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Development, Testing and characterization of Epoxy-Cotton Fiber - Polymer Composites

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ABSTRACT

Natural fibers have been used to reinforce materials for many years. More currently they have been employed in combination with plastics. Many types of natural fibers have been investigated for use in plastics including flax, hemp, jute, cotton and banana. Natural fibers have the advantage that they are renewable resources and have marketing appeal. These agricultural wastes can be used to prepare fiber reinforced polymer composites for commercial use. Application of composite materials to structures has presented the need for the engineering analysis. The present work focuses on the fabrication of polymer matrix composites by using the natural fibers like coir, banana and cotton which are abundant in the nature. The material characteristics (flexural modulus, flexural rigidity, hardness number, % gain of water) of the fabricated polymer matrix natural fiber composites has been studied by conducting tests like flexural test, hardness test, water absorption test, impact test, density test, on sections of the material. The aim of the present study is to examine the mechanical properties of the cotton fiber reinforced epoxy based composites. Cotton fibers with varying number of ply's are reinforced in epoxy resin to manufacture composite materials. The outcome of cotton fiber content on the mechanical behavior of composites has been studied.

Keywords: Epoxy Resin, Cotton Fiber, Reinforcement, Polymer Matrix Composite.

I. INTRODUCTION

Composite materials has attracted researchers all over the world due to its unique feature of having property of both its constituents .Hence it becomes possible to have a material with all the desired properties. It becomes boon for many industries like Aerospace, Military, Automotive and many other industries. Composite materials are gaining popularity due to having following properties: High strength and Stiffness. Light weight ease of fabrication, less expensive, high corrosion resistance, High wear resistance, High chemical resistance, High toughness and High environmental degradation resistance. Material with these characteristics are desirable in aerospace military automobile and many industry Typical engineered composite materials includes :Mortars, Concrete Reinforced plastics, such as fibre reinforced polymers, Metal composites, Ceramic composites (Composite ceramics and metal matrices) Composite materials are generally used for bridges building and structures. Most advanced usage includes spacecraft and aircraft in demanding environment. Polymer Matrix Composite consists of a polymer resin matrix combined with fibrous reinforcing dispersed phase. Reinforcement in a polymer matrix composite provides high strength and stiffness. Polymer Matrix Composite is very popular due to their low cost and simple fabrication method. The PMC is designed so that the mechanical loads to which the structure is subjected in service are supported by the reinforcement. The function of the matrix is to bond the fibres together and to transfer loads between them. The advantages of PMCs are their light weight coupled with high stiffness and strength along the direction of the reinforcement.

This combination is the basis of their usefulness in aircraft, automobiles, and other moving structures. Other desirable properties include superior corrosion and fatigue resistance compared to metals.

II. EXPERIMENTAL DETAILS

2.1 Material

Following material have been used for the reinforcement of polymer matrix composite

a. Matrix material: Epoxy Resin

b. Reinforcement: Layers of cotton fiber with percentage variation i.e. 0%, 20% and 30% cotton fiber.

2.2 Fabrication of Composites

Composite materials can be synthesized by various methods such as compression molding, injection molding, hand lay-up method etc. We have used Hand lay-up process to prepare sample. 154 gm of pure epoxy is taken and The Epoxy is being heated up to 75^0C treated to decrease its viscosity in the furnace. Resin is taken out from the furnace after getting the desired temperature. Once the mixture reaches to the room temperature, hardener (HY-951) is mixed in the ratio of 15:1, i.e. in 154 gm of epoxy 11 gm of hardener is added. As the reaction after adding the hardener is exothermic it emits heat and starts getting hard in next 10 to 15min.Dies are preheated and a coat of mould relief agent is applied on the inner surface to facilitate easy removal of the die after curing. After mixing of hardener, the mixture is poured in preheated shoulder die at 80°C and one layer of epoxy is spread on the base of plate die, and then a layer of cotton fiber mat is kept followed by pressing it uniformly with the help of hand roller to remove any air gaps. The same procedure is repeated for the second and third layer of cotton fiber mat. At the end of this step a composite plate sample is ready with Epoxy and layers of cotton fiber mat. And then when solidification starts the upper plate is closed and the lower and upper dies are screwed. Then both the dies are left for 10 to 12 hrs curing at room temperature and then the samples are removed from the die.

