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Fabrication and testing of natural (sisal) fibre reinforced polymer composites material

Chand Badshah S B V J[1], K.Arun[2], B.Eswaraiah[3]

[1]S.V.College of Engineering,India,Chandbadshah36@gmail.com
[2]S.V.College of Engineering,India,Arunk4u@gmail.com
[3]S.V.College of Engineering,India,Billueswar@gmail.com

ABSTRACT

A composite material can be defined as a macroscopic combination of two or more distinct materials, having a recognizable interface between them. This work comprises of fabrication of sisal fibre polymer composite material samples, followed by the testing of its mechanical properties. Products based on this work will be cheaper and sustainable. Natural fibres have the advantage that they are renewable resources. Natural fibre composites such as sisal polymer composites became more attractive due to their high specific strength, lightweight and biodegradability. In this work, sisal – fibres reinforced composites is developed and their mechanical properties such as tensile strength, compression strength and impact strength are evaluated.

KEY WORDS
Composites, Fabrication, Natural Fibre, Sisal.

1 INTRODUCTION

The term composite can be defined as a material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual materials being superior to the properties of individual material that make up the composite. The scientific name of [1, 2]sisal plant is Agave sisalana shown in figure 1 below. This plant is belongs to southern Mexico, but nowadays it is cultivated all over the world. The fibre is obtained from its rosette of sword shaped leaves. The fibre is extracted by a process known as decortication. The plant has a life span of 7-10 years. On an average per leaf of a sisal plant contain about 1000 fibres. Sisal fibres are also widely used around the globe for various other commercial purposes.

Figure1. Sisal plant (Agave sisalana)

The present work deals with the effect of orientation on tensile, compression and impact properties on sisal fibres oriented composite. Tensile, Compression and impact tests are conducted for the composite and the results exhibit an enhancement in the mechanical properties.

2 MATERIALS

The Sisal plant has a 7-10 year life-span and typically produces 200-250 commercially usable leaves. Each leaf contains an average of around 1000 fibres. The fibre element shown in figure 2, which [2] accounts for only about 4% of the plant by weight, is extracted by a process known as decortication.

- The matrix material used in this investigation was bio epoxy resin Grade D638 and Hardner 3554D. Supplied by Janki Enterprises, Chennai.
- Sisal fibres have been used traditionally in high strength ropes in India especially in South India regions.

Figure2. Sisal fibres

3 FABRICATIONS OF SISAL FIBRE COMPOSITES

- Epoxy resin
- Hardener
- Sisal Fibre
- Sodium Hydroxide (NaOH)
- Weighing Machine
- Roller
- Bowl
- Stirrer

3.1 Manufacturing method

The fibres are powdered**.** Then the fibres are cleaned normally in clean running water and dried. A glass beaker is taken and 6% NaOH is [3] added and 80% of distilled water is added and a solution is made. After adequate drying of the fibres in normal shading for 2 to 3 hours, the fibres are taken and soaked in the prepared NaOH solution.

Soaking is carried out for different time intervals depending upon the strength of fibres required. In this study, the fibres are soaked in the solution for three hours. After the fibres are taken out and washed in running water, these are dried for another 2 hours. The fibres are then taken for the next fabrication process namely the hand-lay process.

3.1.1MOULD PREPARATION

In mould preparation the resin is mixed with hardener in the ratio of 4:1. The mixer [4] is strewed with stirrer for 15 minutes continuously. The below figure.3 gives the process of mould preparation.

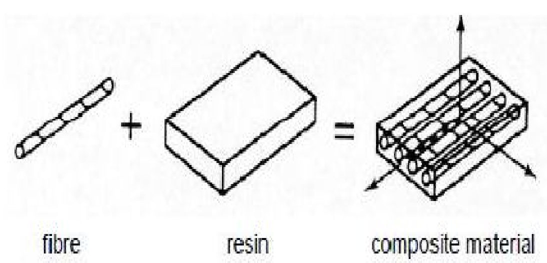

Figure.3 Mould Preparation

3.1.2 PATTERN MAKING

The pattern is designed by as per ASTM standard. The pattern is made up of mild steel. The pattern Size is 235 x 85 x 15 mm (ASTM D37-08).

