ANALYSIS OF MECHANICAL PROPERTIES OF SISAL, JUTE, COIR FIBRE (HYBRID) REINFORCED EPOXY COMPOSITES

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Abstract

In last few years, many new composites are being developed day by day because of their high specific mechanical strength. In this work, analysis of mechanical behavior of sisal, jute and coir fiber reinforced epoxy (LY551) composite was studied. Composite laminates were prepared by mixing sisal, jute and coir fiber and epoxy with proper curing agents by compression molding method. This was placed on the matched plate mold and pressed at 1500PSI for 24 hours at 1000C temperature. The sisal, jute and coir fiber reinforced epoxy Resin Composites were manufactured at various ratios such as (15:5:15, 15:10:10 & 15:15:5 gm.). The composite proportion ratio between fiber and resin was taken as 35:65. We would like to analyze and evaluate the Mechanical Properties of Sisal Jute and Coir Fiber reinforced epoxy resin composites by testing the Tensile Strength, Impact and Water Absorption capacity.

Key words: Mechanical Properties, Sisal, Jute and Coir Fiber, Epoxy Resin

I. INTRODUCTION

Concerning the environmental and ecological issues, natural fibers have the point of attention for the polymer composite due to their advantage over the glass and carbon fiber composite. The importance of the natural fiber polymer composite is increasing the industrial and human application. Natural fibers have a lot of advantages compare to synthetic fiber such as renewable, cheap, bio-degradable and partially or fully recyclable. Engineering materials are produced by synthetic fiber and natural fiber. Synthetic fibers are made by a specific proportion of various constituents and methods in all over the world due to such reason their mechanical and thermal properties do not vary much. But the natural fiber has unique properties because of natural fiber-planted in a natural environment with the help of sun, soil, water and air. The natural conditions are not same all over the world. The natural conditions vary place to place and season to season which affect the mechanical and thermal properties of the natural fiber. The mechanical behavior of natural fiber polymer composite influenced by fiber, matrix, and interface between the fiber and matrix interface. Epoxy thermosets can be used with natural fiber for natural polymer composite. From lots of previous research, it is observed that sisal fiber has less interaction with epoxy resin but we try to overcome interaction problem of sisal fiber with epoxy resin by adding jute and coir fiber to the composite. The Jute and coir fiber makes a good interaction fiber with the composite. Sisal fiber has several advantages in terms of product design flexibility, insulation, and noise-absorption and impact resistance. Due to these properties sisal reinforced composite used in building material (like roofing

sheets etc.), locomotive (like gear case, main doors etc.), automobile (like German automotive industry, Door panel of E-class Mercedes etc.), aerospace and military (like transportation vehicle, safety equipment etc.) applications.

II. METHODOLOGY

A. Materials

a. Sisal Fiber

Sisal fiber is obtained from the leaves of the plant *Agave* sisalana, which was originated from Mexico and is now mainly Cultivated in East Africa, Brazil, Haiti, India, and Indonesia. It is one of the most extensively cultivated hard fiber in the world and it accounts for half the total production of textile fibers. The fibers are extracted through hand extraction machine composed of either serrated or non-serrated knives. The extracted fibers are sun-dried which whitens the fiber. Once dried, the fibers are ready for knotting. A bunch of fibers is 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. This Sisal fiber can be used for making a variety of products.

Properties	Sisal fiber
Density (g/m^3)	1.5
Elongation at break (%)	2-2.5
Tensile strength(MPa)	511-700
Young's modulus (GPa)	9.4-22
Ash (%)	0.6-1

Table 1. Properties of Sisal Fiber

b. Jute Fiber

Jute fiber is 100% bio-degradable and recyclable and thus environmentally friendly. It is a natural fiber with golden and silky shine and hence called The Golden Fiber. It is the cheapest fiber extracted from the bast or skin of the plant's stem. It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, jute is very suitable for agricultural commodity bulk packaging.Jute takes nearly 3 months, to grow to a height of 12–15 ft, during the season and then cut & bundled and kept immersed in water for ‘‘Retting" process, where the inner stem and outer, gets separated and the outer plant gets ‘individualized', to form a Fiber.

