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Fabrication and Evolution of Mechanical Properties of - Epoxy Resin Reinforced with Jute Fiber and Wood Dust by Open Mould Technique

Kushala V B[1], Pooja A M[2], Shoaib Khan[3], Hemanth D R[4],
Mr. Mahanthesh G[5], Dr. B. M Viswanatha[6]
B.E. Scholars, Department of Mechanical Engineering[1-4]
Professor, Department of Mechanical Engineering[5,6]
Kalpataru Institute of Technology, Tiptur, India

Abstract: *The increasing demand for lightweight, cost-effective, and environmentally friendly materials has led to the development of natural fiber reinforced polymer composites. In this study, a composite material reinforced with jute fiber and wood dust as filler was fabricated using the open mould technique. Epoxy resin was used as the matrix material along with a suitable hardener. The objective of this work is to evaluate the mechanical properties of the developed composite and analyze the effect of wood dust addition on its performance. Standard test specimens were prepared and subjected to tensile, flexural, and impact tests as per ASTM standards. The experimental results showed that the inclusion of wood dust improved the interfacial bonding between the fiber and matrix, leading to enhanced mechanical strength. The composite exhibited good stiffness, adequate strength, and low weight, making it suitable for structural and semi-structural applications. The study highlights the potential of using natural fibers and waste materials like wood dust in composite fabrication, contributing to sustainable material development and waste utilization. These eco-friendly composites can serve as an alternative to synthetic fiber composites in various engineering applications.*

Keywords: Natural fiber composites; Jute fiber; Wood dust; Epoxy resin; Mechanical properties; Open mould technique

I. INTRODUCTION

Composite materials are formed by combining two or more different materials to obtain better properties such as high strength, low weight, and good durability. In recent years, natural fiber reinforced composites have gained importance due to their eco-friendly nature and low cost. Jute fiber is a natural, biodegradable material with good mechanical strength, while wood dust is an easily available waste material that can be used as a filler to improve bonding and reduce cost. In this study, a jute fiber and wood dust reinforced composite is fabricated using epoxy resin as the matrix by the open mould technique. The mechanical properties of the developed composite are evaluated through tensile, flexural, and impact tests to understand its performance and suitability for sustainable engineering applications.

II. LITERATURE REVIEW

Several studies have been carried out on fiber reinforced polymer composites to improve their mechanical performance and reduce material cost. Researchers have reported that the addition of fillers and reinforcement fibers significantly enhances properties such as tensile, flexural, and compressive strength. Studies on natural fiber composites using jute, banana, sisal, and glass fibers with epoxy and polymer matrices have shown that natural fibers are lightweight, biodegradable, and cost-effective alternatives to synthetic fibers. Hybrid composites and filler -added composites were found to exhibit better bonding and improved strength-to-weight ratio. However, only limited research is available on epoxy composites reinforced with jute fiber and wood dust filler. Therefore, the present work focuses on the fabrication

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and mechanical property evaluation of jute fiber and wood dust reinforced epoxy composites to explore their potential for eco-friendly engineering applications.

Many researchers have studied fiber reinforced polymer composites to improve their strength and performance. Suresh et al. reported that adding filler materials to fiber composites increases tensile and compressive strength. Srinivasan et al. studied banana fiber epoxy composites and found that natural fibers are lightweight, eco-friendly, and low cost. Raja Mahendran et al. showed that E-glass fiber polymer composites have high strength-to-weight ratio and can replace metals in many applications. Ashraf M.A. et al. studied jute fiber reinforced epoxy composites and observed improvement in mechanical properties. Ramesh et al. analyzed hybrid composites using sisal, jute, and glass fibers and found that fiber content affects strength and water absorption. Venkateshwara et al. highlighted that jute fiber content plays an important role in tensile properties. However, very few studies have been done on jute fiber epoxy composites with wood dust filler, which is the focus of the present work.

III. PROPOSED SYSTEM

A. Material Used

Fig:1

Fig:2

Fig:3

Fig:4

• Jute fiber (Fig:1) is a natural fiber that is low cost, light in weight, and eco-friendly. It is used as the reinforcement material to increase the strength of the composite.

• Wood dust (Fig:2) is a waste material obtained from wood industries and is used as a filler to improve bonding and reduce material cost.

• Epoxy resin (Fig:3) is used as the matrix material to hold the jute fiber and wood dust together and give shape and strength to the composite.

• A hardener (Fig:4) is added to the epoxy resin to help it cure and become hard.

