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Innovative Use of Agro-Waste Reinforcing Epoxy Composites with Bamboo, Pineapple, and Agarbatti Powder

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ABSTRACT

A composite material is made from two or more constituent materials, providing better properties compared to its parent materials. These composites are stronger, lighter, and more economical than traditional materials. In recent years, composites have gained significant attention for advanced engineering structures. This research explores mechanical properties like tensile, flexural, and impact strength of epoxy composites reinforced with natural fibers. Variations of bamboo and pineapple fibers are analyzed, with agarbatti powder hybridization using the hand layup technique. The composites were fabricated and tested as per ASTM standards, demonstrating enhanced mechanical properties. This study aims to identify the optimal composite configuration based on strength parameters.

Key Words: Agarbatti Powder, Composites, Bamboo Fiber, Epoxy Resin, Pineapple Fiber, Reinforcement.

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1. INTRODUCTION

Natural fibers are obtained from plant or animal sources and are valued for their renewability and biodegradability. The growing interest in natural fiber-reinforced composites stems from their lightweight nature, high strength, and reduced environmental impact compared to synthetic fibers. Bamboo and pineapple fibers are increasingly used in composite manufacturing due to their excellent tensile and flexural properties. This study investigates the hybridization of bamboo and pineapple fibers with agarbatti powder to enhance composite properties further. The research aims to analyze the mechanical performance of these composites under various loading conditions.

2. LITERATURE SURVEY

Several studies have explored the use of natural fibers and hybrid composites in material engineering:

- **Rajasekar K. et al.** investigated the potential of bamboo fiber-reinforced composites in helmets for safety applications. The study highlighted improved energy absorption and flexural properties, demonstrating the suitability of natural fibers in protective gear.
- **Sathish Kumar and Jayakumar** emphasized the use of aloe vera and papaya fibers in helmet manufacturing. The research noted increased load-bearing capacity and thermal insulation compared to conventional ABS plastic helmets.
- **V. Pradeep** proposed innovations in lightweight composite helmets, incorporating carbon fiber for enhanced strength and ergonomic benefits. The study demonstrated successful integration of lightness and durability in helmet designs.
- **Sudhir A. et al.** prepared hybrid composites using bamboo and pineapple fibers in varying weight fractions. Tensile and flexural tests revealed optimal performance at a 20:20 bamboo-to-pineapple ratio.

- **Phanindra Varma D. et al.** examined hybrid composites of pineapple and bamboo fibers in epoxy matrices. The hybrid composite with 10:30 weight fractions of pineapple to bamboo exhibited superior tensile strength, while the 20:20 ratio achieved maximum flexural strength.

These studies collectively establish the versatility of natural fiber-reinforced composites for high-strength, lightweight applications.

3. OBJECTIVE OF RESEARCH

The primary objectives of this research are as follows:

1. To explore the use of natural fibers such as bamboo and pineapple in reinforcing epoxy composites.
2. To investigate the effect of hybridization on the mechanical properties of epoxy composites.
3. To analyze the role of agarbatti powder as a filler material in enhancing the performance of natural fiber-reinforced composites.
4. To identify the optimal combination of bamboo, pineapple fibers, and agarbatti powder for maximum tensile, flexural, and impact strength.
5. To evaluate the potential applications of these hybrid composites in lightweight and high-strength engineering components.

4. RESEARCH METHODOLOGY

4.1 Selection of Materials:

The materials used in this research were chosen based on their mechanical properties, availability, and compatibility with epoxy resin. These include:

Natural Fibers: Bamboo and pineapple fibers were selected for their high tensile and flexural strengths.
Epoxy Resin (LY556): A thermoset plastic known for its low shrinkage and excellent bonding properties.
Hardener (HY951): Acts as a curing agent for the epoxy.
Agarbatti Powder: Incorporated as a filler material to enhance mechanical properties.