Advantages of jute include good insulating and antistatic properties, as well as having low thermal conductivity and a moderate moisture regain. Other advantages of jute include acoustic insulating properties and manufacture with no skin irritations. Jute has the ability to be blended with other fibers, both synthetic and natural, and accepts cellulosic dye classes such as natural, basic, vat, sulfur, reactive, and pigment dyes.

Properties	Jute fiber
Density (g/m^3)	1.3
Elongation at break (%)	1.5-1.8
Tensile strength(MPa)	393-773
Young's modulus (GPa)	26.5
Cellulose (%)	61-71
Ash (%)	0.5-2

Table2. Properties of Jute Fiber

c. Coir Fiber

Coir or coconut fiber is a natural fiber extracted from the husk of coconut and used in products such as floor mats, doormats, brushes. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. The coir fiber is relatively waterproof, and is one of the few natural fiber resistant to damage by saltwater. Fresh water is used to process brown coir, while seawater and freshwater are both used in the production of white coir.

Properties	Coir fiber
Density (g/m^3)	1.40
Tenacity (N/mm^2)	10
Breaking Elongation (%)	30
Moisture at 65% RH	10.50
Cellulose (%)	43.44
Water soluble (%)	5.25

Table3. Properties of Coir Fiber

B. Mould Preparation

The sisal, jute and coir fiber is taken in a quantity of 500gm of each fiber for mould preparation. The epoxy resin is mixed with the hardener in the ratio 10:1. The resin and hardener are mixed and stirred continuously 15 minutes. The composite mold is prepared with fiber and resin in a ratio of 35:65.Three sample composite plate is prepared by having different fiber ratio. In sample 1, the ratio of sisal, jute and coir fiber is 15:5:15 gm. Sample 2 is prepared with the fiber ratio 15:10:10 gm. Then sample 3 is prepared with the fiber ratio 15:15:5 gm. The sample plates are prepared using compression moulding method with the size of 290*290*3 mm.

III.MECHANICAL TESTING

A. Tensile test

The sisal-jute-coir hybrid composite material fabricated is cut into required dimensions using a cutter. The specimen used for the tensile test is prepared according to the ASTM D3039 standard. The dimensions, length, cross-head speed are chosen according to the ASTM D3039 standard. The dimension of the specimen is 250*25*3 mm. The tensile test is carried out by mounting the specimen in the machine and tension is applied. The test process continues until the fracture occurs in the specimen when the continuous tensile load is applied. The tensile force is recorded as a function of the increase in gauge length. During the application of tension, the elongation of the gauge section is recorded against the applied force.

The Universal Testing Machine is used to perform the tensile test. There were three different compositions of fiber is used to test the tensile strength. The three composition of three fibers sisal, jute, and coir are 15:5:15, 15:10:10, 15:15:5 which are considered has sample 1, 2 &3. The testing process is repeated several times and average values are used for the analysis.

B. Impact Test

The specimen used for the impact test is prepared according to the ASTM D256 standard. The dimension required for the ASTM D256 standard is 65*13*3mm. There were two types of test were available to test the impact strength. Izod test is taken for the testing of impact strength. The specimen to be tested is placed on the machine and the sudden impact load is applied on the specimen. By the having the impact test, the energy needed to break the material can be measured easily and also can be used to measure the toughness of the material and the yield strength. The strain created by the impact load on the fractured area of the specimen and ductility can be measured by the impact test.

C. Water Absorption Test

The specimen used for the water absorption test is prepared in a certain dimension 20*20*3 mm. The weight of the each specimen which is to undergone water absorption test is measured separately. Then the specimens were immersed in the water for almost 48 hours.After 48 hours, the specimens were weighed separately and weights for each specimen is noted. By having the weights of the specimens before immersed in water and after immersion in water, the water absorption of the each specimen is calculated by using a formula.

IV. RESULTS AND DISCUSSION

In this analysis, the composite made of sisal, jute and coir fibers reinforced epoxy resin is subjected to mechanical testing. The test results for tensile, impact and water absorption test for three different compositions of the composites were discussed and analyzed.

