



DEVELOPMENT OF THE HYBRID NATURAL FIBER REINFORCED POLYMER COMPOSITES USING THE BIDIRECTIONAL SISAL AND WOVEN JUTE FIBER

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Abstract- In the existing scenario requisite of materials for various determinations, increase, so to organize that one's uses of biodegradables are a more electrifying area during this current period. The protagonist of composite materials contained by the sector of engineering is gradually increasing. This study objective to estimate mechanical properties like tensile and flexural strength of hybrid sisal/jute reinforced epoxy composites — the composite samples prepared by hand layup and compression molding technique. The hybrid composites of sisal/jute made-up with various weight ratios (100/0, 70/30, 50/50, 30/70 and 0/100) at 20% and 30% whole fiber fraction. The ultimate lastingness of 41.14 MPa, and 46.85 MPa have 50% jute and 50% sisal for both 20% and 30% fiber fraction respectively. So the hybrid fiber composites have properties better than non-hybrid fiber reinforced epoxy composites.

Keywords- Hybrid, Mechanical Properties, reinforced polymer composite and Compression Molding.

1. INTRODUCTION

In current years, plant fibers are beneficial to exchange plastic in a number of applications, due to their related excellent mechanical properties. Natural fibers are less expensive, and also bio-degradable having no deathtrap. Natural fibres also are sound warm and having audile safeguard properties; environment-friendly. Fibres are existing in plants, minerals, animal etc. Mineral fibres organized into three groups, fiberglass (glass wool and glass filament), and mineral. During a range of fiber content (0–50 wt.%) the flexural strength and flexural modulus of chemically treated fiber reinforced polylactide composites are worthy. Coatings by coatings of optical fiber affect the properties of natural fibre composites, like enhanced the tensile behavior. Whereas, the flexural properties were improved by two covers of optical fibers on a banana–sisal fiber composite as an alternative of three layers of glass fiber. Arthanarieswaran, V. P et al. [1] studied the impact strength was enhanced while sisal and three layers of optical fiber used. Das, P. K. et al. [2] tells about the methods to extract sisal fiber from plant stem. The viscoelastic properties and water absorption properties of prepared samples calculated for fabricated composites. Gupta, M. K et al. [3] studied that the hybrid composite with the best fiber fraction showed better properties than other composites, Y. Karaduman et al. [4] evaluated the flexural properties of cloth using jute. The tensile modulus, tensile property, bending strength, impact strength, the flexural modulus of untreated jute composite was enhanced about 103%, 211%, 95.2%, 42.4%, and 85.9%, respectively. Karasumi et al. [5] tells that woven jute FRP composites in distort situation results higher mechanical conducts than non-woven jute FRPC. Natural fiber has outstanding properties, also the pressure molding technique went to prepare the composites with the assistance of two roll mills, and so the fiber composition is employed as 0, 10, 20 and 40 wt.%, bidirectional jute fiber having impact on mechanical and physical properties of composite [6], [7], [8]. The alkali treatment effects the properties of jute fibre and also indicate the effective change inside the green rubber prepared by this. Banana fiber is helpful to establish reinforced natural fiber and to take better results, the fiber weighting fraction kept 40% constant for entire composites [9], [10]. The alkali-treatment of fibers composites benefits to improve the flexural behavior as related to the raw fiber composite, the flexural strength was enriched from 23 MPa to 57MPa with 10% NaOH treated composite for 24hr. The results presented that the flexural strength of the made-up composites reduced with increased fiber content, whereas, flexural modulus indicated reverse behavior for the same [11], [12]. Sawpan, M. A et al. [13] shows that the chemically treated fibers with alkali and saline were improving flexural modulus and flexural strength, which improved fiber/matrix adhesion. The tensile properties of made-up samples were almost similar to bamboo fiber composite. Flexural con-duct of jowar fiber composite is 4%, 35% better than bamboo fiber and sisal fiber composites, respectively. All composites made-up for the several volume fraction of fibres like 37% for tensile and 39% for dielectric and flexural [14], [15], [16]. The weird length of banana fibers is employed to organize the composites and samples were made for various fiber weight fractions (8%, 12%, 16% and 20%) [17], [18]. [19], [20], [21] gives the approach for determination of equivalent limit load surface of fiber-reinforced

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nonlinear composites. The Natural fibres grounded polymer composites had showed an alternate to plastic in many applications, due to their consistent good mechanical and chemical qualities. Natural fibres are less expensive, bio-degradable and haven't any health risk. As, many studies has been done for the development of green composites, at different process parameters like the sort of natural fibres, fiber fractions, polymers etc. But in the field of hybridization, less work has been done. In this research work hybridization of two natural fibres at altered fiber fraction has been done to recognize the effect of hybridization on mechanical properties of composites.

