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FABRICATION AND TESTING OF HEMP FIBRE REINFORCED EPOXY COMPOSITES

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Abstract

Over the last decennium, composites of polymers reinforced with natural fibers have attracted field both from the academic world and from various industries. The most important of the natural fibers used in composite materials are flax, hemp, kenaf and sisal due to their properties and availability. Natural fibers based on cellulose have a low density, high stiffness and strong compared to those of glass fibers. For the automotive industry, where weight reduction always is an issue, this was said to be the original reason for the development of interior parts with natural fibers as fillers. The works evaluate study of mechanical behavior and develop a polymer matrix composite using hemp fiber by varying percentage weight fraction of hemp fibers by using hand lay-up method. The fabricated composite samples were trimmed according to the ASTM standards for different experiments and its characterization is performed.

***Keywords**:* Natural fibers, Hand lay-up method, Polymer matrix composite

1. INTRODUCTION

With the growing global energy crisis and ecological risks, natural fibers reinforced polymer composites have attracted more research interests due to their potential of serving as alternative for artificial fiber composites [1-3]. Accordingly, extensive studies on the preparation and properties of thermoplastic and thermosetting composites filled with the natural fibers such as cotton, bamboo, sisal, coir, jute, hemp, flax, pineapple leaves, etc., were carried out. Compared with synthetic fibers such as glass fibers or carbon fibers, natural fibers have many advantages like high specific mechanical performance, renewable, low cost, lightweight, environmental friendly etc .Natural fibers are complex, three dimensional, composed of cellulose, hemicellulose, pectin & lignin. These hydroxyl ions containing polymers are distributed throughout the fiber wall. Natural fibers can be considered as consisting of mainly cellulose fibrils (fibers) embedded in lignin matrix (resin).They also contain lesser amounts of additional extraneous components including low molecular wt. organic compounds (extractives) &

inorganic matter (ash). Though often small in quantity, extracts can have large influences on properties such as color, odor and decay resistance. Natural fibers are added to plastics or polymer omposites to improve mechanical performance such as stiffness & strength without increasing the density or cost too much. They are lighter than inorganic reinforcements which can lead to benefits for the automotive industry, where weight reduction always is an issue, this was said to be the original reason for the development of interior parts with natural fibers as fillers. Hemp fibres are finding increasing use as reinforcements in composite materials, often replacing glass fibres. Found in the bast of hemp plant, these fibres have specific strength and stiffness that are comparable to those of glass fibres [4-7]. Hemp fibre is one of the most important natural fillers produced in tropical countries like India, Malaysia, Indonesia, Thailand, and Sri Lanka. Many works have been devoted to use of other natural fillers in composites in the recent past years. Hemp fibre is a potential candidate for the development of new composites because they have high strength and modulus properties along with the added advantage of the high lignin content. The high lignin content makes the composites made with these filler more weather resistant and hence more suitable for application as construction materials. Hemp fibre is also extensively used to make products like furnishing materials, rope etc. The fibre also absorbs less moisture due to its low cellulose content the report focuses on studying the effectiveness of Hemp fibre as a source of natural material for reinforcing epoxy resins towards their flexural properties. The potential of hemp has already explored in terms of various applications, however their use in polymer matrix composites has very rare. To this end, the present research work is undertaken to study the processing, characterization of hemp fibre reinforced epoxy composites. Attempts have also been made to explore the possible use of a natural fiber for making value added product.

2. MATERIALS AND METHODS

Materials and equipment

The raw materials used in this research work are as follows: hemp Fibre, epoxy resin, hardener, Teflon sheet, silicone spray, wooden mould and miscellaneous items. The equipment used are weighing scale, cloth, stirrers, measuring jar, universal testing machine.

2.1 Composites manufacture method

In this study, samples of laminates were made by using hand lay-up method. The technique used in this investigation was employed due to its simplicity and availability of the items. The mould release spray is applied at the inner surface of the mould wall for easy removal. The hemp fibers with different fiber percentage (i.e. 4,7,10 and 13 wt %) are mixed with matrix material consisting of epoxy resin and hardener in the ratio of 10:1 by the simple mechanical stirring. Care was taken to avoid formation of air bubbles during pouring. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 24 hrs. During the application of pressure some polymer squeezes out from the mould. For this, care has already been taken during pouring. After one day the samples were taken out of the mould, cut into different sizes for further experimentation. Figure 1 shows the photograph of the samples.

