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Fabrication and Investigation of Mechanical Properties of Sisal, Jute & Okra Natural Fiber Reinforced Hybrid Polymer Composites

I.V.Surendra[#1], K.Venkateswara Rao [*2], K.V.P.P.Chandu [#3]

[#(]*Masters of Engineering), Mechanical Department, Sir C.R.Reddy college of Engineering, Andhra University*

Eluru - 534007, W.G.Dist., Andhra Pradesh, India

***Abstract*— The main objective of this thesis is to fabricate and investigate mechanical properties of sisal natural fibre reinforced polymer composite and hybrid (sisal + jute + okra) natural fibre reinforced polymer composite. Hybrid composite is fabricated by adding 35% of sisal, 35% of jute and 30% of okra fibre. Mechanical properties such as Tensile properties (tensile strength, tensile modulus), Flexural properties (Flexural strength, Flexural modulus), Impact strength when subjected to varying weights of fibre (0.4, 0.8, 1.2, 1.6, 2 grams) were determined.**

***Keywords*— Hybrid composite, Sisal, jute, Okra, Polymer Composites.**

I. INTRODUCTION

The word "composite" means two or more distinct parts physically bounded together. Thus, a material having two or more distinct constituent materials or phases may be considered a composite material**.** Fiber-reinforced composite materials consist of fiber of high strength and modulus embedded in or bonded to a matrix with distinct interfaces (boundary) between them. In this form, both fiber and matrix retain their physical and chemical identities, yet they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fiber are the principal load-carrying members, while the surrounding matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperatures and humidity. Based on paper "Tensile and flexural properties of sisal/jute hybrid natural fiber composite" which defines that hybrid composite is fabricated by using sisal fiber and jute fiber. By fallowing the composition of mixing of fibers (0/40, 10/30, 20/20, 30/10, 40/0 weight fractions by keeping overall weight fraction as 0.4 weight fraction) gives the fallowing results. Ultimate tensile properties of pure sisal and pure jute are 38.93MPa and 36.93MPa respectively. And flexural properties of pure sisal and pure jute are 87.15MPa and 87.05MPa respectively. At 20/20 ratio (equal ratios of sisal/jute) gives the fallowing results tensile stress is 39.93MPa and flexural stress is 88.33MPa. [1].Also based on paper "Mechanical property evaluation of sisal–jute–glass fiber reinforced polyester composites" which defines that the advantages of mixing glass fiber with sisal and jute natural fiber to develop a new hybrid composite (sisal-jute-glass reinforced polyester composites). And the mechanical properties such as tensile strength, flexural strength and impact strength were determined [2].

II. EXPERIMENTAL PLAN

A. Fiber extraction process

Sisal: Sisal grows well on a dry permeable sandy loam and is exceedingly drought resistant. The leaves are cut for fiber between the third and fourth year. Each plant yields about 250 – 300 leaves during its life time of 7 – 8 years. Sisal leaf is decorticated mechanically to extract fibers which are washed in plain water and sun- dried.

Jute: Jute takes nearly 3 months, to grow to a height of 12–15 feet, during season and then cut & bundled and kept immersed in water for ''Retting'' process, where the inner stem and outer, gets separated and the outer plant gets 'individualized', to form a Fiber. Then the plant get separated and washed to remove dust from the plant.

Okra: The removed okra stems were placed in a pit containing stagnant mud water for 6 days at ambient conditions. On 7th day the stems were washed out with sufficient quantity of water till the complete Pulp detached from the fiber. Then the fiber was dried for 7 days at ambient conditions. The fiber obtained is 5 ft. to 7ft.long.

Sisal fiber

Jute fiber

Okra fiber

B. Methodology

The mould is prepared on smooth ceramic tile with rubber shoe sole to the required dimension. Initially the ceramic tile is cleaned with shellac (NC thinner). Then mould is prepared keeping the rubber sole on the tile. The gap between the rubber and the tile is filled with mansion hygienic wax. A thin coating of PVA (polyvinyl alcohol) is applied on the contact surface of specimen, using a brush. The resulting mould is cured for 24 hours. ECMALON 4411 is an unsaturated polyester resin with clear colorless or pale yellow color and

1.5% of Cobalt accelerator and 1.5% of MEKP catalyst are added for curing the resin at room conditions. Known weight of the fiber is placed along the longitudinal direction of the specimen so that the fibers are oriented 0^0 along the axial direction of the specimen. Then the rest of the mould is filled with the resin making sure that there are no air gaps in the mould. Then, a thin Polyethylene paper of 0.2mm thick is placed on the rubber mould. A flat mild steel plate is placed on the mould and a pressure of $0.05MN/m^{-2}$ is applied and left for 24 hours to cure. Later the specimen is removed and filed to obtain the final dimensions. The specimen is cleaned with NC thinner and wiped off to remove dirt particles.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

Ultimate Tensile Strength**:** It is the ratio of ultimate load to the cross section area of specimen.

Tensile modulus**:** It is the ratio, with in the elastic limit of stress to corresponding strain.