3.1.3. FABRICATION DETAILS

- Sisal FIBER = 75+75g
- NATURAL FIBER TO RESIN = 1:2
- EPOXY WITH HARDENER = 570g
- PRESSURE OF COMPRESSION = 10bar
- TEMPERATURE REQUIRED = 80°c

4 MATERIAL PROPERTIES

The main objective is to determine the material properties (Tensile Strength, Compression Strength and Impact Strength) of sisal FIBRE reinforced composite material by conducting the following respective tests.

- Tensile Test
- Compression Test
- Impact Test

4.1 Properties of sisal fibres

Density	-	800-700 Kg/m^3
Water absorption	-	56%
Modulus of Elasticity (E)	-	15 Gpa
Tensile Strength	-	268Mpa

5 RESULTS AND DISCUSSION

Engineers and Scientists are working together for number of years for finding the alternative solution for the high solution materials. In the present study natural fibres are added to the epoxy resin reinforced composite materials and their effect on mechanical properties is evaluated and their properties are compared.

5.1 Tensile properties

Fabricated composite was cut to get the desired dimension of specimen for mechanical testing. For the tensile test, the specimen size was 235 × 15 mm^2 and gauge length was 85 mm. Tensile strength was tested in UTM machine [5]. The specimen with desired dimension was fixed in the grips of the UTM machine with 7 mm gauge length. The experimental set up for tensile test is shown in Figure 4.

Figure.4 Universal Testing Machine

The specimen size is 260x24x5mm.The different composite specimen samples are tested in the universal testing machine (UTM) and the samples are left to break till the ultimate tensile strength occurs. Stress–strain curve is plotted for the determination of ultimate tensile strength and elastic modulus. The sample graph generated directly from the machine for tensile test with [7] respect to load and displacement for sisal – Epoxy resin is shown in figure 5 below.

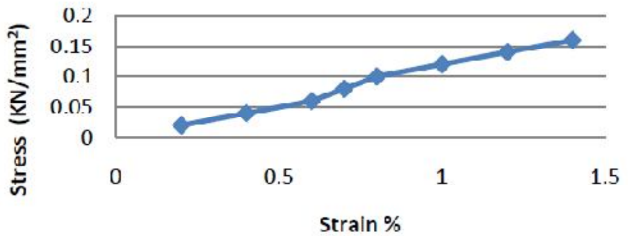

Figure 5.Stress Vs Strain

Figure 6. Specimen after the test

The above figure 6 shows the specimen after conducting tensile test.

5.2 Compression Properties

The specimen size for compression test is 13x13x11mm.The sample graph generated directly from the machine for compression test with respect to load and displacement for sisal – Epoxy resin is shown in below figure8. The compression testing machine is shown in belowfigure7.

Figure 7. Compression Testing Machine

Figure .8 Load vs Displacement

5.3 Impact properties

The impact test specimens are prepared according to the required dimension following the ASTM-A370 standard. During the [6] testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and the yield strength. The impact testing machine is shown in below figure 9.

Figure 9.Impact Testing Machine

The impact test carried out for the present investigation is Charpy impact test. The results indicated that the maximum impact strength is obtained for Sisal–GFRP composites are 18J which are shown in below figure 10. The specimen size of impact test is 64x12x5mm.

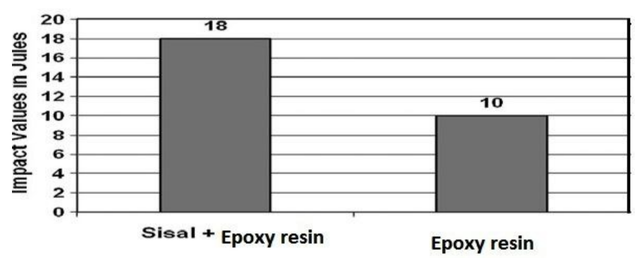

Figure 10. Impact values in Joules

6 APPLICATIONS OF SISAL

Sisal is valued for cordage use because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater. Sisal is used by industry in three grades. The lower grade fibre is processed by the paper industry because of its high content of cellulose and hemicelluloses. The medium grade fibre is used in the cordage industry [8] for making: ropes, baler and binders twine. Ropes and twines are widely employed for marine, agricultural, and general industrial use. The higher-grade fibre after treatment is converted into yarns and used by the carpet industry.

