency, while high temperatures enhance molecular mobility and polarization, increasing dielectric constant at low frequencies. Solvent composition changes during processing yielded distinct phases mainly β-wollastonite and α-wollastonite with influence on crystallinity, porosity, and hence electrical properties. These findings are significant as they create a comprehensive understanding of the interrelation between synthesis conditions, microstructure, and dielectric properties. This is crucial for the optimization of wollastonite biomaterials for medical implant, bone graft, and other bioactive device applications where electric field interactions can impact biological response and functional integration. Thus, dielectric analysis emerges as a core method in the design and development of novel biomaterials for enhanced clinical performance and therapeutic outcomes.

Keywords **–** *Wollastonite; Dielectric Analysis; Permittivity; Biomaterials;*

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Analysis of the Effect of Cutting Parameters on Tool Wear and Chip Morphology in Hard Machining of Ti5553 Titanium Alloy

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Abstract **–** Hard machining has become a key approach in modern manufacturing, particularly for advanced alloys such as titanium, widely used in the aerospace industry due to its high strength-to-weight ratio and thermal stability. However, machining titanium alloys remains challenging because of low thermal conductivity and high chemical reactivity, which accelerate tool wear. This study presents a statistical analysis of the influence of cutting parameters—cutting speed (Vc), feed rate (f), and depth of cut (ap)—and cutting tool material on tool wear and chip morphology during the hard turning of Ti-5553 alloy. Three tool materials were investigated: tungsten carbide, cermet, and composite ceramic CC670. A Taguchi L9 orthogonal array was used to design the experiments efficiently while minimizing the number of trials. The response variables analyzed were surface roughness (Ra), tool wear (VB), and material removal rate (MRR). Analysis of variance (ANOVA) was conducted to determine the significance of each factor, and regression models were developed to predict the responses. Results indicate that feed rate and cutting speed are the most influential parameters affecting surface roughness. Higher cutting speeds led to a significant increase in tool wear for all tool types. In addition, chip morphology varied considerably with cutting conditions, revealing a strong correlation between chip formation and tool degradation. These findings offer valuable insights into the selection of cutting conditions and tool materials for effective machining of Ti-5553, with the goal of improving tool life, chip control, and overall machining performance.

Keywords **–** *Chip morphology; Wear; Turning; Ti5553; ANOVA;*

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Optimization of Thermophotovoltaic GaSb Cells Using COMSOL Multiphysics: Materials Integration and Thermal Management

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Abstract **–** This work presents a COMSOL Multiphysics–based optimization study of GaSb thermophotovoltaic (TPV) cells, focusing on materials integration (substrates, anti-reflection coatings, selective emitters/filters) and thermal management water, cooling). We implement a coupled radiative, conductive and convective model using the Heat Transfer, Surface-to-Surface Radiation, and Semiconductor modules to quantify cell temperature, spectral power density and electrical output as functions of emitter temperature, emitter spectral control, and back-side cooling coefficient. Parametric sweeps determine the best tradeoff between electrical power density and device temperature for realistic emitter temperatures (1000–1800 K). Results identify which material stacks and cooling strategies maximize TPV power and efficiency while keeping GaSb cell temperatures within safe operating limits.

Keywords **–** *Optimal output; cooling; hermophotovoltaic system; efficiency; geometry;*

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Theoretical Prediction of Protein Network–Induced Nonlocal Response in Molecular Resonator Biosensors Incorporating Hydrogen Bonding and van der Waals Interactions

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Abstract **–** In this study, the resonant frequency behavior of microbeam-based biosensors under biomolecular adsorption is investigated, with consideration of shear deformation, nonlocal elasticity, and atomistic-scale interactions. The adsorption energy is described using a distributed coupling scheme that links the biosensor structure with the spike protein, ensuring precise characterization of their mechanical interdependence. Surface stress effects are incorporated through a hybrid formulation that merges functional microbeam theory with localized molecular adsorption mechanics. Intermolecular interactions are modeled using the Lennard-Jones (6-12) potential, which captures van der Waals forces between the adsorbed species and the biosensor surface.
The structural response is analyzed using the nonlocal Timoshenko beam theory, accounting for shear deformation and moment of inertia effects, while residual stresses are treated as an effective axial load. Numerical investigations demonstrate that resonance frequency shifts are strongly dependent on adsorbate type, surface mechanical attributes, and the coupled biosensor-protein dynamics.
The findings emphasize the importance of nanoscale interactions in determining microresonator compliance, validating the necessity of incorporating these effects for accurate predictive modeling. The developed framework provides a robust methodology for assessing biosensor-protein interactions and for estimating the mass and density of spike proteins or viral particles, while capturing adsorption binding phenomena.

Keywords **–** *nonlocal behavior; van der Waals interaction; resonance frequency; adsorbed adatoms; statistical distribution; interatomic potential;*

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Evaluation of the stability of hydroxyapatite (Ca/P = 1.5) derived from sol-gel at different thermal conditions

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Abstract – This study investigates the high-temperature phase stability of non-stoichiometric hydroxyapatite (HA) with a Ca/P ratio of 1.5 synthesized via the sol-gel method. HA is a significant biomaterial due to its structural similarity to natural bone mineral, and the sol-gel technique was employed for its ability to produce high-purity nanocrystalline powders with uniform morphology.
The HA powder was synthesized using triethyl phosphate and calcium nitrate tetrahydrate as precursors in an ethanol-water solvent system. The solution was aged at 90 °C for 24 hours, followed by drying and calcination at 700 °C. Subsequent thermal treatments were conducted at 1100 °C, 1200 °C, and 1300 °C to examine phase stability.
Structural evolution was characterized using X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FT-IR). XRD results identified hydroxyapatite as the primary phase in all samples, accompanied by minor phases of calcium oxide (CaO) and β-tricalcium phosphate (β-TCP). As the temperature increased to 1100 °C, the proportion of β-TCP decreased due to its transformation into HA. At higher temperatures (1200 °C and 1300 °C), β-TCP completely disappeared and α-TCP emerged, indicating a phase transition from β to α modification. A consistent increase in HA crystallinity accompanied this transformation. FT-IR analysis confirmed the presence of phosphate (PO_4^{3-}) groups in all samples, with spectral variations in intensity and bandwidth supporting the XRD findings regarding structural changes induced by thermal treatment.
In summary, the research demonstrates that elevated temperatures promote the conversion of β-TCP to hydroxyapatite up to 1100 °C, while higher temperatures induce a phase transition to α-TCP. These findings provide valuable insights for optimizing the thermal processing of non-stoichiometric HA for biomedical applications.

Keywords *– hydroxyapatite; TEP; sol-gel; CaO;*

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Computational Characterization of Phthalimide Derivatives: A DFT Study of Electronic Properties and Reactivity

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Abstract – This work focuses on the characterization of phthalimide derivatives through theoretical investigation using Density Functional Theory (DFT) at the B3LYP/6-311++G (2d, p) level. The electronic properties and reactivity descriptors were analyzed, including HOMO–LUMO energy gaps, dipole moments, Gibbs free energies, Fukui functions, and molecular electrostatic potential (MEP) maps. These parameters provided a detailed picture of the electronic distribution and the most reactive molecular sites.

The study highlights the carbonyl oxygen atoms as the most favorable sites for electrophilic attacks, while other regions are more prone to nucleophilic interactions. The correlation between HOMO–LUMO gaps and molecular reactivity further confirms the predictive power of computational methods in understanding material behavior.

Such characterization not only deepens the understanding of phthalimide derivatives at the molecular level but also provides valuable insights for the design of new bioactive compounds and functional materials.

Keywords – *Phthalimide; DFT; Electronic properties; Reactivity sites; Materials characterization;*

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Apport De La Mécanique Des Fluides Dans L'étude Des Ecoulement Sanguins

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Résumé **-** Notre étude expérimentale présente une analyse des caractéristiques dynamiques de l'écoulement d'un fluide non newtonien, de nature viscoplastique ou à seuil, à travers un tube sténosé à 75% (par réduction de surface). Le comportement du fluide, modélisant le sang, a été décrit par le modèle non newtonien de Herschel Bulkley. Le fluide non newtonien est une solution aqueuse de Carbopol940 à 0,1 % en masse. Les conditions d'écoulement, en amont de la sténose, sont celles d'un régime laminaire et couvrent une plage de nombres de Reynolds généralisés Reg de 0,20 à 13,66. Les profils de vitesse ont été mesurés avec la Vélocimétrie Laser Doppler (LDV). Cette étude permet de voir l'influence de la géométrie et du caractère non newtonien du fluide sur les profils de vitesse et sur les pertes de charge. Au niveau de la sténose, une corrélation entre le nombre d'Euler et le nombre de Reynolds généralisé a été proposée. Pour comparer les parties amont et aval de la sténose, il est préférable de présenter les pertes de charge par le facteur de frottement f. Ce facteur f en amont et en aval décroît linéairement avec le nombre de Reynolds généralisé Reg.

