International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072
National Conference on "Advances in Mechanical Engineering [AIME-2019]"
Organised by - Department of Mechanical Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India

Evaluation of Mechanical and Water Absorption Behavior of Bamboo Fiber Reinforced Epoxy Composites Filled with SiC Particulate

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Abstract –*In the present work, investigation has been carried out to study the effect of Silicon carbide on bamboo fibers. Based on mechanical testing results, it is found that bamboo fiber mixed with silicon carbide is giving optimum mechanical properties. The addition of Silicon carbide on bamboo fibers has improved tensile, flexural strength. The water absorption tests were performed on immersing specimens into three different water conditions, namely normal, distilled and salt water. Specimen preparation and water absorption studies carried out as per ASTM standards. On the basis of overall study the Silicon carbide with bamboo fiber reinforced epoxy composites is found to be better combination and suitable for fabrication of engineering products.*

Key Words: Bamboo fibre, Polymer matrix composites, Hand layup, Epoxy resin, Mechanical properties, Water Absorption properties.

1.INTRODUCTION

Composites or composite materials are available in nature or engineered fusing two or more materials with considerably different chemical and physical properties, which remain distinct at microscopic or macroscopic level within the finished structure. The constituent material is basically of two categories: reinforcement and matrix, the matrix supports the reinforcement against mechanical and environmental damage by surrounding and maintaining their relative position, while the reinforcement offer physical properties and special mechanical such as dielectric, strength, stiffness etc.

The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry.Natural fibers such as bamboo, flax, hemp, jute and coconut (coir) are renewable resource emerging as good alternatives for reinforcing materials because of their bio based character, high specific mechanical properties that can compete with glass fibers, reasonable cost and sustainable supply. Several studies involving life cycle assessment (LCA), agree that natural fibers are likely to be environmentally superior to synthetic fibers in each phase of the entire life cycle of the composite materials.

2. OBJECTIVES

- To fabricate bamboo with silicon carbide filler matrix hybrid composites using hand layup method.
- To evaluate mechanical properties such as tensile, flexural, hardness and water properties of these composites.
- To compare the properties of composites with and without filler material.
- To study the effect of water absorption behavior of these composite.

3. METHODOLOGY

3.1. Hand lay-up process

Hand lay-up is an open molding method suitable for making a wide variety of composites products from very small to very large as shown in Fig. 1. Production volume per mold is low. However, it is feasible to produce substantial production quantities using multiple molds.

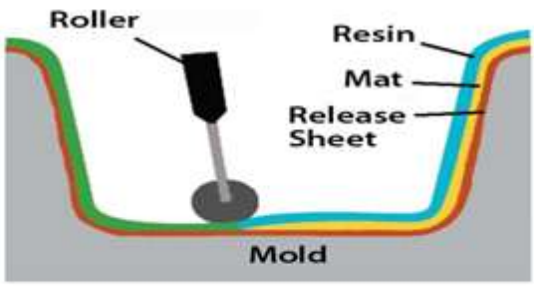

Fig -1: Hand Lay-up Process

Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing and a wide range of part sizes.

3.2Fabrication of specimens

In this study, manual hand layup method is used for preparing composite laminates. First of all, a release gel is sprayed on the flat plate surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the flat plate to get good surface finish of the product. Reinforcement in the form of woven fabrics are cut to a dimension of 28x28cm and 28x26cm. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent).

The process is repeated for each layer of polymer and fiber, till the required layers are stacked. After placing the plastic sheet, a weight is kept on the stacked layers and the pressure is applied. After curing at room temperature for 48hrs, the developed composite part is taken and further processed as shown in Fig. 2.

Fig -2: Preparation of Testing Specimen

4. EXPERIMENTAL DETAILS

The following tests are to be conducted to find mechanical and water absorption properties of the composite material.

4.1 Tensile test

Tensile Test, also known as tension test, is probably the most fundamental type of mechanical test that can be performed on material. To determine how the material will react to forces being applied in tension. As the material is being pulled, material will elongate. The maximum force at which the material fails is known as Ultimate Strength.

4.2 Flexural test

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. The most common purpose of a flexure test is to measure flexural strength and flexural modulus. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen.

4.3 Hardness test

Hardness is a resistance to penetration, wear, a measure off low stress and resistance to cutting and scratching. Hardness property relates to other variables such as the modulus of elasticity, yield point, eliminate strain and permanent deformation and these effects depends in turn on the bonding force between molecules or atoms, as well as the type of surface, temperature and rate of deformation. Shore durometer hardness (Shore-D) test is using in this study for the hardness of the surface of the sample material.

