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Fabrication and Estimation of Mechanical Properties of Composites with Varying Proportions of Carbon and Kenaf Reinforcement

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***Abstract:** Composites are preferred due to their unique ability of being lighter as well as possessing good mechanical properties. On the other hand, the need of the hour is sustainable development. This article aims to combine the properties of composites with the eco-friendly concept of sustainable development and also to find the right mix of artificial and natural reinforcement fibers, such that the mechanical properties are not affected, and the composites can still be functional while being eco-friendly. Three different specimens with varying proportions of Carbon fiber and Kenaf fiber as reinforcement and Polyester resin as the matrix were fabricated. Vacuum Infusion Moulding was used as the method of fabrication. In the fabricated specimen Tensile, Flexural, Impact, Hardness and Water Absorption tests were performed to evaluate their mechanical properties. The results were tabulated and compared. The comparison allows us to find the optimum combination of the Carbon and Kenaf fibers which can be used without compromising on the mechanical advantages composites offers.*

***Keywords:** VART Moulding, Kenaf fiber, Hybrid Composite.*

I. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical and chemical properties that, when combined, produce a material with characteristics different from the individual components. It is used in many industries such as automobile, aeronautical etc. It is found that the kenaf is one of the most important crops commercially grown around the world for fiber, it is the primary source for natural fiber reinforcement, and also has the potential for the use of kenaf fiber in construction and industrial fields [1]. The properties of unidirectional bio degradable composite made with kenaf fiber as reinforcement and a emulsion type PLA resin as the matrix.

The thermal analysis revealed that if the composite is subjected to a temperature of 180°C continuously for 60 minutes, its tensile strength decreases [2].

The fabricated fiber reinforced polymer with kenaf fiber as reinforcement and poly-l-lactic acid (PLLA) as the matrix. The mechanical properties of the FRP fabricated were found to be higher than the individual kenaf sheets or PLLA films [3], and the work studied the behavior of Hybrid composites and their application in structural applications. They found that the natural fiber is used reduced the product weight and also reduced the material cost [4].

The tribological and mechanical properties of Sisal filled glass and carbon hybrid composites note that by increasing the sisal fiber weight, the coefficient of friction of the composites increases, [5] while it predicted that the moisture absorption behavior of Flax and Glass reinforced Hybrid composites with different stacking sequences. It is found that due to the hydrophilic nature of flax, the composites had higher moisture absorption properties [6]. The review of a glass hybrid composite noted that glass fiber possess a scope for versatile application, but can't be used in high strength requiring applications. On the other hand, carbon and Kevlar fiber, has high strength but are costly [7]. The properties of Jute and Carbon fiber reinforced Epoxy based Hybrid composite. They compared the properties of the hybrid composite with separate composites with jute and carbon reinforcements [8].

Further it stated that hybrid composites can accomplish properties that the fibers individually can't. They also found that hybrid composites meet several strategy requirements in addition to economic advantage [9], and conducted a study on the elastic response of Graphene Nano Platelet (GNP) hybrid composite and concluded that GNP dispersion has greater influence on the mechanical behavior of the composite at higher strain rates [10]. The composites of hybrid with 42% fibre content, containing jute and unshredded newspaper in the weight ratio of 1:2. He found that tensile and flexural property of the hybrid composite are higher to those of pure paper-based composite [11].

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The tensile strength of Agave fibre reinforced hybrid composite found that natural fibre reinforced composites were easier when it came to waste disposal. They fabricated composites with orientations of 0° and 90°.

They concluded that the Agave-copper composite with 0° alignment had the highest tensile strength [12], and further stated that due to the affinity of natural fibres to water, they have relatively poor mechanical properties. The synthetic fibres were however not eco-friendly [13].

From the previous work, it is found that the composite materials were tested using jute fiber and carbon fiber. In this Research, the composite material was tested using carbon fiber and kenaf fiber, which is natural, eco-friendly as well as biodegradable, this is chosen because it increases the toughness as well as strength. The objective of this work is to fabricate composite material with varying proportions and evaluate their mechanical properties.

II. EXPERIMENTAL DETAILS

The composites fabricated by hand layup method do not have a proper surface finish and the resin does not permeate perfectly and evenly into the different layers of the reinforcement fibers. The compression mould is used to overcome these difficulties. Vacuum Assisted Resin Transfer Moulding (VARTM) method is chosen to get a better surface finish.