B. Fabrication Process

Fig:5

Fig:6

Fig:7

Fig:8

Fig:9

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Fig:10


Fig:11


Fig:12


Fig:13

Fig. 5: Jute fiber mat was cut into the 25mm*25mm dimensions for laminate preparation.
Fig. 6: The required quantity of jute, epoxy resin and hardener was measured accurately using a digital weighing balance.
Fig. 7: Sieve analysis was carried out to obtain wood dust filler of 150 microns particle size, ensuring uniform filler distribution in the composite.
Fig. 8: The sieved wood dust filler (150 microns) was weighed using a digital weighing balance.
Fig. 9: The epoxy resin, hardener, and measured wood dust filler were mixed thoroughly to form a uniform resin–filler mixture, which was poured over the jute fiber mat placed in the mould.
Fig. 10: The resin mixture was evenly spread over the jute fiber using a brush to ensure proper wetting and bonding.
Fig. 11: Weights were placed on the laminate to remove air bubbles and maintain uniform thickness during curing. Fig. 12: After curing at room temperature, the composite laminate was removed from the mould.
Fig. 13: The cured composite sheet was cut into standard test specimens as per ASTM standards for mechanical testing.

C. Experimental Procedure

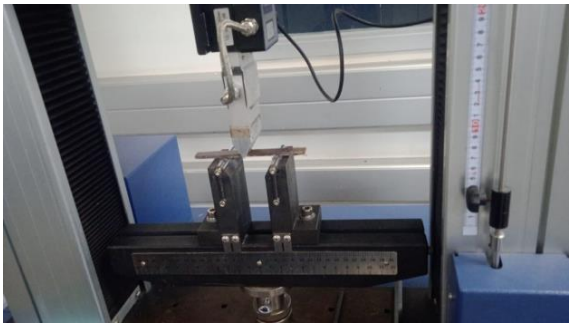
Fig: 14

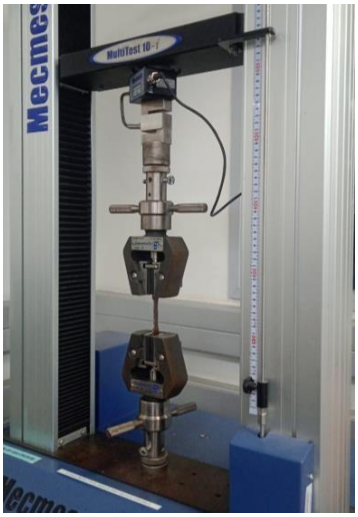

Fig :15

- The cured composite sheet was cut into standard test samples for tensile and flexural tests.
- Tensile test: The sample was fixed in a Universal Testing Machine (UTM) and load was applied until it broke. The tensile strength and elongation were recorded.
- Flexural test: The sample was placed on two supports and a load was applied at the center using UTM until it bent and failed. The flexural strength was noted.
- The tests were repeated for several samples to get accurate results.
- The data was analyzed to see how wood dust filler affected the strength of the jute fiber composite.

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• Fig. 14 and Fig. 15 together show the experimental setup for compression and tension testing using a universal testing machine.
• In compression, the specimen is pushed between plates, and in tension, the specimen is pulled using grips to study its load and displacement behavior.

D. Result and Discussion Tensile Test:

Tensile testing is a basic mechanical test used to understand how a material behaves when it is pulled (stretched). It helps in finding important properties such as tensile strength, elongation, Young's modulus, and fracture behavior.
In this study, a jute fibre–epoxy composite with wood dust filler was tested under tension. The test was carried out to determine the ultimate tensile strength (UTS), maximum load, cross-sectional area, and the stress–displacement response of the material. These results help to decide whether the material is suitable for engineering applications.

Objectives of the Tensile Test

• To measure the ultimate tensile strength (UTS) of the composite material.
• To find the maximum load the material can withstand before failure.
• To study the stress–strain behavior and elongation of the material.

Test Setup and Methodology

• The test was performed using a Universal Testing Machine (UTM).
• The specimen was fixed in the grips and pulled until failure.
• No extensometer was used during the test.

