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ANALYSIS OF MECHANICAL PROPERTIES OF HYBRID BAMBOO/JUTE FIBERS REINFORCED & VINYL ESTER COMPOSITE MATERIAL

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ABSTRACT

Polymer matrix composites (PMC) materials had acquired much attention in the field of Aeronautics over the recent decades as high strength-lightweight materials. These abundantly available fibres are embedded with a light polymer matrix resulting in a high strength and light weight fibre reinforced polymer composites. In this paper, we have investigated the mechanical behaviour of fabricated composite materials with four different combinations consists of Bamboo/Jute as a reinforcing agents and vinyl ester as a polymer matrix. Several tests has been carried out to enhance the properties such as tensile strength, flexural strength, hardness and impact strength and it was compared for different orientations (±90º). It is reported that the hybridization of the constituents with 20% of Jute, 10% of Bamboo shows better Tensile strength, Flexural strength and Hardness number than other combinations examined.

Key words: Tensile, Flexural, Impact, Bi-directional, Hardness, Bamboo, Jute, Vinyl Ester.

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1. INTRODUCTION

Two main constituents such as reinforcement and a matrix are combined to form a composite material. Matrix is a sort of binder which binds the reinforcement and improves several properties of reinforcement. Mostly fibers which have advantages such as low density, high strength-to-weight ratio and high stiffness are used as a reinforcing phase. The properties of matrix along the direction of the reinforcement orientation together with the reinforcement properties show high performance in the mechanical properties of the composites. Hence the finished product has an overall structure versatility. The load and stresses always transfer from matrix to the reinforcement. Natural fibers (bamboo/jute) and polymer matrix (vinyl ester polymer) are the considered ingredients for the present analysis. The term natural fibers is defined as the fibers which are extracted from the natural resources such as plants, trees, animals etc. They are initially utilized in the commercial industries in the field of automobiles and household tools… etc. [2]. Natural fibers are recyclable, less expensive and resistive to breakage or damage, strong and low weight constituents [3]. Mechanical properties of the composite materials made up of quite a few of the fibers such as kenaf, hemp, flax, bamboo and jute are examined numerously by several authors [4,5].For 45^{o} Orientation of hybrid FRP (mixture of polyester, Bamboo and E-glass) yielded better results of mechanical properties is been analyzed and reported [10]. Polymer matrices have light weight, high stiffness, and high strength. It also provide good corrosion resistance. The role of hybridization in improving the mechanical properties of tensile, flexural and shear strength of the composite materials are proven [8].

Short Bamboo/jute fibers are predominantly available resources in nature. Due to high strength along a longitudinal axis and low strength towards the transversal axis, bamboo fiber is also called as natural glass fiber and they are orthotropic in nature. The tensile properties of bamboo based polymer composites are investigated by Kazuya et.al [6]and evaluated that compared to matrix, the tensile and modulus is increased by 15% and 30%, respectively. The ability of natural fibers such as jute, sisal, hemp, coir and banana to form a composite were also studied and proved [7]. The comparisons of numerous polymer matrix composites which are reinforced with the fibers for their mechanical performance [9]. Jute fibers have several properties such as high tenacity, bulkiness, heat insulation property and low thermal conductivity and they are eco-friendly because of their high degradability. Vinyl Ester is one kind of thermoset polymer which is brittle in nature and contains carbon oxygen bond. Generally, the fabrication of composites is done by different methods by changing the matrix for reinforcement. For PMC, we use two kinds of the fabrication process. Open Mould Process and Closed Mould Process.

In this experiment, we have done fabrication of composites by the hand lay-up process (a kind of open mould process) in bi-directional orientation with short fibres. Tensile testing and flexural testing for the material are carried out by Universal Testing Machine (UTM).Impact test has been done by Charpy testing machine. From the stress and strain value, the values of flexural strength and flexural modulus are derived. Rockwell Hardness test is completed with the help of ball indentor.

2. PREPARATION OF MATERIALS

Vinyl ester is used as a polymer matrix material and bi-directional hybrid Bamboo/Jute fibre is picked as reinforcing material. The material is fabricated by hand layup process and expurgated according to the ASTM D standard for the test mentioned above and specimen is aligned for orientation of ±90º.Table 1 shows the different combinations with different percentage of materials. Every specimen will have different values of strength in tensile force, flexural force, impact and hardness.