A.Selection of Material

In order to fabricate a hybrid composite, at least one natural fiber reinforcement, one synthetic fiber reinforcement and one resin which acts as the matrix has to be selected.Carbon fibers about 0.005mm to 0.010 mm in diameter, and are mainly composed of carbon atoms. The carbon fibre has very high strength. The other advantages of selecting carbon fiber include high stiffness and tensile strength.

Cotton and Kenaf fibers are the two most commonly used natural fiber reinforcements. Kenaf fiber have good mechanical properties. Moreover, it is ecofriendly and biodegradable. Because of the good mechanical properties, it is also used in body parts of automobiles. The unsaturated synthetic resins is polyester resin. These resins are initially liquid state. It is converted into solid by cross-linking chains. The main advantages of using polyester resin as the matrix because it is cheap, provides resistance to water.

B.Methodlgy

Vacuum Assisted Resin Transfer Moulding (VARTM) is chosen as the method for fabrication of the specimens. Initially, the reinforcement fibers are cut into the required dimension and weighed. The weight of both carbon and kenaf fiber reinforcements are tabulated as shown in Table 3.1. The bottom glass mould is first cleaned using acetone and coated with wax. After a few minutes, the wax coating is removed and a layer of PVA is applied for easy removal of the composite. The PVA coating is allowed to dry for about 10 minutes and a second layer of PVA coating is applied. Once the wax coating and the two PVA coatings are applied and dried, the reinforcement fibers are stacked on the bottom glass mould in the form of a pile. The order in which the fibers are stacked is noted.

A total of three specimens are to be fabricated, each with varying proportion of carbon and kenaf fibre reinforcements. The quantity is selected on basis of weight ratio. Specimen size of 300 mm × 300 mm is selected. The specimens were fabricated according to composition shown in Table 3.1

Table-1: Composition of Specimens

Speecimen	*Resin*	*Carbon fibre (gm)*	*Kenaf fibre (gm)*	*Layers of Carbon fibre*	*Layers of Kenaf fibre*
A	Polyester	92	42	4	2
B	Polyester	69	63	3	3
C	Polyester	46	84	2	4

Tensile test, Flexural test, impact test, hardness test, is a basic engineering test wherein the sample specimen is subjected to a controlled tension until a point when failure occurs in the sample. The tensile test is conducted using the Universal Testing Machine model UTN 40 and the standard code is ASTM-D638. Flexural test is a bending property of the specimen. The ASTM-D790 standard is followed for the three-point bend test. Impact testis used to evaluate the toughness and the standard code is ASTM-D256.Hardness is the property of the material to resist any surface penetration. The hardness of the fabricated specimens is found using the Rockwell Hardness test. Water absorption test is used to find the moisture retaining capacity of the sample. The samples are then heated in an oven to a temperature of 50°C to remove moisture and then weighed.

III. RESULTS AND DISCUSSION

A. Tensile Test

On comparing the values of tensile strengths of each of the specimen, it is found that the specimen A with maximum carbon fiber content (75%) has the highest Tensile strength. It is followed by specimen C with maximum kenaf fiber content (75%) as shown in Figure 1.

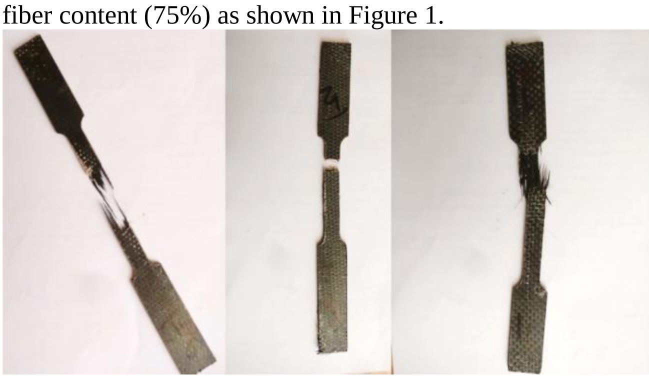

Fig. 1. Tensile Stress

Specimen B with 50% each of carbon and kenaf fiber content has the least tensile strength and the difference is very large and not comparable. The sample graph obtained during testing is shown in Figure 2.

