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Investigation of Natural Fibers Reinforced Polypropylene Composite with Significant Damping Response

[1] Gadhave S.N, [1] Neeraj Kumar
[1,] *Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur, Jagatpura, Jaipur*
[1]sateeshpateel@gmail.com

Abstract— Natural fiber-reinforced polypropylene (PP) composites have attracted considerable attention for their potential in sustainable and versatile applications across multiple industries. This research examines the damping characteristics of these composites, with a specific emphasis on improving their mechanical performance using Particle Swarm Optimization (PSO). Originating from sustainable resources including flax, jute, and hemp, natural fibers offer benefits including biodegradability, low density, and excellent specific strength, making them ideal candidates for reinforcing polymer matrices like polypropylene. These composites are increasingly sought after for their potential to replace conventional materials in automotive, construction, and consumer goods industries, driven by environmental sustainability and regulatory pressures. By utilizing Particle Swarm Optimization, the study achieves improved damping factors, enhancing the suitability of these materials for applications requiring effective vibration and noise control. The findings underscore the potential of PSO as a valuable tool for optimizing composite materials in engineering applications, promoting sustainability and performance in structural design.

Keywords— Natural fibers, Polymer – matrix composites, Mechanical Properties, manufacturing process, thermal properties

I. INTRODUCTION

Damping greatly affects the dynamic properties of materials, significantly influencing system performance, safety, and reliability. It is essential for preventing fatigue failure, premature wear, and dangerous operating conditions. When dynamic loads align with a structure's natural frequency, excessive vibrations can occur, potentially leading to catastrophic failure. Therefore, comprehending the complete vibration response of materials is paramount for designing and applying composites effectively. Many advanced micro-mechanics models, while complex, often lack comprehensive quantitative experimental validation, thereby limiting the accuracy of their predictions. Additionally, efforts have been made to estimate damping using finite element methods, aiming to develop computer codes capable of calculating strain energies at either the global laminate level or the element level. A damping material acts as a performing material with the ability to absorb sound and vibration energy and convert it to internal energy or other types of energy. Viscoelastic damping materials, valued for their distinctive viscosity and elasticity, have long been acknowledged for their effectiveness in mitigating vibration and noise. They find widespread use in military applications such as aerospace and naval vessels, as well as in civilian sectors for reducing vibration and noise in transportation, bridges, buildings, and precision instruments. However, achieving optimal performance below room temperature remains a challenge that aligns with real-world requirements. Because of its remarkable tensile strength, ramie fiber is now used in material composites. Dynamic mechanical analysis studies have shown that adding ramie fiber to a thermosetting matrix raises the storage modulus, thereby increasing the composite's stiffness with higher fiber content. There is a growing trend in extracting and characterizing biodegradable fibers to create fiber-reinforced composites for various applications, including automotive parts and packaging industries. Pending confirmation through life cycle assessments, natural fibers offer a promising environmentally friendly alternative for manufacturing

Correspondence to: Gadhave S.N, Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur
Corresponding author. E-mail addresses: sateeshpateel@gmail.com

composite components. They can potentially offer performance comparable to traditional composites while providing ecological benefits. Furthermore, because of their low cost, strong mechanical qualities, high specific strength, non-abrasive nature, eco-friendliness, biodegradability, non-toxicity, ease of processing, and capacity to absorb CO2 during growth, natural fibers are a highly significant choice for reinforcement in polymer matrices. The natural rubber composites bonded with short coir fibers are the subject of this investigation. In tropical places, coir—a lignocellulosic fiber made from the fibrous husk of coconuts—is frequently grown. Traditionally, just a small percentage of the world's copper supply has been used for manufacturing goods like furniture and ropes.

