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Instinctive Behavior of Replacing Large Percentage of Carbon with Banana Fiber

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Abstract*: *This paper is mainly focused on reducing the certain amount of artificial fiber with green fiber or natural fiber. The replacement of particular amount of synthetic fiber, reduce the cost and made the product economical. By doing so the composite become user friendly. In this experiment, using hand-lay-process, a hybrid polymer matrix is fabricated by replacing some percentage of carbon with banana fiber. The prepared specimen is subjected to mechanical testing. The fabricated work piece resulted in better mechanical properties such as improved tensile strength, hardness, flexural strength and impact strength. This hybrid composite has applications in automobile parts like break lining, leaf springs, etc.

Index Terms: Banana Fiber, Flexural Strength, Hand-lay-up Process, Hardness, Impact Strength...

I. INTRODUCTION

Polymer matrix composites are well known for its light weight, highly resistant to heat, and resistance to chemical reaction. It has major applications in the field of automobile and aerospace components and other components such as sports goods.The polymer composites reinforced with green fibers are environmentally friendly, renewable and cheap compared to glass or carbon reinforced composites. Banana fiber is having good mechanical tensile properties compared to jute fiber in green composite. The tensile strength of jute ranges between 200 to 450MPa and the tensile strength of banana ranges between 529 to 914MPa. In this experiment banana fiber is selected as a natural fiber due to its improved tensile strength [1].The higher percentage of natural fiber, mixed with carbon powder and ceramic powder and reinforced with epoxy shows better values of hardness and less wear. The percentage of natural fiber is 44, the percentage of carbon powder is 10, the percentage of ceramic powder is 15and the remaining is epoxy resin. In this experiment the percentage of banana fiber is higher compared to carbon fiber [2,3].The natural fiber in glass resists the tensile strength up to 156.167N/mm2. The natural fiber in glass and ceramic powder resist the tensile strength up to558.6N/mm2.The material properties such as tensile strength, flexural strength and impact strength are increased constant up to 3% of ceramic filler, and these properties are reduced after 4 % to 6% [4,5].The synthetic fibers, glass and carbon are compared by the author and it was proved that carbon fiber with better mechanical properties such as micro hardness, yield strength, ultimate tensile strength and elongation. In this paper the carbon is reinforced with epoxy along with banana due to its better properties compared to other synthetic fibers [6].The natural bamboo fiber is added in various combinations such as 10%, 15%, 20%, 30%, and 40% with epoxy. The impact strength is maximum with 30% of bamboo fiber and it decreased beyond that. The hardness value is maximum with 20% of bamboo fiber and it is reduced beyond that percentage [7].The novelty of this paper is retaining the mechanical properties of a fabricated specimen by replacing 45% of carbon fiber with natural fiber banana and thus reduced the cost and made this economically.

Fig. 1. Extraction of banana Fiber.

II. EXPERIMENTAL

A. Materials

This resin is a pale yellow color liquid. The epoxy content is about 5.3 to 5.45 eq/kg. The viscosity of the resin at 250C is ranges from 10000 to 12000 MPa S. The density of this resin is from 1.15 to 1.20 g/cm3.Araldite LY 556 is Bi-sphenol – A epoxy resin. It is suitable for high performance fiber reinforced composites applications such as filament winding, Pultrusion and pressure molding. It has excellent dynamic, thermal and mechanical properties [8].

The fineness and spin ability of shiny banana fiber is better than bamboo fiber. The composition of banana fiber is cellulose, hemicelluloses and lignin. It is a strong fiber with less elongation. It absorbs and releases moisture rapidly. It is biodegradable with fineness of 2400N-m. Figure 1 shows the methods to extract the banana from raw banana stem [9]. Figure 2 shows the prepared fiber weaved in the form of mat [4].Carbon fiber is the lightest fiber. It is five times stronger than steel but it is one third of its weight.

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The black colored carbon fiber is used in aerospace structures, military structures and in sporting goods.

B. Methods

Hand Lay Up Process

In hand lay-up process the carbon fiber is woven in the form of mat oriented in 900.