2. PROCEDURE

In this current study, the epoxy resin and two kind of natural fiber (i.e., Sisal and Jute fiber) are selected. Various fiber fractions was used to prepared samples and mechanical properties tensile and flexural strength was evaluated. The Hardener K-59 and epoxy C-51 is used in this work. A releasing agent Vaseline is used in this work.

Table- 2.1 Properties of Natural fibers that are used to Prepared Composite

Properties	Sisal	Jute
Tensile Strength(KN/mm ²)	410-780	610-720
Stiffness(KN/mm)	10-30	30-38
Density(g/cm ³)	1.48	1.34
Elongation at break (%)	1.9	2-3
Moist Absorption	12	11

Bidirectional sisal and Jute mate hybrid and non-hybrid composites made-up by reinforcing the sisal and jute fibers inside the epoxy matrix by hand lay-up technique. The epoxy C-51 and hardener K-59 mixed in the proportion of 2:1 by weight. The composite samples fabricated at 20% and 30% fiber weighting fraction. The fiber fraction of hybrid composites distributed into three sub-parts 15:5, 10:10 and 5:15 (15% fiber fraction contribution given by jute and 5% by sisal and vice versa) for 20% fiber loading hybrid specimens and 10:20, 15:15 and 20:10 just in case of 30% fiber loading hybrid composites.

Jute mate and raw sisal fibers of 320 mm length and 90 mm width used for sample preparation. The lamina comprising of layers of bidirectional sisal and jute mate fibers and number of layers of jute mate be influenced by the load of fiber used, and every layer was of 4g. Before use in the lamina, the fibers dried in sunlight for 1 to 2 hours.

Both resin and hardener kept in sunlight for half an hour, and then homogeneous mixture is prepared. Physical stirrer is used to mix the resin and hardener within the framework. Vaseline is used to smooth the graceful removal of the composite from the mold after curing. Each composite is prepared under the load of 400 KN for 24 hours to desire the right shape and thickness.

First of all, Both the surface of the die was smoothed by the Vaseline. Resin mixture is used over the layer of Vaseline then the primary layer of jute mate fiber is crammed with matrix solution now second layer of jute mate fiber is placed above matrix solution before it becomes dried and so the next layers are packed. The air voids made up between the layers among fabrication are carefully squeezed out by using plate. Then, close the mold with their spouse and kept under load for twenty-four hours at temperature. Likewise, bidirectional sisal composites are ready by changing the direction of sisal fiber and also, hybrid composites are ready by similar method.