II. LITERATURE REVIEW

E.C. Botelho et al. (2006) determined that aluminium 2024 alloy/carbon fiber/epoxy composites exhibit an elastic modulus of 60.9 GPa, a viscous modulus of 0.82 GPa, and a loss factor of 0.014. Aluminium 2024 alloy/glass fiber/epoxy composites, on the other hand, have a loss factor of 0.029, an elastic modulus of 49.7 GPa, and a viscous modulus of 1.46 GPa. The combined storage modulus (E0) of the metal and reinforcement in hybrid composites, including fiber metal laminates, primarily dictates the damping behavior. Hajer Hadiji et al. (2020) report that the loss factor for composites made of hemp and flax is approximately 5%, but it stays below 2% for composites made of glass. Additionally, the loss factors for non-woven composites made of flax, hemp, and kenaf are two to three times more expensive than glass-polypropylene composites. Natural fiber-reinforced nonwovens have substantially better damping qualities than glass-polypropylene composites. The damping capabilities of flax-polypropylene composites decrease in the machine and cross directions, respectively, from 17.9% to 24.28%, as the flax weight ratio rises from 30% to 70%. In contrast, at a porosity level of 64%, the loss factor of flax-polypropylene composites grows dramatically with increasing porosity, reaching approximately 8%. Porosity increases by 611%, from 9% to 64%, improving the loss factor by 108.7%. Natural fiber-reinforced nonwoven composites consistently show higher loss factors compared to glass-polypropylene composites. Khouloud Cheour et al. (2016) noted that for quasi-unidirectional (0°) flax-fiber reinforced epoxy composites, after 4, 11, and 180 days of immersion, the bending modulus drops by 32%, 40%, and 48%, respectively. For quasi-unidirectional (0°), (90°), and (45°) flax-fiber reinforced epoxy composites, the loss factor rises by approximately 75%, 60%, and 54% following four days of water aging, respectively. In quasi-unidirectional flax-fiber reinforced epoxy (UFRE) laminates, loss factors (~3.9–13.2%) decrease with increasing frequency, but bending moduli (~0.9–9.2%) slightly rise. The quasi-unidirectional (45°) loss factor of flax-fiber reinforced epoxy composites is 74.3% and 24.7% higher than those of the quasi-unidirectional (0°) and (90°) flax-fiber reinforced epoxy composites, respectively. M. Colakoglu et al. (2016) observed that Kevlar 29 fiber composites at room temperature (25°C) have a damping factor of 0.0148 and a first natural frequency of 110.53 Hz. The initial natural frequency of polyethylene fiber composite beams is 175.17 Hz, with a damping factor of 0.0124. On the other hand, a damping factor of 0.0044 and a first natural frequency of 65 Hz are seen in 1018 hot-rolled carbon steel beams of different sizes. The elastic modulus at room temperature is 6.98 GPa for Kevlar 29 composites and 25.6 GPa for polyethylene composites. Taiqu Liu et al. (2021) reported the following properties for unidirectional fiber-reinforced epoxy composites: Carbon fiber composites possess a damping factor of 0.9 and a Young's modulus of 100 GPa. Glass fiber composites have a damping factor of 1.3 and a Young's modulus of 36 GPa. Flax fiber composites have a damping factor of 2.8 and Young's modulus of 20 GPa. Sisal fiber composites have a damping factor of 19 GPa. 1.8. Plant fiber composites exhibit damping factor values ranging from 0.7% to 1.4%, while synthetic fiber composites show values ranging from 0.24% to 2.5%. Therefore, plant fiber When it comes to damping capacity, composites typically outperform synthetic fiber composites. According to A. Etaati et al. (2013), composites with a damping factor of 0.054 and a natural frequency of 13.21 Hz are made of 40 weight percent noil hemp fiber and 2.5 weight percent maleic anhydride-grafted polypropylene. In contrast, the natural frequency and damping factor of composites made of 40-weight percent noil hemp fiber and 2.5-weight percent maleic anhydride-grafted polyethylene are 12.19 Hz and 0.053, respectively. The storage modulus of composites comprising 30 weight percent noil hemp fiber was dramatically raised by the addition of 2.5 weight percent maleic anhydride-grafted polypropylene or polyethylene. The composite containing polypropylene grafted with 2.5 weight percent maleic anhydride showed the maximum storage modulus. On the other hand, adding 5 weight percent of maleic anhydride-grafted polypropylene or polyethylene resulted in a reduction in storage modulus. According to Jin Zhangan et al. (2019), bamboo/PLA composites have the lowest resonance frequency at around 1625 Hz. In contrast, cotton/PLA and commercially produced hemp/kenaf/PP composites exhibit higher resonance frequencies at 2170 Hz and 2134 Hz, respectively, compared to flax/PLA composites. These findings underscore the superior damping capability of plant fiber composites and emphasize how different treatments and compositions affect their dynamic characteristics. The heightened damping capacity and customized mechanical properties of plant fiber composites position them as promising options for applications demanding effective vibration and noise reduction. Incorporating The storage modulus of these composites can be increased by coupling agents, such as polypropylene or polyethylene grafted with maleic anhydride, albeit the effect may differ according to the dosage applied. The selection of fiber type and polymer matrix has a substantial impact on the inherent frequency and damping properties of composite materials, highlighting the significance of choosing suitable materials for specific applications. Research overall suggests that

