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Mechanical Characterisation of Kenaf Fibre Reinforced Polymer Matrix Composite for Automotive Sector

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Abstract: *The manmade fibre reinforced composites are costlier, may affect environment, and the scrap produced during fabrication is not reusable. Hence to overcome this we have decided to replace synthetic fibre to natural fibre. The natural fibre selected for present work is kenaf fibre. The present work investigates the strength of kenaf fibre reinforced composite for different proportions of matrix, fibre and filler materials. Experimental investigations are carried out in order to determine mechanical properties by tensile test and bending test. According to ASTM standards specimens are prepared and the results are validated through ANSYS. The specimens were prepared with varying resin 30%, 35% and 40% for specimen A, B and C respectively. This present work contributes for development and characterization of kenaf fibre reinforced composite for Bus Body building activities.*
Key Words: *ANSYS, Kenaf fibre, polymer matrix.*

I. Introduction

Transportation is one of the basic needs of human being. The road transportation facility is applicable to everyone. Hence the production of automotive like bus, trucks, cars etc. play an important role. To increase efficiency of vehicle and to reduce cost of vehicle it is necessary to replace minor metal part of vehicle to polymer matrix composite parts.

Composites are the materials having two or more compositions and among one is called the matrix and other called as the reinforcing material. The matrix and reinforcing constituents are microscopically combined and not soluble in one another. The matrix material used is continuous and they may include polymer, ceramic or metal.

The reinforcing material that is fibre may be natural or man-made. In this plastic era commercial manmade fibre produce environmental hazardous starting from initial production to final degradation level. There are verity of natural fibres available as hybrid original breeding and the natural fibre having low density compare to artificial fibre used in composite manufacture [1].

The application of natural fibre is considerably increasing in many areas such as construction, Automobiles, furniture and packing etc. the natural fibres are ever better compared to manmade fibre and the natural fibre having advantages on artificial fibre as lesser in cost, very less density and weight, easy of production and eco-friendly etc. [2].

Natural Fibre Categorization

For composite fabrication natural fibre is categorized in three types and those are listed as below.

a. Plant fibre
b. Animal fibre
c. Mineral fibre

As we know every part of plant is useful like root, steam, bast, leaf, wood and stalk etc. and the high strength fibre is extracted from specific part of the plant that is called as bast.

The animal fibre consists of mainly silk and wool. There are different types of silks are available based on breed of silk worm and extracting procedure.

Kenaf Fibre

Kenaf is a natural fibre and used for polymer matrix composite as reinforcement. Kenaf fibre having historical role and having numerous application areas such as paper related products, construction materials, absorbents etc. The kenaf requires less processing energy compared to other fibre extraction.

In India, kenaf crop is cultivated in south region and its physical properties are very much similar to the jute fibre. Using kenaf plant leaves, very tasty dishes are prepared and this should be done when the plant age is 10 to 20 days. After 60 to 70 days the plant produces flower and after some days the flower get converted into

fruit so on the plant reaches its maximum age and then plant is harvested for its seeds. The remaining stem buds are stored for fibre extraction.

After separation of seed from plant haulm is soaked in rural area lake or streams for 10 to 20 days. Then the bast is separated from the haulm of the kenaf plant and the bast is processed for further fine fabric. From seed plantation to the final extraction of fibre takes around six month of time. In rural areas the kenaf plant fibre is mainly used for making ropes and whip etc.

Kenaf Fibre Reinforced Composite

Kenaf fibre is a unidirectional long length fibre having bright future in category of natural fibre. In MG Automotive around 40% of bus body parts are prepared by E-glass fibre reinforced polymer matrix composite. At the time of fabrication large quantity of cutting waste is obtained and reuse of this is impossible because it will not undergo burning and degradation process easily. So to overcome this problem we planned for kenaf fibre reinforced composite and this has following advantages over E-glass fibre composite.

a. The scrap produced at the time of fabrication and cutting is reusable on grinding.
b. Low cost of fibre.
c. Environmental friendly.
d. Can burn easily and scrap dumping problem is solved.

Objective

The objective of this work is to experimentally determine the mechanical characterization of kenaf fibre reinforce composite for automotive applications. Using ANSYS v 10.0 analysis software results are validated.

II. Materials And Methodology

Materials Used

The materials used to prepare kenaf fibre polymer matrix composite are as follows.

a. NaoH solution
b. Kenaf fibre
c. Polyester resin
d. Calcium powder
e. K-6 hardener
f. Vinyl gel
g. Wax paste
h. Cotton clothe
i. Brush and other necessary materials and equipments.

