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Mechanical and Hygroscopic Properties of Hybrid Natural Fiber Reinforced Polymer Composite Material

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ABSTRACT: Now-a-days the composite materials have been replaced the traditional materials. The attractive features of natural fibers like jute, Sisal, coir, bagasse and banana have been their low cost, high tensile strength, low thermal expansion, high strength to weight ratio, renewability and biodegradability. This present experimental study aims at learning the Development action of hybrid natural fiber reinforcement polymer composite material such as sisal and sugarcane bagasse fibers with epoxy resin(ER) as a matrix in automobile applications. The test specimens have to be prepared as per ASTM Standard by changing volume fraction (0, 30, 40, 50, and 60%). The specimens are tested experimentally for mechanical properties such as tensile, Rockwell hardness and water absorption.

KEYWORDS: Epoxy resin, hybrid composites, mechanical testing, polymer matrix composites (PMCs), and sisal and sugarcane bagasse natural fibres.

I. INTRODUCTION

In last three decade years the composite materials have got a widely applications in all cutting-edge ranges of advanced materials such as aeronautics, automotives, boats, sports parts and medical devices. Composites are a combination of two materials in which one of the material is called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other material called the matrix [1].

Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material [2].

Interest in natural fiber reinforced polymer composites is growing rapidly due to the high performance in mechanical properties, significant processing advantages, low cost and low density. Natural fibres are renewable resources in many developing countries of the world; they are cheaper, pose no health hazards and finally, provide a solution to environmental pollution by finding new use for waste materials [3].

Various natural fibres such as bamboo, sisal [4], jute, rice straw, vakka , date, flax , jawar[4],sunhemp, Pineapple,hemp,coir [5] used as a reinforcement and thermo set or thermoplastic materials are used as a matrix. The alkalization treatments have improved mechanical properties. After complete the chemical treatment, the natural fiber were need to wash in running water. Then they were dried for Week at room temperature [6].As to the fiber properties, conventional fibers such as short and long glass fibers and carbon fibers are exhibit significantly higher strength values and the natural fibers also attain the nearest value of conventional fibers [7].

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A. Green Composites Materials in the Automotive Industry

In recent years, the automotive industry are observed to reduce the use of expensive glass, aramid or carbon fibers and the natural fibers are started to use due to light weight , low cost and renewability. Renewable fibers as reinforcements were vastly used in composites of interior parts for a number of passenger and commercial vehicles. Mercedes-Benz used an epoxy matrix with the addition of jute in the door panels in its E-class vehicles back in 1996.Lately, Toyota developed an eco-plastic made from sugar cane and will use it to line the interiors and exteriors of the cars.

II.RAW MATERIALS AND PROPERTIES

A. **Matrix**

Epoxy resin is selected as the matrix. The epoxy resin of grade [LY556] and the hardener HY951 was purchased from local dealer, Coimbatore, India. The resin has a density of 1.1-1.4kg/m, elastic modules of 3-6GPa, tensile strength of 35-100 MPa , elongation at break of 1-6%, Water absorption (24h)0.1-0.4%, Izod Impact, Notched 0.3J/cm and Compressive Strength 100-200MPa.

B **Small Particles of Fibres**

Sisal and sugarcane bagasse are collected from local sources. Whose mechanical properties are shown in the Table 1.

Fig 1. Sisal Natural FiberFig 2. Sisal and Bagasse Fiber Table 1. Properties of Sisal Fiber and Sugarcane Bagasse Fiber

Properties	Sisal fiber	Sugarcane bagasse fiber
Specific weight (kg/cm3)	1.5	1.0
Elongation (%)	2.0-2.5	7.5
Tensile strength(MPa)	511-635	24.5
Elastic modules(GPa)	9.4-22	23.7

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III.FABRICATION OF TESTSPECIMEN

A. Mould Preparation

The test specimen is made of well-seasoned teak wood. The fabrication of the polymer composite material test specimen was carried out through hand lay-up technique.

B. Chemical Treatment of the Natural Fibres

The chemical treatments are used to increase the mechanical properties. This alkalization treatment also has improved the tensile properties. The whole natural fibers were subjected to a chemical treatment to remove natural waxes and other unwanted particles. The crushed natural fibers are first washed thoroughly with distilled water then kept for 3hr in 60g/l sodium hydroxide (NaOH). After complete alkali treatment, washing was continued till the fibers were alkali free. The washed fibers were dried next 7days in room Temperature.

C. Test Specimen Preparation Procedure

Polymer composite reinforced with various amounts of natural fibers were prepared by compounding epoxy resin with the alkali treated natural fibers those sisal and sugarcane bagasse. The test specimen was carried out for various concentrations of natural fibers (0, 30, 40, 50, and 60 volume %) as per ASTM standard.

Fig 3.Hardness Test Specimen

Fig 4. Water Absorption Test Specimen

IV. TESTING OF POLYMER COMPOSITE SPECIMEN

After fabrication, the test specimens were contacted to various mechanical tests as per ASTM standards.

A. Tensile Test

The standards followed are ASTM-D638-03 for tensile with test speed of 5mm/min. test was carried using universal testing machine (UTM). The standard specimen size for ASTM is 246mm×19mm×3.2mm. Notice that in 0% volume ratio sisal and sugarcane bagasse fibre value is higher compare to all other and after 30% volume ratio fibre gradually increases still 60% volume ratio fiber.

