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Mechanical Properties and SEM Analysis of Flax/Sisal/Sic Nano Powder Reinforced Hybrid Composites

Ganesh R Kalagi . Rajashekar Patil . Pradeepa shetty . Raviprasad . Sujith kumar . Vinod

Shri Madhwa Vadiraja Institute of Technology Bantakal, Karnataka, India.

ABSTRACT

Natural fibre are those which are made naturally such as Flax, Jute, Hemp, cotton, hair, wool coir and etc. Because of many advantages, Natural fibre are replacing glass fibre and carbon fibre such as its biodegradable nature so that it helps to dump it into the open space after it takes retirement, and its ease of availability, low weight, and better strength in multi axial reinforcement with adding Nano powder particles with it.

In this research work mechanical behavior of SiC Nano powder/flax/sisal fibre reinforced epoxy based hybrid composites and its fabrication has been studied. Work has been carried out to investigate the flexural properties, tensile strength, hardness, and impact strength of the composites. It has been observed that impact strength is improved with the increase in the weight fraction of natural fibers to certain extent. The morphology of composites is studied by using Scanning Electron Microscope (SEM).

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Introduction

Natural fibre reinforced composites are alternative materials for some engineering applications such as aerospace applications, small wind turbine blades, and automobile applications [1]. Natural fibre show shows superior properties such as tensile, flexural and impact then glass fibre [2]. The main advantages of natural fibers are of low cost, light weight, easy production and friendly to environment [3,4]. On the other hand, there are some drawbacks such as their poor mechanical properties and high moisture absorption [5].The reinforcement can be synthetic (e.g. glass, carbon, boron and aramid) or of natural sources (e.g. curaua, sisal, jute, piassava, hemp, coir, flax and banana). Nevertheless, some composite components (e.g. for the automotive sector), previously manufactured with glass fibers are now produced with natural fibers [6]. Applications including door panels, trunk liners, instrument panels, interior roofs, parcel shelves, among other interior components, are already in use in European cars due to the more favorable economic, environmental and social aspects of the vegetable fibers [4]. Low level of volume fraction of fibers provided not only higher modulus of elasticity and mechanical strength under tensile and flexural loadings but also have values of apparent density, apparent porosity and water absorption [7-8]. The addition of sic can improve the stiffness by maintaining its low density [9]. The strength of short fiber composites depends on the type of fiber matrix, fiber length, fiber orientation, fiber concentration and the bonding between the fiber and matrix [10].

Experimental

Materials

The main advantages of natural fibres are their availability, biodegradable, renewable, environmental friendly, low cost, low density, high specific properties, good thermal properties and enhanced the energy recovery, low energy consumption, non-abrasive nature and low cost. These fibres are low-cost fibres with low density and high specific properties which are comparable to synthetic fibres. The raw materials used in this work are, flax fibre, sisal fibre, SiC nano power, epoxy and hardener.

Methodology and fabrication techniques

In this research it composites are fabricated by hand layup process. Flax and Sisal were cut into the dimensions of length and breadth of 300×200mm was used to prepare the specimen. The composite specimen consists of totally 6 multiaxial woven layers of flax and sisal as shown in Fig. 1 and table 1 illustrates the details of angle of each layer. A measure quantity of resin and SiC are taken and which is get mixed with hardener in the ratio of 10:1. The layers of fibres were fabricated by adding the required amount of epoxy resin, 17% of flax ,17% of Sisal and 6% of SiC Nano powder is used. The six 6 layers of different fibres (flax and Sisal) are fabricated using hand layup process. The epoxy resin applied is distributed to the entire surface by means of roller. The air gaps formed between the layers during the processing were gently squeezed out, the processed wet composite were then pressed hard and excess resin is removed. Then it is dried by keeping it in atmospheric conditions for 24 hours to get the perfect samples as shown in Fig. 2.

