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Study of Mechanical Behaviour Natural Fibers Reinforced Composite Materials

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***Abstract* – In this work the investigation of experimental study of the evaluation of the different natural fiber as reinforcement with epoxy composites of mechanical properties. Composites were fabricated using Sisal/epoxy, Banana/epoxy, and Fish scale/epoxy in compression molding method. All the combination of the composite are made same % of combination (fiber + Resin) were fabricated. The results showed that tensile strength of the composite increased in sisal fiber/epoxy composite. Impact strength of Sisal fiber/epoxy composite shows good properties when compared with reaming two combinations. Likewise flexural strength of Sisal fiber/epoxy composite was found higher than those two combinations.**

***Keywords* – Mechanical Properties, Banana Fiber, Epoxy, Fish Scale, Sisal.**

I. INTRODUCTION

1.1. *Natural Fiber Reinforced Composites.*

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites.

1.1.1. *Sisal Fiber:*

Fibre is extracted by a process known as decortication, where leaves are crushed, beaten, and brushed away by a rotating wheel set with blunt knives, so that only fibres remain. The extracted fibers are sun-dried which whitens the fiber. Once dried, the fibers are ready for knotting. A bunch of fibers are mounted or clamped on a stick to facilitate segregation. Each fiber is separated according to fiber sizes and grouped accordingly. To knot the fiber, each fiber is separated and knotted to the end of another fiber manually. The separation and knotting is repeated until bunches of unknotted fibers are finished to form a long continuous strand. This Sisal fiber can be used for making variety of products.

Fig. 1. Sisal fibers extraction and fibre bundles

1.1.2. *Banana Fiber*

Banana Fiber is extracted from the banana Plant. The fibers are extracted through hand extraction machine composed of either serrated or non serrated knives. The peel is clamped between the wood plank and knife and hand-pulled through, removing the resinous material. The extracted fibers are sun-dried which whitens the fiber. Once dried, the fibers are ready for knotting. A bunch of fibers are mounted or clamped on a stick to facilitate segregation. Each fiber is separated according to fiber sizes and grouped accordingly. To knot the fiber, each fiber is separated and knotted to the end of another fiber manually. The separation and knotting is repeated until bunches of unknotted fibers are finished to form a long continuous strand. This banana fiber can be used for making variety of products.

Fig. 2. Banana Fibre

1.1.3. *Fish Scale:*

The most of the fish skins are covered with scales. Scales are very large in structure, shape and size, extent, ranging from strong and rigid armour plates in fishes such as shrimp fishes and box fishes, to microscopic or absent in fishes such as eels and anglerfishes. The sharks fishes are covered with placid scales. Many of the bony fishes are covered with the cycloid scales of salmon and carp scales of perch, sturgeons and gars. Fish scales are part of the fish's integumentary system, and are produced from the mesoderm layer of the dermis, which distinguishes them from reptile scales. The fish scale is collected from the local fish market in Coimbatore.

Fig. 3. Fish Scale

1.1.4. *Epoxy:*

Epoxy resins are low molecular weight prepolymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group. The primary reason for epoxy's popularity is its superb mechanical strength. Epoxy is nearly always cheaper and faster than welding. Epoxy also has excellent resistance to chemicals. Engineers are faced with concerns about heat dissipation, electrical insulation, adhering dissimilar substrates, light weighting, sound dampening, vibration, and reduction corrosion.

1.1.4.1. *Preparation of Epoxy and Hardener*

Epoxy LY556 of density 1.15–1.20 g/cm3, mixed with hardener HY951 of density 0.90 to 0.99g/cm3 is used to prepare the composite plate. The weight ratio of epoxy and hardener is 10:1.