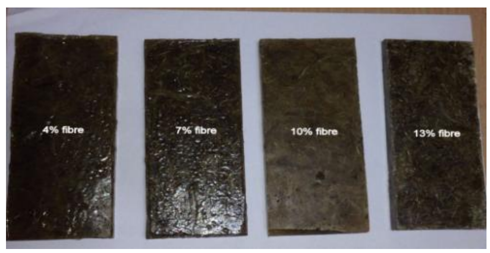

Figure: 1 Samples of the hemp fibers with different fiber percentages by weight

Measurement

2.2 Density

Density is one of the most important mechanical properties of the particle board material. The density of hemp reinforced composite for different fiber percentages are calculated.

2.3 Tensile strength

The tensile test is generally performed on flat specimens. The most commonly used specimen geometries are the dog-bone specimen (Figure 2). The standard test method as per ASTM D 3039-76 [8] has been used; The value of gauge length (L), width (d) and thickness (t)of the test specimen used in the experimentation as 140 mm, 30 mm and 10 mm and tensile strength were calculated from this test.

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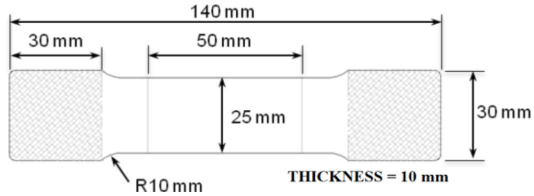


Figure: 2 Line diagram of tensile test specimen

2.4 Short beam strength

This test method determines the short-beam strength of high-modulus fiber reinforced compositematerials.

Figure 3 describes the specimen configuration and based on ASTM D2344, the values of short beam strength are evaluated.

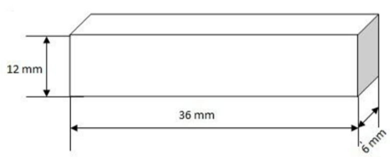


Figure: 3 Short beam test specimen configuration (dimensions in mm)

2.5 Charpy impact test

An impact test measures how much energy is absorbed when an object fractures or breaks under a high speed collision and impact strength is determined as per ASTM D2794.In each case three specimens are tested to obtain the average value

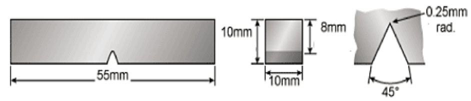


Figure: 4 Impact test specimen dimensions as per ASTM standards

2.6 Compressive strength

Some materials fracture at their compressive strength limit, other deform irreversibly so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. As per ASTM D695 the specimen size should be 10mm x 10mm x 4mm.

2.7 Microstructure

The electrons interact with the atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. The surfaces of the composite specimens are examined directly by scanning electron microscope .The samples are washed, cleaned thoroughly, air-dried and are coated with 100 A^0 thick platinum in JEOL sputter ion coater and observed SEM at 30 kV .

3. RESULTS AND DISCUSSIONS

3.1 Density

The density of hemp reinforced composite for different %wt of fibers are presented below the table-1.From the table it is observed that density decreases with increasing hemp fiber content due to the less thickness in the fiber and due to the reduction in the void numbers.