Specimen Dimensions:

Length: 165 mm
Width: 19 mm
Thickness: 5 mm

SAMPLES COMPOSITIONS:

Sample No.	Jute (%)	Epoxy (%)	Filler (%)	Sum (%)
1	11.76470588	88.23529412	0	100
2	10	90	0	100
3	10	75	15	100
4	8.695652174	78.26086957	13.04348	100
5	10	82.5	7.5	100
6	19.51219512	73.17073171	7.317073	100
7	18.18181818	75	6.818182	100

SAMPLE–1

Composition: Jute = 11.76470588 %
Epoxy = 88.23529412 %
Filler = 0 %
Mass of Filler: = (0/100) × 0.003 × 187500
Mass of Jute: = (11.76470588/100) × 0.00146 × 187500 = 32.206 g
Volume of Jute Fibre: V = 32.206 / 0.00146 = 22058.82 mm³
Number of Jute Layers: No. of layers = 22058.82 / 5568.49 = 3.96 ≈ 4

Average Load(N)	Jute% (g)	Epoxy Resin%(g)	Filler% (g)	Tensile Strength(Mpa)
407	11.76470588	88.23529	0	8.01

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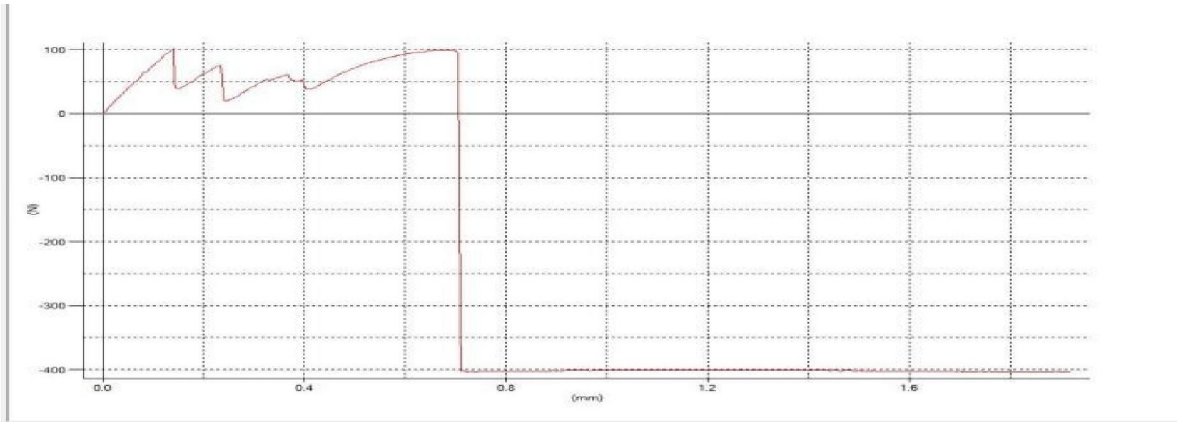
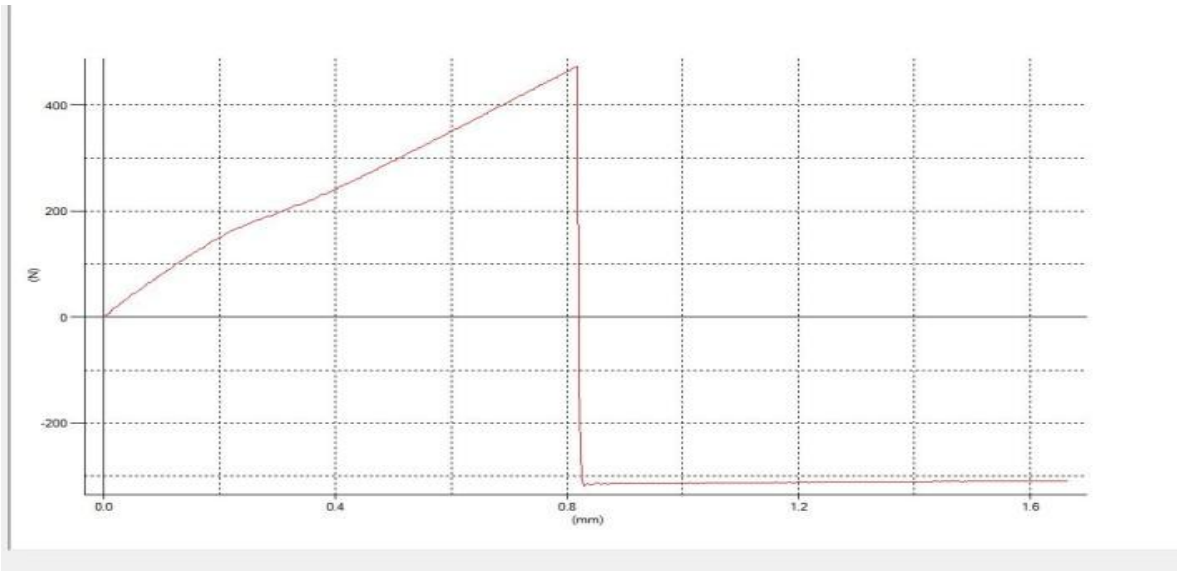
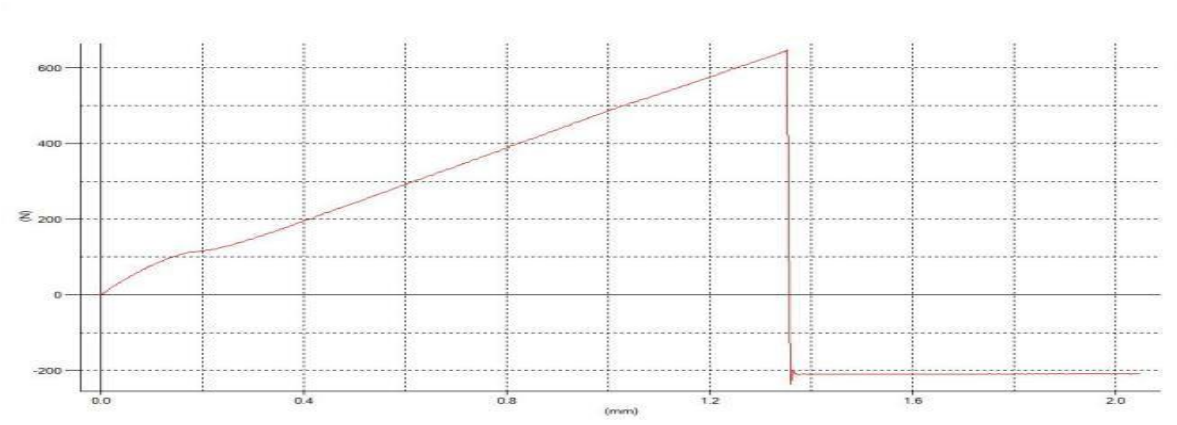
Scale