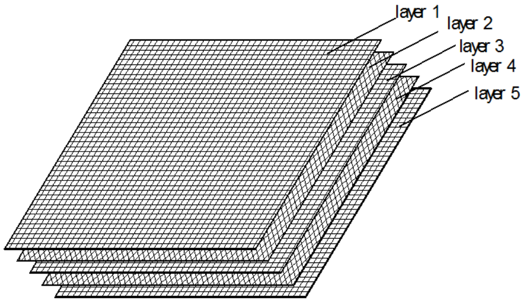

Figure 1: Illustrates multiaxial layers of Flax and Sisal

Corresponding Author: Ganesh R Kalagi, Tel: +91 8497894165
Email: ganeshkalagi082@gmail.com

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Figure 2: Fabricated Flax/Sisal/SiC nano powder/epoxy reinforced hybrid composite using hand layup process

Table 1: Illustrates Details of Multiaxial Layers of Flax and Sisal

Layers	Angle	Fiber Specification
Layer 1	0°/90°	Sisal
Layer 2	+45°/-45°	Flax
Layer 3	0°/90°	Sisal
Layer 4	+45°/-45°	Flax
Layer 5	0°/90°	Sisal
Layer 6	+45°/-45°	Flax

After composite materials dried completely, unwanted surfaces are to be removed using secondary operations and also cut the materials as per the required ASTM standards.

Mechanical Testing

Tensile specimen

Tensile strength of the specimen is determined by carrying tensile test on UTM followed by ASTM Standards. The standard used for tensile strength id ASTM D3039. It has been fabricated according to the ASTM Standards as shown in Fig. 3.

Figure 3: Fabricated specimens for tensile test as ASTM Standards

Flexural specimen

Flexural strength of the specimen is determined by carrying flexural test on UTM followed by ASTM Standards. Three-point bending test of composite sample is carried out in ASTM D 790 test standard. A uniaxial load was applied through both the end. Specimen has been fabricated as shown in Fig. 4.

Figure 4: Specimens for flexural test as ASTM standards

Impact specimen

The energy absorbed by the material is found by charpy testing followed by ASTM Standard of ASTM E23-15b as shown in Fig. 5.

Figure 5: Specimen for impact test as ASTM standards

Results and Discussion

Tensile test

It is found that tensile strength of woven flax/sisal reinforced with Epoxy/SiC Resin is given unfavorable results. Stress strain curve for all the three specimens under tensile load are shown in Fig. 6 and Woven cloth fiber based flax /Sisal reinforced hybrid composites are given average maximum Tensile stress about 28N/mm^2, Maximum Tensile force about 2445N and will have maximum Tensile strain 2.718% as shown in table 2.

Table 2: Tensile test results

Specimen	Tensile stress (N/mm^2)	Maximum force (N)	Maximum Tensile strain (%)
1	29.697	2413.50	2.25917
2	28.121	2362.17	3.39795
3	26.522	2494.51	2.49137

Flexural test

Stress strain curve for all the three specimens under flexural load are shown in Figure 7 and table 3 shows the details of flexural results for three numbers of specimens. From the below graph of stress vs strain it is observed that average flexural stress of material is 63 N/mm^2.

Table 3: Various results of flexural test

Specimen	Flexural stress(N/mm^2)	Maximum force(N)	Maximum strain(%)
1	58.29	71.0328	5.87025
2	60.56	80.05060	4.95108
3	70.01	93.0627	4.58747

Impact test

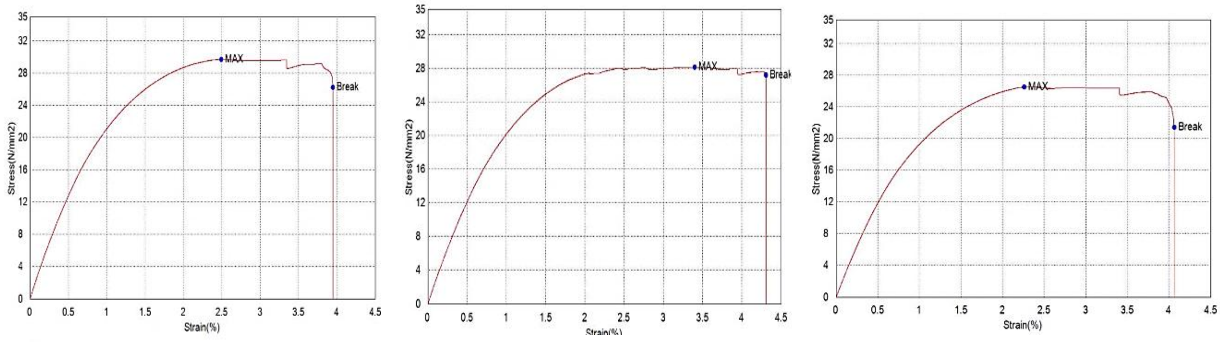
Impact test is conducted to analyses the energy absorbed by the specimen for sudden applied load. The impact test is done by charpy impact test machine. From the table 4 it is observed that average impact strength of composite material is 137.66 KJ/m^2.