Correspondence to: Gadhave S.N, Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur
Corresponding author. E-mail addresses: sateeshpateel@gmail.com

plant fiber-reinforced composites provide a sustainable and efficient solution for damping applications, with opportunities for improvement through meticulous material selection and treatment. On the other hand, PLA reinforced with fibers made of bamboo and cotton showed a coincidence frequency of 2448 Hz. At around 175°C, composites made of cotton and bamboo fibers displayed a high damping ratio of 0.86, whereas composites made of cotton fibers showed the highest damping ratio (0.97). This suggests that hybrid composites made of bamboo and cotton are a promising option for engineering applications where strong bending characteristics, high sound absorption, and efficient vibration damping are required. Fatima Ezzahra El Abbassi et al. (2019) found that polypropylene-hemp reinforced composites have a bending modulus of 3.53 GPa, flexural strength of 46.03 MPa, 3.59 GPa Young's modulus and 21.03 MPa tensile strength. By contrast, alfa fiber-reinforced polypropylene composites treated with saltwater exhibit 2.24 GPa for bending modulus, 37.13 MPa for flexural strength, 3.02 GPa for Young's modulus, and 17.71 MPa for tensile strength. Alfa fiber-reinforced polypropylene composites treated with an alkali solution exhibited a 2.93 GPa bending modulus, 42.34 MPa flexural strength, 3.45 GPa Young's modulus, and 20.35 MPa tensile strength. Following four injection cycles, the storage modulus of the polypropylene-hemp reinforced composites, the alkali solution-treated alfa fiber reinforced polypropylene composites, and the saltwater-treated alfa fiber reinforced polypropylene composites increased by 13%, 12%, and 11%, respectively. These results emphasize the influence of various fiber treatments and composite formulations on the mechanical and damping properties of natural fiber-reinforced polypropylene composites. Despite some stiffness being lost in the process, treated fibers can improve the damping qualities of composites, as evidenced by the reported fall in storage modulus and rise in loss factor. When building composites for applications that demand a balance between damping and stiffness, this trade-off must be considered. In conclusion, natural fiber-reinforced polypropylene composites, especially those treated with specific chemical agents, show promising mechanical and damping properties. Bamboo/cotton hybrid composites are notable for their high damping ratios and potential use in sound absorption and vibration damping. Additionally, various treatments of alfa fibers in polypropylene matrices can customize the composites' properties to meet different performance requirements. The sustainable nature and versatility of these composites make them appealing alternatives to traditional synthetic fiber-reinforced materials in engineering applications.

