Evaluation of Mechanical Properties of Sisal Fiber Reinforced Epoxy Composites

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Abstract

Natural fiber offer several benefits such as low cost, low density, environmentally free and high specific mechanical performance. In this work the tensile, impact and flexural properties of sisal fiber reinforced epoxy composite is investigated. This composite is made up of three layers (longitudinal- transverse - longitudinal) using hand lay -up method with 40 wt% of sisal fibers with epoxy matrix. The mechanical properties like tensile, impact and flexural strength for various types of specimen based on different angle of cutting 0°, 45°, and 90° to the longitudinal axis of the specimen were investigated. It has been observed that maximum value of tensile, impact and flexural properties were obtained for the specimen that was cut at an angle of 0°.

Keywords: sisal; epoxy; tensile properties; flexural properties

1 INTRODUCTION

Natural fibers like sisal, jute, banana, hemp, coconut coir, palm, bamboo and wood has been used as reinforced in polymer composite in recent year [1,3]. The property of natural fiber composite depends upon fiber, matrix and interaction between them. The interaction between fiber and matrix plays an important role in the mechanical property [2]. Natural fibers have recently attracted the interest as composite material reinforcement, thanks to their good mechanical properties in combination with light weight. Additionally, they have environment – friendly characteristics such as low energy utilization, renewability and bio degradability [4]. Natural fibers are not only strong and lightweight but also relatively very cheap [5]. To efficiently use natural fibers in composite materials, it is necessary to investigate the morphology, structure and mechanical properties of the fibers, which influence the properties of their composite. Energy need for production of the sisal fibers is on average less than half of the amount needed for synthetic fibers [6]. Basically content of cellulose, hemi cellulose and lignin are the defining parameters for mechanical properties of natural fibers. A unique characteristic of natural fiber is depended upon the variations in the characteristics and amount of these components as well as difference in its cellular structure. Therefore to use natural fibers to its best advantages and most efficiently in automobile and industrial application, physical and mechanical properties of natural fibers must be considered. Modification to the fiber also improves resistance to moisture in degradation of the interface and the composite properties. In addition, factors like processing condition/ techniques have significant influence on the mechanical properties of fiber reinforced composite [7].

The sisal laminate has the maximum compressive strength of 42MPa and maximum bending strength of 0.0036MPa among the natural fibers [6]. Now a day's natural fibers such as sisal and jute fiber composite materials are replacing the glass and carbon fiber owing to their easy availability and cost [8]. The sisal/ banana hybrid natural fiber composite specimens are prepared with different rations by taking 0.4 volume fraction and tensile properties of these hybrid natural fiber composite are examined by using rule of hybrid mixture [9]. Natural fiber have been used on strings, words, cables, ropes, mats, brushes, hats, baskets and fancy articles like bags [10].

The incorporation of natural fibre such as sisal / Jute with glass fibre composite has gained increasing applications both in many areas of Engineering and Technology [11]. Sisal - Jute - GFRP hybrid composite are environment friendly and user friendly materials and have very good elastic properties. The method of disposal of GFRP and their recycling have been the serious issues and the natural fibre composites play very important role in the environmental situations and variety of applications [12]. The addition of Sisal fibre in the composite increases the tensile strength, flexural strength and impact strength [13]. The flexural properties of Vakka fibre composite closer to the Sisal fibre composites and more than that of the banana fibre composite. [14].

Fibre reinforced polymer composites are considered as replacement for metal materials where the association of metallic fibre with polymeric matrix is attractive material for electronic packaging applications [15]. The mechanical and chemical properties of the composite vary according to the cellulosic content of the natural fiber. The major disadvantage of natural fiber is its hydrophilic nature which affects the mechanical properties of the composites [16,17]. Pre-treatment of fibers with NaOH for a time of less than 10 min could improve the fiber properties [18]. Investigated on mechanical behaviour of twisted natural fiber hybrid composite fabricated by vacuum assisted compression molding technique, It was observed that there is a significant improvement in mechanical properties of composites due to the presence of twisted fibers. It also shows the influence of fiber orientation on mechanical properties [19]. Studied mechanical behavoir of glass fiber – coconut coir – human hair hybrid composite and find that coconut coir reinforced plastic is having maximum tensile load, human - coir -glass -human reinforced plastic has maximum impact strength, coir –glass- human-coir reinforced plastic has the higher hardness value [20].

Many researchers have investigated the performance of sisal fibre epoxy composite with equal proportion of fiber resin (50-50%). But only very few researchers have carried out the performance study for sisal fiber epoxy with composite with higher resin weight percentage than sisal weight percentage.

