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Evaluation of Mechanical Properties of Glass-Jute Fibre Reinforced Hybrid Composites

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ABSTRACT: This paper presents the mechanical properties of Glass-Jute Fibre reinforced with epoxy hybrid composites. The fabrication of these composites were carried out using hand layup process. Glass fibre, jute fibre with coconut powder is used as filler material. The various mechanical properties of the composite viz., tensile strength, flexural strength, impact strength, hardness, density, water absorption capacity were evaluated.

KEYWORDS: Glass-Jute Fibre reinforced hybrid composite, Fibre Reinforced Polymer Composite (FRP)

I. INTRODUCTION

Hybrid polymeric composites are new and more developed composites as compared to the traditional fiber reinforced polymer composites. FRP composite contains on one reinforcing phase in the single matrix but hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing. Nowadays, composite materials are used in large number of engineering applications such as aviation, automobile and robotics due to versatility in their properties which enables them to be applied in large number of fields. Other reasons are their light weight, corrosion resistance and durability. Composite materials are commonly classified at following two distinct levels: The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites. The second level of classification refers to the reinforcement form - fibre reinforced composites, laminar composites and particulate composites. Fibers are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Glass fibers are the earliest known fibers used to reinforce materials [1]. The authors in [2] have applied linear and polynomial equations for finding the mechanical properties, with a simple algorithm that links them. This technique is the accurate method available to determine modulus of elasticity and toughness of the anisotropic materials like composites.

II. OBJECTIVE OF THE PRESENT WORK

On the basis of the available literature following objectives were selected for this work

1. Fabrication of hybrid composites using hand lay-up process.
2. To evaluate the following mechanical properties.
 - Tensile strength
 - Flexural strength
 - Impact strength
 - Hardness

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III. MATERIALS AND METHODS

The raw materials used in this present work are:

1. Glass Fibre^[1]
2. Jute Fibre^[1]
3. Epoxy^[1]
4. Coconut shell powder

The fabrications of composite slab are carried out by conventional hand layup technique. The bi-directional jute fibre and the E-glass fibres are used as reinforcement and epoxy is taken as matrix material. The low temperature curing epoxy resin and hardener are mixed in a ratio of 10:1 by weight percentage. Composites of different compositions like (without filler, 5 % filler and 10 % filler) are made. The cast of each composite is cured under a load of about 50 kg for 24 hours. Finally the specimens of suitable dimension are cut with the help of diamond indenter cutter in for characterization and testing.

Hand Layup Process

Hand lay-up technique is the simplest method of composite processing. First, a release gel is sprayed on the mould surface to avoid the sticking of polymer to the surface. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mould size and placed at the surface of mould. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. After curing either at room temperature or at some specific temperature, mould is opened and the developed composite part is taken out and further processed.

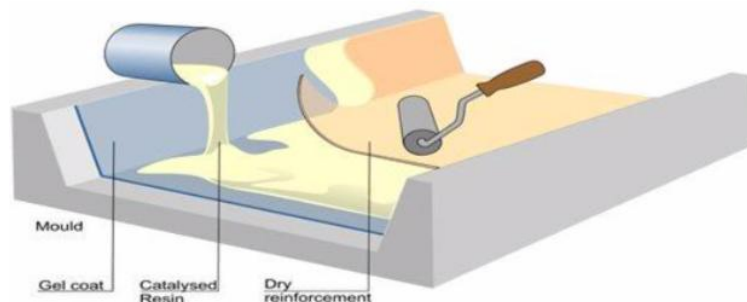


Fig 2.1 Hand Layup Process

Density

The theoretical density of composite material can be calculated using the formula given by.

$$\rho_{ct} = \frac{1}{\frac{w_f}{\rho_f} + \frac{w_m}{\rho_m}} \quad (\text{Eq.2.1})$$

where w and ρ represent the weight fraction and density respectively. The suffix f, m and ct stands for fibre, matrix and composite material respectively.

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Tensile Test

The tensile test generally performed on flat specimen. Tensile test of composite sample is carried out in ASTM D3039 test standard. In tensile test, a uniaxial load was applied through both the end.



Fig 2.2 Loading arrangement of specimen for tensile strength test

Flexural Test

Flexural test is to determine the capability of a material to withstand the bending before reaching the breaking point. The three point bending flexural test provides values for the modulus of elasticity in bending, flexural stress, flexural strain and the flexural stress-strain response of the material.

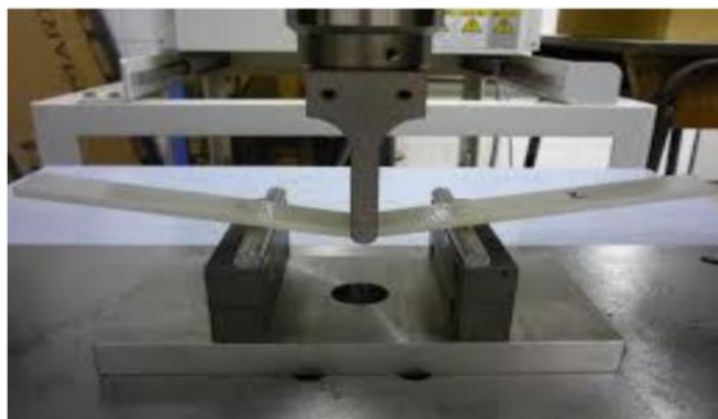


Fig 2.3 Loading arrangement of specimen for flexural test

Impact Test

The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. It is usually used to test the toughness of metals, but similar tests are used for polymers, ceramics and composites. The purpose of impact testing is to measure an object's ability to resist high-rate loading.