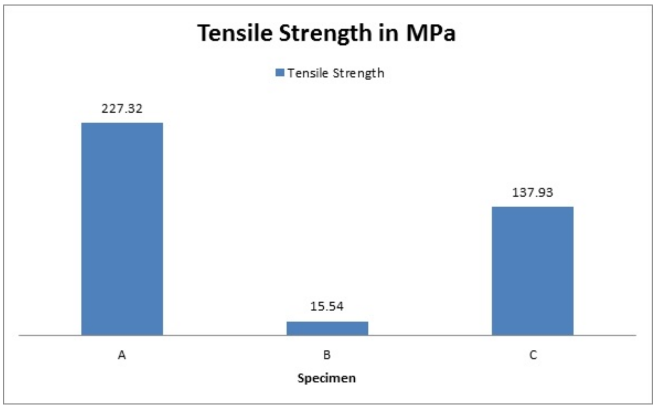

Fig. 2. Tensile Graph

The tensile test was conducted with different arrangement of carbon fiber and kenaf fiber. The carbon fiber increases the strength. The arrangement of different specimen can be seen in Table 1. From the graph it can be seen that the specimen A with more no of carbon fiber and less number of kenaf fiber had high tensile strength.

B. Flexural Test

On comparing the values of flexural strengths of each of the specimen as shown in Figure 3. It is found that the specimen A with maximum carbon fiber content (75%) has the highest flexural strength of 349.68MPa. It is followed by specimen C with maximum kenaf fiber content (75%) with a flexural strength of 159.77MPa

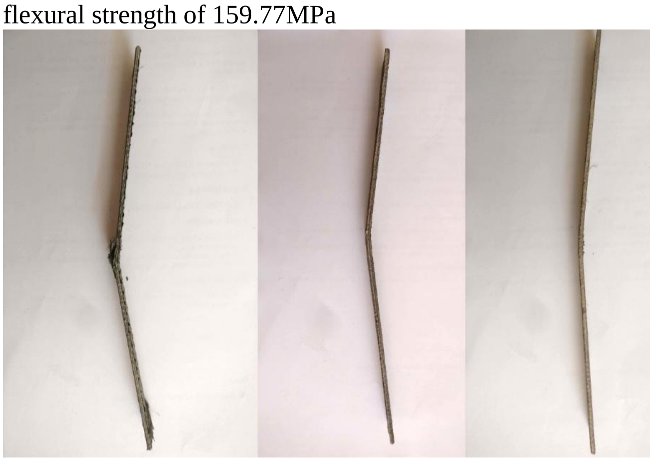

Fig. 3. Flexural test

Specimen B with 50% each of carbon and kenaf fiber content has the least tensile strength of 71.11MPa and the difference is very large and not comparable.

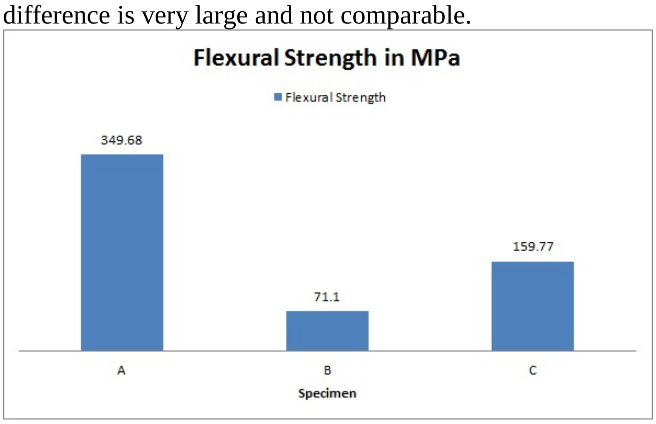

Fig. 4. Flexural graph

The specimen A has the highest Flexural strength because of the more number of carbon fiber than kenaf fiber arranged in varying proportions. The equal number of arrangement of carbon fiber and kenaf fiber has the least flexural strength.

C. Impact Test

Sample A & C exhibit maximum impact strength of 4Joules, while the sample B with equal proportion of carbon and kenaf fibre reinforcements exhibits an impact strength of 2Joules as shown in Figure 5.

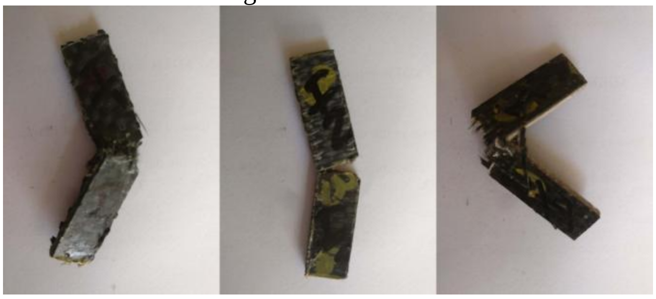

Fig. 5. Impact test

From the graph as seen in Fig 6. The specimen B has the least impact strength whereas the specimen A and C has equal strength.