III. NATURAL FIBRES

Five different types The damping ratio values of three-ply glued laminated timber beams reinforced with glass-reinforced polymer (GRP) sheets were measured. These GRP sheets varied in thickness, position, and orientation. Pine, spruce, and fir wood were used to construct the specimens. The damping was computed using the frequency response function. Ratio using a logarithmic regression analysis technique. According to the findings, the reinforced beams' average damping ratio values were almost 12% greater than those of the beams without GRP reinforcement. [3] Developing a polypropylene composite reinforced with natural fibers involves optimizing the molding process parameters in a compression molding machine to achieve desirable mechanical properties, cost efficiency, and environmental benefits. This process requires a systematic approach, beginning with the selection of suitable natural fibers and polypropylene matrix, followed by an optimization of processing conditions. Material Selection: Natural fibers like jute, hemp, flax, and coir are preferred due to their biodegradability, renewability, and favorable mechanical properties. Polypropylene is selected for its excellent processability, cost-effectiveness, and desirable Mechanical Properties and Preparation of Materials: The natural fibers undergo treatment to improve the polypropylene matrix's adherence them. Fiber-matrix bonding is improved by treatments such as coupling agents, silage treatment, or alkali treatment, which are essential to the performance of the composite. Compression Molding Process: Compression molding involves placing the fiber-reinforced polypropylene mixture into a heated mold cavity, which is then closed and pressure is applied. The key parameters in this process are temperature, pressure, and time. Optimization of Parameters: Temperature: The molding temperature needs to be high enough to ensure proper melting and flow of polypropylene but not so high that it degrades the natural fibers. Typically, temperatures range from 180°C to 200°C. Pressure: Adequate pressure is essential to ensure good compaction and minimize voids within the composite. Pressures generally range between 5 to 10 MPa. Time: Sufficient molding time is required to allow complete impregnation of the fibers and curing of the composite. The optimal time often ranges from 5 to 10 minutes, depending on the thickness and type of fibers used. Evaluation and Testing: After molding, the composites undergo mechanical testing, including tensile, flexural, and impact tests, to assess their properties. Additionally, thermal and morphological analyses are conducted to ensure the uniform distribution of fibers and proper bonding. Results and Adjustments: Based on the testing results, the process parameters are further refined to achieve the best balance of strength, stiffness, and durability. This iterative process of testing and adjusting continues until the optimized composite material is developed. By carefully selecting materials, optimizing process parameters, and thorough testing, polypropylene composites reinforced with natural fibers can be successfully developed, providing a sustainable and efficient alternative to conventional materials.

IV. POLYPROPYLENE COMPOSITES

Graphite is a layered material in order to improve their adherence to the polypropylene matrix. The performance of the composite depends on the fiber-matrix bonding, which

Correspondence to: Gadhave S.N, Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur
Corresponding author. E-mail addresses: sateeshpateel@gmail.com

