Physico-Mechanical Characterization of Bamboo-Glass Fiber Reinforced Polyester Composites filled with pine needle

Anil dhanola
Assistant Professor
MVN University, Palwal, (H.R.)
anildhanola3698@gmail.com

Bharat Singh
Assistant Professor
Phonics Group of Institutions, Roorkee, (U.K.)
bharatsngh239@gmail.com

Gourav Gupta
Assistant Professor
KSVCEM, Bijnor, (U.P.)
gouravgupta560@gmail.com

***Abstract*—**
In this work, an investigation was carried out on E-glass fiber/Bamboo fiber reinforced polyester composites filled with pine needle. The composites were fabricated by hand lay-up technique and the physical properties such as physical density as well as experimental density and % of void fraction and mechanical properties such as ultimate tensile strength, impact strength and hardness of the fabricated composites were tested. The test results of these were compared with unfilled glass/ bamboo fiber composites. From the results it was found that the mechanical properties of the composites increased with the increase in filler content. Composite C5 exhibited maximum tensile modulus and hardness. Maximum impact strength was achieved composite C6

Keywords*— *Bamboo and glass fiber, pine needle, polyester resin, Mechanical properties

I. INTRODUCTION

Over the last years there has been revived interest in the use of natural fibers to replace synthetic fibers in composite applications. Compared with synthetic fibers, natural fibers have many advantages like renewable, environmental friendly, low cost, lightweight, high specific mechanical performance. Among various natural fibers bamboo is one the most potential reinforcement for fiber reinforced polymer composites. Interestingly many types of natural fibers that are abundantly available, such as jute, bagasse, pineapple, sisal, bananas [1-8] have proved to be good and effective reinforcement in polymer matrix composites. Bamboo has numerous advantages over other natural fibers such as its availability, excellent mechanical properties in comparison with its weight due to longitudinally aligned fibers, one of the fastest renewable plants etc. Adding of filler into polymer has been proved to be an alternative for the improvement of the performance the resultant composites. Hybridization of fiber can also be done by adding fillers which helps to improve the properties of composites. The objectives of the work are to fabricate bamboo-glass fibre reinforced polyester matrix composite with/without filler content and evaluation of physical and mechanical properties. Besides the above all, the objective is to develop relatively low cost composites by incorporation cheaper reinforcing phases into a polymeric resin. Also this work is expected to introduce a new class of polymer composite that might find applications in door, vibration absorber, dining table etc. bamboo fibre are prepared from bamboo plant, Polyester resins are produced by the poly condensation of saturated and unsaturated dicarboxylic acids with glycols, pine needle (leaves of pine tree) generally found in hilly areas and glass fiber is produced synthetically.

II. EXPERIMENTAL DETAILS

A. Materials

The bamboo fiber,glass fiber and pine needle filler is taken as the reinforcement and polyester is taken as matrix material in the present study. The bamboo fiber and pine needle is collected from local sources of hilly areas of pauri garhwal and the glass fiber mat and polyester resin with hardener is procured from Amtech Ester Pvt. Ltd. New Delhi.

B. Composite Fabrication

Hand-lay-up technique is the most simplest and conventional method of composites processing. The low temperature curing unsaturated polyester resin corresponding hardener and Cobalt Octoate

are mixed in a ratio of by weight as recommended by the manufacturer. Composites with five different fiber loading (10 wt. %, 20 wt. %, 30 wt. %) with same filler loading (5 wt %) were fabricated and subjected to post-curing at room temperature for 24 hours. The detail designation and composition of composites are given in Table 1. Finally, the composites were cut to the required size as per the standards for the evaluation of physical and mechanical properties.

TABLE I. DESIGNATION AND DETAILED COMPOSITION OF THE COMPOSITES

Designation	Composites
C1	Fiber (5% bamboo+5% Glass fiber)+ pine needle(0%)+ Polyester
C2	Fiber (10% bamboo+10% Glass fiber)+ pine needle(0%)+ Polyester
C3	Fiber (15% bamboo+15% Glass fiber)+ pine needle(0%)+ Polyester
C4	Fiber (5% bamboo+5% Glass fiber)+ pine needle(5%)+ Polyester
C5	Fiber (10% bamboo+10% Glass fiber)+ pine needle(5%)+ Polyester
C6	Fiber (15% bamboo+15% Glass fiber)+ pine needle(5%)+ Polyester

C. Physical and Mechanical Tests

For the composite materials, theoretical density can be obtained in terms of weight fraction calculated by the use of the following equation [9].

$$\rho_{ct} = \frac{1}{\frac{W_f}{\rho_f} + \frac{W_m}{\rho_m}} \qquad (1)$$

Where, W and ρ represent the weight fraction and density correspondingly. The composites under this investigation consists of three components namely matrix, fiber and particulate filler. Therefore the modified form of the expression for the density of the composite can be written as

$$\rho_{ct} = \frac{1}{\frac{W_f}{\rho_f} + \frac{W_m}{\rho_m} + \frac{W_p}{\rho_p}}$$

The actual density of the composite can be obtained experimentally by simple water immersion technique. The volume fraction percentage of voids (Vv) in the composites is calculated by the following equation:

$$V_v = \frac{\rho_{ct} - \rho_{ce}}{\rho_{ct}}$$

The tensile test is generally performed on flat specimens. A uniaxial load is applied through both the ends of the composite samples. The ASTM standard test method for tensile properties of fiber resin composites has the designation D 3039-76. The tensile test is conducted using universal testing machine HEICO and results are analyzed to calculate the tensile strength of composite samples.