Keywords *– Non newtonien; Herschel-Bulkley; Carbopol940; Sténose, LDV;*

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Valorization of Date Palm Fibers for Sustainable Reinforcement in Geopolymer Composites

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Abstract **–** This study investigates the mechanical enhancement of slag-based geopolymer mortar through the incorporation of date palm and glass fibers at varying volume fractions (0.2%, 0.3%, and 0.4%). Recognizing the inherent brittleness of Portland cement and geopolymer matrices under tensile loading, fiber reinforcement was employed to improve ductility, flexural strength, and overall structural resilience. Date palm fibers underwent alkali treatment using a 5% NaOH solution to enhance interfacial bonding and compatibility with the geopolymer matrix. Experimental results reveal that mortars reinforced with 0.3% date palm fibers exhibited the highest flexural strength, particularly under elevated temperature conditions, surpassing both glass fiber-reinforced and unreinforced specimens. These findings underscore the viability of natural, regionally available fibers as sustainable alternatives to synthetic reinforcements, offering promising pathways for eco-efficient and thermally stable geopolymer composites in construction applications.

Keywords **–** *Geopolymers; Pozzolanic effects; Flexural strength; Plant-based materials;*

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Stabilisation optimale des sols à la chaux vive : impact du pourcentage de chaux et du durcissement thermique

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Résumé **-** Cette étude vise à optimiser la stabilisation d'un sol par l'ajout de chaux vive, en déterminant les conditions optimales de dosage et de durcissement thermique. Le sol étudié a été préalablement tamisé à 2 mm puis séché à 65 ± 2 °C durant 24 heures afin d'assurer une homogénéité initiale. Des éprouvettes prismatiques normalisées (4 × 4 × 16 cm³) ont ensuite été confectionnées avec différentes teneurs en chaux (3 à 15 % de la masse sèche du sol) et soumises à des durées de durcissement de 3, 7 et 11 jours dans une étuve à 65 °C. L'approche expérimentale adoptée, croisant ces deux paramètres, permet d'analyser leurs interactions. La teneur en eau a été fixée à 21,35 %, calculée à partir des limites d'Atterberg, afin d'assurer une bonne maniabilité et homogénéité du mélange. Les performances mécaniques ont été évaluées au moyen d'essais de compression simple et de flexion. Les résultats obtenus montrent que la formulation optimale correspond à 7 % de chaux vive et un durcissement de 11 jours, conduisant à une amélioration notable de la résistance mécanique ainsi qu'à une stabilité thermique satisfaisante. Ces résultats constituent une base pertinente pour le développement de solutions durables dans le domaine des matériaux de construction stabilisés.

Keywords **–** *Stabilisation des sols ; Chaux vive ; Optimisation expérimentale ; Durcissement en étuve ; Stabilité Thermique ;*

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Development and Evaluation of a Parabolic Trough Solar Collector System Using Indigenous Materials

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Abstract **–** In this study, a qualitative evaluation of an initial prototype of a parabolic trough solar collector was conducted, supported by a MATLAB-based program developed to estimate solar radiation across the 58 provinces of Algeria. The prototype was constructed using low-cost, locally available materials, and the final manually assembled system integrates both a hydraulic circuit and a data acquisition unit. Solar radiation estimation was performed using five established models: Liu and Jordan, Klucher, Hay & Davies, Reindl, and Brichambaut. The developed software was validated for the region of M'sila. A comparison between the calculated global solar radiation and experimental measurements revealed that the Liu and Jordan model provided the most accurate estimation for this region. The results confirmed that M'sila is a highly favorable site for solar energy exploitation, with a Global Horizontal Irradiance (GHI) of 1.79 MWh/m²/year and a Direct Normal Irradiance (DNI) of 2117.93 kWh/m²/year. Given their cost-effectiveness and wide adoption in concentrated solar power (CSP) applications worldwide, parabolic trough collectors are strongly recommended for deployment in this context.

Keywords **–** *Solar energy; Parabolic Trough Solar Collector; Global Solar Radiation; CSP technology and Low-cost materials;*

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Comprehensive Analysis of the Physicochemical and Mechanical Behavior of Natural Fiber Extracted from Bassia Indica

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Abstract – This study presents the extraction and characterization of a natural cellulosic fiber obtained from the stems of Bassia indica, a little-known and underutilized plant species. The objective is to evaluate its potential for use in sustainable bio-based materials by analyzing its anatomical, morphological, structural, thermal, and mechanical properties. Anatomical analysis confirmed a typical dicotyledonous vascular structure with well-defined bundles. The extracted fibers displayed an average length of 1.25 mm and a diameter of 20.5 µm, with thick cell walls. Scanning Electron Microscopy (SEM) revealed a rough surface with longitudinal cavities, favorable for fiber–matrix adhesion in composites. X-ray Diffraction (XRD) analysis indicated a crystallinity index of approximately 48%, characteristic of a semi-crystalline lignocellulosic structure. Thermogravimetric Analysis (TGA) showed thermal stability, with degradation of hemicellulose and cellulose beginning at 250 °C and 340 °C, respectively, and a total mass loss of about 80% at 600 °C. Mechanical testing showed promising results, with a tensile strength of 417.50 MPa and a Young's modulus of 17.46 GPa. These findings demonstrate that Bassia indica fiber possesses desirable thermal and mechanical characteristics, making it a strong candidate for eco-friendly composite applications. This study confirms the viability of Bassia indica fibers as a green reinforcement solution, contributing to both the mechanical enhancement of adobe bricks and the sustainable use of indigenous plant resources in ecological construction

Keywords – *Bassia Indica; Natural Cellulose Fiber; mechanical properties; Thermal Stability and Bio-composites;*

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Unified Jacobian–Torsor Framework for Automatic Tolerancing and Geometric Variation Analysis

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Abstract **–** In the field of design and manufacturing, three-dimensional (3D) tolerancing plays a crucial role in ensuring product functional compliance under increasingly stringent requirements. This work proposes a deterministic approach based on the unified Jacobian–Torsor model, which enables accurate modeling and analysis of the propagation of geometric and dimensional deviations in mechanical assemblies. The method aims both to transform functional requirements into exploitable geometric principles and to reduce the uncertainties associated with traditional empirical approaches. A case study involving an insertion assembly of two components is presented to illustrate the effectiveness of the model in terms of accuracy and ease of use for defining tolerance zones. The results demonstrate that this approach facilitates automatic tolerancing, while enhancing design robustness, calculation accuracy, and overall process efficiency.

Keywords **–** *3D Tolerancing; Jacobian–Torsor Model; Deterministic Analysis; Automatic Tolerancing; Geometric Variations; Mechanical Assemblies; Design Robustness;*

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Influence of Applied Voltage on the Fatigue Performance of Copper-Embedded Multifunctional Composites

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Abstract **–** The behavior of a multifunctional composite material with an embedded 0.05 mm copper foil strip under cyclic loading was investigated. Materials able to bear load while conducting electricity are crucial in various applications in high-tech industries. The effects of applied stress and voltage levels on the material response were analyzed. The composite was subjected to tensile and fatigue tests. The results revealed that the introduction of the 0.05 mm copper foil had an impact on the Maximum Tensile Resistance (MTR). The examination of fatigue-damaged specimens provided important insights into the evolution of the copper/composite interface debonding area under different loading conditions. Fatigue test results allowed the plotting of fatigue curves and the establishment of fatigue equations specific to each voltage level (U = 5, 9, and 12 ± 0.3 V). These results also highlighted the influence of electrical voltage, showing that higher voltage levels improved fatigue resistance.

Epoxy resin was chemically dissolved to restore the damaged copper. Naked-eye inspection, along with scanning electron microscope (SEM) observations, revealed important aspects of the metallic insert behavior, including the coexistence of ductile and brittle rupture features and the influence of voltage on the fractured surface.

Keywords **–** *Multifunctional composite material; fatigue; electrical tension; metallic insert; debonding;*

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Influence of Normal Load on the Wear Resistance of NickelBased Alloys

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Abstract **–** This study investigates the wear behavior of complex nickel-based alloys produced by arc melting under argon atmosphere. Microstructural analysis (SEM/EDS) reveals hard phases (carbides, borides, silicides) that enhance wear resistance. Tribological tests show that mass loss increases with applied normal load, indicating intensified shear mechanisms. Surface observations confirm the formation of grooves aligned with the sliding direction. These findings highlight the potential of these alloys for demanding mechanical applications.

Keywords *–: Wear; tribology; microstructure;*

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Parametric study on the performance of a new earth-air heat exchanger configuration for heating applications

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Abstract **–** The earth-to-air heat exchanger (EAHE) is a suitable technique for cooling and heating buildings, as it is an effective way of reducing energy consumption. This study presents a numerical analysis of the thermal performance of a spiral-shaped EAHE designed for winter heating in Constantine. Three-dimensional simulations were performed using ANSYS FLUENT software. A new geometry of the EAHE has been used to investigate how the outlet air temperature and the EAHE's mean efficiency are affected by the thermal conductivity of the pipe and soil, pitch, pipe length, soil temperature, inlet air temperature and flow velocity. The difference with the outside temperature determines the possibilities offered by geothermal heating technology for use in cold climate locations in Algeria.