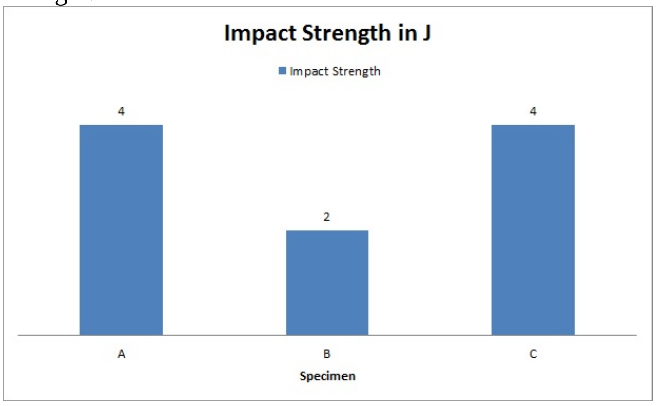

Fig. 6. Impact Strength Graph

D. Hardness Test

The hardness test results shows that the specimen A with 75% carbon content has the highest average hardness value, and the hardness values of specimens B&C is not comparable to that of A as shown in Figure 7.Since the carbon fiber has the high strength when compared to kenaf fiber, the sample A having 75% carbon fiber has high hardness value.

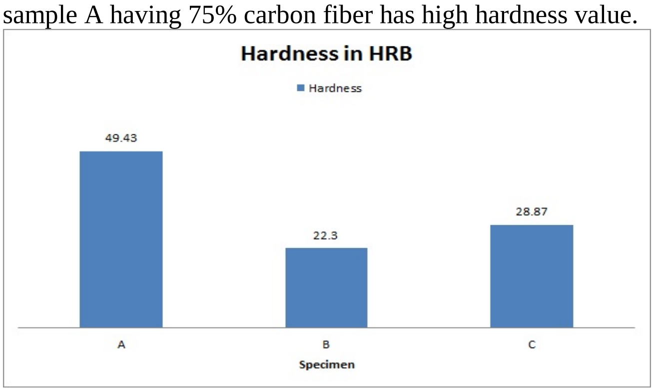

Fig. 7. **Hardness** Graph

E. Water Absorption Test

The higher amounts of natural fiber (kenaf) content in specimens B & C has led to specimen B having the highest percentage by weight of water absorbed, followed closely by specimen C as shown in figure 8.

The specimen A due to its high level of carbon fiber content, absorbs the least amount of water at 1.19% of its initial weight.

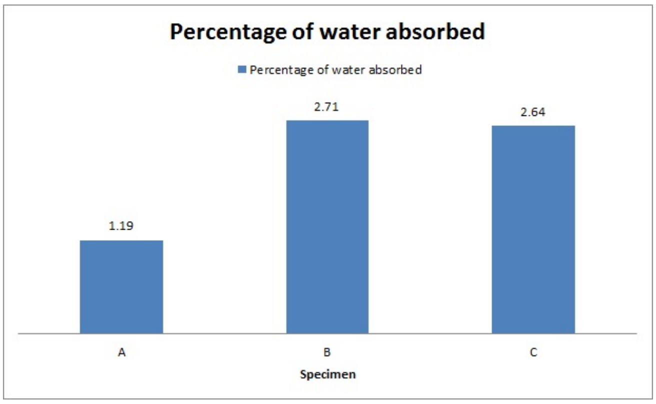

Fig. 8. Water absorbed graph

IV. CONCLUSION

Specimen A with maximum carbon fiber reinforcement shows the best tensile and flexural strength. It can be seen that carbon fiber reinforced composites will have greater mechanical properties when compared to natural fiber reinforced composites. The specimen C, with 75% Kenaf fiber reinforcement and 25% Carbon fiber reinforcement follows with comparable mechanical properties. The main advantage of specimen C is eco-friendly as compared to specimen A due to the presence of 75% kenaf fiber reinforcement. Thus, the applications with slightly lesser mechanical properties, specimen C is recommended and also it is eco-friendly, without compromising on the mechanical properties.

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