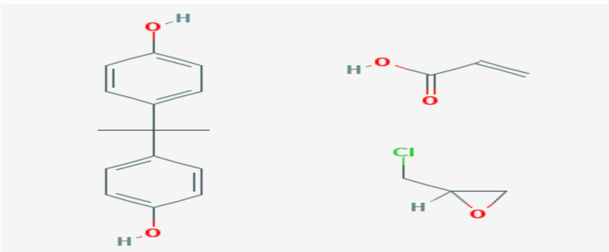

Fig. 4. Epoxy Resin Molecular Structure

II. Methodology

Compression molding is one of the original processing methods for manufacturing plastic parts developed at the very beginning of the plastics industry. In fact, it was widely used in the bakery industry for cookie or cake molding before plastic materials existed. Although it is also applicable to thermoplastics, compression molding is commonly used in manufacturing thermoset plastic parts. The raw materials for compression molding are usually in the form of granules, putty-like masses, or preforms. They are first placed in an open, heated mold cavity. The mold is then closed and pressure is applied to force the material to fill up the cavity. A hydraulic ram is often utilized to produce sufficient force during the molding process. The heat and pressure are maintained until the plastic material is cured. The most common method is Dough Moulding Compound (DMC) or Bulk Moulding Compound (BMC). Thermosetting resins are used in a partially cured state, either in the form of granules, putty-like masses or perform. The preheated material is placed directly into a heated mould. The material is forced into all cavities when the mould is closed with a top force. Heat and pressure are maintained until the material is cured. Another method is Sheet Moulding Compound (SMC). This process involves placing a reinforcing material, such as glass fibres, between layers of a thermoplastic and heating the materials so as to bond them together into a single sheet of material. This is then cut to size and reheated before being placed in a compression moulding press. This has a higher cost due to the handling and manufacturing costs in making the sheet. The material used in making the sheet is also heated three times – when making the initial thermoplastic sheet, then again when bonding with the reinforcement and finally, when making the part itself.

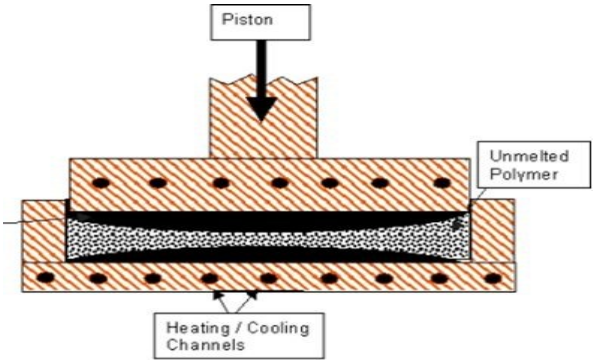

Fig. 5. Compression Moulding.

III. Preparation of Samples

For the sample preparation the first and foremost step is the preparation of the mould which ensures the exact dimension of the composite to be prepared. Prepare the mould for the preparation of 30%, 35%, fiber of the composite. The weight percentage of basalt fiber in the polyurethane composites determined. They next for The functions of these plates are to cover, compress the fiber after the polyurethane is applied, and also test samples according to tensile strength [ASTM D3039] of size 3x25x250mm, Flexural Modulus [ASTM D790] of size 3x12.7x50.8mm, Shear modulus of size 3x12.8x50mm were prepared from the cured sheet using cut off machine. As, the same procedure was repeated for using the resin only the ratio will be changed.

3.1. *Details of Specimen*

The size of the laminate is 290 x 290 x 3. From this laminate the specimens are carried out. The commonly used specimen for tensile test is the flat type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250 x 25 x 3) mm typical points of interest when testing a material include: ultimate tensile strength or peak stress; offset yield strength which represents a point just be-yond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates into pieces. The tensile test is performed in the universal testing machine in strong 1195 and results are analyzed to calculate the tensile strength of composite samples. For flexural test Sample was cut into flat shape 130 x 13 x 3 mm, in accordance with ASTM standards. For impact test, the test sample dimension is 60 x 13 x 3 mm.