Keywords **–** *Geothermal energy; earth-air heat exchanger; spiral pipe; heating; simulation;*

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Synthesis and Multiscale Characterization of Nanocrystalline $CoAl_2O_4$ Spinel

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Abstract **–** Cobalt aluminate (CoAl2O4) is a spinel oxide known for its remarkable thermal stability, optical properties, and wide applications in pigments, catalysis, and functional materials. In this work, nanocrystalline CoAl2O4 was synthesized by the sol–gel method under controlled conditions. The crystalline structure and phase purity were confirmed by X-ray diffraction (XRD), which revealed the formation of a well-defined spinel phase with nanoscale crystallite size.

Scanning electron microscopy (SEM) was used to investigate surface morphology, while Raman spectroscopy provided vibrational information supporting the spinel structure. UV Vis analysis confirmed the characteristic optical absorption of CoAl2O4, related to its electronic transitions. The nanoscale nature of the obtained material was further validated by the broadening of diffraction peaks and the uniform particle distribution observed microscopically.

This study highlights the efficiency of the chosen synthesis route for producing CoAl2O4 nanomaterials with controlled size and structure, and underlines their potential for advanced technological applications in catalysis, sensing, and optical devices.

Keywords **–** *$CoAl_2O_4$, Spinel Oxide, Nanomaterial, XRD, SEM, Raman Spectroscopy, Optical Properties, Functional Materials;*

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Effect of the HTL Layer (a-Si) on the Efficiency of the CdS/CdTe Solar Cell via Numerical Simulation

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Abstract – In this study, we investigate the effect of incorporating a silicon layer on the performance of a base solar cell (ZnO/CdS/CdTe/Al), focusing on both its efficiency and current-voltage (J-V) characteristics, using the one-dimensional simulation tool AMPS-1D (Analysis of Microelectronic and Photonic Structures in One Dimension). We also analyzed how the thickness of the absorber layer (CdTe) influences the cell's performance. The highest efficiency, 25.028%, was obtained for the simulated cell with an added amorphous silicon (a-Si) layer. In this configuration, the active CdTe layer had a thickness of 1000 nm, while the a-Si layer was 10 nm thick. The integration of the a-Si HTL layer enhances the overall efficiency of the cell by minimizing losses due to recombination at the CdTe/electrode interface. Furthermore, the results demonstrate that optimizing the thickness of the CdTe absorber is crucial for balancing light absorption and carrier collection, thereby maximizing device performance. These findings highlight the potential of combining CdTe absorbers with thin a-Si layers as a promising pathway for improving next-generation thin-film solar cells, offering a cost-effective and efficient alternative for photovoltaic applications.

Keywords –

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Structural Study of The Insertion of Silicon, Iron And/Or Bismuth in The Framework of $AlPO_4$-5

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Abstract **–** Microporous aluminophosphate-based materials have attracted growing attention as promising candidates for advanced functional applications, particularly in the context of renewable energy. Building on previous thesis work, this study deepens the structural and spectroscopic understanding of AlPO_(4)-5, a P6cc-phase aluminophosphate, selectively doped with silicon, iron and/or bismuth. A broad suite of characterization techniques is employed to examine the impact of dopant incorporation on the material's framework and physicochemical properties. Structural features are probed using X-ray diffraction (XRD), while morphology and surface composition are assessed through scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX). Textural parameters and porosity are evaluated via nitrogen adsorption–desorption isotherms (BET method). Optical properties are explored using UV-Vis diffuse reflectance spectroscopy (DRS), and electronic environments of paramagnetic centers are investigated through electron paramagnetic resonance (EPR). Finally, iron-specific sites and oxidation states are examined using Mössbauer spectroscopy, providing insight into the local coordination and redox behavior of dopants. Together, these techniques offer a comprehensive picture of the structural, electronic, and spectroscopic evolution of MeSAPO-5 materials, with an emphasis on building robust structure–property correlations, thereby guiding predictions for any photocatalytic performance.
This systematic approach is designed to establish strong structure–property correlations, thereby guiding predictions of photocatalytic performance.

Keywords **–** *Microporous Material; Aluminophosphates; XRD; SEM-EDX; BET; UV-Vis diffuse reflectance spectroscopy; Mössbauer spectroscopy; Structural characterization; Spectroscopic Analysis; Framework modification; Solid-State Materials*

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Enhancement of Transmittance and Strength of Sandblasted Glass by Deposition of Silica and Zirconia Thin Films

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Abstract – This study investigates the effect of SiO_2–ZrO_2 composite thin films, deposited via the sol-gel method, on the optical and mechanical properties of sandblasted glass. Sandblasting erosion (abrasive mass: 200 g) on soda-lime glass significantly reduced its optical transmittance from 90.83% to 55% and its mechanical strength to 45 MPa.

To remediate these surface defects, a primary silica (SiO_2) coating was applied using a sol-gel process. This treatment resulted in a significant recovery of transmittance to 73%. However, the mechanical strength remained insufficient, reaching only 62 MPa.

The subsequent deposition of a secondary zirconia (ZrO_2) layer substantially increased the mechanical strength to 125 MPa. In contrast, this second layer provided only a marginal further improvement in transmittance, which reached a final value of 79%.

Keywords – *Glass; silica; zirconia; sol-gel; strength; transmittance;*

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Numerical simulation by the Eulerian–Lagrangian approach of Erosion in Cement-Mill Fan: Effects of Blade Outlet Angle and Count

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Abstract **–** This study investigates the erosion issues faced by cement-mill fans operating in dust-laden conditions downstream of cement production. The continuous exposure of fan components to highly concentrated and abrasive cement particles shortens service life and can trigger mechanical instabilities, such as vibrations caused by asymmetric rotor wear. To explore these effects, Computational Fluid Dynamics (CFD) simulations coupled with a Lagrangian particle-tracking model were performed. The analysis focused on two geometric parameters: the impeller blade outlet angle and the number of blades. Five outlet angles (71°, 67°, 62°, 58°, and 56°) were examined while keeping the blade count constant. The results showed a clear pattern—erosion on the pressure side of the blades decreases as the outlet angle decreases. This behavior was linked to variations in governing factors such as particle impact frequency and angle, while impact velocity distributions remained nearly unchanged across different outlet angles. The investigation of blade number showed comparatively weaker influence on overall erosion patterns, though impellers with fewer blades exhibited localized erosion hotspots, especially near the mid-chord region, due to higher local impact frequency. These findings underscore the dominant role of blade outlet angle in erosion processes and highlight the need to balance blade count when designing durable, high-performance cement-mill fans.

Keywords *–CFD, Erosion, Centrifugal fan, two-phase flow, Particle transport model, Induced draft fan, Discrete phase model*

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Characterization of a cross-linked polyethylene subjected to electrical discharges

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Abstract **–** The phenomenon of partial discharges constitutes the main cause of electric ageing and insulators surface degradation. Solid insulating materials are the basic building blocks of electrical equipment insulation. A deeper understanding of the characteristics of dielectric materials is essential to ensure the reliability of high-voltage electrical systems. This experimental study focuses on the characterization of cross-linked polyethylene (XLPE) subjected to electrical discharges, using scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) spectroscopy. Under this electrical stress, XLPE degrades and hydroxyl groups are formed. The surface analysis of the samples revealed significant morphological degradations of material, which directly depend on the exposure time to the discharges. The main degradations observed include the formation of tree-like structures and a change in surface color.

Keywords **–** *electric; discharges; XLPE; polymer; FTIR; SEM;*

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3D simulation of aortic butterfly mechanical heart valve at peak systole

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Abstract – The current study presents three-dimensional modeling and analysis of blood flow through the Butterfly valve prosthesis in the aortic position at systolic peak phase in order to better understand the relationship between the prosthetic heart valve design and thromboembolic potential such as hemolysis, platelet activation and device failure. The study considered Newtonian flow model and solved the three dimensional and steady Navier Stokes (NS) equations for systolic peak inlet velocity. The simulation results showed disturbed flow (such as flow separation, stagnation) as well as abnormal hemodynamic parameters (HPs) distributions (including the low and high wall shear stress (WSS) and oscillation of wall shear stress).

Keywords – *Heart valve Prosthesis; Blood Flow; Hemodynamics; Computational Fluid Dynamics (CFD); systolic peak; 3-D simulation;*

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Thermo-Economic Analysis of a Solar Power Tower Plant with Two-Tank Molten Salt Thermal Storage System for application in the Algerian arid climate

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Abstract – To address the rapidly increasing global demand for electricity, the deployment of concentrated solar power technologies has emerged as a key strategy adopted by many countries as part of their sustainable energy transition.

