EXPERIMENTAL STUDIES ON HYBRID EPOXY MATRIX COMPOSITE

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Abstract- Jute and sisal fibers are the most potential natural fibers to produce composites currently used for industrial structures and as bio-materials. In the present investigation jute and sisal fibrous mat is reinforced in an epoxy matrix by manual layup technique to produce a hybrid composite. The composite is tested for tensile strength and impact strength.
The fabricated composite with $[0^0/0^0]$ orientation of fibers exhibited higher tensile strength than that of composite with $[0^0/90^0]$ orientation of fibers.The energy absorbing capacity of later was high than the former type of composite. The scanning electron microscopy image of thefractured specimensrevealed that de-bonding between fiber matrix interface and void nucleation growth are the major factors influencing failure of the material.

key words- jute fiber, sisal fiber, hand layup, impact and void nucleation

I. INTRODUCTION

Composite material is basically a combination of two or more materials that results in better properties than those of the individual components used alone. Most composites have been created to improve combinations of mechanical characteristics such as stiffness, toughness, and ambient and high-temperature strength. From the recent past there has been more research inclination towards the fiber reinforced polymer matrix composites than the monolithic materials because of their unique advantages of high strength to weight ratio, non-corrosive property and high fracture toughness[1].
Until recently, the use of natural fibre composites starts gaining popularity in engineering applications. This is due to the fact that this material possesses characteristics that are comparable to conventional materials. Properties like light weight, low material cost, renewable and environmentally friendly are among the most important selling points of this material. Despite its strength and durability are somewhat poorer than conventional materials, these properties can be improved by interfacial treatments [2].

One of the major drawbacks of the natural fibre reinforced composites is their low impact strength as compared to glass fibre reinforced thermoplastic and thermoset composites [3, 4]. In the present day scenario sisal and jute fibers are replacing the glass and carbon fibers due to their easyavailability and cost [5]. The layer sequence has greater effect on flexural and inter laminar shear properties and placing theglass fiber reinforced polymer layers at the ends possess good mechanical strength [6]. Sisal/jute fiber composites are environment friendly anduser-friendly materials [7] and have very good elastic properties [8].

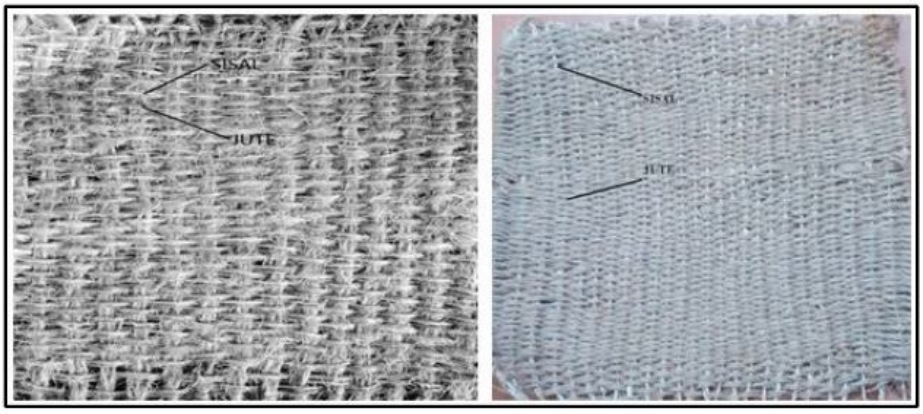
In the present work jute and sisal are used as reinforcements because of their light weight and low cost. The composite from these reinforcements are expected to have reduced weight and cost.
The reinforcing fiber in the present experimental study is in a interweaved mat form, as the interlacing of fiber bundles has major advantage of enhancing the strength of the lamina by the proper bonding of the fiber and the greater damage tolerance.

