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Mechanical Properties of Unidirectional Hybrid JUTE-SISAL Fiber Reinforced Epoxy Composites

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Abstract : *At present scenario, natural fibers are being used in the field of composites as reinforcement. The reason behind this fact is that natural fibers are eco friendly plenty of available, low cost, biodegradable and nontoxic. Research is going on to develop newer fiber-reinforced plastic composites in order toreplace metals and alloys.The aim of this paper is to investigate the effect of long continuous fiber loading on the mechanical properties of jute-sisal fiber reinforced epoxy based hybrid composites. The strength analysis of the jute-sisal fiber reinforced composites has been made with weight fraction of different combinations i.e 0/40, 25/15, 20/20, 15/25 and 40/0 are prepared by hand lay-up technique. Tensile test and flexural test specimens are prepared according ASTM standards. The entire experimentation were carried out by using universal testing machine (UTM). The experimental results showed that hybridization play vital role for improving mechanical properties when compared to pure composites.*

Keywords : *Natural fibers, hybrid composites, jute sisal fibers and mechanical properties*

I. INTRODUCTION

Natural fibre composites are emerging as realistic alternatives to replace the glass reinforced composites in many applications. Natural fibres such as banana, coir, sisal and jute have attracted the attention of scientists and engineers for application in automotive, aerospace and other civil structures. Natural fibres have many advantages compared to synthetic fibres like low density, cheaper, acceptable specific properties and also they are renewable and biodegradable. These composites possess high strength and stiffness, good thermal and insulating properties. However, the main disadvantage of these natural fibre/polymer composites seems to be the compatibility between the hydrophilic natural fibres and the hydrophobic matrix that makes necessary to use coupling agents in order to improve the adhesion between fibre and matrix. Natural fibres have some limitations like low strength and high water absorption property. These limitations can be overcome by using hybridization technique. Hybrid composite are those which have more than one reinforcement in a single matrix or single reinforcement with multiple matrix or multiplereinforcement with multiple matrix. In hybridization two different fibres are used with their different elongation. The fibre having low elongation will break first and then the load may be carried by the fibre having high elongation without the failure of matrix, inducing better stress transfer from matrix to fibres and thus resulting in increased mechanical properties [1]. Palanikumar et.al [2] reviewed the mechanical properties of natural fibers, their extraction process with suitable manufacturing process employed along with the resins used in the composite. UdayaKiran et.al [3] studied the tensile properties of the composites made from short sun hemp, banana, and sisal and it has been identified that sun hemp shows favorable tensile strength. Venkateshwaran et.al [4] analyzed hybrid composites of sisal/banana for its tensile properties which was determined by rule of hybrid mixture. Its values are found to be higher while compared with experimental values. Variations of tensile properties are also observed due to the occurrence of micro voids in the composites during the fabrication. Rathika et.al [5] determined the mechanical characteristics of sisal-PALF banana- glass fiber reinforced with polyester hybrid composites indicated that there is a vast increase in the superior properties like tensile, flexural and impact strength of sisal-PALF-banana fiber when it is reinforced with glass fiber in the polyester composites. ArumugaPrabu et.al [6] identified the mechanical properties such as tensile, flexural and impact are found to be improved marginally by adding red mud (an industrial waste) into sisal and banana fiber reinforced unsaturated polyester composite fabricated by compression molding technique. Thiruchitrambalam et.al [7] experimented by treating sodium laurylsulfate as an alternative to sodium hydroxide in woven Banana/Kenaf hybrid composite. It is observed that tensile, flexural and impact strength is found to be increased. Sathishkumar et.al [8] studied the tensile properties of the newly identified snake grass fiber composite with isophthallic polyester resin. From the experimental evidence the volume fractionincreases the tensile and flexural strength of the composite. In this paper, effect of mechanical characterization onjute-sisal long continuous fibers reinforced hybrid composites is studied.

II. Materials And Methods

2.1 Fiber and matrix material

Unidirectional jute and sisal fibers which are presented in figure 1 were procured from Lakshmi fibers from cherukupalli. Matrix material selected is epoxy resin LY556 and hardener HY951 as binder for the resin.

Fig 1. Reinforcement and matrix materials

Sisal fiber: Sisal (Agavaceae) fiber is extracted from the leaves of sisal plant. The fibers are extracted through hand extraction machine composed of either serrated or non-serrated knives.

Jute fiber: Jute is long, soft and shiny, with a length of 1 to 4 m and a diameter of from 17 to 20 microns. Jute fibers are composed primarily of the plant materials cellulose (major component of plant fiber) and lignin (major components of wood fiber). The fibers can be extracted by either biological or chemical retting processes.