is improved by treatments including coupling agents, silage treatment, and alkali treatment. Expanded graphite (EG) can be produced by separating these loosely bonded graphene layers, resulting in extruded graphene sheets. The production of expanded graphite involves rapidly heating a graphite intercalation compound (GIC). This rapid heating causes a sudden release of gases trapped between the layers, leading to significant expansion and deformation of the graphite structure. The process involves the unidirectional expansion of guest molecules and the early formation of platelets, which contribute to the unique properties of expanded graphite. Expanded graphite demonstrates enhanced surface area, porosity, and flexibility, rendering it well-suited for a range of applications, including thermal management, energy storage, and environmental protection. The manufacturing process of expanded graphite, which includes rapid thermal treatment of graphite intercalation compound (GIC), plays a pivotal role in defining the material's ultimate characteristics and potential uses (Source 16). Evaluating Polypropylene (PP) composites reinforced with natural fibers for their mechanical, morphological, and thermal properties, specifically tailored for dashboard and door interior casing applications, requires thorough assessment to ensure durability and performance in automotive interiors. Mechanical Properties: The mechanical attributes of natural fiber-reinforced PP composites are crucial in automotive contexts. These properties include tensile strength, flexural strength, impact resistance, and stiffness. Evaluating these characteristics is essential to ascertain the composites' ability to withstand the mechanical stresses typical in automotive interiors. Tensile strength measures the material's resistance to stretching forces, while flexural strength evaluates its ability to withstand bending stresses. Impact resistance is vital for durability against sudden impacts, and stiffness indicates the composite's rigidity, contributing to the overall structural integrity. When assessing natural fiber-reinforced polypropylene (PP) composites, typical criteria like impact resistance, flexural strength, and tensile strength are evaluated. The greatest stress a material can withstand when being stretched or pushed is determined via tensile tests. providing insight into its overall strength. Flexural tests gauge the material's resistance to bending forces, which is crucial for components such as dashboards that may undergo dynamic loads. Impact tests evaluate the composite's ability to absorb sudden shocks, which is particularly important for door casings susceptible to potential impacts. Morphological Properties: The analysis of morphological properties focuses on understanding the distribution and SEM, a technique used for evaluating the interface between fibers and matrix, can be used to examine the interaction between natural fibers and the PP matrix in the composite. To ensure strong adhesion and even dispersion. A strong fiber-matrix interface enhances mechanical properties and mitigates issues like fiber pull-out or matrix cracking under stress, thereby ensuring sustained performance over time. Thermal Properties: In automotive applications where components face diverse temperature conditions, thermal stability, and conductivity are crucial considerations. Thermo gravimetric analysis (TGA) determines the onset of material degradation, indicating its thermal stability. Meanwhile, differential scanning calorimetry (DSC) quantifies specific heat capacity and glass transition temperature, impacting material performance over different temperature ranges. Process Optimization: The characteristics of polypropylene (PP) composites reinforced with natural fibers are significantly impacted by the manufacturing process. Optimizing parameters like fiber content, processing temperature, and molding pressure is crucial to achieve the desired mechanical and thermal properties. Injection molding or compression molding techniques are commonly employed for fabricating automotive components such as dashboards and door casings from these composites. Environmental Considerations: Natural fibers offer environmental advantages due to their renewable origin and biodegradability, which are increasingly valued in the automotive industry's drive toward sustainability. However, their ability to absorb moisture and maintain dimensional stability under changing humidity levels are also assessed to ensure sustained performance and reliability in automotive interiors. Performance Testing: Prototypes of dashboard and door casings are subjected to extensive performance evaluations replicating real-world conditions. These tests encompass assessments for vibration resistance, UV stability, flammability, and durability to ensure adherence to industry standards and meet customer expectations.

V. DAMPING FACTOR

All experiments were conducted under ambient conditions in air and at room temperature. Damping characteristics were assessed with respect to fiber orientation and beam ratio. For unidirectional materials, the experimental findings indicate that maximum damping occurs at 75 degrees fiber orientation, with a slight deviation noted at the maximum. Composite materials underwent analysis utilizing a cantilever beam damping test model and impulse excitation technique with reinforcement by unidirectional glass and Kevlar fibers. Damping characteristics were determined by fitting analytical Fourier responses to kinetic responses expressed in model coordinates. The study investigated how damping varied with fiber orientation, employing different attenuation models. Results indicated that the Adams-Bacon and Ni-Adams models effectively captured the experimental damping trends observed in glass fiber composites, highlighting substantial variations influenced by fiber orientation. [17] Examining the damping characteristics of natural fiber-reinforced polypropylene composites entails a comprehensive study of how these materials dissipate mechanical energy and reduce vibrations, crucial for various structural and automotive applications. Importance of The term "damping properties" describes a material's capacity to both absorb and release energy. When subjected to mechanical vibrations or impacts. In contexts like automotive parts, construction elements, and sports equipment, damping properties are pivotal for enhancing