This study presents a thermo-economic analysis of a 100 MWe solar power tower plant equipped with a thermal energy storage system, designed for operation under the arid climatic conditions of Algeria, specifically in the M'Sila region. The System Advisor Model (SAM), a thermo-economic simulation tool, was employed to estimate the plant's monthly and annual electricity generation, levelized cost of electricity (LCOE), and annual water consumption.

The results of this study indicate that the proposed plant can operate year-round, producing electricity from 8:00 a.m. to 9:00 p.m. with an average power output ranging between 20 MWe and 100 MWe. Thanks to favorable weather conditions and the integration of a thermal energy storage system, the plant is capable of achieving up to 18 hours of continuous production from April to October. Moreover, the solar power tower plant's annual electricity generation reached approximately 350 GWh, with a levelized cost of electricity (LCOE) of 14 ¢$/kWh and an annual water consumption of about 60000 m^3.

These results demonstrate that the deployment of concentrated solar power technologies particularly solar tower systems under Algerian arid climatic conditions offers a technically and economically viable solution for clean energy production, while significantly enhancing the country's energy security and reducing its dependence on conventional energy resources.

Keywords *– Solar power tower; Thermal Storage System; Algerian arid climate; System Advisor Model; Levelized cost of electricity;*

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Development of a Python-Based Abaqus Plugin for Random Distribution of Unidirectional Fibers in Composite Materials

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Abstract **–** Fiber-reinforced composites are among the most prominent engineering solutions for enhancing durability and reducing weight. However, the accuracy of their numerical modeling depends on properly representing the random distribution of fibers within the matrix. In the case of unidirectional fibers, an ideal or uniform distribution is often assumed, while in reality randomness in positions and variations in diameters occur. This creates difficulties in manually constructing models and increases the likelihood of overlaps and inaccuracies in volume fraction estimation. This study addresses this issue by developing a Python-based plugin integrated into the Abaqus environment to generate randomly distributed unidirectional fibers within composite matrices. The plugin supports both 2D and 3D models, allowing users to define model dimensions and select either constant or variable fiber diameters within a specified range, while ensuring the targeted volume fraction and preventing overlaps. The results show that the proposed plugin significantly reduces model preparation time and provides a more realistic representation of the material microstructure, thereby improving the accuracy of numerical analysis of composites. The details of the algorithm and the program interface are presented in the paper.

Keywords **–** *Unidirectional fibers; Random distribution; Composite materials; Finite Element Analysis (FEA); Abaqus;*

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Magnetohydrodynamic Conjugate Mixed Convection Heat Transfer of a Ternary Nanofluid in Lid-Driven Triangular Cavities.

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Abstract – This study investigates magnetohydrodynamic (MHD) mixed convection of a ternary nanofluid inside a triangular cavity under uniform thermal boundary conditions. The cavity is filled with a ternary hybrid nanofluid composed of three types of nanoparticles suspended in a base fluid to improve its thermal performance. A uniform external magnetic field with variable strength and orientation is applied, and the governing equations of continuity, momentum, and energy are numerically solved using the finite volume method, accounting for the Lorentz force and effective thermo-physical properties of the nanofluid. Parametric analyses are conducted by varying the Richardson number, Hartmann number, and nanoparticle concentration. The results reveal that the ternary nanofluid considerably enhances the convective heat transfer compared to the base fluid. Meanwhile, the magnetic field strongly influences the flow circulation and temperature distribution. Higher Hartmann numbers suppress fluid motion, leading to reduced convective strength and lower Nusselt numbers. The findings highlight the combined effects of ternary nanofluids and MHD control on thermal behavior in enclosures, offering potential for advanced thermal management applications.

Keywords – *Mixed convection; Magnetohydrodynamics; Ternary nanofluid; Uniform heating; Triangular cavity; Heat transfer enhancement;*

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Impact of Structural Defects on the Behavior of Reinforced Concrete Structures

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Abstract **–** Reinforced concrete is considered the material of choice in construction, yet structural failures and pathologies continue to occur. These issues often arise from multiple causes, such as design errors, calculation mistakes, poor workmanship, or chemical actions. Such disorders can manifest as structural instabilities, partial failures, or even complete collapse. To prevent these pathologies, it is essential to conduct thorough on-site inspections, focusing on the concrete mix composition, material quality, and the proper placement of reinforcement steel.

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Energy Absorption Performance of 3D-Printed PLA and PLA/Flax Sandwich Cores with Optimized Geometries

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Abstract **–** This work investigates the energy absorption performance of sandwich cores fabricated via 3D printing using neat PLA and PLA/flax biocomposites. Three core geometries (circular, honeycomb, and tri-grid) were tested under quasi-static bending to quantify crashworthiness metrics, including energy absorption (EA) and specific energy absorption (SEA). Results revealed that flax reinforcement substantially enhanced energy absorption, particularly in circular cores, achieving a 131% increase compared to neat PLA. Tri-grid configurations exhibited superior structural consistency by promoting stress homogenization and delaying failure. The combined effect of fiber reinforcement and geometry optimization highlights the potential of PLA/flax biocomposites as sustainable, high-performance candidates for automotive and construction applications requiring lightweight crash-resistant structures. Future research will focus on dynamic loading conditions and scaling strategies for industrial adoption.

Keywords **–** *Natural fiber composites; additive manufacturing; sandwich structures; energyabsorption; sustainable materials; finite element analysis;*

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Effect of Welding Parameters on the Microstructure and Mechanical Properties of Resistance Spot Welded AISI 430 Stainless Steel Sheets

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Abstract **–** Resistance spot welding is a fast and widely used technique for joining stainless steel sheets. The process involves passing a high-intensity electric current through the parts held under pressure between two electrodes. Joule heating leads to the formation of a molten zone, called the nugget, which ensures the bonding between the sheets. In this work, ferritic stainless steel AISI 430 sheets were joined by spot welding under variable welding conditions. The influence of welding current intensity and holding time on the microstructure and mechanical properties of the welded joints was investigated. Tensile tests and microhardness measurements were carried out to characterize the mechanical strength and fracture mode of the welds. The results reveal that nugget size, tensile strength, and microhardness distribution are strongly dependent on the welding parameters. Microstructural analysis made it possible to interpret the metallurgical transformations generated during the process.

Keywords *–Stainless steel; Nugget formation; Microstructure; Mechanical properties;*

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Optimization Of Drill Point Angle for Enhanced Hole Quality in Date Palm Fiber Biocomposites: Experimental Investigation and Numerical Modeling

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Abstract **–** This work investigates the drilling performance of palm fiber powder/epoxy (PFPE) biocomposites with an emphasis on the influence of machining parameters on hole quality. Drilling tests were carried out at spindle speeds of 500,1000, and 1500 rpm, feed rates of 50,100, and 150 mm/min, and drill point angles of 85°, 115°, and 135°. The analysis focused on circularity and cylindricity deviations measured in the machined holes. Results showed that higher spindle speed reduced circularity errors while increasing cylindricity deviations. In contrast, greater feed rates amplified both error types. Among the studied drills, the 115°-point angle provided the best compromise, yielding high-quality holes when combined with 500 rpm spindle speed and 100 mm/min feed rate. To validate and predict the drilling outcomes, both Artificial Neural Networks (ANN) and the Taguchi approach were applied. ANN exhibited superior predictive accuracy compared to Taguchi, highlighting its effectiveness for modeling drilling responses in biocomposites. The study emphasizes the critical role of selecting appropriate cutting parameters to ensure dimensional accuracy in bio-based composite machining.

Keywords *–Drilling performance; Hole accuracy; Drill point angle; Artificial Neural Networks; Taguchi design; Circularity and cylindricity errors;*

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Effect of Fired Brick Powder on the Physical and Mechanical Properties of Earthen Mortars

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Abstract **–** This study investigated the potential of recycling fired brick powder by incorporating it with lime to produce durable earthen mortars suitable for brick jointing. To achieve this, four experimental mixtures were prepared with different waste contents (10%, 20%, 30%, and 40%), while maintaining a constant base composition of lime, soil, and sand. The samples were subjected to a comprehensive series of tests to assess their mechanical performance, including compressive and flexural strength. The results revealed a marked superiority of the mixture containing 40% red brick waste, which exhibited significant improvements across all measured parameters compared to the control sample. Specifically, compressive strength increased by approximately 40%, from 9.98 MPa to 13.97 MPa, while flexural strength rose from 1.65 MPa to 4.30 MPa. In addition, the dry density increased, confirming the effectiveness of crushed red brick waste in stabilizing earthen mortars.