Similarly the banana fiber is oriented along 900 in the form of a mat. The mats are placed alternately with epoxy resin in between the mats. The fibers in the form of mat are placed initially, then the epoxy resin is drenched over the mat. The rollers played an important role of impregnation of resin with the fiber.

Testing Methods

Tension Test is a basic test on materials. It is an inexpensive standardized test. In this test the prepared work piece material is subjected to controlled tension based on ASTM D638 up to failure. In this work the prepared specimen, epoxy with banana and carbon fiber is subjected to a tensile test as shown in the figure 2.3. The specimen is placed between upper and lower jaw in a universal testing machine. Pulling load is applied gradually until the failure and the corresponding ultimate tensile strength, percentage elongation and yield stress is noted. A stress, strain graph is generated automatically and recorded and strength valued is tabulated.

Fig. 2. Banana Fiber mats

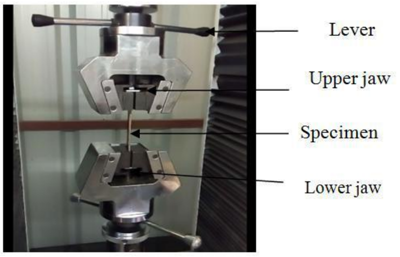

Fig. 3. Universal Testing Machines with Hybrid Polymer Composites

Hardness Test is the resistance of a material against distortion, indentation, or riddling. It is the quality and condition of being hard. The Rockwell hardness number is recorded for composite material and it is noted along the L scale show in figure 4. The indenter is either a diamond or a steel ball, the applied force ranges from a minor load of 0kg to maximum load of 10kg. The indenter is forced against the work piece and the load is gradually increased up to the maximum. The diameter of indentation on the specimen and the indenter is measured.

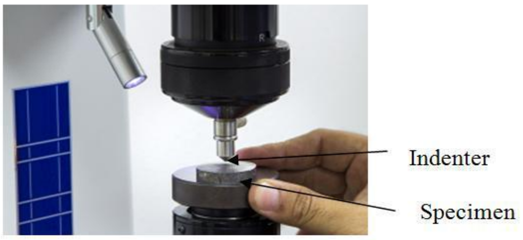

Fig.4. Hardness Tester.

Impact Test is the measure of material toughness or impact strength. The flaw specimen is subjected to impact loading and the energy absorbed by the specimen during a failure is noted. This machine consists of a pendulum whose weight is known and it is dropped from a known height. The energy absorbed is a measure of difference between the height of the pendulum before failure and the height of the pendulum dropped after failure. The figure 5 shows the impact testing machine.

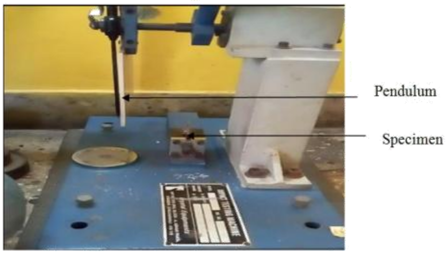

Fig. 5. Impact Testing Machine

Flexural Strength is bending strength. It has been the measure of stress just before the yield. The load is applied perpendicularly to the longitudinal axis of the specimen. During flexural load, the tensile stress is produced on the convex side and the compressive stress is along the concave side and shear is along the mid plane. The deformation is controlled by adjusting the length to depth ratio. The specimen is placed on two parallel supporting pins and load is applied by a loading pin towards the center. The figure 6 shows the setup of flexural tester.

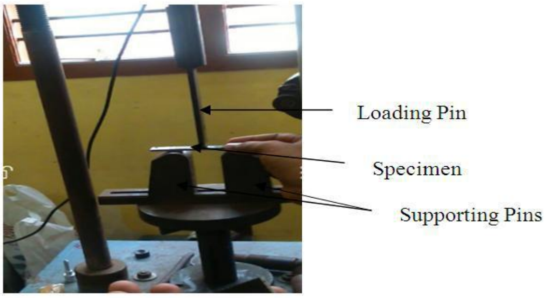

Fig.6. Flexural Testing Machine

III. RESULTS AND DISCUSSIONS

A. Results from Universal Testing Machine

The graphical output along with the tabulated values is recorded as shown in the figure 7.