Correspondence to: Gadhave S.N, Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur
Corresponding author. E-mail addresses: sateeshpateel@gmail.com

longevity, minimizing noise, and optimizing overall performance. Natural Fiber Reinforcement: Hemp, flax, jute, and coir are examples of natural fibers that are increasingly employed as reinforcements in polypropylene composites because of their renewable nature, lightweight properties, and advantageous specific characteristics such as strength and stiffness. These fibers also possess inherent damping properties, which can be beneficial in reducing vibrations and improving the comfort and safety of structures and products. Experimental Techniques: Several techniques are employed to investigate the damping characteristics of reinforced polypropylene composites. With natural fibers: Dynamic Mechanical Analysis (DMA): DMA evaluates the viscoelastic properties of materials under varying frequencies and temperatures. It aids in understanding how the composite behaves under dynamic loading conditions, providing insights into its damping characteristics. Vibration Testing: Techniques such as modal analysis and forced Composite structural damping coefficients and resonance frequencies are found by vibration testing. These tests replicate real-world scenarios and evaluate the composite's effectiveness in dissipating energy. Loss Factor Measurements: Loss factor, often measured using DMA or other vibration analysis methods, quantifies the energy dissipation capability of the material. A higher loss factor indicates better damping properties. Analysis and Interpretation: After conducting experiments, data on damping properties are analyzed to evaluate the effectiveness of natural fibers in enhancing damping in polypropylene composites. Variables like fiber composition orientation, and surface treatment impact damping characteristics. The results help in optimizing composite formulations and processing parameters to achieve desired damping characteristics. Applications and Benefits: Polypropylene composites reinforced with natural fibers, characterized by improved damping properties, find applications in various sectors: Automotive Industry: Used in vehicle interior panels, dashboards, and door panels to reduce noise and vibrations, enhancing passenger comfort. Construction: Employed in building materials to improve structural stability and reduce noise transmission. Sporting Goods: Applied in equipment such as skis, snowboards, and tennis rackets to enhance performance and durability.

VI. PARTICLE SWARM OPTIMIZATION

In existing literature, the methods and applications of PSO lack a structured taxonomy, and there is a notable absence of analytical evaluations that could provide meaningful insights. Certain studies also overlook essential evaluation factors related to the methods and applications of PSO. Literature reviews often lack formal organization in their structure, and the criteria for selecting papers are frequently unclear. [1] Currently, there is a lack of clear specifications regarding concepts and guidelines for selecting control parameters. Existing review studies do not adequately cover the variations of BSO needed for analytically assessing swarm heterogeneity, aggregation behavior, and stagnation. The search behavior aspects of BSO have not yet undergone thorough theoretical analysis. Moreover, the existing literature often fails to provide a systematic treatment of PSO across many previous research studies in this field. [2] Some variant PSO algorithms aim to design new topological structures that ensure population diversity and avoid premature convergence. Various well-known topologies have been introduced in PSO algorithms to accomplish this objective. For instance, the Full Information PSO algorithm leverages neighborhood information comprehensively, while the Learning PSO algorithm introduces a new learning strategy. This strategy enhances each particle's performance by utilizing the individual best information of all other particles. [3] Developing a mathematical model and simulating it for validation using Particle Swarm Optimization (PSO) involves a systematic approach to optimize parameters and fit the model to experimental data. Here’s a detailed overview: Mathematical Model Development: Model Formulation: Begin by formulating a mathematical model that represents the relationship between input parameters and observed experimental outcomes. This model could be linear, nonlinear, empirical, or based on physical principles, depending on the nature of the data and the system under study. Parameter Identification: Identify the parameters within the model that need to be estimated or optimized. These parameters could represent coefficients, constants, initial conditions, or other variables that define the behavior of the model. Objective Function Definition: Define an objective function that quantifies the goodness of fit between the model forecasts and the experimental data. This could be a least squares error function, maximum likelihood estimator, or another metric that reflects the discrepancy between predicted and observed values. Simulation and Validation using PSO: PSO Algorithm Selection: Choose an appropriate variant of PSO for parameter estimation and model validation. PSO is well-suited for optimizing complex, nonlinear objective functions and has been widely used in parameter estimation tasks due to its ability to efficiently explore parameter space. Initialization: Initialize the PSO algorithm by defining the population size, maximum number of iterations, inertia weight, acceleration coefficients, and other parameters that govern the search behavior of particles. Fitness Evaluation: Each particle in the PSO swarm represents a potential solution (i.e., a set of model parameters). Evaluate the fitness of each particle by computing the objective function, which measures how well the corresponding model parameters fit the experimental data. Particle Update: Adjust the position and velocity of each particle using its individual best-known position (personal best) and the best-known position within its local neighborhood (global best). This iterative process helps particles converge toward optimal parameter values that minimize the objective function. Convergence Criteria: Monitor the convergence of the PSO algorithm by tracking the best fitness value across iterations. Convergence typically occurs when the objective function reaches a satisfactory level of accuracy or when further iterations do not significantly improve the fitness. Model Validation: Comparison with Experimental Data: After optimization,