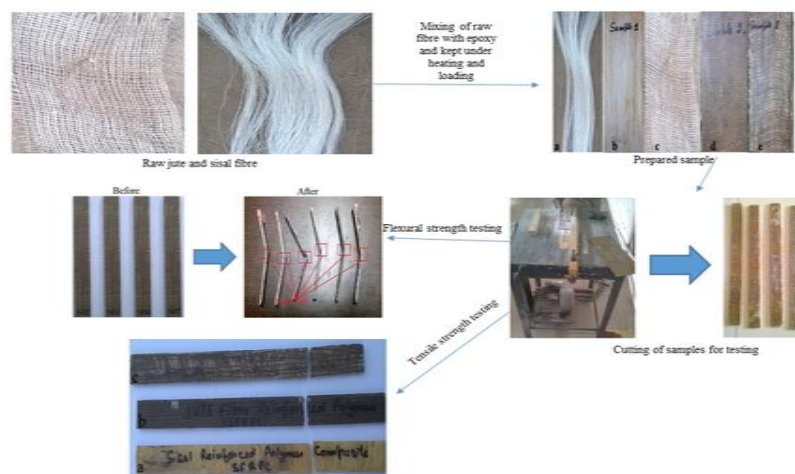


Fig. 2.1 Details Steps that Involved in the Preparation of Natural Fiber

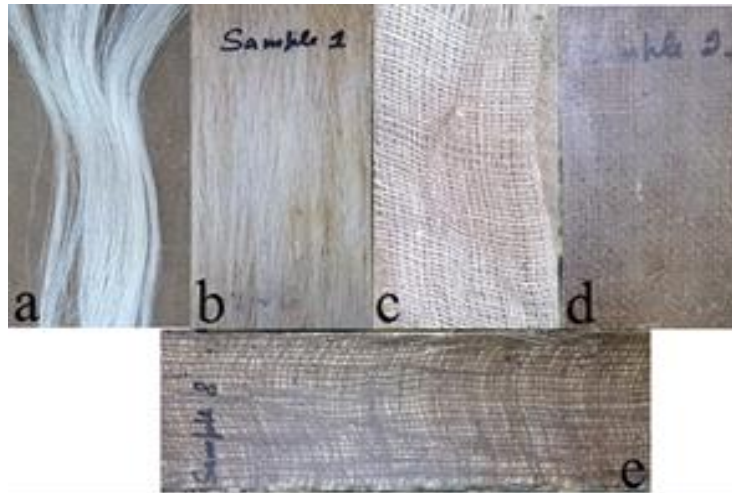


Fig. 2.2 Fabricated Samples (a) Raw Sisal (b) Sisal Composite, (c) Raw Jute, (d) Jute Composite (e) Hybrid Jute Sisal Composite

Table 2.2 indicate the detail of fabricated hybrid and non- hybrid composites. It's clear that 26-28 gm of fiber and 130-135 gm of resin provide fiber fraction of 20% whereas 44-46-gm fiber and 160 gm of resin give fiber fraction of 30% at 400 KN load. Samples S₁, S₂, S₆, and S₇, are non-hybrid composites and the samples S₃, S₄, S₅, S₈, S₉, and S₁₀ are a hybrid composite of sisal/jute epoxy composites at different %age of jute and sisal fiber.

Fiber loading percentage within the composite are often calculated either by volume or by weight percentage. Jute/sisal fiber reinforced epoxy composite samples weight fraction ratios calculated with the help of following formulas [19].

Table-2.2 Detail of Samples

Samples	WF			WC	PFU		TPFC
	J	S	Tt		J	S	
S ₁	0	26	26	134	0	100	20
S ₂	28	0	28	140	100	0	20
S ₃	18	8	26	124	70	30	20
S ₄	13	13	26	121	50	50	20
S ₅	8	18	26	130	30	70	20
S ₆	0	44	44	148	0	100	30
S ₇	45	0	45	152	100	0	30
S ₈	32	14	46	150	70	30	30
S ₉	22	22	44	150	50	50	30
S ₁₀	14	32	46	153	30	70	30

(WF = Weight of Fiber (gm), WC = Weight of Composite (gm), PFU = Percentage of Fiber Used, TPFC= Total Percentage of Fiber in Composite, S= Sisal, J= Jute, Tt= Total.)

$$\%Wf = wf / wc \times 100 \quad (1)$$

$$\%Wr = wr / wc \times 100 \quad (2)$$

Where %Wf and %Wr are the weight fraction % ratios of fiber and resin respectively in composite; wf (g) and wr (g) are the weight of fiber and resin mixture used and wc (g) is the weight of composite.

3. RESULT AND DISCUSSION

The mechanical properties of the hybrid and non-hybrid sisal/jute reinforced epoxy composites have been discussed in this section. Mechanical characteristics of composites, tensile and flexural strength have been studied and discussed.

3.1 Tensile Strength

A tensile test is the best recognized test in respects to conclusion for the behavior of the material. The tensile testing samples prepared by using file and emery paper. Three different types of the sample prepared, 1st contains Sisal fibers, 2nd was of Jute fibers, and 3rd was the hybrid of sisal/jute FREC (Fiber Reinforced Epoxy Composite). The specimen prepared according to the ASTM 3039 standard with dimensions as 250 mm x 25 mm x 4 mm. This test is performed on universal tensile machine to check the rigidity at the break.

The bonding between the matrix and fiber is the most beneficial parameter which defines the quality of the fiber composite. The superiority of the NFRPC (Natural Fiber Reinforced Polymer Composites) also be influenced by fiber content, fiber strength, fiber length, and alignment of fiber used. As in the Table 3.1 at 20% and 30%, fiber weight fraction for tensile behavior of non-hybrid and hybrid composites results obtained. The tensile strength of non-hybrid bidirectional sisal composites (S_1 , S_6) is better than jute mate composites (S_2 , S_7).