S.No	% Hemp Fiber	Density (g/cm^3)
1	4	1.35
2	7	1.32
3	10	1.09
4	13	1.12

Table: 1 Density of samples

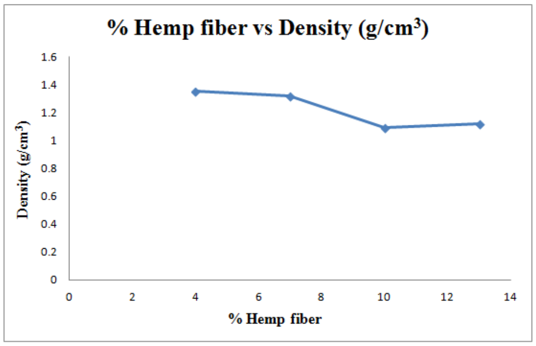


Figure 5: Variation of density with different percentage fiber contents

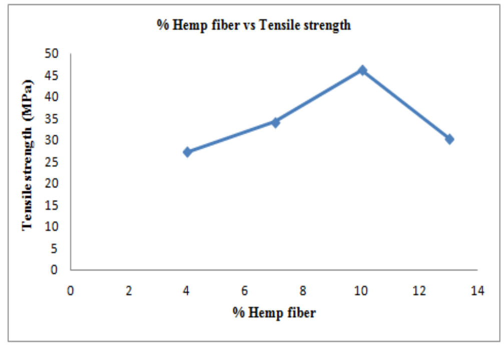


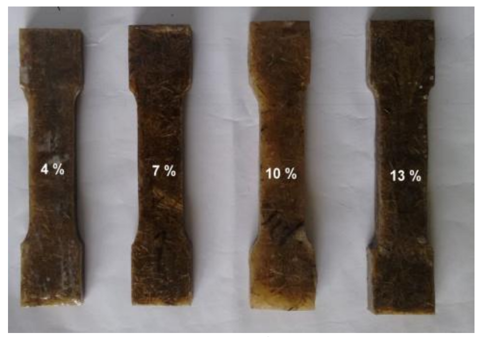
Figure 6: Variation of tensile strength values with different percentage fiber contents

3.2 Tensile test

Table 2 shows the effect of fiber loading on tensile strength of composites. The tensile strength increased by the increase of fiber loading up to 10 wt%. and then decreased at 13 wt% i.e. 46.2 MPa to 30.4 MPa respectively. The sudden drop is due to failure of specimens and the arrest points correspond to breakage and pull out of individual fibers from the resin matrix. This is due to higher stiffness of hemp composite and the improved adhesion between the matrix and the fiber. This decrease is attributed to the inability of the fiber, irregularly shaped, to support the stresses transferred from the polymer matrix and poor interfacial bonding generates partially spaces between fiber and matrix material and as a result generates weak structure. Reason behind increase in tensile strength with increase in percentage of hemp fiber is due to impregnation

S.No	% Hemp Fiber	Tensile strength (MPa)
1	4	27.3
2	7	34.2
3	10	46.2
4	13	30.4

Table 2 Tensile strength of the samples



Specimens before test

Specimens after test

Figure 7: Specimens before and after tensile test

3.3 Short beam strength

Short Beam Shear is used to determine interlaminar shear strength of parallel fibers. In the present investigation all the tests are conducted as per ASTM Standard D2344.

S.No	% Hemp Fiber	Short beam strength (MPa)
1	4	15.2
2	7	12.5
3	10	21.1
4	13	18.3

Table 3: Short beam strength of the samples

It is calculated by formula $F_{sbs} = \frac{0.75 \times P_m}{(b \times h)}$

Where:

F_{sbs} = short-beam strength, MPa

P_m = maximum load observed during the test, N

b = measured specimen width, mm

h = measured specimen thickness, mm

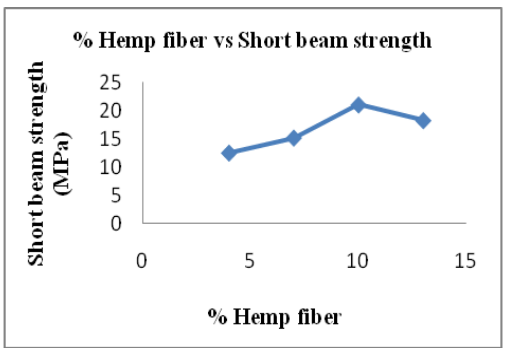


Figure 8: Variation of short beam strength values with different percentage fiber contents

3.4 Impact strength

From the table 4 it is observed that the energy absorbed as the fiber increase with the increase in the percentage of hemp fiber. The decrease in impact strength or smaller variation in strength may be due to induce micro-spaces between the fiber and matrix polymer, and as a result causes numerous micro-cracks when impact occurs, which induce crack propagation easily and decrease the impact strength of the composites.

