Effect on Mechanical Properties by Layering Pattern of Natural Fibers

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Abstract

Banana fibers and Kenaf fibers are natural fibers with good tensile strength. We can prepare epoxy based biocomposite from these fibers. In this work, banana (B) and kenaf (K) fibers reinforced unidirectional (UD) hybrid biocomposites are prepared. Totally two plates are manufactured. First Plate is 4 layer unidirectional 15% Banana + 15% Kenaf fibers alternate layers composite (UD B-K-B-K). Second Plate is 4 layer 15% Banana + 15% Kenaf fibers cumulative layers composite (UD B-B-K-K). Tensile, Flexural and Izod impact tests are carried out as per ASTM standards. Effect of layering sequence on these mechanical properties is investigated experimentally. It is found that cumulative layer (UD B-B-K-K) has better tensile and flexural strength than alternate layers (UD B-K-B-K) biocomposite. Whereas alternate layer (UD B-K-B-K) biocomposite shows better impact strength than cumulative layer (UD B-B-K-K) biocomposite.

Index Terms—Banana Composite, Biocomposite, Kenaf Composite, Banana-Kenaf Hybrid Biocomposite, Epoxy Biocomposite

I. INTRODUCTION

Composite materials are nothing but mixing of two or more materials together to form new material for better mechanical properties. There are three types of composites- Polymer Matrix Composite (PMC) and Ceramic Matrix Composite (CMC) and Metal Matrix Composite (MMC). Mostly they are light weight and with good mechanical strength.

Now days natural fibers are used to prepare fiber reinforced composite materials. Such materials are called biocomposite materials. There are different natural fibers like banana, kenaf, coir, bamboo, jute, hemp, sisal, etc. natural fibers are biodegradable, ecofriendly, non-toxic, harmless to skin, renewability, recyclability. These composites materials are used in space flight, building constructions, packaging and automobile industries.

II. LITERATURE REVIEW

V.P. Arthanarieswaran, A. Kumaravel, M. Kathirselvam [1] evaluated mechanical properties of Banana- Sisal-Glass fiber epoxy composites. They have compared mechanical properties like Tensile Strength, Flexural Strength, Impact Strength of different kinds of stacking sequences of Banana, Glass and Sisal fibers. Experimentally they found Tensile Strength of Banana and Sisal composites 21MPa & 23MPa respectively; (Banana + Sisal) Hybrid composite 25MPa; (Banana + Sisal + Glass) composite as 104 MPa. Whereas flexural Strength of Banana and Sisal composites 56 & 62MPa respectively

followed by (Banana + Sisal) Hybrid composite as 61Mpa and (Banana + Sisal + Glass) hybrid composite as 192 MPa. Izod Impact test had given results as Banana and Sisal composites as 7.6 J

& 8.4 J respectively; followed by (Banana + Sisal) Hybrid composite 7.4 J and (Banana + Sisal + Glass) hybrid composite as 13.3 J.

V.S. Srinivasan, S. RajendraBoopathy, D. Sangeetha, B. VijayaRamnath [2] evaluated mechanical properties of Banana- Flax- Glass fiber based hybrid Biocomposite. They have prepared Hybrid Epoxy Biocomposite specimens with different layers of Banana, Flax and Glass fiber for Tensile, Flexural and Impact Test. They concluded that hybrid composite has far better properties than single fibre reinforced composite under impact and flexural loads.

R. Badrinath and T. Senthilvelan [3] compared mechanical properties of Banana and Sisal epoxy composites. They had manufactured unidirectional (UD) as well as bidirectional (BD) three layered composites by Hand Lay-up technique. UD sisal fiber composite has tensile strength of 56.5 MPa, Flexural strength of 26.4MPa and Impact strength of 1.3 kJ/m^2 whereas UD Banana fiber composite has tensile strength of 20 MPa, Flexural strength of 33.5 MPa, and Impact strength of 2.5 kJ/m^2. BD sisal fiber composite has tensile strength of 16 MPa, Flexural strength of 96.375 MPa and Impact strength of 1.35 kJ/m^2 whereas BD Banana fiber composite has tensile strength of 32.5 MPa, Flexural strength of 33.49 MPa, and Impact strength of 2.8 kJ/m^2.

Fig. 2 – Kenaf Fiber

V. Paul, K. Kanny, G.G. Redhi [4] studied mechanical properties of Banana Fiber and novel Banana Sap based resin. They found Tensile strength of Banana Sap based composite as 26.5 MPa and flexural strength of 32.3 MPa. While Tensile strength of Banana fibers with normal polymer resin composite we 22.2 MPa, but there was no any significance change in Flexural strength.