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Fig 2.4 Experimental setup for impact test

Water Absorption Test

Moisture absorption studies were performed according to standard test method for moisture absorption of composite. The weights of the samples were taken and then dipped them to normal water. After 24 hrs. the samples were taken out from the moist environment and all surface moisture was removed with the help of a clean dry cloth or tissue paper. The weight gain in percentage of the samples was measured at regular time intervals of time by using the following equation

$$\%W = \frac{(W_I - W_F)}{W_F} \times 100 \quad (\text{Eq. 2.2})$$

Where W_I is the initial weight of specimen and W_F is the final weight of specimen after water absorption.

Hardness Test

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex. By varying the test force and ball size, nearly all metals and composites can be tested using a Brinell test. Brinell values are considered test force independent as long as the ball size/test force relationship is the same.

IV. RESULTS AND DISCUSSIONS

A. *Water Absorption Test*

The water absorption ability of the composites was carried out according to ASTM D 570-98. The water absorption testing is performed after the hardness testing was done. It was measured by soaking samples of each composite in three glass beakers of water at 25 °C for different periods (up to 24hrs). Table 3.1 shows the water absorption test results.

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Table 3.1 Water Absorption Test

Particulars	Sample(% of water absorption)
Without Filler	1.30
5 % Filler	1.42
10 % Filler	2.19

B.Tensile Test

The different composite specimen samples were tested in the universal testing machine (UTM) according to ASTM standard D-3039. The samples were left to break till the ultimate tensile strength crosses. Stress–strain curve is plotted for the determination of ultimate tensile strength and elastic modulus. The sample graph was generated directly from the machine for tensile test with respect to load and displacement. Figure 3.1 shows the load versus deflection and stress versus strain results of tensile test.

Table 3.2 Ultimate tensile load

Particulars	Ultimate tensile load (kN)
Without filler	14.7
5 % filler	9.76
10 % filler	8.56

Table 3.3 Ultimate tensile strength

Particulars	Ultimate tensile strength (MPa)
Without filler	189.7
5 % filler	123.26
10 % filler	116.56

From Table 3.2 and 3.3 it was observed that ultimate tensile strength and load carrying capacity decreases with increase in filler content due to limiting load transfer capacity of matrix to the fibre.

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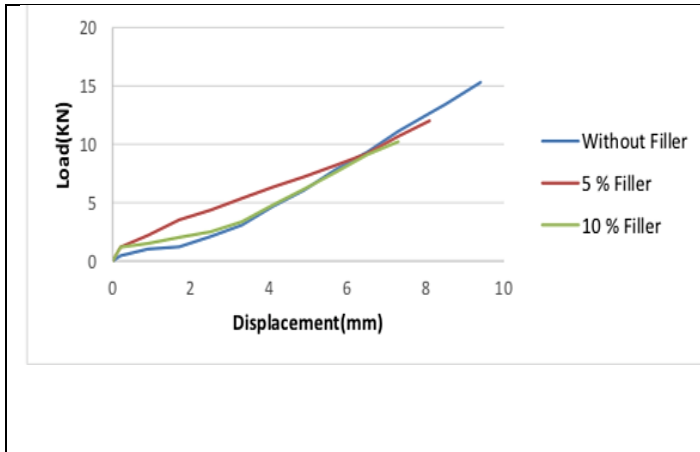


Fig 3.1 Load vs Displacement

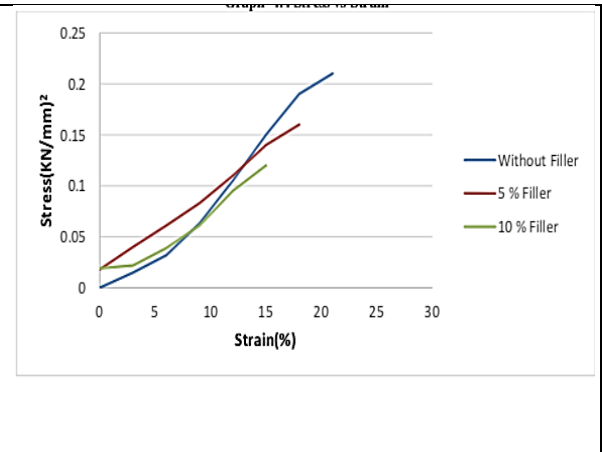


Fig 3.2 Stress vs Strain

C. Impact Test

The impact test specimens are prepared according to the required dimension following the ASTM-A370 standard. The center of the specimen is made into a shape of V-notch and it is loaded for testing. The pendulum is present in the idle position and it is released and made to hit the V-notch repeatedly until it gets fractured. The effect of strain rate on fracture and ductility of the material can be determined by using the impact test. Figure 3.3 shows the impact strength of different composite samples.