Table 1 Percentage values of the specimens used

Specimen	Combinations	Percentage (%)
A	Vinyl Ester Jute Bamboo	70 15 15
B	Vinyl Ester Jute	70 30
C	Vinyl Ester Bamboo	70 30
D	Vinyl Ester Jute Bamboo	70 20 10

3. FABRICATION PROCESS AND METHODOLOGY

The hybrid composite materials made up of bamboo, jute and vinyl ester will have weaves in bi-directional. The bidirectional orientation is proved to produce more strength than the unidirectional orientation. Hybrid composite will possess superior characteristics against individual composite because natural fibre has high level of weight reduction comparing to the glass fibre. Here, we considered 4 combinations aligning with bamboo, jute and vinyl ester. Below all 4 combinations are shown with a percentage value of every material in composite material with bi-directional orientations.

The fabrication is processed by the above mentioned Hand Lay Up process. It is a very old method to fabricate the composite material, it is less expensive and require minimum amount of tooling. In hand lay-up process, initially, the gel coat is applied on the mould using a spray gun, since the composite material which we are fabricating can be detached from the mould effortlessly. After curing the gel, the reinforcements are placed by hand in a mold as per the required percentage in a different orientation. Then the laminating resin is applied by pouring and by using the roller the laminate is consolidated and the entrapped air is removed from the combination. We have made four specimens with different percentages of the bamboo, jute and vinyl ester. We have done all the experiments to get the values of tensile strength, flexural strength, hardness and impact test on the specimen so that the points of failure of the material, elongation of material and impact resistance of the material can be determined. All the manufacturing and fabrication are done according to the ASTM standard.

Tensile strength and tensile modulus are determined after the point of failure. Flexural strength and flexural modulus are also explored by the values of stress, strain, bending stress etc. Rockwell hardness test material is presented on the platform and by ball indentor, the force is been applied on it and the relative hardness of the material was indicated by the dial gauge. There is only one notch for Charpy test and the impact is not applicable at an angle.

4. RESULTS AND DISCUSSIONS

For the all combinations of Vinyl Ester + Jute + Bamboo with the addition of diverse quantities, the specific mechanical properties (Tensile strength, tensile modulus, Flexural strength, Flexural Modulus, Hardness and Impact strength) are obtained. The mentioned tests are carried out by the Universal Testing Machine. The tensile strength is the measurement of maximum force required to break the specimens whereas tensile modulus is a measure of the stiffness of a solid material. Flexural test is also known as a breaking test is done by the application of point load on the prepared composites.

Table 2 Mechanical properties of the combined specimen

Specimen	Tensile strength (MPa)	Tensile modulus (GPa)	Flexural strength (MPa)	Flexural Modulus (GPa)
A	470.37	36.09	260.32	27.16
B	395.5	28.65	200.5	19.34
C	379.48	30.32	257.40	23.72
D	507.076	38.76	279.74	24.68