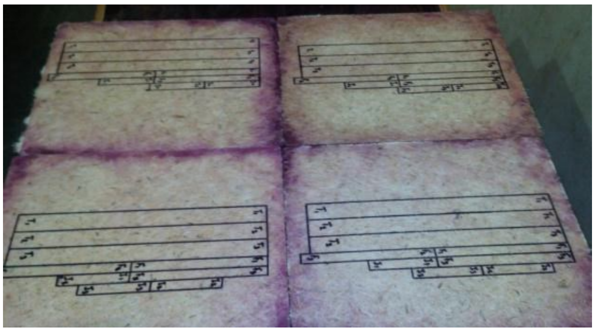

Fig. 6. Samples Composite Plates.

3.2. *Standard Specimen Sizes*

- Tensile testing (ASTM D3039)
- Flexural testing (ASTM D750)
- Impact testing (ASTM D256)

3.3. *Mechanical Testing*

In this project mainly investigating the some of the mechanical properties such as tensile properties, flexural properties, fatigue properties.

3.3.1. *Tensile Testing*

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the flat type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250 x 25 x 3) mm.

3.3.2. *Flexural Testing*

Flexural strength is defined as a materials ability to resist deformation under load. The short beam shear tests are performed on the composites samples to evaluate the value of inter laminar shear strength. It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conducted as per ASTM standard using UTM. The dimension of the specimen is (130 x 13 x 3) mm.

3.3.3. *Impact Testing*

Impact test was carried out on Izod impact tester. The specimens are cut from the fabricated composite plates in accordance with ASTM D-256. The specimen size for impact test is 60 x 13 x 3 mm.

IV. Results and Discussions

This chapter presents the mechanical properties of the various fibers like sisal, banana, Fish scale /epoxy, composites prepared for this present investigation. Details of processing of these composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here. These includes evaluation of tensile strength, flexural strength, impact strength has been studied and discussed.

4.1. *Tensile Test*

Tensile testing of specimen prepared according to ASTM D 3039 type IV sample was carried out, using electronic tensile testing machine with cross head speed of 2mm/min and a gauge length of 115 mm. The tensile modulus and elongation at beak of the composites were calculated from the stress strain curve. Four specimens were tested for each set of samples and mean values were reported.

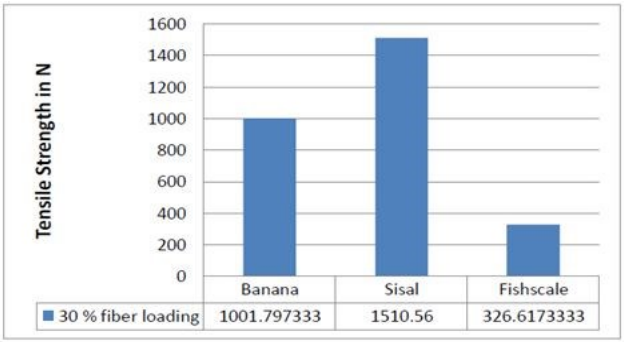

Fig. 7. Tensile properties of various natural fiber/epoxy composite

The tensile strength of various fibers/epoxy composites is shown in Figure 7. It can be clearly seen that the tensile strength of the samples increases in sisal fiber/epoxy composites and banana and fish scale natural fibers composite were less in tensile strength when compared sisal/epoxy composite material. The range of the tensile strength was between 326.617 to 1510.56 N. The maximum tensile stress value of the composites was 1510.56 N for sisal/epoxy composites. The tensile strength of a composite material is mainly dependent on the strength and modulus of fibers, the strength and chemical stability of the matrix and fibers in transferring stress across the interface. when fiber reinforced composites are subjected to load, the fibers act as carries of load and stress is transferred from the matrix along the fibers leading to effective and uniform stress distribution, which results in a composite having good mechanical properties.

4.2. *Flexural Test*

The flexural test was performed by the three point bending method according to ASTM D 790, and cross head speed of 1 mm/min. three specimens were tested, and the average was calculated. The specimen was freely supported by a beam, the maximum load was applied in the middle of the specimen, and the flexural modules are calculated from the slope of the initial portion of the load deflection curve.