As per using an impact tester the impact tests are done on the composite samples. The Pendulum impact testing machine determines the notch impact strength of the material by devastating the V-notched sample with a pendulum hammer, calculating the impact strength. The standard sample size is 55 × 10 × 10 mm and the depth of the notch is (t/5=2 mm) 5 mm of the notch. The scale of the machine is 1division=2 joule.

Brinell hardness test was conducted on the specimen using a standard Brinell hardness tester. A load of 200 kg was applied on the specimen for 30 sec using 2.5 mm diameter hard metal ball indenter and the indentation diameter was measured using a microscope. The hardness was measured at three different locations of the specimen and the average value was calculated.

III. RESULTS AND DISCUSSION

A. Density and Void fraction

The theoretical and experimental densities of the composites with the corresponding volume fraction of voids are shown in Table 2. It is observed that the composite densities values are calculated theoretically from weight fractions by Eq. (1) are not equal to the experimentally measured values. This difference is due to the presence of voids in the composites. As the fiber content increases the percentage fraction of void is also found to be increasing. In the case of addition of filler the percentage fraction of void is also increased but not much increased than without filler.

TABLE II. MEASURED AND THEORETICAL DENSITIES OF THE COMPOSITES

Composites type	Theoretical density(g/cm^3)	Experimental density(g/cm^3)	Volume fraction of voids (%)
C1	1.44	1.41	2.08
C2	1.48	1.43	3.37
C3	1.49	1.46	2.01
C4	1.48	1.43	3.37
C5	1.50	1.47	2.0
C6	1.52	1.49	1.97

B. Tensile strength

Mainly fibres are used in composites to enhance strength properties. Variation in tensile strength of the glass fiber and bamboo fiber reinforced with and without filler (Pine needle) polymer composites with different fiber loading are shown in fig. 1. It is noticed that tensile property is increasing with increasing fiber loading in both cases i.e. with and without filler content. It is also noticed that addition of filler influence the tensile property in every wt% of fibers that we have taken.

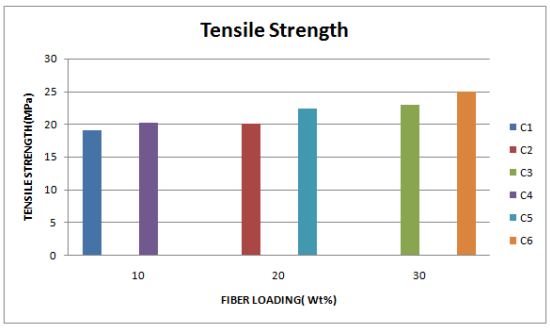

Fig. 1 Effect of different composition of composite materials on tensile strength

C. Impact strength

Fiber loading and filler affect the impact strength which is shown in fig. 2. It is observed from the figure that same pattern is observed as tensile strength here impact energy increases with increasing fiber loading but the addition of pine needle filler leads to improved impact strength of the composites and the impact energy and impact energy increasing with fiber loading in the matrix. In figure it is clearly indicated that composites C6 exhibited maximum impact strength when compared with unfilled composites this due to that good bonding strength between filler, matrix and fiber and flexibility of the interface molecular chain resulting in absorbs and disperses the more energy, and prevents the cracks initiator effectively.

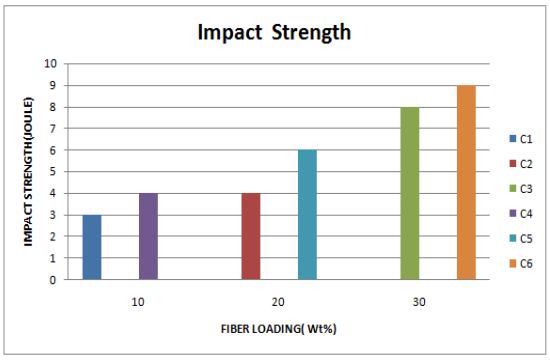

Fig. 2 Effect of different composition of composite materials on impact strength

D. Hardness Strength

"Fig. 3" indicates that exhibited maximum hardness number of 35 BHN when compared to other filled and unfilled composites, this may be due to uniform dispersion of particles and good bonding strength between fiber and matrix. Literature survey revealed that the increase in hardness was a function of filler content and hardness was directly proportional to the filler content.

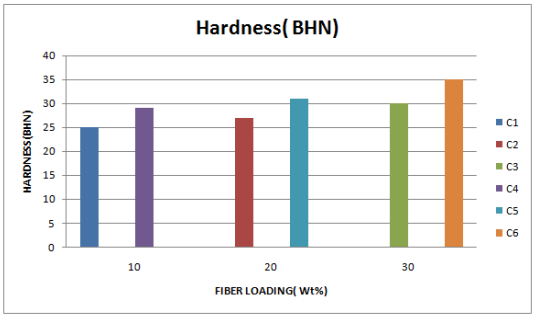

Fig. 3 Effect of different composition of composite materials on Hardness

IV CONCLUSION

The following conclusions are drawn from this study

A. A new type of bamboo-glass fibre hybrid composite filled (pine needle) and unfilled laminates has been fabricated successfully by hand lay-up technique.

B. It has been studied that physical, mechanical behaviour of the composites are greatly influenced by the fibre loading and filler materials. The void content of composites increases with increase the fibre loading.

C. In tensile testing, as the fiber concentration increases tensile strength of composite increases. It is also found that filler filled composites shows excellent tensile strength compared to unfilled composites. As a result, the maximum tensile strength obtained in case of 30% fiber filled with 5% pine needle.

D. In the testing of impact strength, it was observed that the impact strength increased with increase of fiber loading and here maximum value obtained is at 30% fiber filled with 5% pine needle.

E. In the testing of hardness, it was observed that the hardness increased with increase of fiber loading and here maximum value obtained is at 30% fiber filled with 5% pine needle.

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