x-axis = Displacement(mm) y-axis=Force(N)







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Flexural Test:

The flexural test is used to check how the material behaves under bending load. From this test, the flexural strength, maximum load, and bending behavior of the material are obtained. These results help to understand whether the material is suitable for structural and load-bearing applications.

The test was performed using a Universal Testing Machine (UTM) with a three-point bending setup. The specimen was placed on two supports, and load was applied at the center until failure occurred.

Objectives of the Test

The primary objectives of this flexural test are:

- To measure the flexural strength of the composite material.
- To record the maximum load the material can withstand under bending before failure.
- To determine the material's mechanical properties, including load-deflection behavior and flexural deformation.

Specimen size:

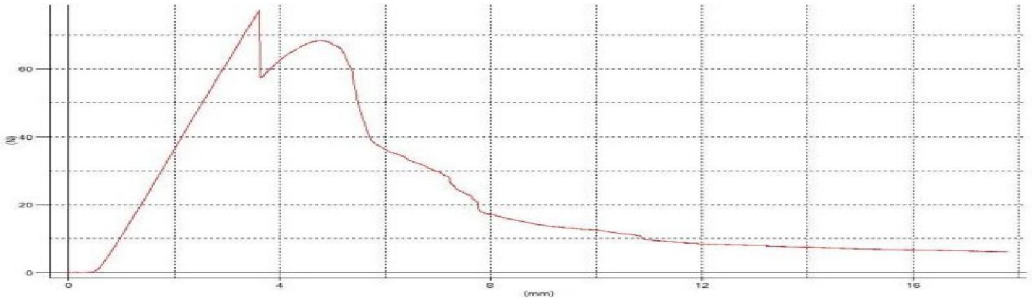
Length: 126 mm
Width: 12.7 mm
Thickness: 5 mm