Keywords **–** *Earthen mortars; Lime; Fired brick powder; Mecanical proprieties;*

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An Experimental Study on Recycled Polypropylene and High-Density Polyethylene: A Comparative Study Based on The Tensile Strength

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Abstract – Plastic recycling is a process aimed at reusing plastic materials instead of disposing of them improperly, reducing environmental pollution, and contributing to the preservation of natural resources. Also, plastic recycling helps reduce the amount of waste ending up in landfills and incinerators Producing plastic from raw petroleum materials requires large amounts of energy, while recycling plastic consumes less energy.
In this study, two type of recycled polypropylene (RPP) and high-density polyethylene (R HDPE) are investigated. The mechanical properties of these materials such as tensile strength, Young's modulus are tested and analysed.
After taking and measuring the pieces of RPP and RHDPE plastics, RPP has shown good results in terms of Hardness and Young's Modulus. This difference in mechanical properties between the two is due to the different chemical composition of each, with the RPP composition giving it greater rigidity, making it more resistant and tolerant to breakage compared to RHDPE. Hence RPP can be utilized in automotive and engineering applications

Keywords – *Plastic recycling; polypropylene; high-density polyethylene; mechanical properties.*

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Post-Weld Heat Treatment Effects on The Microstructure and Mechanical Behavior of In-738 Lc Joints

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Abstract – This research addresses the critical need to optimize weld integrity in IN-738 LC, a nickel-based superalloy widely used in high-temperature aerospace and industrial applications. The study examines the effect of post-weld heat treatment (PWHT) on the microstructural evolution and mechanical properties of welded joints. A comprehensive methodology is employed, combining advanced welding techniques with systematic heat treatment protocols. Microstructural characterization is carried out using scanning electron microscopy methods, while mechanical properties are evaluated through tensile testing. The findings reveal a strong correlation between PWHT parameters and the resulting microstructure, which significantly influences the mechanical of the welded joints. Optimizing PWHT enhances creep resistance and fatigue life, both of which are critical for the longevity and reliability of components operating under extreme conditions. These results provide practical guidelines for improving welding procedures for IN-738 LC, contributing to greater component durability and reduced operational costs

Keywords – *IN-738 LC; welding; filler metal; post-weld heat treatment; microstructure; mechanical properties; creep; fatigue;*

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The Impact of Incorporating Marble Waste on The Tensile Strength of Composite Tubes, Plastic-Bonded Sand Analysed Using the Split- Disk Test (SDT)

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Abstract **–** The problem of recycling plastic waste, particularly polypropylene (PP), is a major ecological and economic challenge. In this context, this study focuses on the incorporation of polypropylene waste into polymer concretes intended for the manufacture of composite tubes. The objective is to exploit this abundant plastic waste to improve the mechanical and physical properties of composites, while proposing a sustainable and economically advantageous solution. To evaluate the effectiveness of this approach, two types of tests were conducted: the split-disk test, which determines indirect tensile strength, and the water absorption test, which provides information on the open porosity and durability of the material. The results obtained confirm that the addition of recycled polypropylene significantly improves the mechanical strength of composites, while reducing their water absorption capacity. This dual improvement demonstrates the good cohesion between the matrix and the incorporated plastic waste, reflecting overall high-performance performance. Beyond these performance benefits, the adopted approach contributes to reducing the environmental impacts associated with plastic accumulation and offers economic benefits through the reduced use of virgin raw materials. The ultimate objective of this research is the design of composite pipes based on improved polymer concretes, suitable for various uses, such as hydraulic networks, industrial infrastructure, and transportation applications. In conclusion, the experimental results, confirmed by both the split-disc test and the water absorption test, demonstrate that the incorporation of polypropylene waste into polymer composites is a satisfactory, feasible, and promising solution for large-scale application.

Keywords **–** *Composite materials; Plastic waste; Polypropylene; Polymer concrete; Tensile strength; Durability;*

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Numerical Study of Thermal and Hydraulic Behavior of Nanofluids in Perforated Pin-Fin Heat Sinks

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Abstract **–** This study presents a numerical investigation of mixed convective heat transfer in a heat sink equipped with circular perforated pin fins and cooled by different nanofluids. Three types of nanoparticles TiO_2, Al_2O_3, and Cu were dispersed in water at volumetric concentrations ranging from 2% to 10%. The simulations were conducted for Reynolds numbers between 100 and 400 to ensure laminar flow conditions, with the corresponding Richardson number in the range of $1 \leq Ri \leq 22$.

The three-dimensional steady-state Navier–Stokes and energy equations were discretized using the finite volume method and solved iteratively through the SIMPLE algorithm. The results indicate a significant enhancement in heat transfer performance when nanofluids are used compared to pure water. The improvement becomes more pronounced with increasing Reynolds number and decreasing nanoparticle concentration. Among the nanofluids studied, Cu exhibited the highest average Nusselt number, followed by Al_2O_3 and TiO_2.

Although the addition of nanoparticles slightly increases both the friction factor and the required pumping power, the overall heat transfer enhancement demonstrates that nanofluids are effective coolants for improving the thermal performance of perforated pin-fin heat sinks under mixed convection conditions

Keywords **–** *Nanofluids; Mixed convection; Heat sinks; Perforated pin fin; Finite volume method ; Computational fluid dynamic;*

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Effect of Fabric Type on the Performance of Composite Materials: A Comparative Study between Intra-Ply Woven Alfa/Jute Fabrics and Commercial Plain-Weave Jute Fabric

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Abstract – The incorporation of plant fibers as reinforcement in thermoplastic and thermoset matrices is becoming increasingly widespread. The unique characteristics and environmentally friendly nature of these fibers provide promising opportunities for the development of innovative composite materials. Several plant fibers, such as Alfa, diss, and palm, are abundant in Algeria and exhibit remarkable durability in their natural environments. Consequently, many researchers have explored their use as reinforcements in composite materials. However, the poor compatibility of cellulosic fibers with certain polymer matrices remains a major challenge that limits their broader application. In this context, our study aims to address this limitation by developing a hybrid woven fabric composed of Alfa and Jute fibers. The proposed hybrid fabric was manually produced using a traditional loom. Three types of Alfa fibers were used: untreated Alfa fibers, Alfa fibers treated with 2% sodium hydroxide, and Alfa fibers treated with 2% sodium hydroxide followed by potassium permanganate treatment. For comparison, a commercial plain-weave Jute/Jute fabric was also used. Four composites were then fabricated using a thermosetting matrix and the vacuum molding technique. The obtained results present and discuss the mechanical behavior of these composites, highlighting the influence of the different chemical treatments on their tensile properties under static loading.

Keywords – *Natural fiber; hybridization; interplay fabric; Chemical treatments; mechanical performance;*

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Magnetic Suppression of Natural Convection in a Fin-Enhanced Annular Cavity Filled with Fe_3O_4 MWCNT/Water Nanofluid

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Abstract **–** In this paper, we study numerically the natural convection of MHD hybrid nano fluid (Fe_3O_4-MWCNT) in annular cavity fitted with fins under magnetic fields. The inner cylinder is subjected to volumetric heat generation while the outer cylinder is kept adiabatic.
The governing equations of mass, momentum and energy equation for both the fluid and the solid are solved by the finite volume method, using the commercially available CFD software Fluent 6.3.26. The fluid is a water-based hybrid nanofluid containing various nanoparticle combinations of Fe_3O_4 with MWCNT. The effect of the magnetic field is carried out and investigated for different Hartmann number Ha, for a cavity without fins N=0 and with fins N=8. Results are presented by magnetic field and temperature contours as well as velocity profiles in the gap of the cavity with and without fins. The results indicate that, Increasing Ha suppresses convective currents, leading to stratified temperature profiles and a transition towards conduction-dominated heat transfer. The addition of fins reduces fluid temperature and enhances heat transfer within the cavity.

Keywords **–** *Annular cavity; Hybrid nanofluid; Natural convection; Numerical simulation; MHD;*

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Modeling & Simulation of Mechanical System for Jersey Barrier

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Abstract **–** Commonly made of reinforced concrete for durability, to prevent vehicles from crossing into oncoming traffic, the Jersey barriers largely used in highway road as safety guard. Unfortunately the traditional barrier are static and do not respond to any emergency incident. This paper present a 3D modeling and simulation of a new mechanical system that designed to fit with the shape of this kind of barrier. The device can be open/close remotely in real time via IoT, it contains a hydraulic cylinder to ensure the safety against car crash. Here, it is mainly discussed the design of the developed mechanical system with features.

Keywords **–** *Jesrey barrier; Highway; 3D design; Safety guard; IoT;*

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The Impact of a Metallic Additive on the Structure of Nanostructured Alloys

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Abstract **–** This study successfully investigated the effect of nickel addition on the structural and microstructural properties of nanostructured alloys synthesized via mechanical alloying. X-ray diffraction analysis confirmed that for all compositions, a single-phase disordered solid solution with a body-centered cubic structure was formed. The key findings revealed a clear trend where increasing the nickel concentration caused a progressive contraction of the lattice parameter. Furthermore, the addition of nickel led to significant grain refinement, reducing the average crystal size to the nanoscale, while simultaneously inducing a gradual increase in internal micro-strain. These results demonstrate that nickel serves as an effective microstructural modifier, playing a crucial role in refining grain size and altering the defect structure within the material, which are critical factors for tailoring the properties of nanomaterials.