Resins: Epoxy Ly556 (Diglycidyl ether of biphenyl-A) and HY951 (Triethylene tetramine) hardener was purchased from Shakti glass fibers and traders Chennai.

Fig 2. Composite preparation

2.2 Preparation of the composite

The composite is prepared by using epoxy resin LY556 and the hardener HY951 is stirred with a ratio of 10:1. This solution is used as a matrix. The catalyst was added to the epoxy and the mixture was stirred properly with correct timing before applying into the mold. The molds should be dust free before applying epoxy. The unidirectional fibers of jute and sisal were used as reinforcements. Five types of composites prepared are pure jute, pure sisal, and hybrid combinations 15/25, 20/20, 25/15.The fabrication of these laminates were done by the hand lay-up technique. The main advantage of hand lay-up process is its fabrication ease of large and complex parts in a very short time. Each laminate consists of four layers sequentially distributed by the matrix. The dimension of the mold was 200 mm X 200 mm X 4 mm. Ohp sheet is placed bottom of the mold for easy removal and to get good surface finish of the laminates. The resin gets distributed uniformly on the entire area of each surface by brushing and pressing with roller, air bubbles formed are removed completely. Laminates were taken from the mold and curing time is maintained at room temperature for 24 h.

III. Method Of Testing

1. Tensile Test: The hybrid composite specimens are prepared according to ASTM D638 standard for tensile test [9]. The tensile test is performed on the Universal Testing Machine (UTM) FIE make. There are five different kinds of specimens are prepared according to the fibers used. The fractured specimen after tensile test for each case 3 samples are tested and the average values are reported.

2. Flexural Test: The flexural specimens are prepared as per the ASTM D790 standards [10]. A3-point flexure test is used in the present investigation. Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement. The testing process involves placing the test specimen in the universal testing machine and applying force on it until it fractures and breaks.

3. Impact Test: The Izod impact test is a standardized high strain rate test which determines the amount of energy absorbed by a material during fracture. In accordance with American Society for Testing Materials (ASTM) method D256 to measure impact properties thickness 5mm, width 12.7mm and length 65mm [11].

IV. RESULTS AND DISCUSSIONS

TABLE 1.Summary of Tensile Properties and flexural properties of Different Composites.

Sample Id	% Weight fraction	Ultimate Tensile strength (Mpa)	Flexural Strength (Mpa)	Impact strength (j)
S1	40/0	38.93	84.15	5
S2	15/25	31.32	77.68	8
S3	20/20	39.93	88.33	10
S4	25/15	36.70	80.03	6
S5	0/40	36.43	78.26	8

The tensile strength of pure sisal is found to be 38.93MPa. The variation of tensile strength and modulus for various laminate stacking sequences is shown in below Fig 3. The tensile strength of the composite is influenced by the strength and modulus of the fibres (Munikenche Gowda et al., 1999) [12]. The tensile strength and modulus of laminateS1 when only sisal fibres are reinforced in the matrix is greater than the tensile strength and modulus of the pure jute composite of S5. It is found that there is sharp increase in the tensile strength with the incorporation of sisal fibre as extreme sisal plies (S2, S3 and S4). The increase in the tensile strength and modulus of hybrid composite is attributed to the reason that, sisal fibres are stronger and stiffer than jute fibres. An increase in the tensile strength and modulus of 53% and 30% is observed for 20:20 jute-sisal fibre-reinforced hybrid laminate (S3) when compared to that of only jute laminate. The results are reveal that the tensile properties are slightly affected by layering sequence. Observation of failed specimens revealed that failure in jute laminates is sudden with no or little pull out of jute fibres, whereas in hybrid laminates, failure is governed by extensive fibre pull out and breakage.