Correspondence to: Gadhave S.N, Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur
Corresponding author. E-mail addresses: sateeshpateel@gmail.com

compare the simulated model predictions with the experimental data to assess the accuracy and reliability of the model. Visual inspection, statistical tests, and other validation techniques can be employed. Sensitivity Analysis: Conduct sensitivity analysis to ascertain the impact of each parameter on the model's forecasts. This helps identify which parameters have the most significant impact on the model's behavior and can guide future experimental or computational studies. Applications and Benefits: Engineering Design: PSO-based modeling and simulation can be applied in various engineering disciplines, such as mechanical, civil, and chemical engineering, to optimize design parameters and improve system performance. Scientific Research: In scientific research, PSO facilitates parameter estimation in complex models, aiding in understanding biological, ecological, and physical systems. Optimization: Beyond parameter estimation, PSO is used for optimization tasks in machine learning, data mining, and artificial intelligence, where finding optimal solutions in large parameter spaces is crucial.

CONCLUSION

The study examined the viscoelastic behavior and vibration characteristics of polypropylene composites reinforced with hemp short noil fibers. This involved doing dynamic mechanical analysis and free vibration testing. Melt-mixing and injection molding techniques were used to create the composites, with variations involving coupled and uncoupled agent combinations. The study looked into how these materials' inherent frequency and damping ratio were affected by different frequency parameters, noil fiber content, and the addition of POE- or PP-MAH. Understanding the inherent damping characteristics of different materials and utilizing them in component design significantly enhances the versatility and effectiveness of vibration damping. Recent studies have also developed hybrid methods to address the limitations of traditional wave equation solutions, which are often inadequate for estimating damping properties in structures that do not fit conventional beam or plate configurations. Moreover, integrating SC fibers into a polyester matrix has been found to increase the stiffness and modulus of the composites. However, this enhancement in stiffness in SCPCs (Short Carbon Fiber Reinforced Polyester Composites) leads to a reduction in the damping ratio compared to pure polyester materials. Among different combinations of fiber length and loading, SCFRPCs (Short Carbon Fiber Reinforced Polyester Composites) were produced Despite not reaching the greatest values, those with a critical fiber length of 30 mm and a fiber loading of 40 wt% were shown to be ideal in terms of modulus. Since chemical treatment increased interfacial adhesion, SCFRPCs showed better dynamic characteristics. This improvement affected the composites' damping qualities in addition to their storage and loss moduli. The increases in tensile and bending strength from reinforcement are counterbalanced by attributes that decrease rigidity. Which are only partially mitigated by the use of a high-molecular coupling agent. While utilizing two consecutively arranged presses offers significant time savings, this advantage is tempered by greater reductions in storage modulus at elevated temperatures. Furthermore, due to challenges in achieving higher filling grades and shorter average fiber lengths, injection molding parameters decrease disproportionately as temperatures rise.

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