The graph is generated by the gradually increased load along the Y-axis and their corresponding displacement along the X-axis. The tabulated value contains ultimate load in KN, ultimate tensile strength in N/mm^2, breaking load in KN, breaking stress in N/mm^2, maximum displacement in mm, percentage elongation, and yield load in KN and yield stress in N/mm2. These data are recorded based on specimen width, thickness, temperature, cross sectional area and speed. The same test is repeated three times in different specimen with the same proportions. Figure 8 shows the specimen subjected to tensile test.

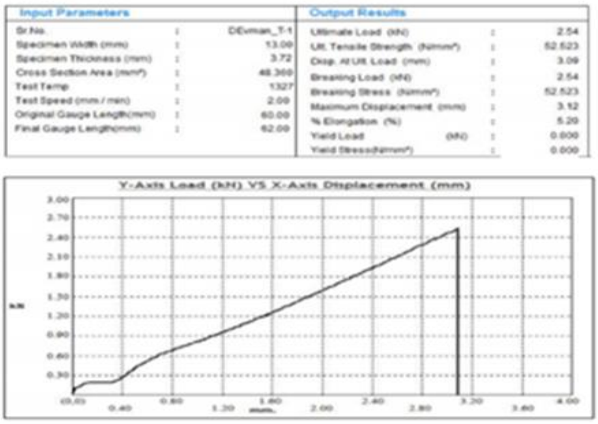

Fig. 7. Graphics and Tabulated output for Tension Test

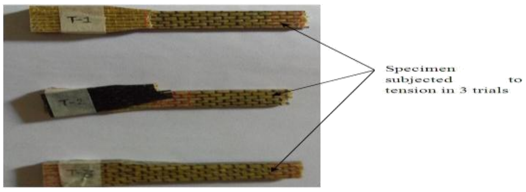

Fig.8.Specimen Subjected to Tensile Test

Table. 1 Comparative Results of Universal Testing Machine

Composites	Breaking Load in (N)	Ultimate Tensile Stress (N/mm^2)
Epoxy + Sisal [10]	1730	19
Epoxy + Aloe Vera [11]	1220	25
Epoxy +Aloe Vera + Sisal [11]	1530	27
Epoxy/Banana [12]	-	14.94
Epoxy/Banana/Carbon	**2540**	**52.532**
	2890	**59.760**
	3750	**77.543**
	Average	**63.278**

This table 1 describes that the prepared specimen (Epoxy/Banana/Carbon) has better tensile strength compared to the previous researches with different natural fiber sisal, aloe Vera. The combination of banana and carbon with epoxy shows the highest tensile strength of 63.3N/mm^2

B. Results from Vickers Hardness Tester

The specimen is machined to a proper geometric shape and the load is applied either by a diamond tip or steel ball and the corresponding scale value is noted in three trials. The work piece subjected to the load is shown in figure 9. The table 2 displays the comparative study of prepared specimens with the previous researches, this table proved that the carbon-banana with epoxy with better hardness value when compared to other natural fiber reinforced with epoxy.

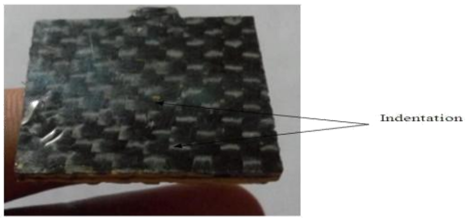

Fig. 9. Specimen Subjected to hardness Test

Table. 2 Comparative Results of Hardness Tester

Material	Trials	Hardness Value (HRB)
Epoxy + Sisal [10]	-	55
Epoxy/Banana[12]	-	23
Epoxy/Banana/ Carbon	**1**	**65.3**
	2	**63.9**
	3	**65.9**
	Average	**65.03**

C. Results from Flexural Testing Machine

Three specimens subjected to flexural load is shown in figure 10 and these specimens are machined to a proper ASTM standard. The flexural strength is obtained in a graphical form with load along the y-axis and displacement along the X-axis and the corresponding values of displacement, ultimate strength is also listed in a tabular form in figure 11. Table 3 displays the comparative results of flexural strength values of various natural fibers with the epoxy. The comparative results conclude that hybrid fiber with better flexural value compared to other fibers.