4.4 Water absorption test

The water absorption tests were performed on immersing specimens into three different water conditions, namely normal, distilled and salt water. Specimen preparation and water absorption studies carried out as per ASTM standards. Voids are one of the most common manufacturing induced defects during the fabrication of composite. Higher voids content leads to low resistance to water penetration in addition to both increased variation and poor strength properties of composites. In particular, a good composite should have less than 1% voids. Whereas a poorly made composite can have up to 5% voids content.

5. RESULTS AND DISCUSSION

The composite specimens were made as per the ASTM D638 to measure the tensile properties. The length, width and thickness of the specimens were 150, 13 and 3 mm, respectively.Ultimate strength is low in Laminate composition 1 fibers than in Laminate composition 3 fibers. The influence of filler content on tensile strength of bamboo epoxy composites can be seen that the tensile properties have been improved with the incorporation of SiC particles in the bamboo epoxy composites.

Table-1: Tensile Strength of Different Laminate

Sl No.	Composite	Ultimate Tensile Strength
1	L1 – Epoxy + Bamboo fibers (5%)	48
2	L2 – Epoxy + Bamboo fibers (5%) + SiC (4%)	53
3	L3 – Epoxy + Bamboo fiber (5%) + SiC (8%)	76

The significant improvement of tensile strength is observed up to 8% SiC content. From tensile test results on all composites and graph analysis it is observed that laminate composite 3 with 5% of bamboo, 8% of SiC has exhibited good tensile strength 76 MPa compared to others as shown in Fig. 3.

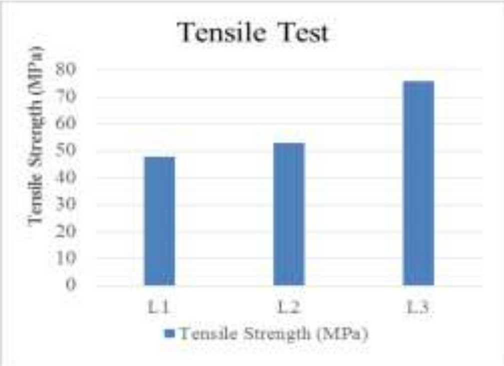

Fig-3: Laminate Composition v/s Tensile Strength

The composite specimens were made as per the ASTM D790 to measure the flexural properties. The length, width and thickness of the specimens were 127, 13 and 3 mm, respectively.

Table-2: Flexural Strength of Different Laminate

Sl No.	Composite	Flexural Strength
1	L1 – Epoxy + Bamboo fibers (5%)	34.4
2	L2 – Epoxy + Bamboo fibers (5%) + SiC (4%)	53.7
3	L3 – Epoxy + Bamboo fiber (5%) + SiC (8%)	76.2

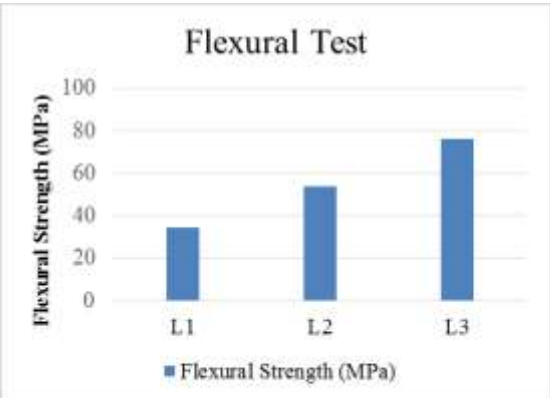

Fig-4: Laminate Composition v/s Flexural Strength

Fig. 4 shows laminate composition v/s flexural strength of three laminate, which were tested for flexural strength with different proportions of SiC.From the above result it is clear that the laminate L3 shows more flexural strength which consist of 8% SiC and its flexural strength is about 76.2MPa.

Surface hardness of composite material is sometime a matter of concern when the composite material so produced is encountered for space application. The hardness test was carried out as per the ASTM D224 Standard.