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Fig 5. Tensile Specimen the After Test

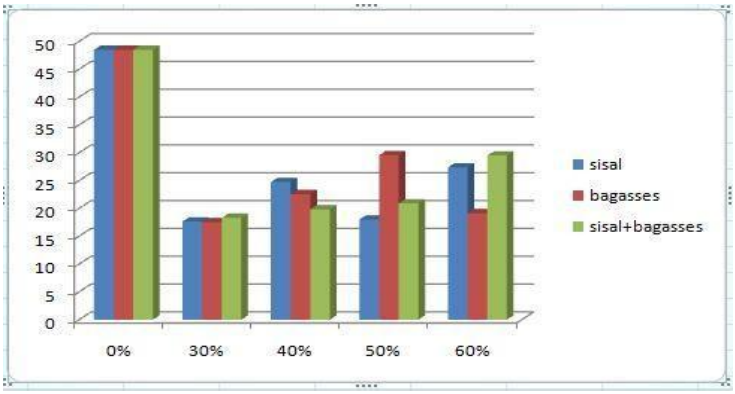

Fig.6. Tensile Test Result

The Rockwell hardness test is a hardness measurement based on the net increase in depth of impression as a load applied. The test specimen was taken out as per ASTM standard D785. The result is carrying out using Rockwell hardness tester. A standard specimen size 6.4mm thickness.

Fig 7. Rockwell Hardness Tester

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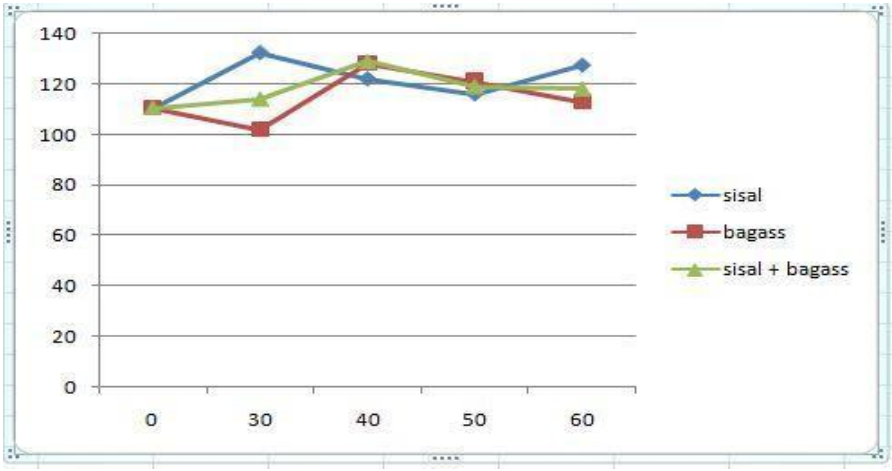


Fig 8. Rockwell Hardness Test Result

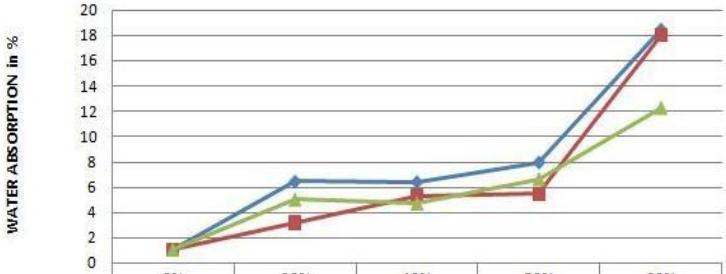
In the above graph clearly see that 0% volume ratio sisal and sugarcane bagasse hybrid fibre value is less compare to 20% volume ratio fibre and 40% volume ratio fibres gives maximum volume. Again the value starts decreases gradually until 60% volume ratio fibre.

B. Water absorption test

Water absorption is used to determine the amount of water absorbed under specified condition. The test specimen was manufactured as per ASTM standard D570. The water absorption is expressed as increasing weight percent.

Fig 9. Water Absorption Test Result

By looking the graph 60% volume ratio sisal and sugarcane bagasse fibre absorbs more water % compare to other



	0%	30%	40%	50%	60%
sisal fiber	1.035645472	6.416101412	6.3809248	7.939339875	18.42983317
bagasse fiber	1.035645472	3.172158916	5.242868157	5.45414559	17.97372342
sisal +bagasse fiber	1.035645472	4.979298322	4.680742814	6.596638655	12.21381644

volume ratios. 0% volume ratio fibre gives the better value and gradually starts increase until 50% volume ratio fibre.

V.FUTURE WORK

There is an increasing demand from automotive companies for materials with sound abatement capability as well as reduce weight for fuel efficiency; therefore the use of natural fibers over conventional glass and carbon fibers. However, the properties of these natural fibers reinforced composites are depend on the properties of the natural fiber between fiber and matrix. The enhancement of the properties of the composites can be achieved by changing the volume of matrix and the fiber. The chemical modification also increases the mechanical properties.

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VI. CONCLUSION

These technologies offer a way of light weighting and high strength of automotive components. In the view of fuel economy the natural fiber are given extreme output. The crushed medium density of hybrid natural fiber sisal and sugarcane bagasse is help to fabricate of large composite components. This study has been found that

- 60 %(volume) of sisal and sugarcane bagasse hybrid natural fiber reinforced polymer composite composition attain the maximum tensile strength (29.49 N/mm^2).
- 40 %(volume) of sisal and bagasse hybrid natural fiber reinforced polymer composite composition absorbed the less amount of water content (4.680%).
- 40 %(volume) of sisal and bagasse hybrid natural fiber reinforced polymer composite attain maximum hardness (B129).

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