Maximum flexural stress $S = \frac{3PL}{2bt^3}$

Flexural modulus $E_B = \frac{L^3 m}{4bt^3}$

Where

m = slope of load deflection curve (N/mm).
b = width of the specimen (mm).
L = span length of specimen (mm).
t = thickness of specimen (mm).
P = maximum load.

Impact stress I=E/t

E = energy observed by the specimen (j)

t = thickness of composites (m)

A. Tables And Figures

TABLES 1

MEAN ULTIMATE TENSILE STRENGTH OF SISAL FIBER AND HYBRID COMPOSITE.

S.NO	Weight of the fiber (g)	Volume Fraction (Vf)	Sisal	Hybrid (sisal +jute + okra)
			Tensile Strength (MPa)	Tensile Strength (MPa)
1	0	0	36.88	36.88
2	0.4	10	45.3	49.96
3	0.8	16	52.8	58.29
4	1.2	21	59	67
5	1.6	27	63.4	72.6
6	2	36	71	78.3

TABLE 2

MEAN ULTIMATE TENSILE MODULUS OF SISAL FIBER AND HYBRID COMPOSITE

S.NO	Weight of the fiber (g)	Volume Fraction (Vf)	Sisal	Hybrid (sisal +jute + okra)
			Tensile Modulus (GPa)	Tensile Modulus (GPa)
1	0	0	568	568
2	0.4	10	785	810
3	0.8	16	813	947
4	1.2	21	960	984
5	1.6	27	1029	1047
6	2	36	1083	1177

TABLE 3

MEAN ULTIMATE FLEXURAL STRENGTH OF SISAL FIBER AND HYBRID COMPOSITE

S.NO	Weight of the fiber (g)	Volume Fraction (Vf)	Sisal	Hybrid (sisal +jute + okra)
			Flexural Strength (MPa)	Flexural Strength (MPa)
1	0	0	78	78

2	0.4	10	72.5	89.71
3	0.8	16	89.63	113.67
4	1.2	21	115.72	126.84
5	1.6	27	132.88	139.65
6	2	36	148.49	155.46

TABLE 4

MEAN ULTIMATE FLEXURAL MODULUS OF SISAL FIBER AND HYBRID COMPOSITE

S.NO	**Weight of the fiber (g)**	**Volume Fraction (Vf)**	**Sisal**	**Hybrid (sisal +jute + okra)**
			Flexural Modulus (GPa)	**Flexural Modulus (GPa)**
1	0	0	940	940
2	0.4	10	870	896
3	0.8	16	1032	1124
4	1.2	21	1272	1348
5	1.6	27	1497	1521
6	2	36	1542	1637

TABLE 5

MEAN ULTIMATE IMPACT STRENGTH OF SISAL FIBER AND HYBRID COMPOSITE

S.NO	**Weight of the fiber (g)**	**Volume Fraction (Vf)**	**Sisal**	**Hybrid (sisal +jute + okra)**
			Impact Strength (J/M)	**Impact Strength (J/M)**
1	0	0	45	45
2	0.4	10	92.5	107.68
3	0.8	16	121.63	143.2
4	1.2	21	195	240.86
5	1.6	27	263.86	336.28
6	2	36	318.44	425.3

TABLE 6

ASTM STANDARDS FOR FABRICATING SPECIMENS

S No	**ASTM STANDARDS**	**SPECIMENS**
1	ASTM D638M – 89	Tensile test
2	ASTM D790M – 86	Bending test
3	ASTM D256 – 97	Impact test

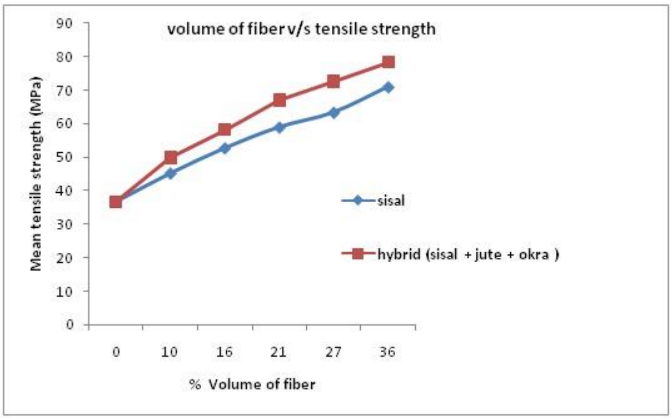

Fig. 1 tensile strength v/s volume fraction of sisal fiber and hybrid composite.

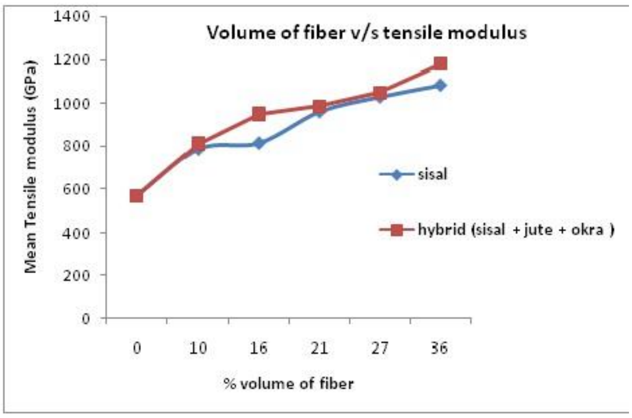

Fig. 2 tensile modulus v/s volume fraction of sisal fiber and hybrid composite.