II. METHODOLOGY

2.1 Fabrication of composite

Initially the mould surface is thoroughly cleaned so as to remove any foreign particles present on it. The peel ply (film) is then aligned along the surface of the mould and also along its cover, and then fixed to it. Later polyvinyl acetate is applied across the film by using cotton.After duration of 5 min, car wax was applied to the film. The woven mat (1x1) feet (Fig: 1) was oriented along the mould surface.Then a calculated amount of epoxy (ratio of 1:6) was poured into a container. Separately hardener (in the ratio of 1:10) was drawn into syringe and mixed into the container with epoxy. While this was being done, the epoxy resin and hardener mixture is thoroughly mixed for about 5 to 6 min.After the resin and hardener have been mixed, the mixture was poured evenly across the surface of the mat. Simultaneously it was spread out with the help of brush.Rolling was done on the mat with the roller continuously till the mixture was distributed uniformly over the mat. Every effort was made to cover the empty spaces present in the mat. As that helped in removing air entrapped on it and hence removed the subsequent voids that may present itself upon completion of the composite laminate.Now the mat was left as it is for a few minutes to allow the exothermic chemical reaction.The mould was covered with the peel ply film and then mounted over the mould bottom. Weights up to 20 kg are kept on the mould cover and kept for the curing.After 24 hrs of curing the laminate was ejected from the mould using the ejector pins. The composite was visualised for any voids and

excessive edges were trimmed. The wooden mould used is as shown in Fig:2.



(a) (b)

Fig: 1 (a): [$0^0/0^0$] woven mat and (b): [$0^0/90^0$] woven mat.

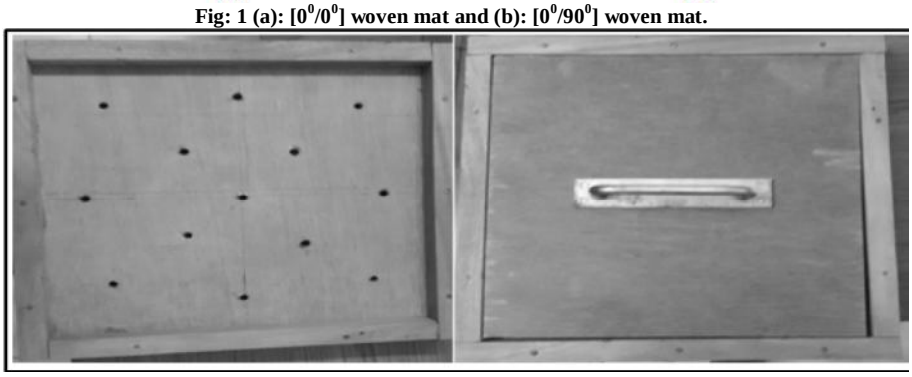


Fig: 2 Mould used for hand layup.

2.2 Testing of Composite

2.2.1 Tensile test

The tensile test is carried out as per ASTM D3039. The tensile test is carried out on a computer interfacedINSTRON UTM. Typical tensile test specimens are as shown in Fig: 3 and the fractured specimens are shown inFig: 4. Initially the composite specimen with [$0^0/0^0$] is tested by applying the steady tensile load in the fibers longitudinal direction and the online plot of load-vs-displacement is obtained. Also the procedure is repeated to know the tensile behaviour of [$0^0/90^0$] composite by applying the steady tensile load in the longitudinal direction of jute fiber. The fracture behaviour is a analyzed by SEM micrograph (Fig: 8) taken on the fractured surface of [$0^0/90^0$] composite.