Products made from sisal are being developed rapidly, such as furniture and wall tiles made of resonated sisal. A recent development expanded the range even to car parts for cabin interiors. Other products developed from sisal fibre include spa products, cat scratching posts, lumbar support belts, rugs, slippers, cloths and disc buffers. Sisal wall covering meets the abrasion and tearing resistance standards of the American Society for Testing and Materials and of the National Fire Protection Association.

Apart from ropes, twines and general cordage sisal is used in low-cost and specialty paper, dartboards, buffing cloth, filters, geo textiles, mattresses, carpets, handicrafts, wire rope cores and macrame. In recent years sisal has been utilized as a strengthening agent to replace asbestos and fibre glass as well as an environmentally friendly component in the automobile industry. Products made from sisal fibre are purchased throughout the world and for use by the military, universities, churches and hospitals.

6.1 Future Applications

In future, the final composite material coated by calcium phosphate and hydroxyapatite (hybrid) composite can be used for both internal and external fixation on the human body for fractured bone.

7 METALLURGICAL MICROSTRUCTURE

The surface characteristics of the composite material used for the investigation is studied through microscope. The Microscope images are taken to observe the interfacial properties, internal cracks [9] and internal structure of the fractured surfaces of the composite materials. All the specimens are coated with conducting material before observing the surfaces through microscope. The image Observed for the sisal–Epoxy resin composite material subjected to tensile test is presented .The image for the sisal–Epoxy resin composite material which subjected to impact test is shown in below figure 11.

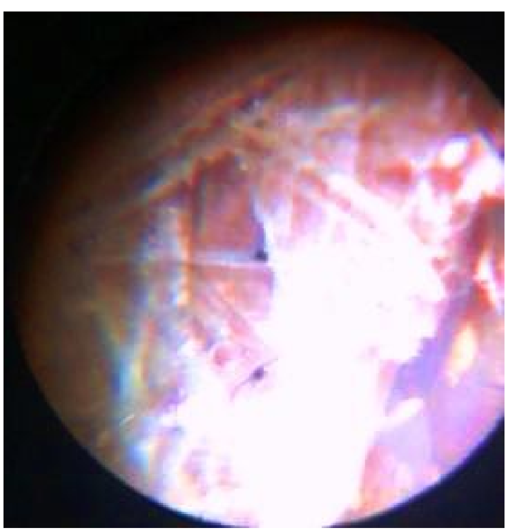

Figure 11. Microstructure at 100x magnification

8 CONCLUSIONS

A lot of research has been done on natural fibre reinforced polymer composites but research on Sisal (Agave sisalana), polymer composites is very rare. Against this background, the present research work has been undertaken, with an objective to explore the potential of the above said fibre polymer composites and to study the mechanical and material characterization of different composites.

Thus the Sisal-GFRP composite samples are fabricated and tested. The hybrids composite are subjected to mechanical testing such as tensile, compression and impact test. Based on the results, the following conclusions are drawn:

The results indicated that sisal–Epoxy resin specimen gives tensile strength is low. The Maximum tensile force (MTF) of the sisal–Epoxy resin composite is in the range of 24 KN.

- In the compression test the result indicates that very high strength 29 KN and the respectively displacement is 2.3mm.
- The maximum impact strength is obtained for the sisal-Epoxy resin fibre composite and has the value of 18 joules.
- The microstructure of the fibre is obtained in the breaking point of tensile and impact test of specimen. To obtain the interfacial properties, internal cracks and internal structure of the fractured surfaces of the composite materials.

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