Fig. 3.1 Tested Tensile Samples (a) Sisal composite, (b) Jute compo-site, (c) Hybrid composite

Table- 3.1 Tensile Strength of Jute/Sisal Hybrid and Non-Hybrid Composites

TPRC (Weight Fraction)	Samples	Composites type	Tensile strength (MPa)
20%	S_1	Non-hybrid	27.92
	S_2	Non-hybrid	25.21
	S_3	Hybrid	32.26
	S_4	Hybrid	41.41
	S_5	Hybrid	40.38
30%	S_6	Non-hybrid	43.49
	S_7	Non-hybrid	35.97
	S_8	Hybrid	40.10
	S_9	Hybrid	46.85
	S_{10}	Hybrid	45.65

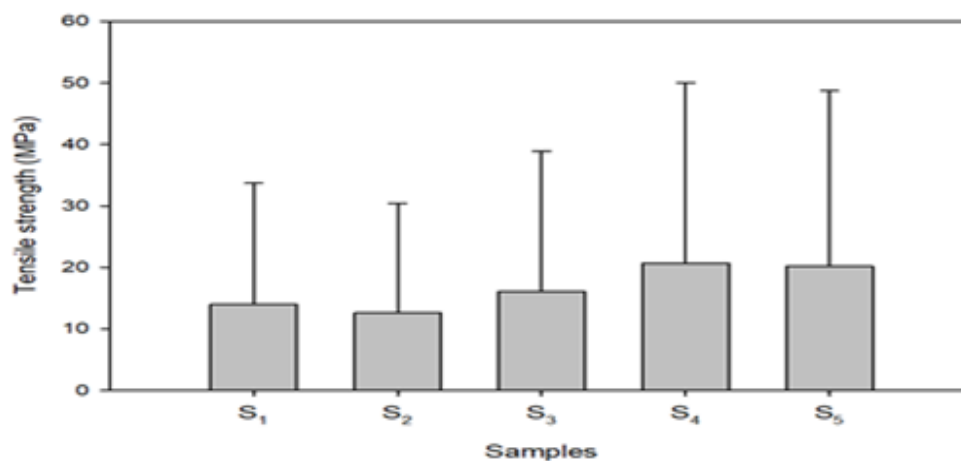


Fig. 3.2 Tensile strength of 20% fibre fraction composites

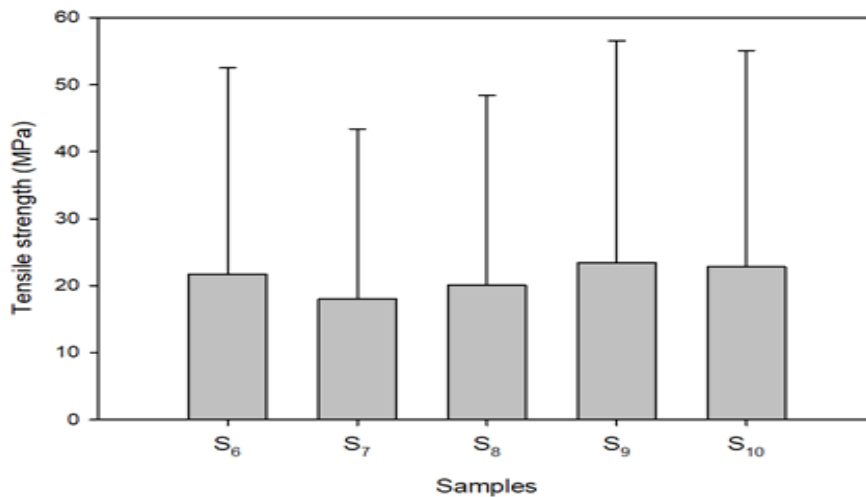


Fig.3.3 Tensile strength for 30% fiber fraction composites

The results found from Fig. 3.2 and Fig. 3.3 for tensile behavior of non-hybrid and hybrid composites at 20% and 30% fiber weighting fraction. The lastingness of non-hybrid bidirectional sisal composites (S₁, S₆) is preeminent than jute mate composites (S₂, S₇). The properties of jute composite improve by adding sisal fiber in jute fiber composite (hybrid samples S₃, S₄, S₅, S₈, S₉, and S₁₀). For the primary two hybrid composites, its tensile property increases by adding sisal fiber than after adding extra amount of sisal fiber in jute composite its value decline. The greatest tensile property obtained for samples S₄ and S₉ by 20% and 30% fiber fraction is 41.41 MPa and 46.85 MPa respectively. The tensile behavior of composites is rises by rising fiber fraction.