2. EXPERIMENT METHODOLOGY

2.1 Materials

Commercially available LY 556 epoxy resin and HY 951 hardener has been used as matrix and hardner. The resin – hardener ratio have been maintained as 10:1 by weight percentage. Sisal fiber have been collected from local sources. The property of Sisal fiber is discussed in Table 1.

Table 1 Property of Sisal fiber

Fiber type	Density (g/cc)	Tensile strength (MPa)	Young’s modulus (MPa)	Elongation of break %
Sisal	1.42	700	35	2.9

2.2 Processing of Sisal fiber reinforced composites.

Stainless steel mould having dimensioned 400 mm × 400 mm × 4 mm. The sisal fiber epoxy composites are made with the dimension of 300 mm × 300 mm × 3.5 mm fabricated by stacking of three layers. The order of stacking sequence which contains sisal fiber arranged in longitudinal – transverse direction – longitudinal direction as shown in Fig.1. A releasing agent was used to facilitate easy removal of composite from the mould after curing. Each composite was cured under a load of 30 kg for 24 hours before removing the mould. This composite was post cured in the air for 24 hours after removal from mould.

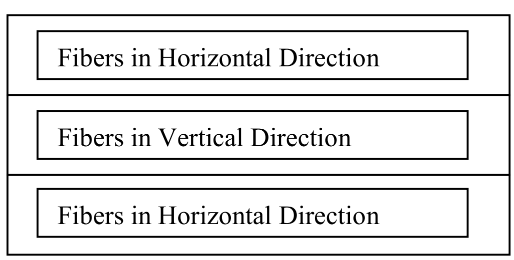

Fig.1. Stacking sequence of sisal fiber reinforced epoxy composites

2.3 Tensile Test.

All tension testing specimens were cut into a dog-bone shape. The tensile test were conducted following the standard of ASTM D638-V using Instron (Model 4301) universal testing machine with load cell of 1 KN and using crosshead speed of 1 mm/min. The test has performed until the tensile failure occurred.

2.4 Flexural Test

The flexural tests were carrying out at room temperature at a crosshead speed 3 mm/min as per ASTM D 790. Rectangle shape specimen of 165 mm × 26.09 mm × 3.5 mm were tested with gauge length 100 mm. Calculations of flexural strength and flexural modulus were evaluated by using following formula

$$\text{Flexural Strength} = (3P_{max}\ L)/(2bd^{2})(3P_{max}\ L)/(2bd^{2}) \quad - \quad (1)$$

$$\text{Flexural modulus} = (mL^{3}) / (4bd^{3})(mL^{3}) / (4bd^{3}) \quad - \quad (2)$$

Where

Pmax- Ultimate failure load (N)

L -span length between centre of support (mm)

b -width of the composite specimen

d -thicknessof the composite specimen

m- slope of tangent to the initial straight line portion of the load – deflection curve.

2.5 Impact Test

Impact test has been done in charpy impact test machine. The v- notched specimen for impact test with dimension of 100 mm × 13.04 mm × 3.5 mm. The specimen was placed horizontal in the test bed. The pendulum was lifted and made to hit the specimen from the standard height.Fig.7 shows the failed specimen of the impact test.

3. RESULTS AND DISCUSSION

3.1Tensile Strength

The tensile properties of bidirectional sisal epoxy composite were investigated by universal testing machine and tested specimen as shown in Fig 2.The test specimen is cut by water jet machine with 0°, 45°, and 90°. The tensile properties of sisal epoxy composite is high along the horizontal orientation of fibercomposite compare with the load applied on other specimens of 45° and 90°angle orientation of fiber composite.

Fig.2 Failure tensile test specimen of Sisal fiber reinforced epoxy composites

Table 2 shows the tensile strength of 0 °, 45° and 90° specimen in which the results shows that two layer arranged in horizontal direction withstand for higher breaking load as compare to other orientation.

Table 2 Tensile strength

Test specimen with various angle (°)	Tensile Strength (MPa)
0	17.46
45	12.06
90	10.18