Table 3.4 Impact Strength

Particulars	Impact strength(J/mm ²)
Without Filler	0.22
5 % Filler	0.16
10 % Filler	0.12

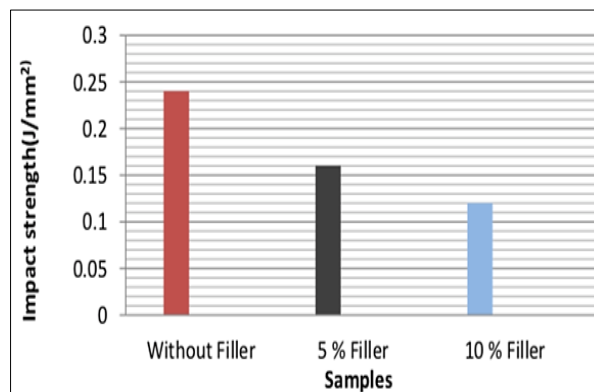


Fig 3.3 Impact Strength

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D. Hardness Test

A Brinell hardness result measures the permanent width of indentation produced by a ball indenter applied to a test specimen at a given load, for a given length of time. Typically, an indentation is made with a Brinell hardness testing machine and then measured for indentation diameter in a second step with a specially designed Brinell microscope or optical system. The resulting measurement is converted to a Brinell value using the Brinell formula or a conversion chart based on the formula. Figure 3.5 shows Brinell test results of hardness test.

Table 3.5 Hardness (BHN)

Without Filler	57.3
5 % Filler	89.8
10 % Filler	101.6

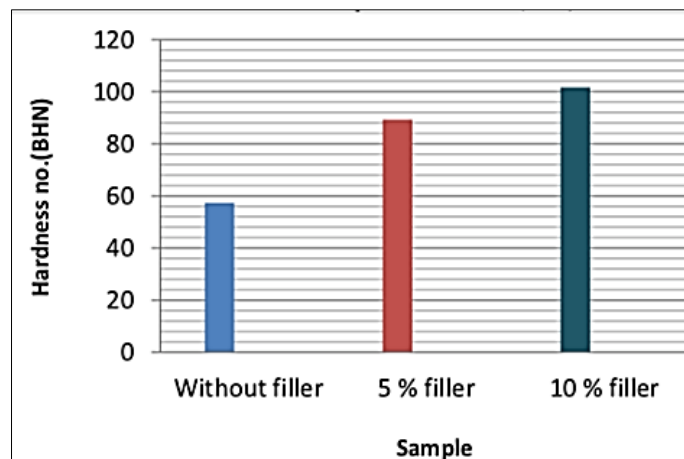


Fig 3.4 Hardness (BHN)

E. Flexural Test

The flexural specimens are prepared as per the ASTM D790 standards. The 3- point flexure test is the most common flexural test for composite materials. Specimen deflection is measured by the crosshead position. Flexural test was carried out for developed composites and it was observed that the flexural strength increases with addition of filler material. In flexural test, load is applied in transverse direction the matrix resist the deformation with the addition of filler material, so that the composite with 5% and 10% Filler material exhibit better flexural strength. Figure 3.5 shows the load versus deflection test results of three point bending test.

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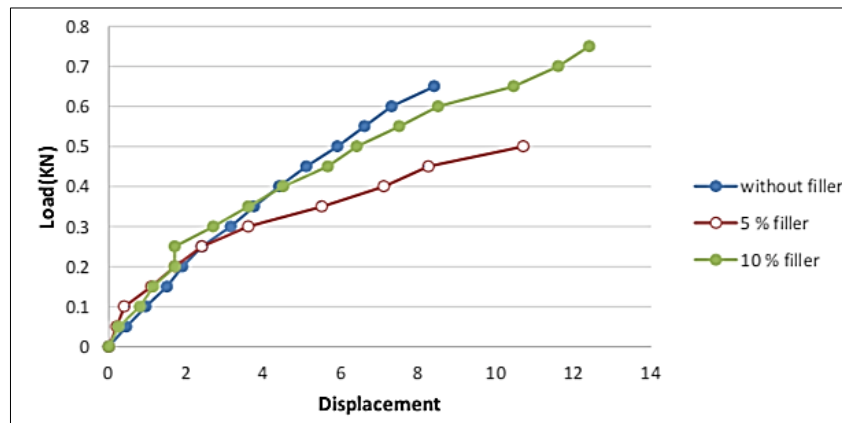


Fig 3.5 Load vs Displacement

V. CONCLUSIONS

This experimental study on evaluating mechanical properties of Glass-Jute hybrid composites has lead to the following conclusions:

1. The water absorption test result shows that water absorption rate is well within the limits, hence is clear that voids in the developed composites is less.
2. The tensile test shows that ultimate tensile strength and load carrying capacity is maximum for the hybrid composite without filler material.
3. The composite filled with 10 % volume coconut shell powder exhibited maximum flexural strength and hardness. The composite filled with 10 % volume coconut shell powder exhibited maximum impact strength.

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