Keywords **–** *Lattice Parameter; Grain Size; Micro-strain; Mechanical Alloying;*

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Optimization Of Alkali Treatment for Stipa Tenacissima Fibers in Polyester-Based Composites

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Abstract – Water soaking was used to recover fibers from the Djelfa region in southern Algeria, which were then modified with sodium hydroxide at various concentrations (3%, 6%, and 9%) for 5 h at 40 °C. Manual stacking and compression molding procedures were used to create composite samples containing 10 vol % treated and untreated esparto fibers in a polyester matrix. The samples were analyzed using FTIR, XRD, TGA, SEM, and three-point flexural testing. Esparto fibers treated with 9% NaOH demonstrated a 60.39% higher crystallinity index versus raw fibers. Flexural characteristics analysis revealed that composites reinforced with esparto fibers modified with 9% NaOH exhibited superior mechanical performance relative to those containing untreated fibers, with improvements of 47.90% in flexural strength and 48.46% in flexural modulus, respectively. These findings indicate that when chemically treated, Stipa tenacissima fibers hold strong potential as a sustainable alternative to synthetic fibers for reinforcing polymer composites in structural applications.

Keywords – *Composite; alkali treatment; cynodon dactylon; adhesion; hydrophilic;*

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Assessment and Characterization of Indigenous Mineral Materials: Three Local Clays from M'sila Region, Algeria"

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Abstract – In the context of combating climate change, earth-based construction materials represent a promising alternative to conventional concrete by significantly reducing CO_2 emissions in the building sector. This study provides a comprehensive multi-technique characterization of three distinct clay types (red, green, and yellow) from the Soubella region (M'sila Province, Algeria) to assess their potential for sustainable construction applications. Through integrated geotechnical, physicochemical, mineralogical, and thermal analyses, we reveal significant differences in material behavior. Geotechnical results show that red and green clays are silty-sandy with plasticity indices of 17.3% and 18.55% respectively, while yellow clay exhibits higher plasticity (IP = 25.15%). Mineralogical and chemical analyses indicate that yellow clay contains the highest calcite content (50.35%), compared to green (38.67%) and red clays (24.78%). Conversely, red and green clays are richer in quartz (28.52% and 29.38% respectively). Thermal analysis (25-1100°C) demonstrates how mineralogical composition, hygroscopic behavior, and organic matter content distinctly influence thermal response. These findings demonstrate the strong potential of M'sila clays for manufacturing compressed earth blocks (CEB) and other eco-friendly building materials that align with current environmental standards.

Keywords – *Clay; Physical-Chemical Properties; Mineralogical Composition; Characterization; Plasticity Index; Sustainable Construction;*

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Alkali Treatment of Woven Palm Fibers: Boosting Performance for Eco-Composites

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Abstract – Plant fibers are gaining increasing interest as reinforcing materials for polymers due to their sustainability, renewable potential, biodegradability, and light weight, as well as their excellent mechanical and thermal properties, making them promising candidates for environmentally friendly composite applications. This study demonstrates the effects of alkali treatment on woven palm fibers to enhance their suitability as reinforcing materials in polymer composites. Sodium hydroxide (NaOH) was applied at concentrations of 2%, 4%, and 6% for a fixed treatment time of 3 h at room temperature. Chemical analysis revealed a significant decrease in hemicellulose content, resulting in increased accessibility and crystallinity of cellulose (from 53.44% to 62.07%). FTIR and XRD analyses confirmed the removal of amorphous components, which contributed to enhanced fiber stiffness and thermal stability. Tensile testing showed a significant increase in tensile strength (from 158.30 MPa to 233.82 MPa), while TGA results indicated an improvement in thermal resistance, with the decomposition onset temperature rising from 257.24°C to 267.08°C. Scanning electron microscope (SEM) imaging revealed an increase in surface roughness, facilitating better interfacial adhesion to the polymer matrix. Overall, the alkali treatment significantly improves SPF performance, enhancing its potential as a high-performance and sustainable reinforcing material. These results support efforts to optimize natural fiber treatments and develop environmentally friendly composite materials.

Keywords – *Alkali treatment; Palm fiber; Polymer composites; Mechanical properties; Thermal stability; Sustainable materials*

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Enhancement of Mechanical Properties of Unsaturated Polyester Composites Reinforced with Treated Alfa Fibers and Marble Additives

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Abstract – The composite was prepared using Alfa fibers as a reinforcement of the unsaturated polyester matrix and marble as an additive. The aim of this study is to improve the mechanical properties of this compound. Plant fibers are characterized by high physical and chemical properties that are abundant in nature light weight biodegradability and low cost these properties made vegetable fibers competitive with synthetic fibers in the preparation of compounds, to improve the surface of the Alfa fibers we treated them with benzoyl, permanganate 0.2 %, soda 9 % for 24 h and placed in the microwave for 10 min. The results obtained from the tests conducted on the compound and fiber showed that the treatment with soda at a concentration of 9 % for 24 h had an effect in improving the mechanical properties of the composite and the fibers compared to the untreated fibers. Other treatments also proved that the added marble had a significant effect in improving the mechanical behavior. Among the diagnostic tests used in this study are infrared spectroscopy, tensile test.

Keywords – *unsaturated polyester; composite materials; Stipa Tenacissima ; Tensile strength ;*

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Enhanced Diabetic Retinopathy Classification via MobileNetV3-Large Using Combined RGB and CLAHE Retinal Fundus Imagery

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Abstract **–** Diabetic retinopathy (DR) remains one of the most common causes of vision loss among diabetic patients worldwide. Early detection through automated image analysis can provide a cost-effective and reliable approach to preventing blindness. This study presents an enhanced DR classification framework employing the MobileNetV3-Large convolutional neural network, trained separately on standard RGB and Contrast-Limited Adaptive Histogram Equalization (CLAHE)-enhanced fundus images. Model tuning was performed by adjusting hyperparameters such as learning rates and batch sizes to determine optimal configurations. The best-performing MobileNetV3-Large model achieved an accuracy of 97.82%, recall of 98.12%, and F1-score of 97.86% using RGB images, while CLAHE preprocessing produced comparable outcomes with accuracy of 97.68% and F1-score of 97.72%. These findings demonstrate that MobileNetV3-Large, as a lightweight and efficient model, provides strong generalization ability for DR screening tasks, supporting its integration into scalable and real-time diagnostic systems in healthcare environments with limited computational resources.

Keywords **–** *Diabetic Retinopathy; MobileNetV3-Large; Deep Neural Networks; Fundus Image Classification; CLAHE Enhancement*

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Caractérisation Mécanique et Micromécanique D'un Composite (Fibre Végétale/Résine Thermodurcissable)

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Résumé **–** Ce travail explore la caractérisation mécanique et micromécanique d'un biocomposite innovant à base de fibres végétales incorporées dans une matrice thermodurcissable. L'étude vise à évaluer non seulement les performances mécaniques globales du matériau, mais également les phénomènes à l'échelle microscopique qui influencent son comportement. Des essais mécaniques classiques tel que traction a permis de déterminer les propriétés structurales du composite, tandis que des analyses micromécaniques, telles que microgouttes a révélé des informations clés sur l'interface fibre/matrice, la distribution des contraintes et les mécanismes de rupture. Les résultats montrent que l'adhésion interfaciale, le traitement des fibres, ainsi que leur orientation et leur taux de renfort jouent un rôle crucial dans la performance du matériau. Ce biocomposite présente ainsi un excellent compromis entre propriétés mécaniques, légèreté et durabilité environnementale, faisant de lui une alternative prometteuse aux composites synthétiques dans des applications techniques et écoconçues.

Mots-clés **–** *fibre végétale ; IFSS; biocomposite; test micromécanique; l'adhésion ;*

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L'impact des Systèmes D-FACTS sur les Performances du Facteur de Puissance des Réseaux de Distributions

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Résumé – L'augmentation de la consommation d'électricité, due à l'industrialisation et à la croissance démographique, nécessite un renforcement des infrastructures électriques, ce qui entraîne des coûts élevés et des impacts environnementaux. Pour répondre efficacement à ces nouveaux défis, il devient crucial d'optimiser les réseaux électriques en travaillant près de leurs limites de stabilité. Les méthodes classiques de contrôle deviennent insuffisantes face à la complexité croissante du réseau. Ainsi, des dispositifs électroniques de puissance, appelés D-FACTS, sont développés pour améliorer la réactivité et le contrôle des réseaux de basse tension. Ces technologies permettent un meilleur contrôle de la puissance, une régulation plus précise de la tension et une exploitation plus efficace des réseaux, tout en assurant la qualité, la sécurité et la stabilité du système.