A. Tensile Strength

The different composition of the composite samples are tested in the Universal testing machine and the samples are allowed to break till the ultimate tensile strength occurs. The load is applied to each various composition of the composite until the ultimate tensile strength occurs.

The sample 1 containing the fiber ratio 15:10:10 gm. of sisal, jute and coir fiber has the high ultimate tensile strength of
20.78 N/mm^2. The composite sample 2 with fiber ratio of 15:5:15 gm. has a low ultimate tensile strength of 15.25 N/mm^2. Sample 3 withfiber ratio of 15:15:5 gm. has ultimate tensile strengthof 19.96N/mm^2

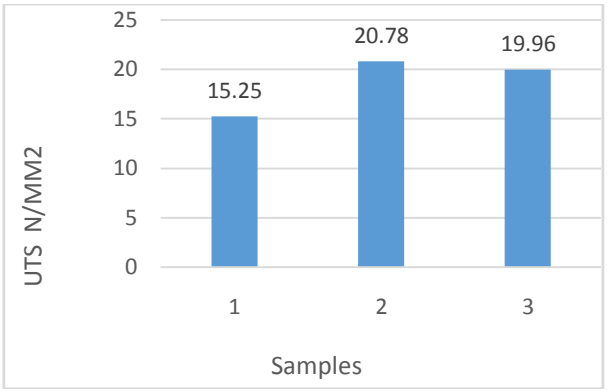

Fig1. Ultimate tensile strength

B. Impact Strength

For analyzing the impact capability of the different composition of specimens, an impact test is carried out. The impact test is carried out for the present investigation is Izod impact test. The sample 1 containing the fiber ratio 15:5:15 gm. of sisal, jute and coir fiber has the high impact strength of 0.4166J. The other composite sample 2 containing the fiber ratio 15:10:10 gm. of sisal, jute and coir fiber has the high impact strength of 0.433J. The composition sample 3 with fiber ratioof 15:15:5 gm. impact strength of 0.4166J.

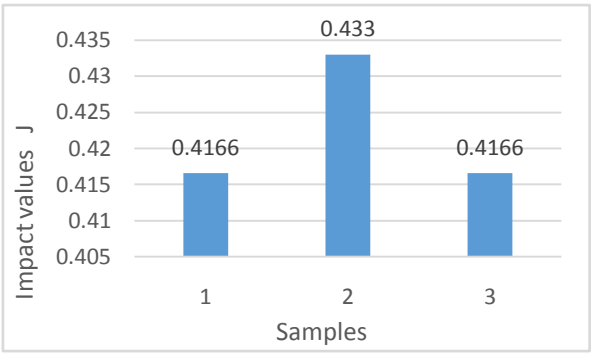

Fig2. Impact strength

C. Water Absorption

The water absorption test is taken for three different specimen composites. The sample 2 with fiber ratio 15:10:10 gm. has good water absorption rate of 22.5%. The sample 1 with fiber ratio 15:5:15 gm. has water absorption rate of 34.53%. Then the sample 3 with fiber ratio 15:15:5 gm. has poor water absorption rate of 36.03%.

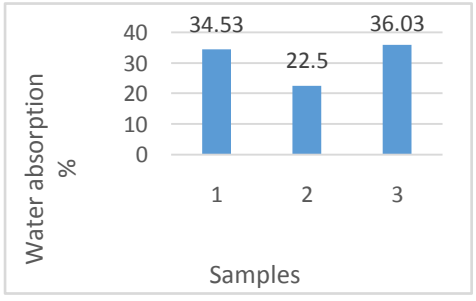

Fig3. Water Absorption

V.CONCLUSION

The sisal, jute and coir fiber composite samples are fabricated with three different proportions of fibers. This hybrid composite is subjected to mechanical testing such as tensile, impact and water absorption test. By analyzing the results of this tests, the following conclusions are drawn.

The results show that composite specimen with fiber ratio 15:10:10 gm. which was the sample 2 has a high ultimate tensile strength and can hold the strength up to 20.78N/mm^2. And high impact strength 0.433J and low water absorption 22.5%.

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