Development and Evaluation of Fly Ash Filled Jute Fiber Epoxy Composites for Sustainable Automotive Interior Applications

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Abstract
This study focuses on the development of eco-friendly composite materials using jute fiber and fly ash as reinforcement and filler within an epoxy matrix. The objective is to evaluate mechanical performance for potential use in automotive interior components. Composites were fabricated with a constant jute fiber content of 30 percent by weight, while fly ash was varied from 0 to 15 percent. Mechanical properties including tensile, flexural, and impact strength were examined using standardized testing procedures. Results indicate that the inclusion of fly ash improves stiffness and structural stability up to an optimum level. Beyond this level, performance reduction is observed due to particle clustering. The findings demonstrate that the developed composite offers a balance of strength, cost efficiency, and environmental sustainability.

Keywords: Jute fiber, Fly ash, Epoxy composite, Sustainable materials, Automotive interiors

1. Introduction

The increasing environmental concerns and demand for sustainable engineering materials have encouraged the use of natural fiber reinforced polymer composites. Jute fiber is biodegradable, renewable, low-cost, and possesses acceptable specific mechanical properties. Fly ash, a by-product of thermal power plants, is abundantly available and can be utilized as a value-added filler material. Incorporating fly ash reduces environmental waste while improving composite stiffness and reducing production cost.

2. Materials and Methodology

2.1 Materials Used

- Jute Fiber – Reinforcement (30 wt.%)
- Fly Ash – Filler material (0–15 wt.%)
- Epoxy Resin – Matrix material
- Hardener – Mixed with epoxy in 10:1 ratio

2.2 Composite Formulation Calculation

Step 1: Total composite weight assumed = 1000 g (1 kg)
Step 2: Jute fiber fixed at 30 wt.% → 300 g
Remaining (Resin + Fly Ash) = 700 g
Step 3: Fly Ash Variation and Resin Adjustment
Step 4: Hardener calculated based only on resin weight (Epoxy : Hardener = 10 : 1)

Sample	Jute (g)	Fly Ash (g)	Resin (g)	Hardener (g)	Total (g)
0% FA	300	0	700	70	1070
5% FA	300	50	650	65	1065
10% FA	300	100	600	60	1060
15% FA	300	150	550	55	1055

Note: Hardener is calculated as Resin/10.

2.3 Fabrication Process

Composite laminates were fabricated using the hand lay-up technique followed by compression molding. Measured quantities of jute fiber were placed uniformly in the mold. Fly ash was dispersed thoroughly in epoxy resin before adding hardener. The mixture was poured over fiber layers and compacted. Specimens were cured at room temperature for 24 hours.

Composite laminates were fabricated using the hand lay up technique followed by compression molding. Jute fibers were arranged uniformly in the mold. Fly ash particles were first dispersed into the epoxy resin to ensure uniform distribution. The hardener was then added, and the mixture was poured over the fiber layers. The laminate was compressed and allowed to cure at room temperature for 24 hours.

Fig-1.1: Jute & Fly Ash mixed with Epoxy Composite Material

2.4. Mechanical Testing

Mechanical characterization was carried out using standard testing methods. Tensile properties were evaluated according to ASTM D3039, flexural strength was measured using ASTM D790, and impact resistance was determined using ASTM D256. These tests provide a comprehensive assessment of material behavior under different loading conditions.

2.5. Automotive Interior Applications

The developed composite can be applied in door panels, dashboards, parcel trays, seat back panels, and interior trim components. Advantages include reduced weight, lower cost, eco-friendliness, and improved vibration damping compared to conventional synthetic fiber composites.

2.6. Results and Discussion

The results show that the addition of fly ash enhances the stiffness and load bearing capacity of the composite up to 10 percent filler content. This improvement is attributed to effective stress transfer between the matrix and reinforcement. However, at higher filler levels, a decline in strength is observed due to poor dispersion and particle agglomeration. Impact resistance shows moderate improvement, indicating better energy absorption characteristics.

2.7. Applications

The developed composite material is suitable for non structural automotive interior components such as door panels, dashboards, seat back panels, and trim parts. The advantages include reduced weight, lower production cost, and improved environmental compatibility compared to conventional materials.

2.6. Conclusion

Fly ash filled jute fiber epoxy composites were successfully developed using controlled weight percentages. Optimal performance was observed at 10 wt.% fly ash. The study confirms that such composites are promising candidates for sustainable automotive interior applications. Future work may focus on fiber surface treatment, hybridization, and thermal property evaluation.

References

1. Pickering, K.L., Natural Fibre Composites: Materials, Processes and Properties.
2. Mohanty, A.K., Misra, M., Drzal, L.T., Natural Fibers, Biopolymers and Biocomposites.
3. ASTM D3039 – Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials.
4. ASTM D790 – Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics.
5. ASTM D256 – Standard Test Method for Determining the Izod Pendulum Impact Resistance of Plastics.