Toshihiko HOJO, Zhilan XU, Yuqiu YANG, Hiroyuki HAMADA [5] compared Tensile Properties of Bamboo, Jute and Kenaf Mat-Reinforced Composite. Tensile testing specimens of Bamboo, Juteand KenafBiocomposite were fabricated. Tensile test of all specimens is done to obtain stress-strain curves. Kenaf fiber composite has highest tensile strength of 27.9 MPa then Jute composite has 23 MPa followed by Bamboo composite which has 22.4 MPa. There were no considerable changes in Tensile Strengths after Low Cycle Fatigue (LCF) of specimens.

III. OBJECTIVES

1. Theoretical and Experimental Evaluation of Mechanical properties of Epoxy Based Banana-Kenaf fiber Hybrid Biocomposite
2. Fabrication of Epoxy based Banana and Kenaf fiber Hybrid Biocomposite ASTM Standard specimens for Tensile, Flexural and impact testing
3. Finite Element Analysis (FEA) using theoretical values of Material properties of Epoxy based Banana and Kenaf fiber Biocomposite for comparison with experimentation results.

IV. METHODOLOGY

A. Materials-

Table 1- Properties of Banana and Kenaf Fiber

Properties	Banana Fiber	Kenaf Fiber
Density (kg/m^3)	1350	1400
Tensile Strength (MPa)	56	350

i. Banana Fibers-

Banana fibers are extracted from the pseudo stem of the banana plant. The stalk of banana plant is cut and its outer sheath is removed. Then these stalks are crushed in Banana Extractor Machine. This machine removes the pulpy material between the fibers. Extracted fibers are washed by water and dried in sunshine to remove the moisture content.

Fig. 1 – Banana Fiber

ii. Kenaf Fibers [6,7]-

Kenaf fibers extracted from Bark and core of kenaf tree. Kenaf now days used as an alternative raw material in place of wood used in pulp and paper industries to avoid the destruction of forests. It has also been used to make non-woven mats in the automotive industry and textiles.

iii. Epoxy resin and Hardener-

Mixture of Epoxy resin LY 556 (diglycidyl ether of biphenyl-A) and Hardener HY 951 are used in 9:1 by weight ratio [2]. This acts as a matrix material for composite. This resin has good binding properties [2].

Properties of Banana Fibers and Kenaf Fibers [1, 10] are explained in Table 1.

B. Manufacturing -

The weighted quantity of banana and Kenaf fibers are taken. Epoxy resin and hardener are mixed in 9:1 ratio by weight. In this work two different composite laminated plates were fabricated. First Plate is 4 layer unidirectional 15% Banana + 15% Kenaf fibers alternate layers composite (UD B-K-B-K). Second Plate is 4 layer 15% Banana + 15% Kenaf fibers cumulative layers composite (UD B-B-K-K) [9].

Firstly all fibers are dried in sunlight to remove moisture. Plain uniform layer of fibers is skillfully prepared. A mold of 200 X 100 X 4 mm is prepared for Hand lay-up process. Weighed quantity of we stirred mixture of Epoxy resin is spread uniformly on each layer of fibers by brush as shown in figure 3.Hand- Gloves were necessary to avoid contact with resin. Finally this is cured for 8 to 10 hours.

Once this plate is formed, it is cut to prepare testing specimens. Tensile testing specimen is prepared as per ASTM D638 standard in the form of Dumb-bell shape with overall dimensions 200mm length, 20 mm width and 4 mm thick.

Fig. 3- Hand Lay-up Process

In dumbbell shape gauge length kept for testing is 100mm and 50 mm on both sides is kept for mounting on UTM. In the testing area width of dumbbell was 12mm. Flexural test specimen is prepared as per ASTM D 790 Standard with dimension 127 mm in length, 13mm width, 4 mm thick. Distance between supports at the time of testing was 64mm. Izod impact test specimen is prepared as per ISO 180 standard with dimensions 80mm length, 10mm width and 4mm thick with small 2mm deep 45^{o} V-Notch. All specimens are shown in Figure 4.

V. EXPERIMENTATION

1) Tensile Test [8] -

Tensile test is done to determine tensile Strength. Tensile Strength is an ability of substance to stretch without breaking under tension. For epoxy composites, tensile test is done as per ASTM D638. It is done on Universal Testing Machine (UTM). The specimen is held on UTM Jaws and

Table 3- Flexural Behaviour

No.	Specimen Type	Flexural Strength (MPa)
1	UD B-K-B-K	131.4
2	UD B-B-K-K	143.6

allowed to stretch with rate of 5mm/min. From this test Tensile Strength, Young’s Modulus, can be determined.