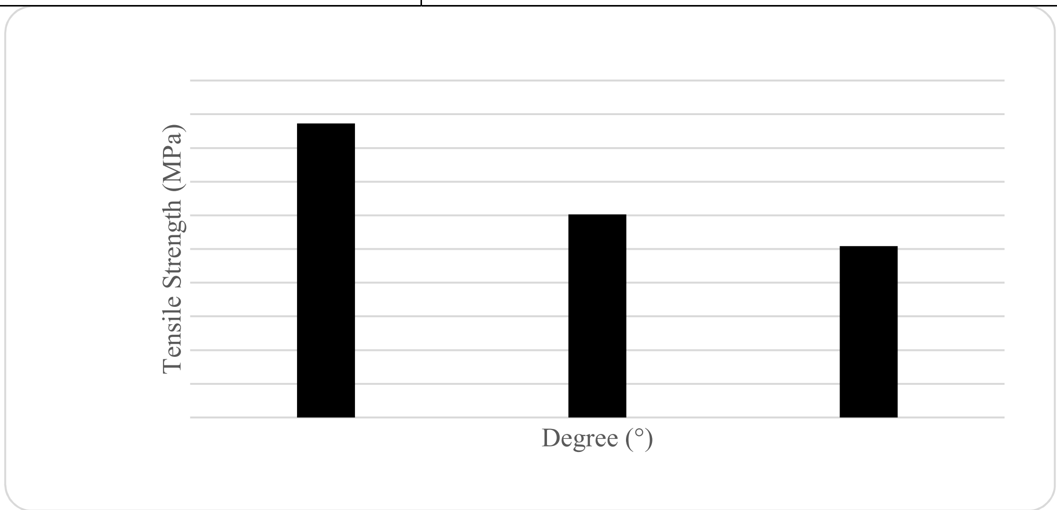

Fig. 3 Fig.3 Tensile strength of 0 °, 45° and 90° cut specimen

3.2 Flexural Strength

The flexural strength of bidirectional sisal epoxy composite is plotted in Fig.4 whose data value is shown in Table 3. The flexural properties of sisal epoxy composite are high along the horizontal orientation of the composite compare with the load applied angle of 45° and 90° of the composite due to two layers of horizontal stacking sequence of sisal fiber, which results shows that two layer arranged in horizontal direction withstand for higher breaking load as compare to other orientation.