The hybridization at 20% weight fraction leads to a rise of lastingness of hybrid composites by the measure of 48.31% and 64.26% than sisal and jute FREC respectively. In case of 30% weight fraction, the lastingness of HFREC enhanced by the amount of 7.72% than Sisal Fiber Reinforced Epoxy Composite (SFREC) and 30.24% than Jute Fiber Reinforced Epoxy Composite (JFREC). Also, the greatest lastingness achieved when 50% jute fiber and sisal 50% fiber used for fabricating composites at both fiber fraction.

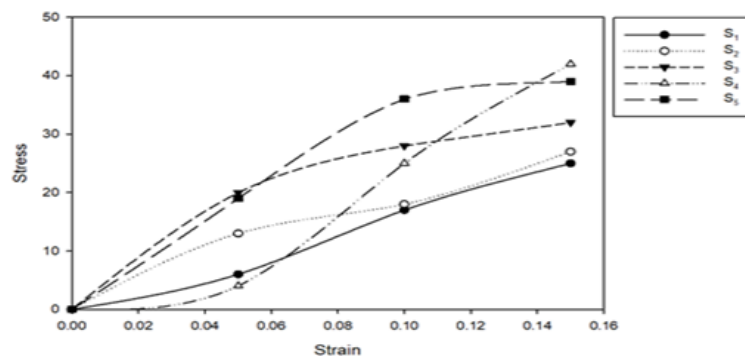


Fig. 3.4 Stress vs Strain Curve of 20% Fiber Fraction Composites

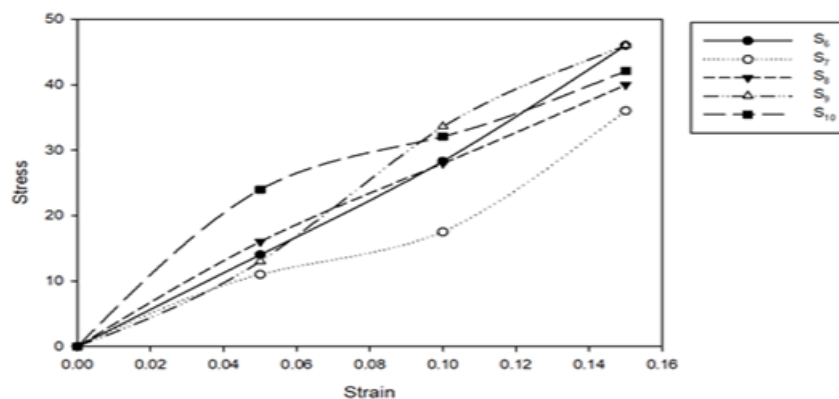


Fig. 3.5 Stress vs Strain Curve of 30% Fiber Fraction Composites

Fig. 3.4 and Fig. 3.5 signify stress vs. strain curves of all composites at 20% and 30% respectively. The stress-strain curves display the performance of natural fiber composites under tensile loading. The fashion indicates that made-up composites come in the category of brittle material.

3.2 Flexural Strength

As listed in the Table 3.2 the hybridization of jute and sisal fiber at 20% weight fraction rises bending strength of hybrid composites by the amount of 52.28% and 74.75% than sisal and jute composites respectively. In the case of 30% weight Fraction, the flexural strength of hybrid composites enhanced by the extent of 16.74% than SFREC and 37.41% than JFREC. Also, the extreme flexural strength achieved when 30% jute and 70% sisal fibre used for producing composites at both fiber fraction.

Table-3.2 Flexural Behaviour of Jute/Sisal Hybrid and Non-Hybrid Composites

TPRC Fraction)	(Weight	Samples	Composites type	Flexural Strength (MPa)
20%		S ₁	Non-hybrid	35.0
		S ₂	Non-hybrid	30.5
		S ₃	Hybrid	33.9
		S ₄	Hybrid	43.4
		S ₅	Hybrid	53.3
30%		S ₆	Non-hybrid	47.2
		S ₇	Non-hybrid	40.1
		S ₈	Hybrid	43.9
		S ₉	Hybrid	50.2
		S ₁₀	Hybrid	55.1