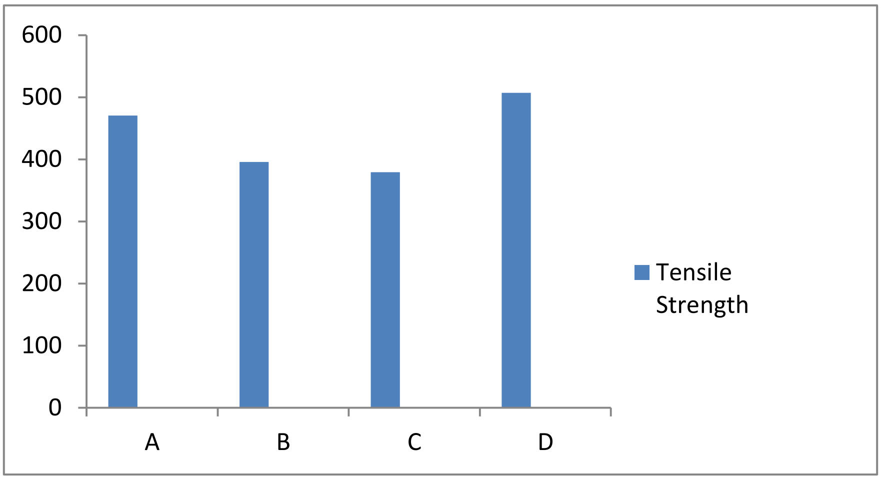

Figure 1 Tensile Strength Graph for 4 Specimens

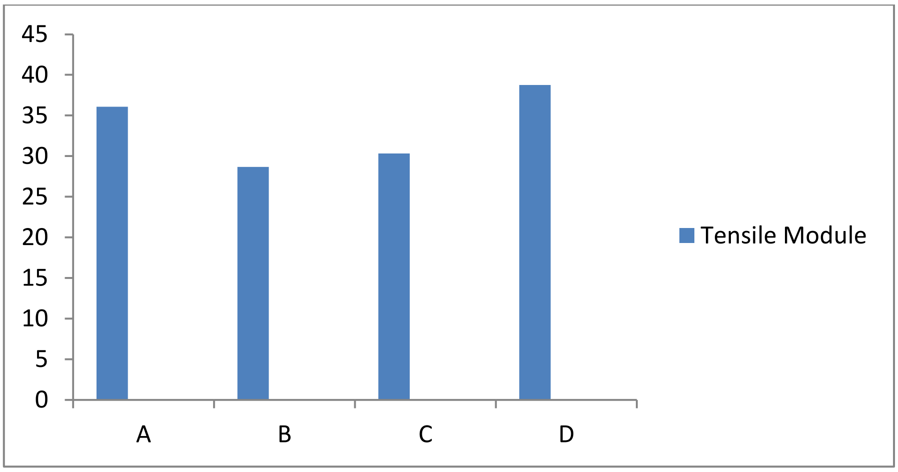

Figure 2 Tensile Modulus Graph

Figures 1 and 2 shows that the hybrid specimen D which contains short Jute fibres in greater proportion than Bamboo indicated a high resistance to beak compared to the other orientations. Along with it the modulus of rupture or flexural strength is shown to be promising for the hybridization of the composite D which implies that the material has higher ability to resist deformation under load. Bending modulus or a flexural modulus exposes the tendency for a material to bend is high for the hybrid composite specimen A with the same fraction of Jute and Bamboo.

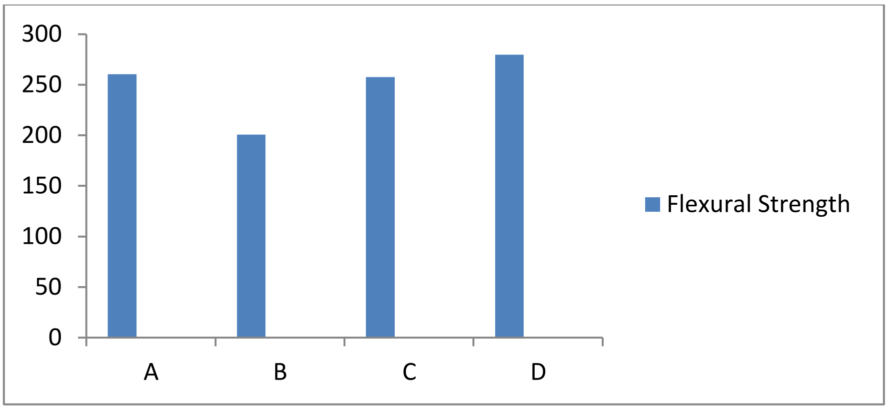

Figure 3 Flexural Strength Graph

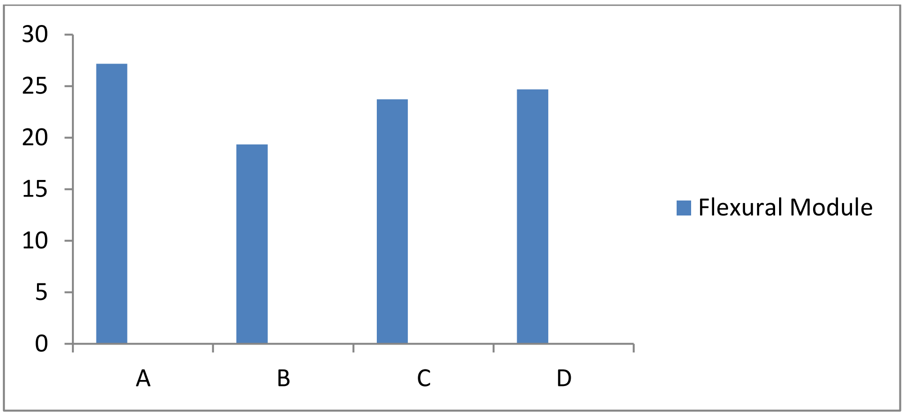

Figure 4 Flexural Modulus Graph

Rigidity of the material is evaluated as hardness using the Rockwell hardness tester and the related Rockwell hardness numbers are determined. The impact toughness of the material is found by Charpy Impact test.