Methodology

The methodology involved to carry out the overall project work is listed below.

- **Material selection:**

The required raw material is collected in required proportions. The kenaf fibre is selected on the basis of percentage of scar and colure of fibre. Here the kenaf with large scar on the bast gives lower durability and low scar bast give long life and hence light colored fibre is best suited for any type of processing. Similarly suitable runner, resin and quality calcium powder is selected.

- **Fabrication:**

a. Chemical treatment: The kenaf fibre is treated with NaoH solution to improve physical properties and strength. 250gm of kenaf fibre is treated with 500ml of sodium hydroxide solution for 4 hours at room temperature.

b. Fabrication: Initially the mould is prepared as per requirement to obtain desired shape and size. The mould is cleaned by wax paste. Venyl gel is coated on mould for easy removal of specimen. Here, hand layup technique is adopted for preparing specimens. In hand layup technique kneaf fibre is used as reinforcement material, calcium powder as a filler material and polyester resin as matrix material. After layup, the specimens are left at least 4 hours for curing.

c. Specimen preparation: As per ASTM standard specimens are prepared with different volume fraction. Volume fraction is calculated using below formula

- **Mechanical testing:**

As per ASTM standard Tensile, Flexural (Bending) tests are carried out.

- **Analysis:**

The specimen subjected to bending and tensile loading are to be analyzed by using ANSYS v 10.0.

- **Validation of result:**

Validation is done by comparing ANSYS and experimental results.

RESULT AND DISCUSSION

Tensile Test

Specimen A The varying resin specimen A consists of 30% Resin, 42% fiber and 28% of calcium powder. The observation made is discussed as follows.

Specimen B

The specimen consists of 35% of resin, 39% of fiber and 26% calcium powder.

Specimen C

The specimen consists of 40% of resin, 30% of fiber and 30% calcium powder and other required catalyst etc. as per requirement.

The below fig. 4.1 and fig. 4.2 indicates the variation of load with respect to displacement and stress strain plot respectively as follows.

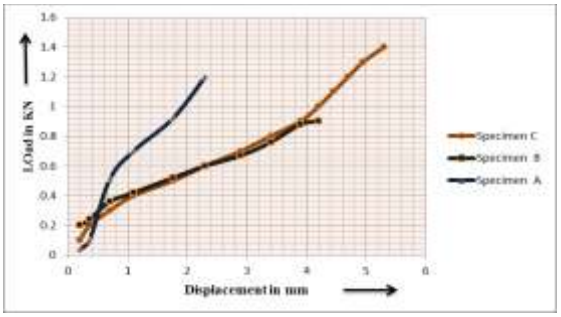

Fig 1 load v/s Displacement plot for varying resin specimens

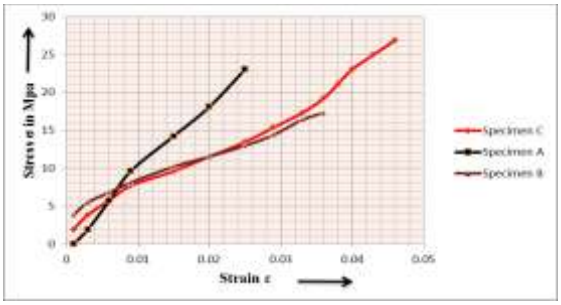

Fig 2 Stress v/s Strain plot for varying resin specimens

By considering all three resin proportion specimens, the specimen C can withstand maximum load and having maximum displacement values.

Bending Test

Specimen A

The specimen is prepared with 30% of resin, 42% of fiber and 28% of calcium powder

Specimen B

The specimen is prepared with 35% of resin, 39% of fiber and 26% of calcium powder

Specimen C

The specimen is prepared with 40% of resin, 30% of fiber and 30% of calcium powder

The variation of combined bending load with respect to displacement and combined stress strain relation is shown in fig 4.3 and fig 4.4 respectively.