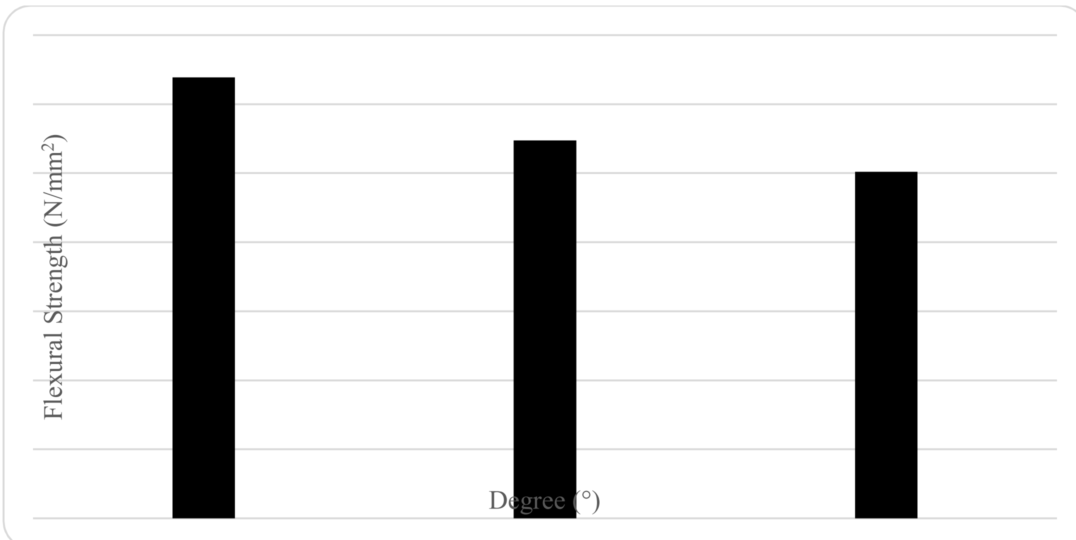

Fig. 4 Flexural strength of 0 °, 45° and 90° cut specimen

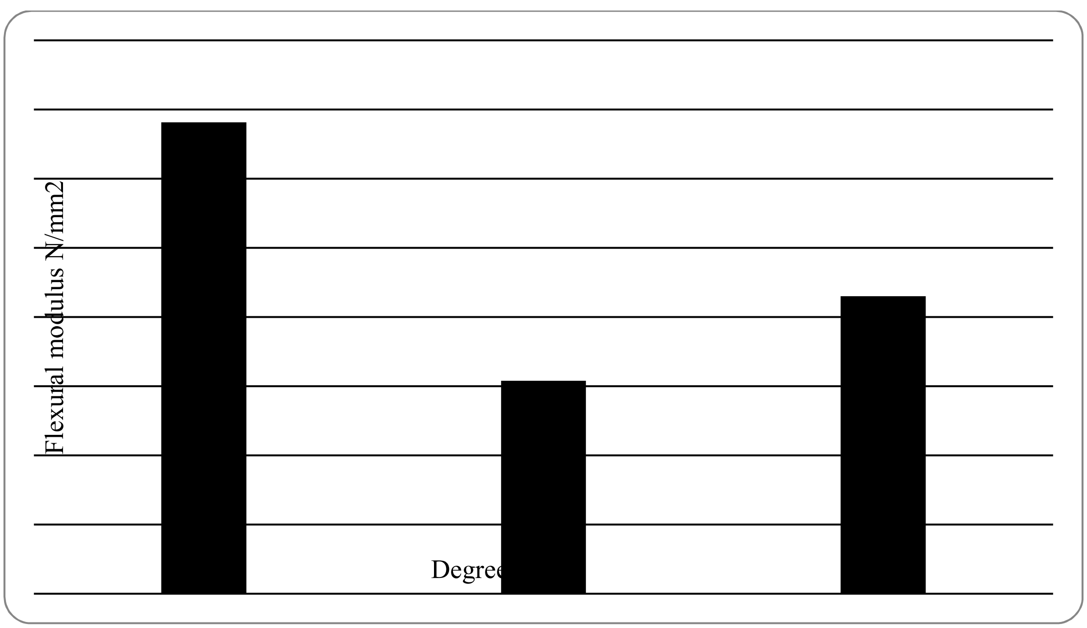

Fig. 5 Flexural modulus of 0 °, 45° and 90° cut specimen

Fig. 6 Failure specimen of flexural test specimen

Table 3 Flexural strength and Flexural Modulus

S.No	Test specimen with various angle (°)	Pmax (N)	Flexural Strength (N/mm^2)	Slope (N/mm^2)	Flexural Modulus (N/mm^2)
1	0	140	63.86	63.64	13630
2	45	120	54.74	43.60	6156.64
3	90	110	50.18	49.31	8601.55

3.3 Impact Test

It is observed that the impact strength of the 0°, 45° and 90° cut specimen having same impact strength 2 Joule.

Fig. 7 Failure specimen of impact test specimen

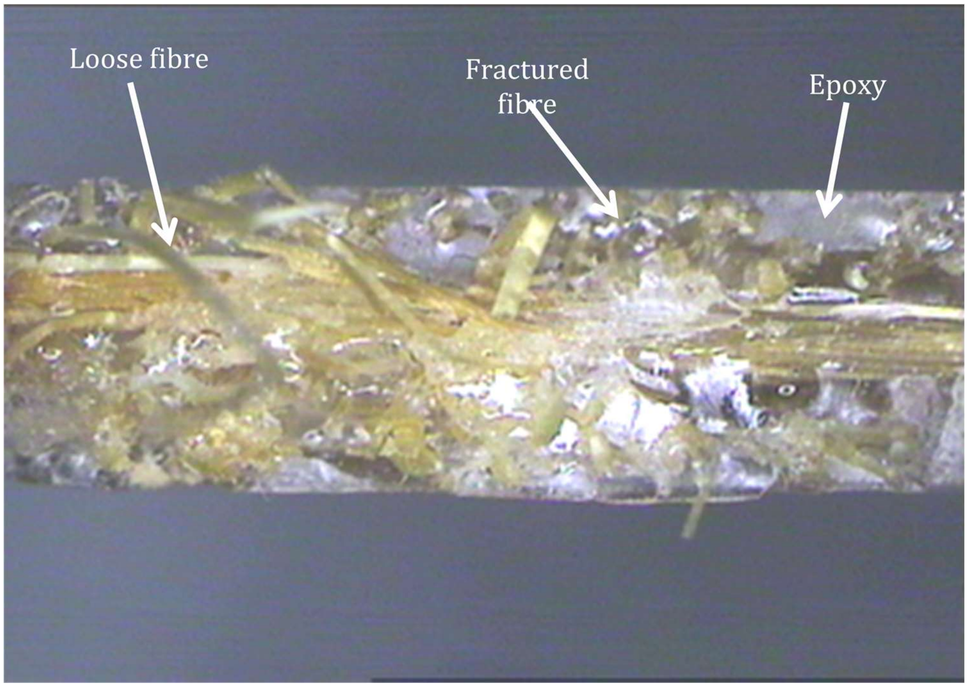

Fig. 8 Macroscopic images of fractured specimen of sisal epoxy composite

4. Conclusion

Sisal fiber epoxy composites with higher weight percentage of resin than fiber weight percentage has been successfully fabricated and tested for 0°, 45 ° and 90° angle of cutting with reference to the longitudinal axis. It is observed that the 0° cut specimen has exhibited tensile strength, flexural strength and flexural modulus of 17.46 MN/mm2, 63.64 N/mm2and 13.630 KN/mm2 respectively which is better than that of 45 ° and 90° cut specimens. Such sisal fiber composites could be used in automobile body parts like motorcycle body panels, car bumper panels, so as to withstand deflection due to wind pressure from all directions.

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