Table 3 Values of hardness and impact strength

Specimen	Rockwell Hardness Number	Impact Strength (J)
A	44	2.57
B	36	3.83
C	35	4.06
D	47	5.01

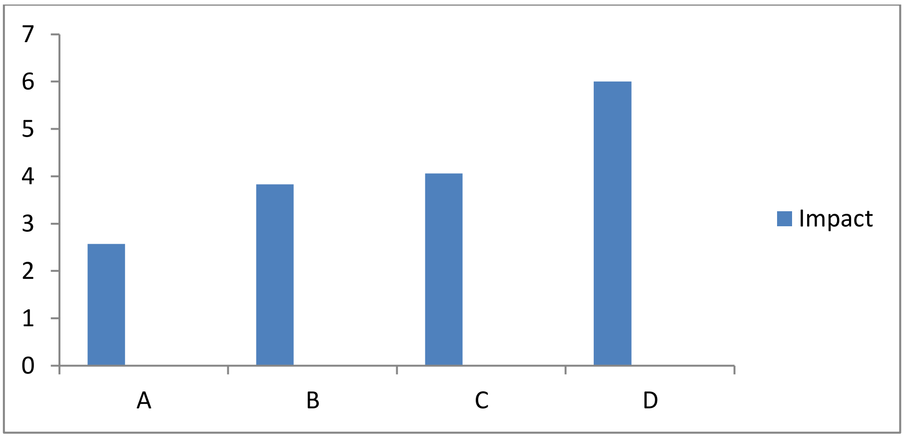

Figure 5 Impact strength of the composites

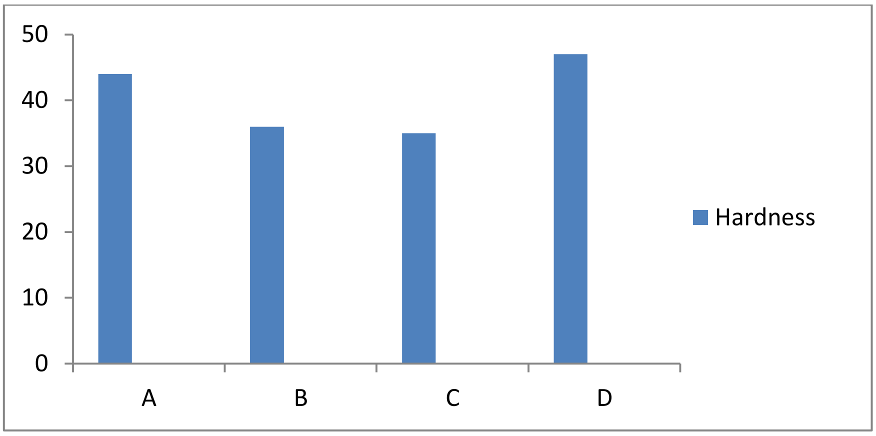

Figure 6 Hardness of the composites

Observations of the Figures 5 and 6 results that the hardness and impact strength of the composite D is greater show its ability to withstand considerable loads.

5. CONCLUSIONS

In this analysis of four combination of the Bamboo/Jute fibre reinforced with the vinyl ester matrix yields the following conclusions:

- The structural strength exposed by Jute is greater than the Bamboo and thus the accountability of that fibre is more.
- From the analysis, it is observed that the hybrid specimen D shows high tensile strength of 507.76 MPa and flexural strength of 270.74 MPa compared to other combinations.
- Also, The Specimen A consists each of Jute and Bamboo as15% resulted in higher flexural modulus of 24.68 GPa.
- Hardness test and impact test on the specimen D reportedly exposed high values in hardness number and impact strength.
- By the above results, it is suggested that this composite can be used in the commercial aircrafts for reducing the overall weight of the aircraft and to satisfy the necessary structural strength requirements.
- The overall value of strength of the PMC material performs better mechanical properties and sustainability over the individual forms of reinforcement and matrix.

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