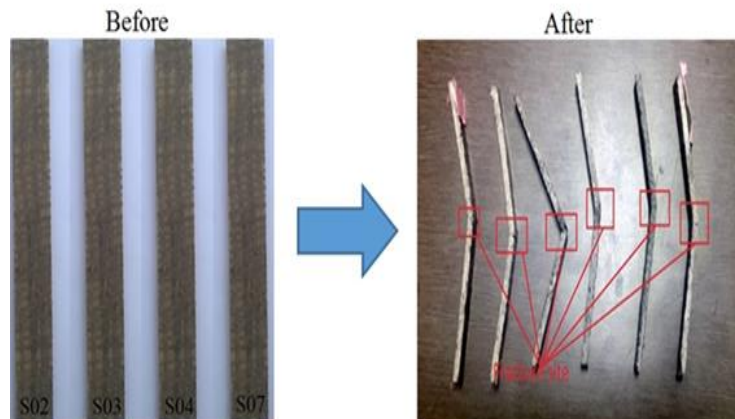


Fig. 3.6 Representation of Test Samples and Fractured Sample of Flexural Testing

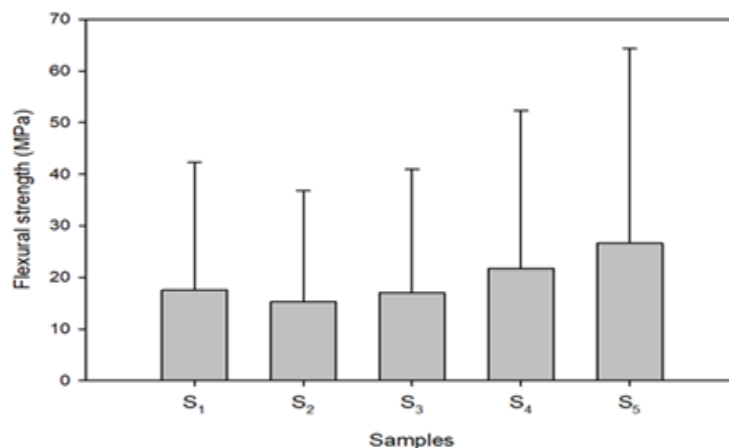


Fig. 3.7 Flexural Strength of 20% Fiber Fraction Composites

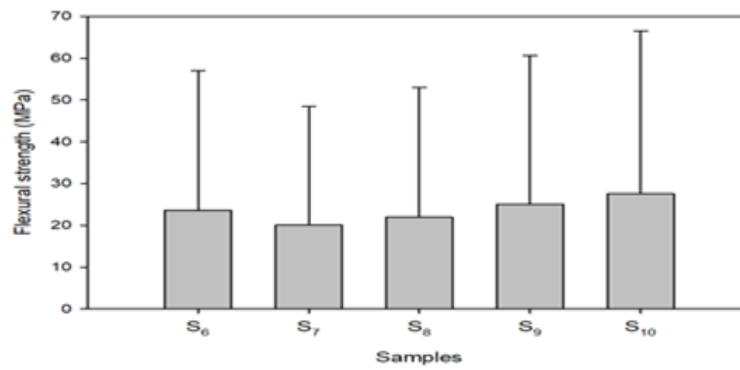


Fig. 3.8 Flexural Strength of 30% Fiber Fraction Composites

Fig. 3.7 and Fig. 3.8 represent flexural behavior of fabricated non-hybrid and hybrid composites at 20% and 30% fiber weight fraction. Similarly, the flexural strength of non-hybrid bidirectional sisal composites (S₁, S₆) is greater than jute mate composites (S₂, S₇). When sisal fiber mixed in jute fiber composite, it increases the bending properties of jute composite (hybrid samples S₃, S₄, S₅, S₈, S₉, and S₁₀). The maximum flexural strength is 53.3 MPa and 55.1 MPa obtained by samples S₅ and S₁₀ respectively for 20% and 30% fiber fraction. The flexural behavior of composites is increased by increasing fiber fraction. As the bonding area at the interface increases the mechanical properties of the reinforced hybrid fiber like tensile strength increases

CONCLUSION

Successfully developed the hybrid natural fiber reinforced polymer composites with the assistance of hand lay-up and compression molding technique. The lastingness and flexural strength of natural fiber reinforced polymer composites has been improved as compared to pure epoxy. The utmost lastingness of 41.14 MPa and 46.85 MPa is achieved by the composite having 50% jute and 50% sisal for both 20% and 30% fiber fraction respectively. The utmost flexural strength of 53.3 MPa and 55.1 MPa is achieved by hybrid composites having 30% jute and 70% sisal fiber for both fiber fractions i.e. 20% and 30% respectively.

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