Mots-clés *– D-FACTS, Facteur de puissance, Wind, Qualité d'énergie*

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Comparaison des viscosités de quelques types d'huiles usagées flottantes dans des récipients de différents diamètres

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Résumé – La viscosité est une mesure de résistance à l'écoulement d'un fluide. La difficulté de viscosité d'une huile moteur usagée s'explique par l'impossibilité d'utilisation de la méthode de Stokes par la mesure de la vitesse d'une bille tombante dans ces huiles. Puisque selon la loi de Stokes qui permet de déterminer la viscosité cinématique des liquides pour les fluides newtoniens et surtout pour les fluides transparents. Cette impossibilité se caractérisée par la non visibilité de cette bille à l'intérieur de notre fluide (huile usagée) de couleur noir. La nouvelle idée dans ce travail se concrétise dans la possibilité de vision de la bille au moment où elle quitte la partie flottante juste à la surface supérieure de l'eau sur laquelle elle se trouve. Et tous cela pour indiquer le temps mis par cette bille. Une bonne concordance a été trouvée en comparant nos résultats à ceux donnés par la littérature.

Mots-clés – *Viscosité, Huile usagée, Flottation, Recyclage.*

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Mots-clés – *Viscosité, Huile usagée, Flottation, Recyclage.*

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Investigation Expérimentale Des Facteurs Influençant Le Processus D'impression 3d Avec L'utilisation De Filaments Pla Fondus

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Résumé **–** Les structures cellulaires sont souvent intégrées à la conception et à la fabrication de panneaux isolés afin de réduire leur poids, mais les méthodes traditionnelles pour y parvenir sont complexes et limitées dans la création de diverses structures cellulaires, ce qui rend leurs coûts de fabrication élevés. L'impression 3D offre une plus grande flexibilité que les méthodes traditionnelles, notamment la technologie de fabrication de couches par dépôt à chaud (FDM), largement utilisée en conjonction avec le polylactide (PLA) pour fabriquer des pièces légères. Par conséquent, dans le cadre de cette étude, nous avons cherché à comprendre comment les paramètres d'impression 3D affectent les performances mécaniques des pièces légères. La rigidité et la durabilité sont des aspects importants pour les applications d'ingénierie, c'est pourquoi nous avons fabriqué des pièces légères en PLA à l'aide d'une imprimante 3D, en faisant varier la densité de remplissage pour obtenir différentes densités. Ensuite, nous avons évalué la dureté et la durabilité de ces pièces dans différentes directions de chargement en effectuant des tests de traction, de flexion et de compression. À l'intersection des données expérimentales et analytiques, nous avons déterminé la structure cellulaire et la densité optimales, en tenant compte des besoins mécaniques spécifiques de chaque application d'ingénierie.

Mots-clés **–** *Structures Cellulaires ; Panneaux Isolés; Réduction Du Poids ; Méthodes Traditionnelles; Impression3D ; Fabrication Additive; FDM; PLA*

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Contrôle Géométrique Sur Machine A Mesurer Tridimensionnelle (MMT) Des Pieces Fabriquées Par Impression 3d Et CNC

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Résumé **–** Ce travail a pour objectif principal de promouvoir l'utilisation efficace de la machine à mesurer tridimensionnelle (MMT), afin de faciliter son intégration dans les projets futurs des étudiants en génie mécanique. Il est en effet important de souligner que la MMT n'avait encore jamais été exploitée dans le cadre des projets étudiants et même pour les travaux pratique, et que ce travail constitue une première démarche concrète dans cette direction. Dans ce contexte, ce travail porte sur l'analyse géométrique comparative de pièces réalisées par impression 3D et par usinage CNC, en utilisant la MMT comme principal outil d'inspection.

Avant d'entamer de mesure, la fiabilité de la machine a été vérifiée à l'aide d'une pièce de référence en aluminium, mesurée à quatre reprises. Les résultats ont démontré une bonne stabilité et une reproductibilité satisfaisante, garantissant ainsi la fiabilité de l'appareil.

La seconde phase du projet a consisté à mesurer et comparer les pièces issues des deux procédés de fabrication. Les résultats obtenus indiquent que l'usinage CNC offre une précision géométrique supérieure, tandis que les pièces issues de l'impression 3D présentent des écarts plus marqués par rapport aux dimensions nominales. Cette étude met en évidence l'importance des mesures tridimensionnelles pour orienter le choix d'un procédé de fabrication et en valider la qualité, tout en soulignant les avantages et les limites de chaque méthode en matière de précision.

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Optimisation mono et multi-objective des paramètres de coupe lors de l'usinage de l'acier AISI D2 en utilisant la lubrification MQL

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Résume **–** L'un des principaux objectifs des industriels aujourd'hui est l'augmentation de la productivité et de réduire les coûts des opérations d'usinage tout en obtenant le meilleur état de surface possible. Cette recherche étudie l'effet des paramètres de coupe (Vc, f et ap) et deux types de plaquettes de coupe (Cermet et Carbure-CVD) sur la rugosité de surface Ra, l'effort de coupe Fz et le taux d'enlèvement de matière MRR. L'usinage a été réalisé sur des éprouvettes en acier à outil pour travail à froid AISI D2 en utilisant la technique de minimum de quantité de lubrification MQL. Un plan d'expériences basé sur la table de Taguchi L16 (22x43) a été adopté, ce qui a permis de faire une analyse statistique de la variance (ANOVA). Les résultats montrent que les composantes de l'effort de coupe sont influencées principalement par la profondeur de passe. L'avance par tour est le facteur le plus significatif sur la rugosité de surface de la pièce usinée. Une étude d'optimisation mono-objective selon l'analyse de Taguchi basée sur le rapport signal/bruit (S/N), et la méthode multi-objective de l'analyse relationnelle grise GRA ont été utilisées, satisfaisant des objectifs technologiques divers, à savoir une rugosité (Ra) minimale, un effort de coupe (Fz) minimal et débit de copeau (MRR) maximal.

Mots-clés **–** *Tournage ; AISI D2 ; Optimisation ; Rugosité ; Débit copeau ; Effort de coupe ; MQL ;*

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Caractérisation de couches minces de chrome déposées sur un acier fortement allié après recuit de diffusion

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Résume – Cet article présente une série de traitements thermiques appliqués à un acier fortement allié préalablement recouvert de chrome dans un bain électrolytique, avec une couche d'environ 10 µm, dans le but d'obtenir une couche de carbure de chrome aux bonnes propriétés mécaniques et physico-chimiques. Un recuit de diffusion à 1000 et 1100 °C pendant 1 heure et 2 heures a permis d'obtenir des couches de carbure de chrome adhérentes, uniformes et présentant une très haute dureté. Ces résultats ont été confirmés par des moyens de caractérisation tels qu'un microscope optique, un duromètre et un diffractomètre, utilisés pour déterminer les phases naissantes de ce cycle de traitement.

Mots-clés – *recuit, revêtement, carbure de chrome, acier ;*

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Caractérisation de bétons polymères à base de sable et de déchets plastiques et renforcés par la sciure de bois

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Résume **–** Les déchets plastiques posent des défis environnementaux, sanitaires et économiques majeurs en raison de leur longue période de décomposition et de la pollution résultant de leur combustion. Leur recyclage suscite un intérêt croissant, notamment dans le secteur de la construction grâce à l'utilisation de béton polymère, qui remplace le ciment traditionnel par un liant polymère. Cette étude examine les effets de la combinaison de déchets plastiques avec du sable et de la sciure de bois pour produire du béton polymère. Différents pourcentages de sciure, estimés à 5 %, 10 % et 15 %, ont été ajoutés au sable fin et aux déchets plastiques. Des essais de flexion, de compression et d'absorption d'eau ont été réalisés sur les échantillons. Les résultats ont montré que le béton polymère présentait de bonnes propriétés, avec des résistances à la flexion et à la compression atteignant respectivement 9,45 MPa et 24,25 MPa pour les échantillons contenant 10 % de sciure. Le taux d'absorption d'eau a été estimé à 1,51 %. La sciure améliore la densité et l'isolation thermique. Les résultats suggèrent que l'utilisation de ces matériaux recyclés peut offrir des alternatives durables et économiquement viables au béton conventionnel.

Mots-clés **–** *Béton polymère; Déchet plastique; Sciure de bois; Propriétés mécaniques; Recyclage;*

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Etude Du Comportement A La Corrosion D'une Armature En Acier Dans Un Milieu Cimentaire Modifie Avec Des Fines De Liege

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Résume – La corrosion des armatures en acier est le mode de dégradation le plus important des structures en béton armé, notamment celle situées dans des atmosphères polluées telles que les atmosphères marines et/ou industrielles. Ce phénomène, d'origine électrochimique, dépend dans une large mesure de la composition et des propriétés physicochimiques du milieu cimentaire avec lequel l'acier est en contact. En effet, toute modification de la composition du béton ou du mortier visant à améliorer la compacité et diminuer la porosité permet d'améliorer les propriétés anticorrosion de ces milieux et de protéger ainsi l'acier d'armature.

