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Research Article

Experimental study of the Mechanical Properties of Jute fiber and Coconut Shell Powder reinforced Epoxy Composites

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ARTICLEINFO

ABSTRACT

Sustainability issues and environmental protection are becoming more and more important to scientists and engineers working in the field of materials. As compared to conventional synthetic fiber composite materials, the preference is given to Natural Fibers because of their environmental compatibility, biodegradable properties and sustainability. Using a hand lay-up approach, an epoxy piece made of a Jute fiber-epoxy composite mixed with coconut shell powder is created. An open style mild steel plate mold has been utilized for this purpose. The strength of the jute epoxy composite was found to be superior in both compressive and tensile properties. Fiber bundle strength declines in support of this; a bundle of coconut shell powder is applied. Reinforcement using jute fiber improves both compressive and tensile strength. We enhanced our research in by adding other composite kinds, mixes, and a host of additional differential features. It will enable us to develop more strength and some fictitious items. For applications such as aircraft and vehicles, the resulting material may be applied.

Keywords: Jute fibers, Coconut shell particulate, Epoxy resin (LY556), Hardener, Tensile strength, Compression strength, Flexural and Water Absorption Testing.

Introduction

This study examines the production and performance characteristics of epoxy composites made from jute fibre and coconut shell powder. The use of natural fibres and fillers for reinforcement in polymer composite materials attracted much interest due to their low cost, renewable nature and biodegradable properties. In recent years, researchers have been working on the development of composite materials with improved mechanical characteristics such as hardness, stiffness and strength.

Jute fiber and coconut shell powder are two potential natural reinforcements for polymer composites.Jute fibre is a lignocellulosic fiber obtained from the stems of jute plants. It's got high tensile strength, low density, and good flexibility. Coconut shell powder is a waste product obtained from the coconut industry. It has high lignin and cellulose content, which makes it a suitable filler for polymer composites.

This article goes over the preparation of jute fiber and coconut shell powder reinforced epoxy composites making use of the hand lay-up method which measures 290 * 290 sq.mm with thickness of 3mm. We will also investigate the mechanical characteristics of these composites, which consist of 30% jute fiber, 5% coconut shell powder, and epoxy resin with a 55% + 10% hardener ratio. Tensile strength, flexural strength, and impact strength of these composites are being researched. Finally, we're going to discuss the possibilities of

using these composite materials in a variety of industries like automotive, aerospace and building.

Methodology

Preparation of Composite Material

The matrix is decided to make using the hand lay-up procedure. Epoxy resin is applied to the inside side of the mold, which is utilized to fabricatethe composite. The mold dimensions are 290 x 290 x 3 mm. The fiber is positioned in the mold after being dipped in the resin and placed in it. A roller at room temperature is used to push the upper side until the matrix is properly established. For a full day, the setup is left to cure at room temperature. As per ASTM regulations, the produced composite was now cut according to the specimen's dimensions for testingactivities & also in the testing labs.

Stage-01

Chemical Reaction Process

•Jute fiber was purchased from Erode, Tamil Nadu, India. Coconut shell powder was prepared by its own. The fibers were then treated with 30% + 5%. After that, fibers are dried at 100°C for two hours to get rid of any remaining moisture)

Stage-02

Matrix Process

•The matrix is decided to make using the hand lay-up procedure. Epoxy resin is applied to the inside side of the mold, which is utilized to fabricate the composite. The mold dimensions are 290 x 290 x 3 mm. The fiber is positioned in the mold after being dipped in the resin and placed in it. A roller at room temperature is used to push the upper side until the matrix is properly established. For a full day, the setup is left to cure at room temperature. As per ASTM regulations, the produced composite was now cut according to the specimen's dimensions for testing.

Stage-03

Testing and Analysis

- Generation of composite matrix, In-process & finished Good sampling & analysis.

In pharma industry, Upstream, Downstream activities further listed as below:

- Preparation of Composite
- Fiber Preparation
- Coconut Shell Powder Preparation
- Epoxy Matrix Preparation
- Mixture Component
- Degassing and Casting
- Curing Process
- Tensile Testing
- Flexural Testing
- Compression Testing
- Impact Testing
- Water Absorption Testing

Preparation of Composites

- **Fiber Preparation** - Since being cleaned, jute fibers should be dried to get rid of any moisture or contaminants. After that, the fibers should be chopped or cut into the appropriate lengths depending on the needs the for reinforcement and the function optimization. The jute fibers can be further treated with a surface modifier or coupling agent to enhance their adhesion with the epoxy matrix.
- **Coconut Shell Powder Preparation** - After being accumulated, coconut shells need to be carefully cleaned to get rid of any dirt or debris. Using an appropriate grinding machine or mill, the shells can be crushed or ground into a fine powder. For the powdered coconut shell to have a consistent distribution of particle sizes, it must be sieved.
- **Epoxy Matrix Preparation**- Based on the required properties and the intended use, choose an epoxy resin system that is appropriate. Using the manufacturer's suggested ratio, measure out the right amount of epoxy resin and hardener. Thoroughly mix the epoxy resin and hardener in a clean container using a mechanical stirrer or mixer until a homogeneous mixture is obtained.