Fig.10. Specimen Subjected to Flexural Load

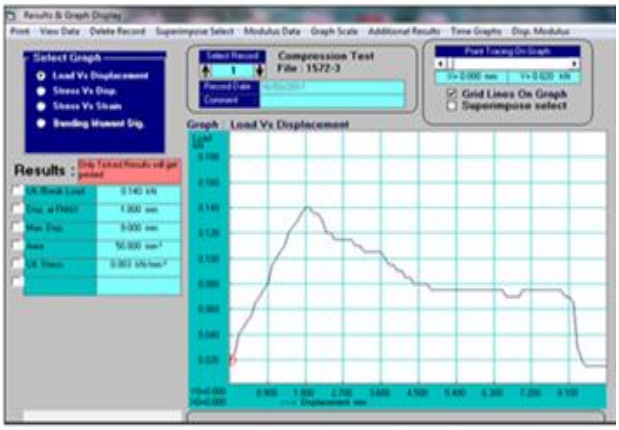

Fig. 11. Graphical output Obtained due to Flexural Load

Table. 3 Comparative Results of Flexural Testing Machine

Materials	Trials	Flexural Value (mm)
Epoxy + Sisal [10]	-	1.9
Epoxy + Aloe Vera [11]	-	2.1
Epoxy/Carbon/Banana	1	2.2
	2	2.7
	3	1.8
	Average	2.233

D. Results from Impact Testing Machine

The prepared specimen is machined to a standard dimension and impact test is carried out on three trials. Figure 12 shows the specimen machined and subjected to the impact loads. Comparison of prepared hybrid composites shows highest impact values compared to other natural fibers.

Fig. 12. Specimen subjected to Impact Load

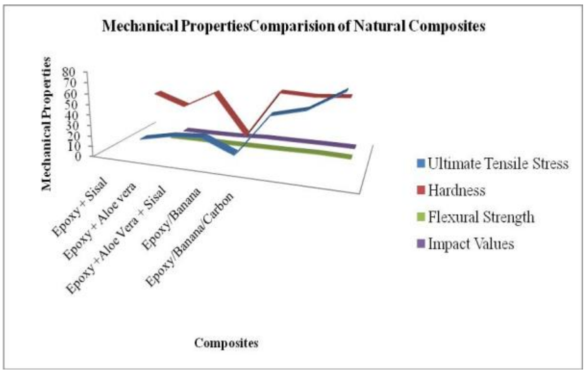

Fig. 13. Comparison of Mechanical Properties of fabricated banana Composite with other natural fiber

The variation of mechanical properties with respect to the percentage of natural reinforced composites is shown in figure 13. Mechanical properties include ultimate tensile stress, hardness, and flexural strength and impact values. The above graph displays there is a rise in the properties by incorporating the higher percentage of artificial fiber with natural ones.

IV. CONCLUSION

In this paper the properties of epoxy reinforced with lower percentage of carbon and higher percentage of banana fiber. The properties of prepared specimen are compared with the previous researches with natural composites such as sisal, aloe Vera.

1. The ultimate strength with ASTM standard D638 of epoxy reinforced with carbon and banana is the maximum (63.278N/mm^2) compared to epoxy reinforced with sisal (19N/ mm^2), epoxy with aloe Vera (25 N/mm^2) , epoxy with aloe Vera and sisal (N/mm^2) and epoxy with banana (27N/ mm^2)
2. The hardness value with ASTM standard D638 of hybrid epoxy with carbon and banana shows the maximum value (65.03HRB) compared to other natural composites such as epoxy with sisal (55HRB), epoxy with banana (23HRB).
3. The flexural strength with ASTM standard D790 in terms of displacement for the prepared hybrid epoxy reinforced with carbon and banana shows highest value (2.233mm) compared to other epoxy reinforced with natural composites, epoxy reinforced with sisal (1.9mm) and aloe Vera (2.1mm).
4. The Impact value of the prepared epoxy reinforced carbon banana is maximized (2J) compared to epoxy with sisal (0.4J), epoxy with aloe Vera (0.3J), epoxy with aloe Vera and sisal (0.6J).

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