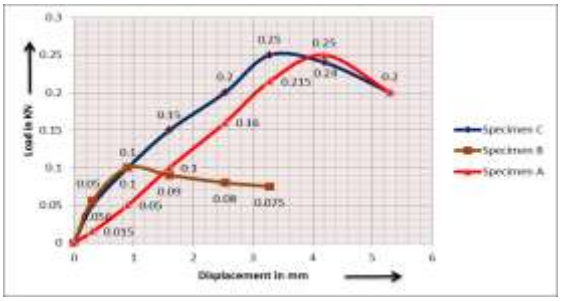

Fig 3 load v/s Displacement plot for varying resin bending specimens

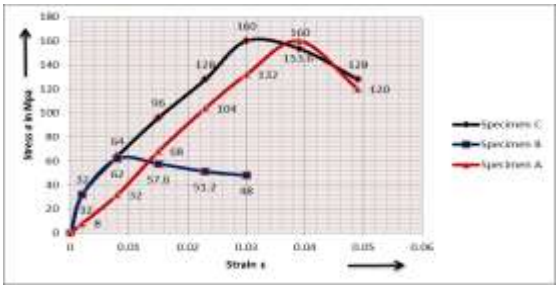

Fig 4 Stress v/s Strain plot for varying resin bending specimens

Considering above fig 4.3 and fig 4.4 it is concluding that specimen C having higher load and stress value. Hence specimen C having highest bending strength compare to specimen A and specimen B.

Analysis for tensile and bending test

The specimen is modelled as per standard dimension for tensile test in ANSYS software as shown in below fig 4.5.

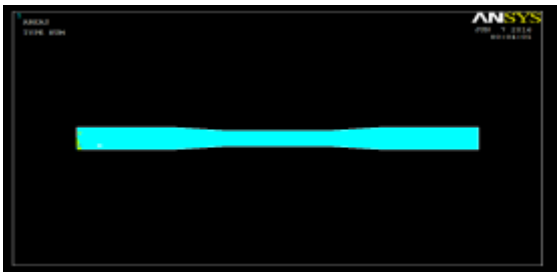

Fig 5 Modelling for tensile test

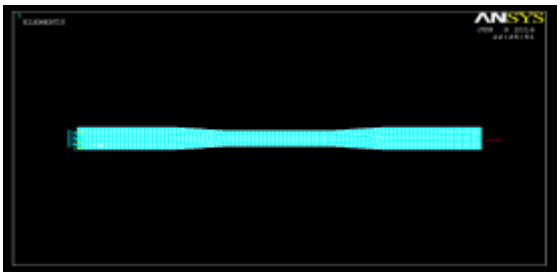

Fig 6 Load apply for tensile test

After modelling, analysis is carried out in order to obtain displacement and stress values.

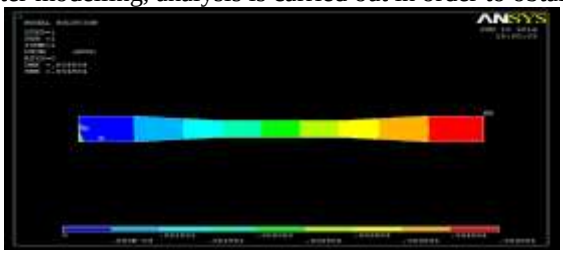

Fig 7 Displacement for varying resin tensile specimen **C**

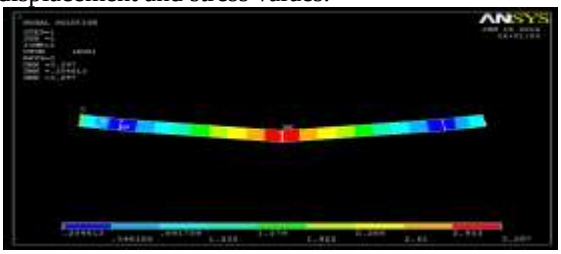

Fig 8 Displacement for varying resin bending specimen C

Validation of results

The result validation is done by comparing experimental results with ANSYS results and is summarized in following table.

Table 1 Comparison of tensile test results

Specimens	Load F in N	Experimental displacement value in mm	ANSYS displacement value in mm	Error or difference in mm
Varying resin A	1200	2.88	2.027	0.853
Varying resin B	900	4.05	2.764	1.286
Varying resin C	1400	5.3	4.504	0.796

Table 2 Comparison of bending test results

Specimens	Load F in N	Experimental displacement value in mm	ANSYS displacement value in mm	Error or difference in mm
Varying resin A	250	4.081	4.101	0.02
Varying resin B	100	0.52	0.521	0.001
Varying resin C	250	3.28	3.297	0.017

III. Conclusion

By considering overall result and discussion we can conclude as follows.

1. By considering first step of the characterization process were the specimens are prepared with varying resin i.e. 30%, 35% and 40% out of these the specimen with 40% of resin having better tensile and bending strength.
2. In case of constant resin proportion the specimen named C gives the considerable result for tensile and bending test. The specimen having composition 40% resin, 30% kenaf fiber and 30% calcium powder.
3. Considering impact strength here also constant resin specimen 'C' gives higher strength compared to other two. Hence it is conclude that specimen 'C' is best suited for sudden loading areas of Bus like bumper, foot step etc.

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