2.3 Characterization of composite

A numbers of tests are performed to analyze the mechanical behavior of the composite.

2.3.1 Tensile Testing

Tensile test are performed to measure the ability of material to withstand stress in tension. In this test sample is analyzed under control tension until failure of material occur. A result from tensile test provides measure for selecting a specimen for applications. It predicts the behavior of the material under different types of forces. Maximum elongation, young's modulus, poison's ratio; yield strength, reduction in area and ultimate tensile strength can be calculated by this test.

2.3.2 Flexural Testing

Flexural test is performed to find out the strength of material before breaking during bending. It also provides values of flexural strain, flexural stress and flexural stress strain behavior of the material. Generally three point bending test is used to analyze the behavior of the composite. For this test sample preparation is simple, however results are sensitive to strain rate and specimen loading geometry.

2.3.3 Impact Testing

To understand the toughness of any material impact tests are suitable test. In this test, the test is performed to understand the toughness of material. During the test, specimens are subjected to large amount of force for a very small period of time. This test indicates the energy absorption capacity of a material before failure. Large impact energy simply refers to high plasticity and high toughness.

The mechanical behavior of cotton fiber polymer composite with epoxy resin has been described here. Mechanical tests were carried out using at Central Institute of Plastics Engineering and Technology (C.I.P.E.T.), Bhopal. Specimens were developed according to ASTM sample specification for polymer and plastic materials.

III. RESULTS AND DISCUSSION

3.1 Mechanical Properties of Cotton fiber polymer composite

Table 3.1 Reading of Mechanical Test

Fiber Composition in %	Tensile Strength (MPa)	Flexural Strength (MPa)	Impact Strength (KJ/m²)
0	36.29	91.23	12.44
20	37.04	58.78	7.95
30	45.35	62.81	10.47

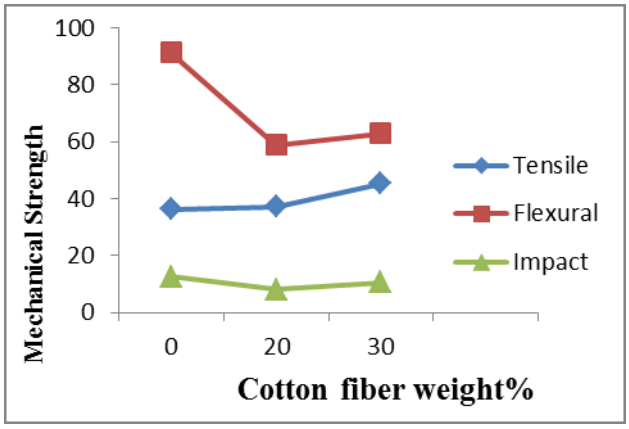

Figure 3.1 Effect of variation of cotton fiber weight% on Mechanical properties

3.2 Discussion

The results show that Tensile strength increases as the weight percentage of cotton fiber is increased. The value of tensile strength varies from 36.29 to 45.35 MPa. The maximum tensile strength is of 45.35 MPa in case of 30 % of cotton fiber. The increase in the tensile strength with the increased weight percentage of cotton fiber may be due to the fact that the cotton fibres have more tensile strength than the epoxy. Good adhesion between the Cotton fiber and matrix is also responsible for the good resistance to crack propagation during the test.

The results show that with increase in wt. Percentage of cotton fiber, flexural strength first decreases and then increase. The decrease in flexural strength with 20% cotton may be due to decrease in thickness of 20% cotton fiber sample in comparison to pure epoxy sample and then increase in flexural strength 30% cotton as compare to 20% cotton is due to increase in thickness of 30% cotton fiber sample. The impact test shows pure epoxy sample due to no reinforcement has the more impact Strength as the energy absorption is higher as compared to 20% and 30%

Epoxy+Cotton fiber samples. This interprets that brittle character comes into play after adding cotton fiber.

IV. CONCLUSION

On increasing the percentage of cotton fiber from (0-30%), Tensile strength increases. On increasing the percentage of cotton fiber from (0-30%), flexural strength first decreases for (0-20%) of polymer matrix cotton fiber composites, then increases for (20-30%) of cotton fiber. On increasing the percentage of cotton fiber from (0-30%), Impact energy first decreases for (0-20%) of cotton fiber, then increases for (20-30%) of cotton fiber.

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