- **Mixture Component**- Mix the jute fibre, coconut shell powder and epoxy resin mixture in a separate container. In order to provide a consistent dispersion and distribution of reinforcement materials, slowly mix the jute fibres and coconut shell powder into the epoxy resin while it is being stirred or mixed constantly. Continue mixing until the fibres and powder are thoroughly coated with epoxy resin, thereby achieving a homogeneous mixture.
- **Degassing and Casting**- Degassing is a crucial step in preparing a mixture, using vacuum or pressure techniques to remove air bubbles. It's versatile and can accommodate various shapes and sizes. The compaction phase requires precision and care to achieve a perfect finish, compacting the mixture within the mold without leaving holes or gaps.
- **Curing Process** –To ensure optimal results with cast mixtures, follow manufacturer's cure time and temperature, considering variables like epoxy resin system. The curing process can be controlled in an oven or natural at room temperature, depending on the system's characteristics. Flexibility allows for changes and adaptations, ensuring a finished product meeting or exceeding quality and performance expectations.

Tensile Testing:

This examination is conducted using a Hounsfield Tensiometer. The chosen scale has a range of 0-500 kgf (0-2452.5 N). The specimen, which measures 250 mm by 25 mm by 3 mm, is prepared in compliance with ASTM D 3039-76 standard.

Where A is cross-sectional area;

Following are the details of the specimen:

i. Length = 250 mm,
ii. Width = 25 mm,

Sample No.	Cross Sectional AREA	PEAK LOAD In N	Percentage of Elongation	Ultimate Tensile Strength
01	75.000	2497.214	3.190	33.295
02	75.000	2025.461	1.470	27.007
03	75.000	2609.293	3.410	34.786
04	75.000	2249.894	1.330	29.999

Flexural Testing:

In this study the flexural strength of natural fiber reinforced polymer composite fibres increases with increasing fibre content and peaks at 40 per cent loading. However, if the fibre content is increased to 60%, the observed values will decrease. The specimen shall be prepared in accordance with the ASTM D 790 standard as follows: 125 mm x 13 mm x 3 mm.

Sample No.	Cross Sectional AREA	PEAK LOAD In N	Flexural Strength (MPa)	Flexural Modulus (GPa)
01	39.000	84.415	54.112	4243.145
02	39.000	64.462	41.322	3644.320
03	39.000	92.194	59.099	4261.663
04	39.000	102.416	65.652	8452.279

Compression Testing:

Sample No.	Cross Sectional AREA	PEAK LOAD In N	COMPRESSIVE STRENGTH
01	75.00	304.375	4.061
02	75.000	700.248	9.339
03	75.000	478.934	6.389
04	75.000	684.297	9.123

Using a Hounsfield Tensiometer, a compression test is carried out for the U/D jute fiber epoxy composite. The load scale of 19.62 kN to 2000 kg has been handpicked. The dimensions of the specimen, as per the ASTM D 3410 Standard, are 150 x 25 x 3 mm

Impact Testing:

Impact resistance is crucial for evaluating material performance and durability, especially in industries like automotive components. It helps engineers and designers assess a material's ability to withstand fractures and damage under different loads. This information is crucial for informed material selection and design optimization, ensuring product safety and longevity. Impact resistance testing is essential for quality control

in sectors like construction, aerospace, and sports equipment manufacturing. Prioritizing this aspect during product development instills confidence in industries and customers, delivering top-notch results that exceed expectations.

Sample No.	For the given thickness, the impact value of Izod is J.
01	0.65
02	0.30
03	1.00
04	0.25

Water Absorption Testing:

Water absorption testing is a crucial method for evaluating and analyzing materials, providing insights into their ability to absorb and retain water. It helps researchers and engineers assess a material's performance and durability, and predicts its behavior when exposed to different humidity levels. This testing is essential for quality control in industries like construction, textiles, and automotive manufacturing. It also helps in assessing long-term durability, allowing manufacturers to make informed decisions about suitable applications and ensure optimal performance under various conditions.

Sample Number	Weight before test in gms	Weight after test in gms (24hrs)	Percentage of water absorption
01	1.15	1.2	4.3
02	1.14	1.18	3.5
03	1.27	1.32	3.9
04	1.33	1.36	2.3

Conclusion

The inclusion of jute fibres and coconut shell powder in epoxy composites significantly enhance their mechanical properties is the main conclusion of a study entitled "Preparation and Mechanical Properties of Jute Fibers and Coconut Shell Powder Reinforced withEpoxy Composites". Compared to the raw epoxy material, composite materials have shown an improvement in stiffness, flexibility, impact tests, compression test and water absorption testing resistance. In the aftermath of analysing the composite materials, the epoxy composite reinforced with jute fiber and coconut shell powder performed well in the water absorption test and improved in other testing methodologies. This indicates that the combination of jute fibers and coconut shell powder might be a feasible and environmentally friendly choice for reinforcing epoxy composites in a variety of sectors.

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