S. No	%Hemp fiber	Impact Energy(J)
1	4	8.36
2	7	10.89
3	10	15.26
4	13	11.47

Table 4: Impact strength values of the samples

Also energy absorbed by the specimen increases with increase in percentage of the fiber and 10% fiber has the highest energy of absorbed

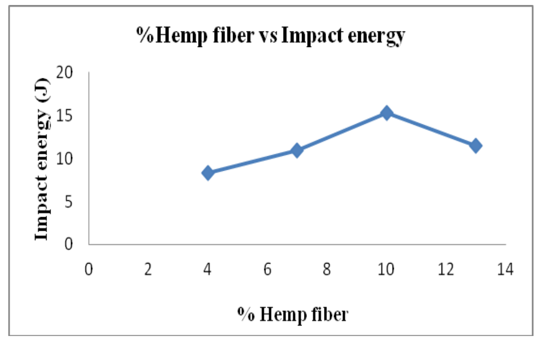


Figure 9: Variation of Impact energy values with different percentage fiber contents

3.5 Compressive strength

Some materials fracture at their compressive strength limit, other deform irreversibly so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. As per ASTM D695 the specimen size should be 10mm x 10mm x 4mm.

S. No	%Hemp fiber	Compressive Strength(N/mm^2)
1	4	101.4
2	7	107.6
3	10	115.2
4	13	91.58

Table 5: Compressive strength values of the samples

This decrease in compressive strength is due to the maximum void contents and weak interfacial adhesion in the case of composites i.e. when the material is stressed in compression test it tends to contract and when the compressive load is applied the bond between hemp fibers and epoxy resin weakens and leads to the loosening of hemp fibers and leads to fracture of material

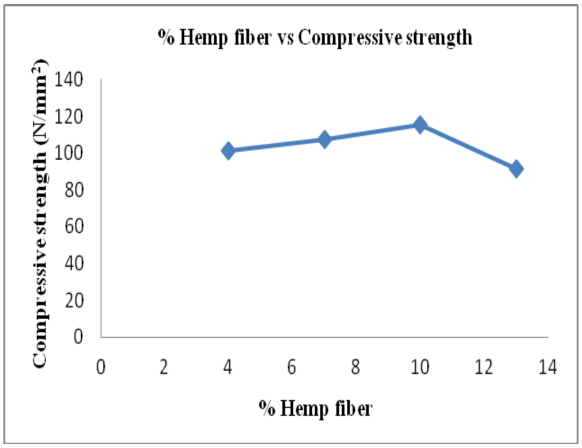
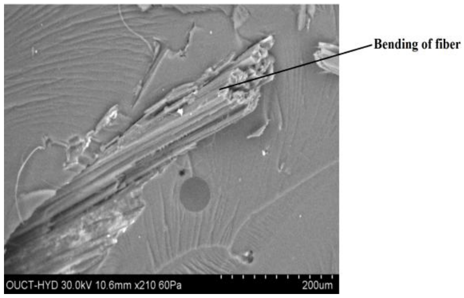


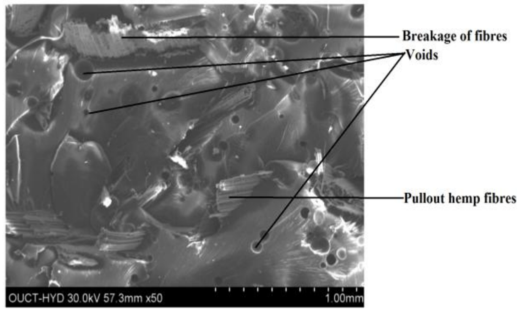
Figure 10: Variation of compressive strength values with different percentage fiber contents

3.6 Scanning Electron Microscope (SEM) Test

Figure 11 shows the SEM image of a fractured surface of only hemp reinforced epoxy composite under tensile load .The fiber breakage and pull out of fiber along loading direction from the matrix is clearly visible. The formation of voids due to fiber pull out is also noticed because of poor resin compatibility with natural fibers. The figure shows the tensile failure of hemp reinforced epoxy composite. The stretching and elongation and bending of hemp fiber are visible due to the applied tensile load. Also breakage of hemp fiber without any stretching is clearly visible. The stretching of hemp fiber indicates that the strength of the composite increased due to the incorporation of hemp fiber, and this supplement to the results The SEM micrograph of flexural specimen for tensile side as indicated in fig of the under flexural load. De-bonding of fiber with the matrix is clearly visible.