2) Flexural Test-

This is also called as three point bending test. Flexural tests were performed on an UTM, using the three-point bending fixture according to ASTM D 790-10 standard [1]. Crosshead speed is 5 mm/min. The distance between supports was kept at 16 times thickness of Specimen. From this test, Flexural Strength is determined. Maximum load at failure was used to determine flexural strength.

Table 2- Tensile behaviour

No.	Specimen Type	Tensile Load (N)	Deflection (mm)	Tensile Strength (MPa)
1	UD B-K-B-K	3400	7.9	63.8
2	UD B-B-K-K	3800	9.4	71.3

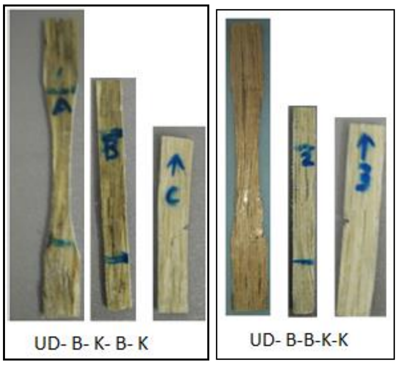

Fig. 4- Testing Specimens

3) Impact Test-

Izod Impact test is carried out as per ISO 180 standards [8]. Notched specimens were fixed in Izod Impact Test machine and broken by single shot of Pendulum. Velocity of pendulum was 6m/s. This test determines amount of energy required to break under impact which is related to toughness of material.

VI. RESULTS AND DISCUSSION

1) Tensile Strength-

Elongation is directly proportional to the load applied till the specimen breaks. Tensile Properties of Laminates are explained in Table 2.

Tensile Strength of UD BBKK is 71.3MPa which more than that of UD BKBK which is 63.8MPa. Figure 5 shows Load Vs Elongation graph of tensile tests.

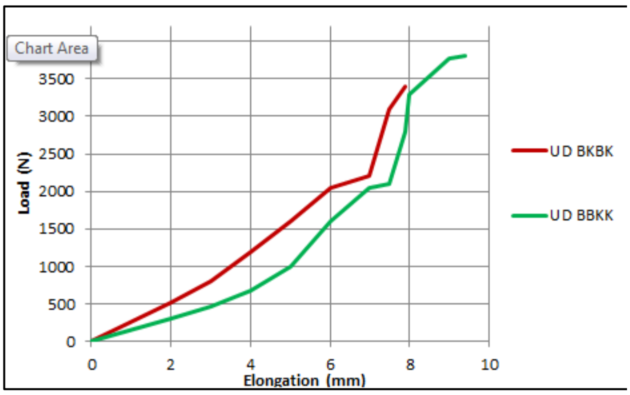

Fig. 5- Load Vs Elongation graph of Tensile Tests

2) Flexural Strength-

Flexural test also shows similar trend as tensile behaviour. In flexural strength top layers get under compression whereas bottom layers get under tension. Flexural strength of UD BKBK and UD BBKK are 131.4 MPa and 143.6MPa respectively. Table 3 and Fig. 6 show flexural analysis.

3) Impact Strength-

Table 4- Impact Strength

No.	Specimen Type	Impact Strength (KJ/m^2)
1	UD B-K-B-K	15.4
2	UD B-B-K-K	8.8

Impact strength of UD BKBK is found to be higher than followed by UD BBKK. Table 4 shows impact strength of specimens.

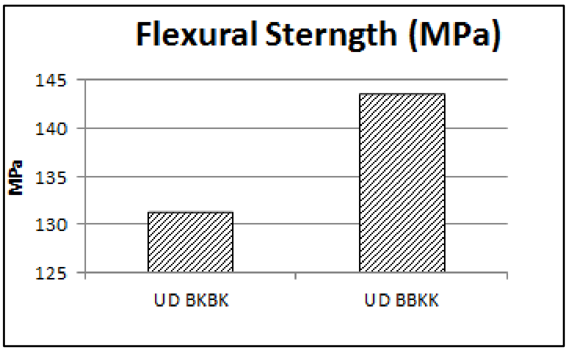

Fig.6- Flexural Strength

VII. CONCLUSION

1. Cumulative and Alternative layering sequence of fiber reinforced biocompositeshave different mechanical strength.
2. Cumulative staking (UD B-B-K-K) has 10% more Tensile strength and 8.5% more Flexural strength than alternate staking (UD B-K-B-K). This also shows relevance with conclusion of K. Senthil Kumar [9].
3. Alternate staking (UD B-K-B-K) has 42% more impact strength than cumulative stacking (UD B-B-K-K).
4. Hybrid Banana- Kenaf Epoxy Biocomposite can be used in various decorative automotive interior parts and domestic furniture applications.

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