Table 4: Impact test results as per ASTM standards

Specimen	Impact strength(KJ/m^2)
1	142.05
2	99.43
3	170.45

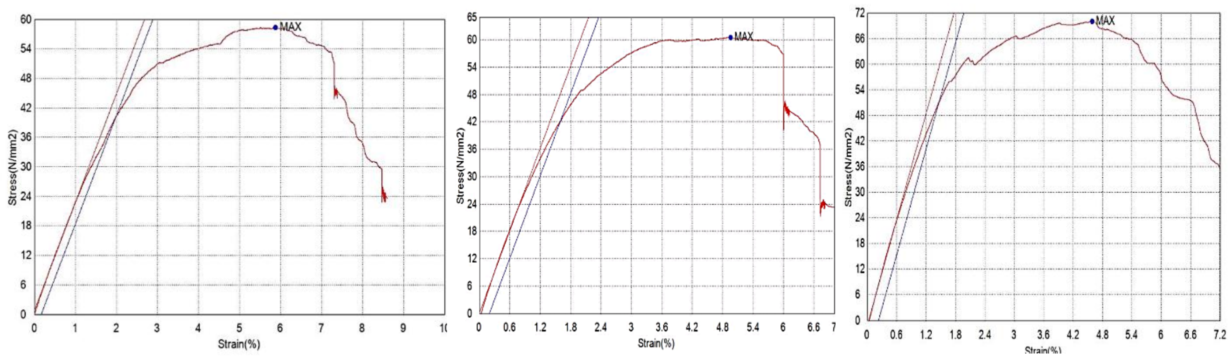
SEM Analysis

Figure 8 shows sample's surface topography of flax/Sisal reinforced with SiC nanopowder/epoxy resin after fabrication. The SEM test shows the various of mechanical properties through phase distribution information. Figure shows that phase of flax/Sisal/SiC nanopowder/epoxy reinforced epoxy composite. It is observed that due to hand layup process, Sic and epoxy resin are taken uneven surfaces which may reduce tensile and flexural properties comparatively but it is proven that this uneven surfaces of Sic and resin may increase impact strength of material.



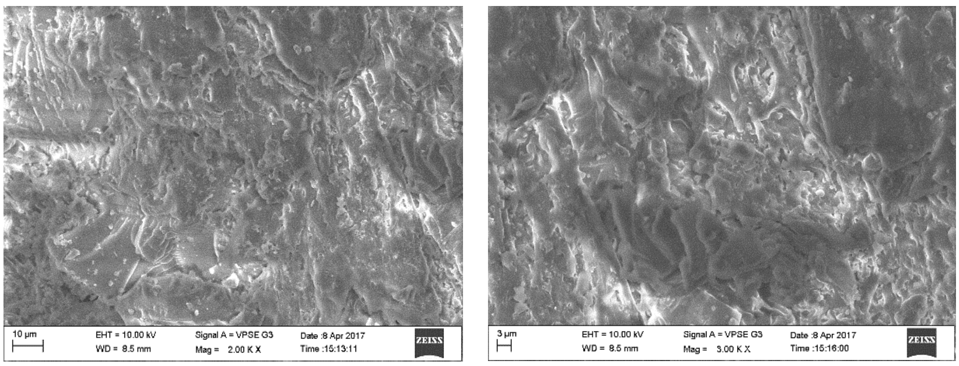
(a) (b) (c)

Figure 6: (a) Stress vs strain diagram for specimen 1 under tensile load, (b) Stress vs strain diagram for specimen 2 under tensile load, (c) Stress vs strain diagram for specimen 3 under tensile load



(a) (b) (c)

Figure 7: (a) Stress vs strain diagram for specimen 1 under flexural load, (b) Stress vs strain diagram for specimen 2 under flexural load, (c) Stress vs strain diagram for specimen 3 under flexural load



(a) (b)

Figure 8: SEM Images of Flax/Sisal reinforced with Sic/epoxy resin (a) 2000 Magnification, (b) 3000 magnification which shows uniform distribution of flax and sisal

Conclusions

Natural fiber reinforced composites form one such class of materials which not only possess superior mechanical properties but are also bio-degradable in nature. Natural fiber reinforced composites can be a potential candidate where they can replace the conventional material system of wind industry. But it is very difficult to replace the synthetic fibers by natural fibers only, in order to get better properties, it is essential to use some amount of nano-powder such as SiC to improve its mechanical properties with low density.

From this research work it is found that adding 6% of SiC nano-powder of size 20 micron in Epoxy is improved the impact strength and hardness of composite by reducing its density.

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