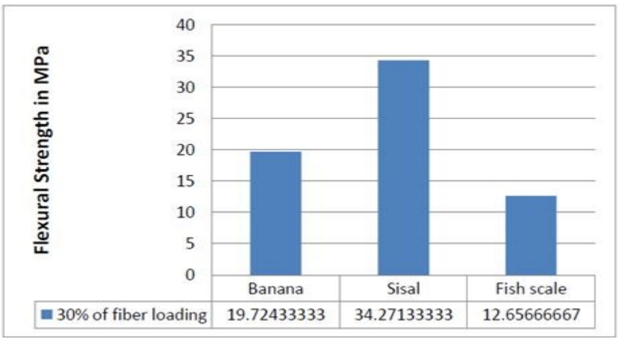

Fig. 8. Flexural properties of various natural fiber/epoxy composite

The flexural properties of various natural fiber/Epoxy composites shown in figure 8. Flexural strength is a combination of the tensile and compressive strength and varies with the interfacial shear strength between the fiber and matrix. Flexural test in various mechanisms such as tensile, compressive, shearing etc. will take place simultaneously. In order to achieve effective fiber reinforcement, interfacial strength between the fiber and matrix is the most essential factor. It was observed from figure 8 that the flexural strength and modulus of sisal/epoxy composite is highest flexural strength when compared with remaining two various natural fiber/epoxy composites. The maximum flexural stress of the composite was 34.271 N. The range of the flexural strength was between 12.656 to 34.271 N.

4.3. *Impact Test*

The relationship between fibre loading and impact strength is shown in Figure 9. The impact property of a material shows its capacity to absorb and dissipate energies under impact or shock loading. The impact energy level of the composites depends upon several factors such as the nature of the constituents, construction and geometry of the composites, fibre arrangement, fibre/matrix adhesion, and test conditions. The matrix fracture, fibre matrix debonding, fibre breakage and fibre pull out are important modes of failure in the fibre composites due to impact loading. The applied load, transferred by shear to the fibres, may exceed the fibre/matrix interfacial bond, and debonding may occur.

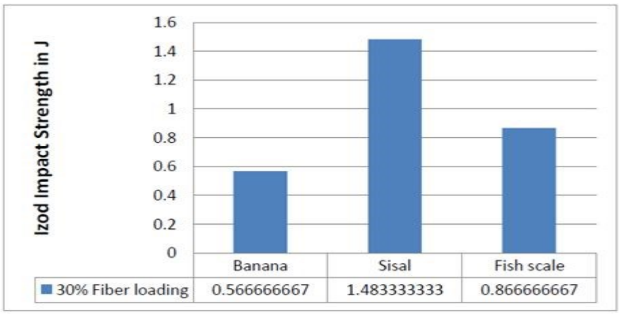

Fig. 9. Impact properties of various natural fiber/epoxy composite

The frictional force along the interface may transfer the stress to the debonded fibre. If the fibre stress level exceeds the fibre strength, fibres may breakage. The breakaged fibres may be pulled out of the matrix, and this involves energy dissipation. The impact strength of sisal fiber/epoxy composite was found to high level impact strength. These results suggest that the fibre is capable of absorbing energy because of strong interfacial bonding between the fibre and matrix composite. The range of the impact strength was between 0.5667J to 1.4833J. The maximum impact strength was found in sisal/epoxy composite 1.4833J.

V. Conclusion

In this work, mechanical properties of various natural fibers/epoxy composites were investigated. The tensile, flexural and impact properties of the composites as a function of various natural fibers of manufacturing were analysed.

- The tensile strength of Sisal fiber/epoxy composite is high when compared with Banana/epoxy, Fish scale/epoxy combination.
- The flexural strength of Sisal fiber/epoxy composite is best value when compared with other two combinations.
- Impact properties of Sisal fiber/epoxy composite is better value when com-pared composite.

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