Table-3: Shore-D Hardness of Different Laminate

Sl No.	Composite	Shore-D Hardness
1	L1 – Epoxy + Bamboo fibers (5%)	83.2
2	L2 – Epoxy + Bamboo fibers (5%) + SiC (4%)	86.7
3	L3 – Epoxy + Bamboo fiber (5%) + SiC (8%)	88.3

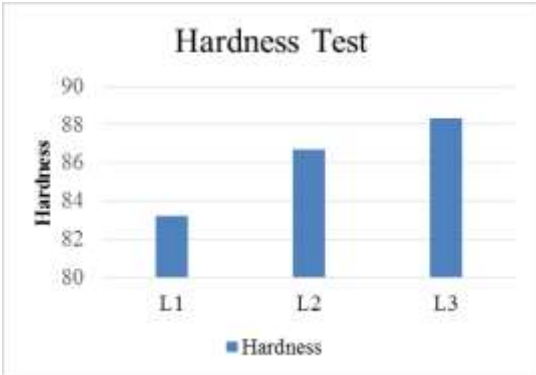

Fig-5: Laminate Composition v/s Shore-D Hardness

The laminate L1 shows less flexural strength because it consists of only natural fiber and epoxy resin. The variations of flexural properties of the Bamboo-fiber reinforced epoxy composites with SiC particle content are shown in the table 2 flexural strength of the composites increased with filler content of up to 8%. The linearly increasing trend of flexural strength with increasing filler material contents suggests that the bonding between the fibers and the matrix is relatively good. The effect of weight fraction of fiber on mean flexural strength for other fiber reinforced composites in comparison to bamboo composites are more.

Hardness test specimens were cut into the ASTM standard of dimension 30x30x3mm. Tests were carried out using hardness-testing machine. The test results were plotted for Shore-D hardness versus specimen composition as shown in Fig. 5.

Water absorption studies were performed following the ASTM D57 method. The samples were taken out periodically and weighed immediately, after wiping out the water on the surface of the sample, to find out the content of water absorbed. It is clear that the composites absorb water very rapidly at the initial stage, and later a saturation level was attained without any further increase in water absorption as shown in Fig. 6 to Fig. 8.

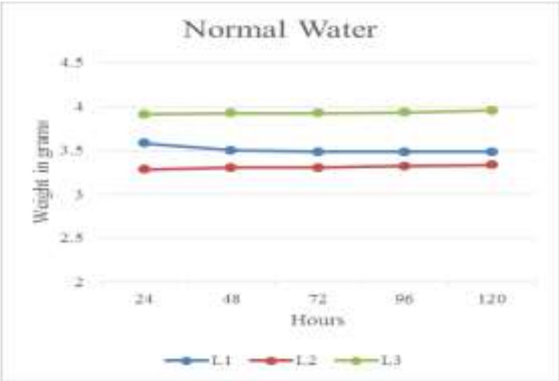

Fig-6: Water Absorption of composite in Normal Water

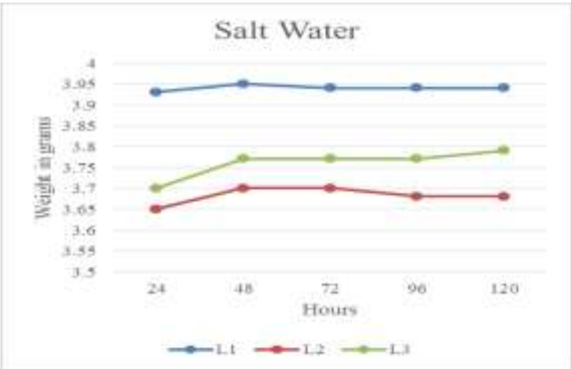

Fig-7: Water Absorption of composite in Salt Water

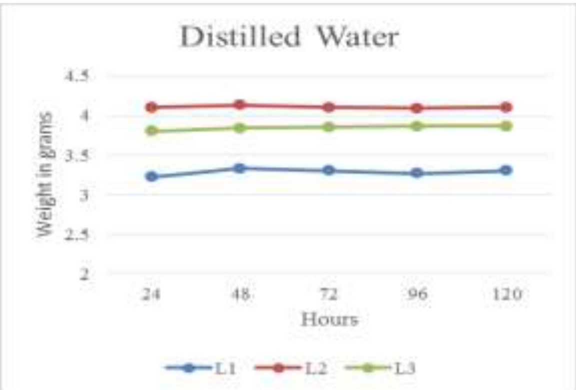

Fig-8: Water Absorption of composite in Distilled Water

6. CONCLUSION

The current research work present work studies on the effect of silicon carbide on mechanical behavior of epoxy resin composite reinforced with Bamboo fiber using hand layup method. From the tests the following conclusions are drawn:

I. The tensile and flexural strength of laminate composite 3 is high, which is very economical and environmental friendly.

II. The laminate composite 1 shows very poor results when compared with laminate composite 3 and 2 mainly because of the laminate L1 only consist of bamboo fibers.

III. SiC can be added in order to develop the components, which are under the load of tensile and flexural with the proper proportions in order to develop economic class of material.

IV. Hardness test shows that the laminate consist of SiC filler material shows the superior result compared to other laminates.

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