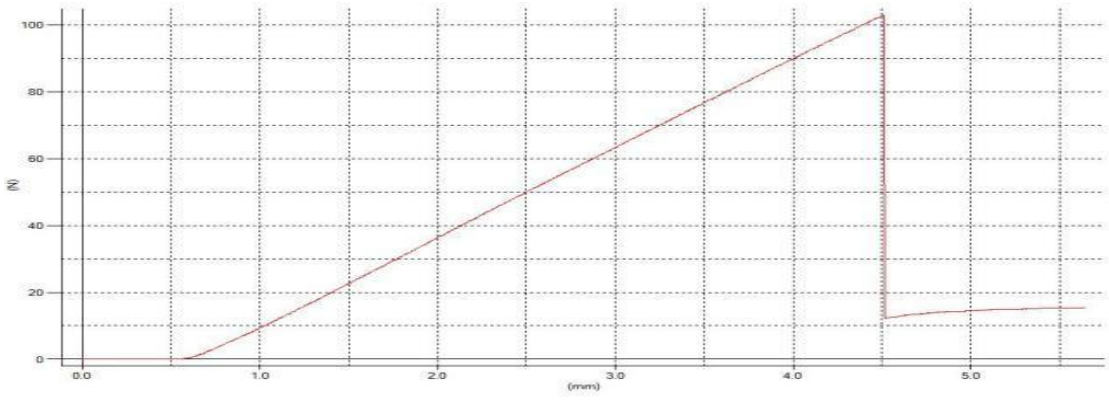
Sample-1

Average Load(N)	Jute% (g)	Epoxy Resin%(g)	Filler% (g)	Flexural Strength(Mpa)
102.3	11.7647	88.2352	0	64.00

Scale

x-axis = Displacement(mm) y-axis=Force(N)





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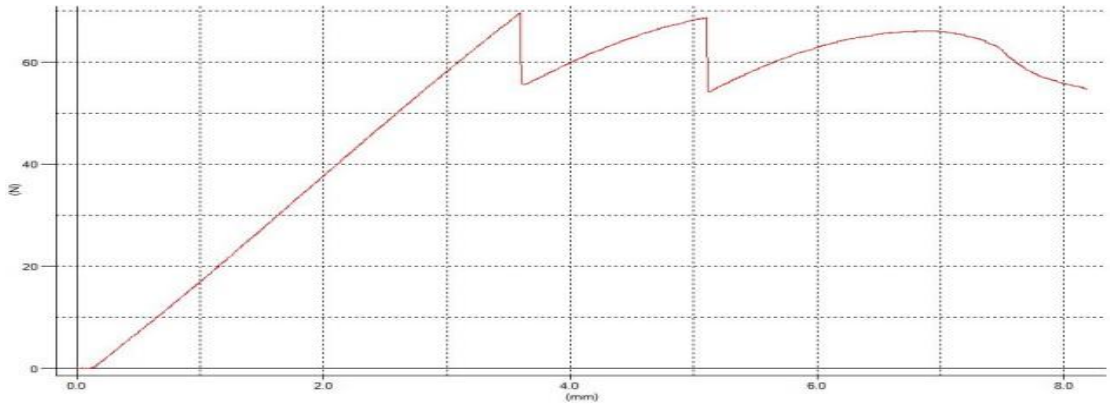

Advantages

• Lightweight: The composite is lighter than metals, making it suitable for applications where weight reduction is important.
• Eco-friendly: Uses natural fibers (jute) and waste material (wood dust), making it biodegradable and sustainable.
• Cost-effective: Jute and wood dust are inexpensive and easily available.
• Good mechanical properties: Addition of wood dust improves tensile and flexural strength of the composite.
• Easy to fabricate: Can be prepared using simple techniques like open moulding.

Limitations

• Moisture absorption: Natural fibers like jute absorb moisture, which can reduce mechanical strength.
• Lower strength than synthetic composites: Does not match the strength of composites reinforced with carbon or glass fibers.
• Limited thermal resistance: May not be suitable for high-temperature applications.
• Durability issues: Long-term exposure to water or UV may degrade the material.

Applications

• Automotive parts: Interior panels, door trims, and dashboards.
• Construction materials: Lightweight panels, partition boards, and ceiling panels.
• Furniture: Eco-friendly chairs, tables, and decorative items.
• Packaging materials: Biodegradable containers or boxes.
• Consumer goods: Handicrafts, mats, and small household items.

IV. CONCLUSION

In this study, a jute fiber reinforced epoxy composite with wood dust filler was successfully fabricated using the open mould technique. Mechanical tests such as tensile and flexural tests showed that the addition of wood dust improved the bonding between the fiber and matrix, resulting in better strength and stiffness compared to plain epoxy. The composite is lightweight, cost-effective, and environmentally friendly, making it suitable for applications in automotive, construction, and household products. However, the material has limitations such as moisture absorption and lower thermal resistance compared to synthetic composites. Overall, the study demonstrates that natural fiber composites with wood dust filler can be a sustainable alternative to conventional materials while maintaining good mechanical performance.

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