Le but de ce travail est d'étudier le comportement électrochimique d'une armature en acier dans des spécimens en mortier, modifié par l'ajout de liège en poudre, sans et en présence des chlorures. Les résultats obtenus par les différentes techniques de caractérisation électrochimiques utilisées indiquent que la présence de liège sous forme de poudre fine permet d'améliorer sensiblement la résistance à la corrosion de l'acier dans le milieu cimentaire contaminé avec les ions chlorures sans qu'il affecte les propriétés mécaniques de ce dernier. En effet, une parfaite corrélation entre la finesse et la teneur en liège, la résistance à la compression du milieu cimentaire et la résistance à la corrosion de l'acier d'armature à été établie.

Mots-clés *– Liège; corrosion; acier; mortier; béton; chlorures;*

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Développement et validation d'un code numérique pour l'analyse statique et dynamique de plaques minces

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Résume – Cette étude présente le développement et la validation d'un code numérique, implémenté en langage Pascal, destiné à l'analyse statique et dynamique des plaques minces en état plan de contrainte. Le programme permet de déterminer, en analyse statique, les déplacements nodaux, les réactions et les contraintes dans chaque élément, et, en analyse dynamique, les fréquences propres ainsi que les modes propres — des fonctionnalités décrites en détail dans le mémoire. L'approche adoptée repose sur l'utilisation d'éléments rectangulaires pour discrétiser la plaque, l'assemblage des matrices de rigidité et de masse, puis la résolution du système à l'aide de la méthode de Gauss–Jordan (statique) et de la méthode de Rutishauser (dynamique). Plusieurs cas numériques, notamment un maillage de 16 éléments avec différentes conditions aux limites et chargements, sont étudiés et comparés aux résultats obtenus avec SAP2000. Les comparaisons mettent en évidence une bonne concordance, les critères de validation fixés (erreur ≤ 5 % pour les déplacements/réactions et ≤ 10 % pour les contraintes) étant globalement respectés. Les résultats soulignent l'apport de la simulation numérique dans la conception et l'analyse structurale, qu'il s'agisse de prédire les déplacements, les réactions, les contraintes ou les fréquences et modes propres et ouvrent des perspectives d'extension vers des problématiques plus complexes.

Mots-clés – *Eléments finis ; plaques minces; analyse statique; analyse dynamique; fréquences propres; Pascal; SAP2000;*

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Elaboration Des Mortiers Géopolymères A Base De La Brique Rouge Pour Etudier Le Comportement Mécanique Et Physique A La Haute Température

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Résume – La plupart des matériaux recyclés sont généralement utilisés pour les travaux routiers ou de remblai en Algérie. Des ingrédients clés intervenant dans la composition des matériaux cimentaires, à savoir le clinker, est responsable pour une large part de l'émission de CO2 rejeté dans l'atmosphère. Aussi, l'augmentation du volume des résidus industriels comme des matériaux recyclés au cours des dernières années et le manque de la valorisation est devenue un grave problème environnemental. L'objectif de notre recherche est d'appliquer une nouvelle technique appelée l'activation alcaline à partir de l'utilisation des solutions chimiques, pour exploiter les résidus industriels locaux, on a choisi la brique rouge afin d'obtenir les mortiers géopolymères qui sont équivalents en ciment dans leurs propriétés, pour préserver les matières premières et de réduire la consommation d'énergie. Expérimentalement, on a fait la cure dans des différentes hautes températures entre 100 °C – 800 °C pendant une heure pour étudier le comportement mécanique et physique des mortiers de brique à l'état durci après 28j et comparé par rapport la cure à température ambiante 25 °C pendant 24h. Cette étape augmente la résistance à la compression jusqu'à 85 MPa et à la flexion jusqu'à 27 MPa, à cause de la réduction des pores et l'absorption d'eau par l'effet de la température et la technique d'activation alcaline.

Mots-clés – *Géopolymères; Mortier; Ciment; comportement mécanique ;*

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Etude De L'efficacité Inhibitrice D'un Extrait D'atractylis Gummifera Vis-A-Vis A La Corrosion De L'acier E335 Dans Un Milieu D'acide Chlorhydrique

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Résume **–** Ce travail porte sur l'étude de l'efficacité inhibitrice d'un extrait d'Atractylis gummifera contre la corrosion d'un acier doux (E335) en milieu acide chlorhydrique molaire (1M HCl). L'évaluation des performances inhibitrices de l'extrait a été réalisée par plusieurs méthodes, à savoir : la méthode de perte de masse, des tests électrochimiques stationnaires et instationnaires, la microscopie électronique à balayage (MEB) et la diffraction des rayons X (DRX). Les tests ont montré que l'extrait présente des performances inhibitrices pertinentes, qu'il est de type mixte et qu'il agit par adsorption physique à la surface de l'acier selon l'isotherme de Langmuir

Mots-clés **–** *Corrosion, Atractylis gummifera, Acier doux, Tests électrochimiques.*

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Estimation des besoins en eau d'irrigation à l'aide des modèles climatiques CMIP6 dans la région de la Mitidja, Algérie

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Résume – Cette étude a pour objectif d'estimer les besoins en eau d'irrigation dans la région de la Mitidja (Algérie) en utilisant les modèles climatiques de la sixième phase du Coupled Model Intercomparison Project (CMIP6). Trois stations agricoles situées à Ahmeur, Mouzaïa et Hadjout ont été analysées à partir des principales variables climatiques : température, humidité relative, rayonnement solaire et précipitations. Le modèle climatique EC-Earth3 a été appliqué pour le calcul de l'évapotranspiration de référence (ET0) selon la méthode de Hargreaves-Samani, utilisée comme indicateur fondamental pour déterminer les besoins hydriques des cultures.

La méthodologie adoptée comprend la préparation et le traitement des données, l'estimation des besoins en eau d'irrigation à partir des valeurs d'ET0, puis la validation des résultats par comparaison avec les volumes d'eau réellement utilisés pour l'irrigation, mesurés au niveau des exploitations agricoles. Les indicateurs statistiques (R^2 = 0,71, RMSE = 0,42 mm/jour, MAE = 0,33 mm/jour) confirment une bonne cohérence entre les valeurs simulées et observées, bien qu'une calibration locale du modèle soit nécessaire pour réduire les écarts résiduels.

Dans un contexte de changement climatique, les projections indiquent une hausse des températures et une augmentation de l'évapotranspiration, ce qui risque d'accroître les besoins en irrigation dans la plaine de la Mitidja. Ce travail contribue ainsi à l'amélioration des prévisions hydriques et à la mise en place de stratégies d'irrigation intelligentes, durables et adaptatives, permettant d'optimiser la gestion des ressources en eau et de renforcer la résilience du secteur agricole face aux changements climatiques.

Mots-clés *– CMIP6 ; EC-Earth3 ; évapotranspiration de référence (ET0) ; besoins en eau d'irrigation ; Mitidja ; Algérie ; changement climatique ; agriculture durable.*

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Étude expérimentale de l'effet des conditions d'exploitation sur la fatigue des matériaux en contact

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Résume – L'objectif de cette étude est d'examiner expérimentalement le comportement en fatigue cyclique de l'acier au carbone de nuance C45 (également connu sous le nom de XC48). Ce type de sollicitation en fatigue est couramment observé dans de nombreux dispositifs et composants mécaniques soumis à des flexions rotatives ou à des vibrations. Les travaux expérimentaux ont été centrés sur la réalisation d'essais de fatigue sur des éprouvettes cylindriques lisses. Ces éprouvettes ont été soumises à des tests pour évaluer l'influence de divers paramètres opérationnels sur la fatigue due à la flexion rotative de l'acier C45, notamment : la dureté (H), la rugosité arithmétique (Ra) et la charge appliquée (Q) sur la durée de vie de l'éprouvette (l'évolution du nombre de rotations (N)). Les résultats ont été analysés statistiquement par le biais d'une analyse de variance (ANOVA). Enfin, les conclusions de cette étude mettent en lumière les facteurs qui contribuent à la réduction de la durée de vie des mécanismes.

Mots-clés – *Fatigue; flexion rotative; ANOVA; Endurance; durée de vie; modèle mathématique;*

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Enhancement of Mechanical Properties of Unsaturated Polyester Composites Reinforced with Treated Alfa Fibers and Marble Additives

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Résume – The composite was prepared using Alfa fibers as a reinforcement of the unsaturated polyester matrix and marble as an additive. The aim of this study is to improve the mechanical properties of this compound. Plant fibers are characterized by high physical and chemical properties that are abundant in nature light weight biodegradability and low cost these properties made vegetable fibers competitive with synthetic fibers in the preparation of compounds, to improve the surface of the Alfa fibers we treated them with benzoyl, permanganate 0.2 %, soda 9 % for 24 h and placed in the microwave for 10 min. The results obtained from the tests conducted on the compound and fiber showed that the treatment with soda at a concentration of 9 % for 24 h had an effect in improving the mechanical properties of the composite and the fibers compared to the untreated fibers. Other treatments also proved that the added marble had a significant effect in improving the mechanical behavior. Among the diagnostic tests used in this study are infrared spectroscopy, tensile test.

Mots-clés – *unsaturated polyester ; composite materials ; Stipa Tenacissima ; Tensile strength ;*