(a)



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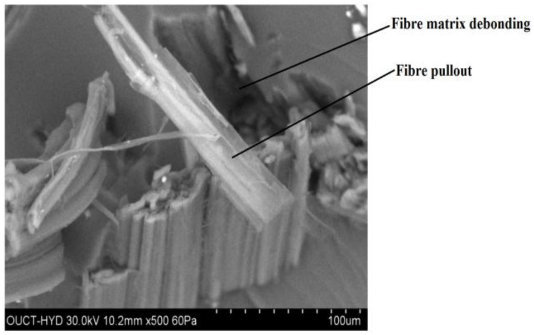

(c)

Figure 11: Micrographs showing the distribution of the reinforcement in the composite

3.7 Comparison of Hemp Fiber Reinforced composite with other Natural Fiber Reinforced Composite

The test results which are investigated with hemp fiber reinforced composite is compared with the properties of other natural fibers which were investigated by several researchers [9].

Mechanical Properties	Banana fiber	Sisal fiber	E-glass	Ukam fiber	Coconut shell Powder	Hemp fiber
Compressive strength (MPa)	16.75	42	37.75	39.25	30.35	**115.2**
Tensile strength (MPa)	6.5	5.4	63	16.25	3.2	**46.2**
Impact strength (J)	7.47	8.36	17.82	9.89	8.36	**15.26**

Table 6: Comparison of Hemp Fiber Reinforced composite with other Natural Fiber Reinforced Composite

4. CONCLUSION

- Hemp fibre reinforced epoxy composites are prepared by using a fabrication method known as hand-lay-up process. The raw material through different stages such as dissolving, preparation of the solution, formation of reinforcement, and drying to get the composite block as per ASTM standards.
- The experiment is conducted in different machines and as per the machine, specific specimen is prepared. From those tests the changes are measured and explained as density decreases with increasing hemp fiber content due to the less thickness in the fiber and due to the reduction in the void numbers.
- The tensile strength increased by the increase of fiber loading up to 10 wt%, and then decreased at 13 wt% i.e. 46.2 MPa to 30.4 MPa respectively . The sudden drop is due to failure of specimens and the arrest points correspond to breakage and pull out of individual fibres from the resin matrix.
- The energy absorbed by the specimen increases with increase in % of the fiber and 10% fiber has the highest energy of absorbed in impact test. In these compression test, the increase in hemp fiber content leads to decrease in the value of the material.
- The different layers of hemp fiber are determined by using Scanning Electron Microscope

References

[1] Bledzki AK, Sperber VE, Faruk O. Natural and wood fibre reinforcement in polymers. Rapra Review Reports, vol. 13, No. 8, Report 152, 2002.

[2] Pritchard G. Two technologies merge: wood plastic composites. Plast Addit Compd 2004; 6:18–21.

[3] Mishra S, Mohanty AK, Drzal LT, Misra M, Hinrichsen G. A review on pineapple leaf fibers, sisal fibers and their biocomposites. Macromol Mater Eng 2004; 289:955–74.

[4] Gowda T. M, Naidu A. C. B, and Chhaya R, “Some Mechanical Properties of Untreated Jute Fabric-Reinforced Polyester Composites”, Journal of Composites Part A:Applied Science and Manufacturing, 30(3), 1999, pp. 277- 284

[5] Luo S, Netravali A. N, “Mechanical and thermal properties of environmentally friendly green composites made from pineapple leaf fibres and poly (hydroxybutyrate-co-valerate) resin”, Polymer Composites, 20(3), 1999, pp. 367-78.

[6] Madhukiran.J, Dr. S. Srinivasa Rao, Madhusudan.S (2013) Fabrication and testing of natural fiber reinforced hybrid composites Banana/Pineapple. International Journal of Modern Engineering Research, pp-2239-2243.

[7] H. Belmares A. Barrera and M. Monjaras “New Composite Materials from Natural Hard fibers. Part Fatigue Studies and a Novel Fatigue Degradation Model”, Industrial Engineering Chemical Product Research and Development, 22 (1983), pp. 643–652.

[8] ASTM D3039/D3039-00, “Standard test method for tensile properties of polymer matrix composite materials,” ASTM International.

[9] Olusegun David Samuel, Stephen Agbo, Timothy Adesoye Adekanye, 2012 "Assessing Mechanical Properties of Natural Fibre Reinforced Composites for Engineering

Applications" Journal of Minerals and Materials Characterization and Engineering, 2012, 11, 780-784.

A Brief Author Biography

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