Figure 4.1 Hybridization of bamboo and pineapple fibre with 10gm of agrbatti powder reinforced with Epoxy composite

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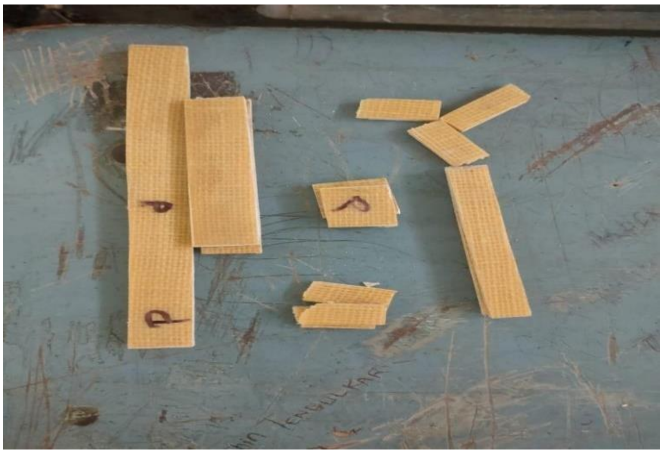

Figure 4.2 Pineapple fibre reinforced Epoxy composite

4.2FabricationProcess:

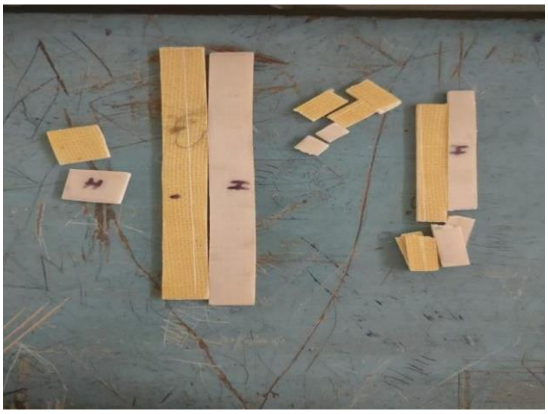

Figure 4.3 Hybridization of bamboo with pineapple fibre reinforced with Epoxy composite

The hand layup technique was employed for composite fabrication. This method involves the manual placement of fibers and matrix layers to create the composite. The following configurations were prepared:
Bamboo fiber reinforced epoxy composite, Pineapple fiber reinforced epoxy composite, Hybrid composite (bamboo + pineapple fibers), Hybrid composite with 10g agarbatti powder, Hybrid composite with 20g agarbatti powder, Specimens were cast into molds of 200x200 mm size with a thickness of 4 mm and cured at room temperature.

1. Testing Protocols:

Figure 4.4 Impact machine for impact testing

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Mechanical testing was performed as per ASTM standards to evaluate the composite's performance under different loading conditions:

Tensile Testing: Conducted on an electronic tensometer to measure the tensile strength and elongation of the specimens.

Flexural Testing: A three-point bending setup was used to determine the flexural strength.

Impact Testing: Charpy impact tests measured the energy absorbed during a sudden impact.

5. DATA ANALYSIS:

The results from mechanical tests were compiled and analyzed to identify the composite configuration with the best performance. Graphical representations and comparisons were made to evaluate the impact of hybridization and filler addition on tensile, flexural, and impact properties.

6. RESULT AND DISCUSSION

Mechanical Properties results of tensile, flexural, and impact tests are summarized in Table 1.

Table 1. Mechanical Properties of Developed composites

Composite Type	Tensile Strength (N/mm^2)	Flexural Strength (MPa)	Impact Strength (J)
Bamboo Fiber	5.7	87.15	83
Pineapple Fiber	7.54	87.05	83
Bamboo + Pineapple	6.46	88.33	85
Bamboo + Pineapple + 10g Agarbatti Powder	4.66	83.50	83
Bamboo + Pineapple + 20g Agarbatti Powder	8.26	89.25	86

Tensile Strength The addition of 20g agarbatti powder significantly enhanced the tensile strength, achieving 8.26 N/mm^2. The hybridization of fibers improved the composite's load-bearing capacity.

Flexural Strength The flexural strength peaked at 89.25 MPa for the composite with 20g agarbatti powder, highlighting the synergistic effects of hybridization and filler addition.

Impact Strength The hybrid composite with 20g agarbatti powder exhibited the highest impact strength (86 J), demonstrating better energy absorption capabilities.

7. CONCLUSION

This study successfully developed hybrid epoxy composites reinforced with bamboo, pineapple fibers, and agarbatti powder. The hybrid composite with 20g agarbatti powder showed superior tensile, flexural, and impact properties. These findings suggest potential applications in lightweight and high-strength engineering components.

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