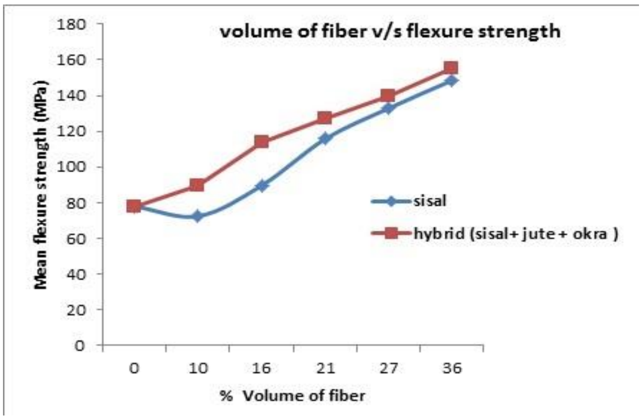

Fig. 3 flexural strength v/s volume fraction of sisal fiber and hybrid composite.

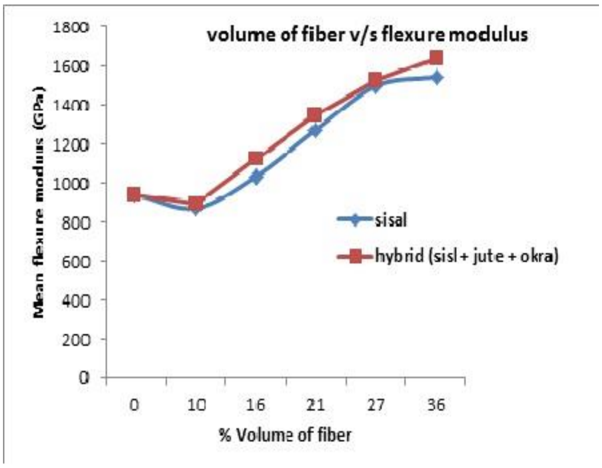

Fig. 4 flexural modulus v/s volume fraction of sisal fiber and hybrid composite.

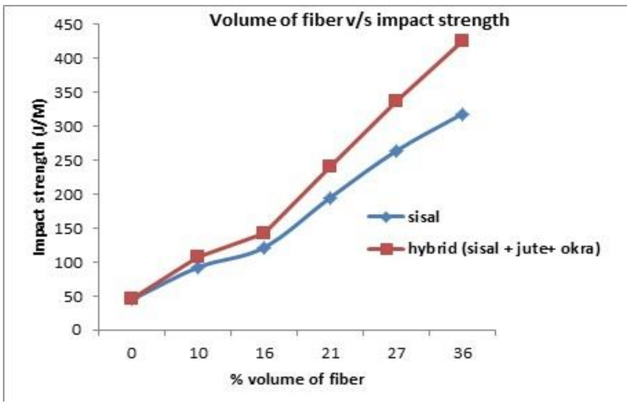

Fig. 5 impact strength v/s volume fraction of sisal fiber and hybrid composite.

Fig. 6 Sisal fiber composite specimens subjected to tensile testing

Fig. 7 Hybrid fiber composite specimens subjected to tensile testing

Fig. 8 Sisal fiber composite specimens subjected to flexural testing

Fig. 9 Hybrid fiber composite specimens subjected to flexural testing

Fig. 10 sisal fiber composite specimens subjected to impact testing

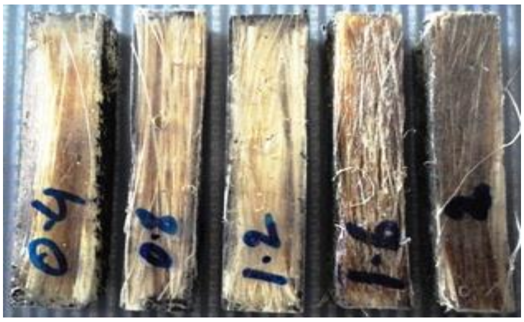

Fig. 11 Hybrid fiber composite specimens subjected to impact testing

IV. CONCLUSION

The maximum tensile strength of hybrid (sisal + jute + okra fiber) reinforced polymer composite is 9.8% higher than that of sisal fiber reinforced polymer composite.

The maximum tensile modulus of hybrid (sisal + jute + okra fiber) reinforced polymer composite is 8.7% higher than that of sisal fiber reinforced polymer composite.

The maximum flexural strength of hybrid (sisal + jute + okra fiber) reinforced polymer composite is 4.7% higher than that of sisal fiber reinforced polymer composite.

The maximum flexural modulus of hybrid (sisal + jute + okra fiber) reinforced polymer composite is 6.2% higher than that of sisal fiber reinforced polymer composite.

The maximum impact energy of hybrid (sisal + jute + okra fiber) reinforced polymer composite is 33.6% higher than that of sisal fiber reinforced polymer composite.

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