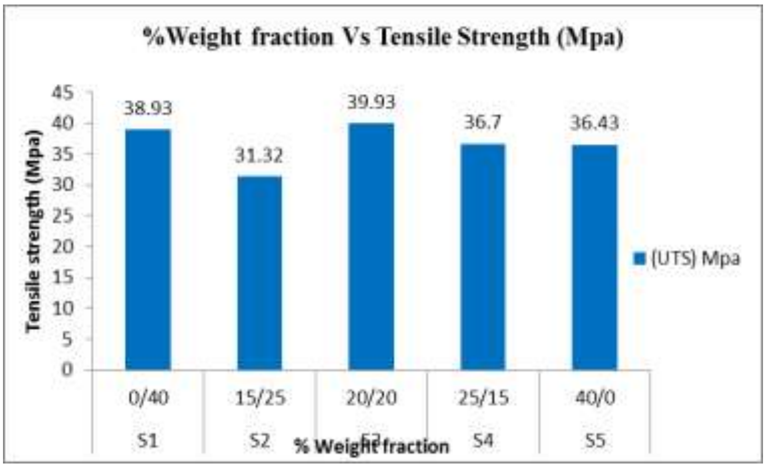

Fig: 3 Tensile Strength Comparison of the Composite samples

The load-deflection diagrams for various hybrid laminate stacking sequences are shown in Fig.4. All the curves indicate non-linear behavior. The point of deviation from linearity is the indication of failure initiation due to development of crack on the tension side. Flexural strength and modulus for laminates with different stacking sequences are compared in above figure. Flexural properties are increased with increase in the sisal fibre content from 0 to 40% of the total fibre weight. However, no further increase is noticed with the increase in sisal fibre weight to 60%. It is interesting to note that the laminate S1 sequence with sisal fibre weight of 40% has 6.7% higher flexural strength compared to sequence S2 is hybridize with jute fiber little bit low value. The laminate S3 is found to have highest flexural strength of 88.33MPa.By altering the sequence of arrangement as in the cases of S4, and S5, no improvement in the flexural properties is achieved. The sequence S5 exhibits lowest flexural strength (78.26MPa) among all hybrid combinations.

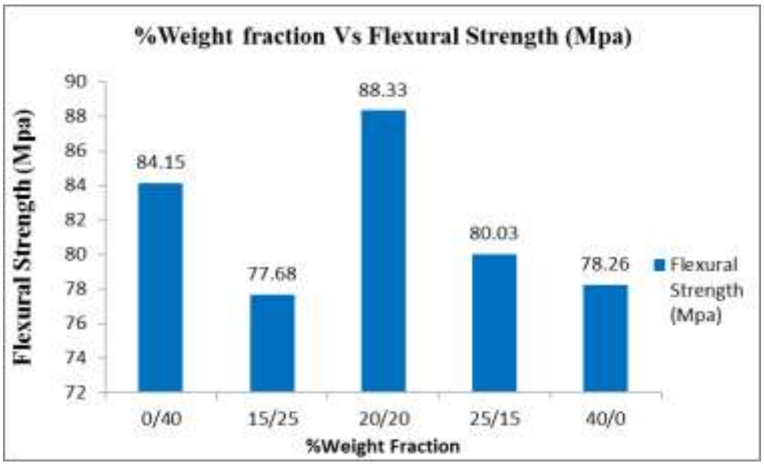

Fig :4 Flexural Strength Comparison of the Composite samples

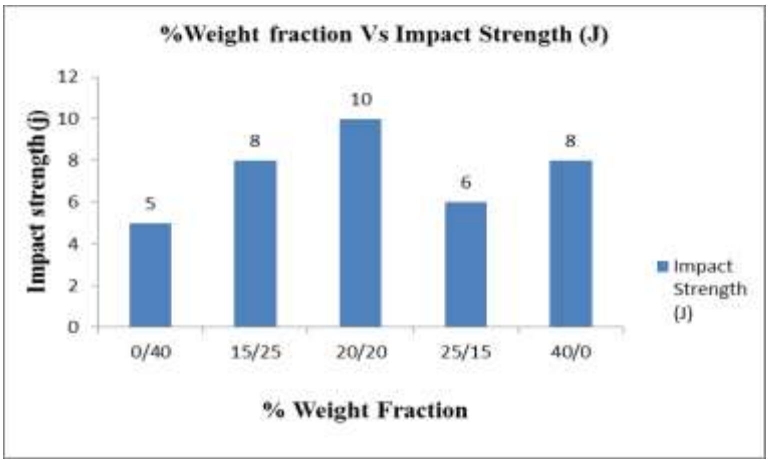

Fig: 5 Impact Strength Comparison of the Composite samples

High strain rates or impact loads may be expected in many engineering applications of composite materials. The suitability of a composite for such applications should therefore be determined not only by usual design parameters, but by its impact or energy absorbing properties. The decrease in impact strength or smaller variation in strength may be due to induce microspaces between the fiber and matrix polymer, and as a result causes numerous micro-cracks when impact occurs, which induce crack propagation easily and decrease the impact strength of the composites [13, 14]. Generally the impact strength of composite materials increases with the increasing fiber content however the lower values of impact strength at higher composition of fiber may be because of improper adhesion between the matrix and the fibers.

V. CONCLUSIONS

From the results of this study, the following conclusions are drawn.

1. Incorporation of sisal in jute fibre composites enhances the properties of resulting hybrid composites.
2. Layering sequence (altering the position of sisal plies) significantly affects the flexural strength.
3. Overall comparison between the properties of all the laminates revealed that the hybrid laminate with two extreme sisal plies on either side is the optimum combination with a good balance between the properties and cost (which increases with the increase in the weight of sisal fiber).
4. For the same relative weight fraction of jute and sisal fibre, layering sequence has little effect on tensile Properties.

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