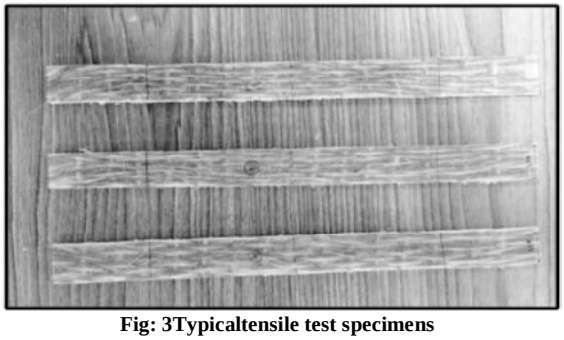


Fig: 3Typicaltensile test specimens

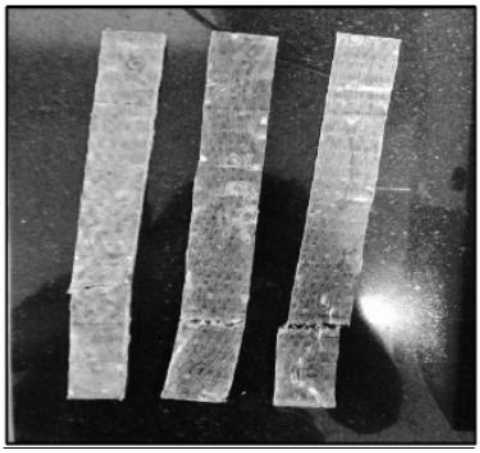


Fig: 4Fractured tensile test specimens

2. Charpy impact test

The Charpy test is carried out as per ASTM D6110. In the present work Charpy test is used to determine the energy absorbed for rupture and impact strength of the composite by a swinging weight striking the beam specimen with a U-Notch facing away the striker. The energy absorbed due to impact is known by the after impact pointer reading on the scale of impact test machine in Joules. By measuring the area (S_o) below the notch impact strength is calculated by the following relation-

Impact strength (J/cm^2) = Energy absorbed (Joules) / S_o

The specimens are found to undergo fracture exactly along the notch and fractured specimens have been shown in Fig:5.

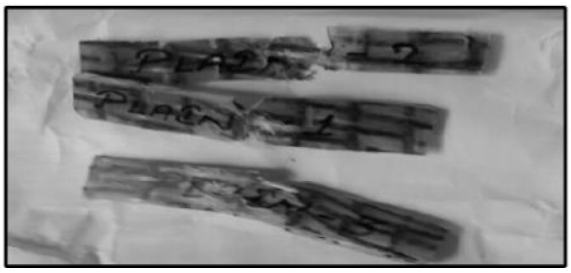


Fig: 5 Fracturedimpact test specimens

III. RESULTS AND DISCUSSION

3.1 Tensile test

The composite with [$0^0/0^0$] orientation of fibers has higher tensile strength than the composite with [$0^0/90^0$] fibers. This could be because of the reason that individual fibers will always be stronger in the longitudinal direction than in the lateral direction. As there are two types of fibers oriented in the loading direction cumulatively they add to higher tensile property of the composite. As the tensile strength of jute is higher as compared to the sisal fibers [1], the [$0^0/90^0$] composite exhibits higher tensile strength when load is applied in the jute direction than when applied in the sisal fiber direction. The comparative variation of tensile strength of the tested composites has been shown in Fig: 6. The percentage elongation at break is found to be decreasing as the tensile strength is increased and this variation is as shown in Fig:7. Similar behavioral trend is observed in the work by researchers in [9].

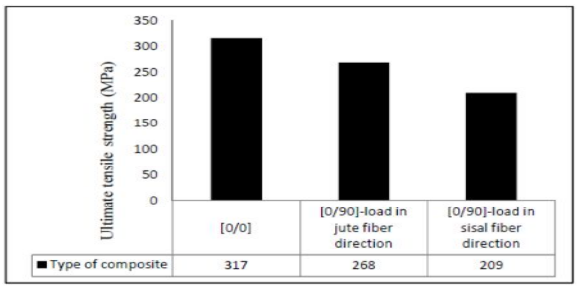


Fig: 6 Comparison graph of ultimate tensile strength for different composite

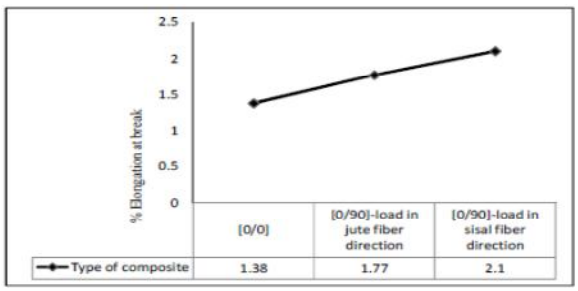


Fig: 7 Comparison graph of % elongation at break for different composite

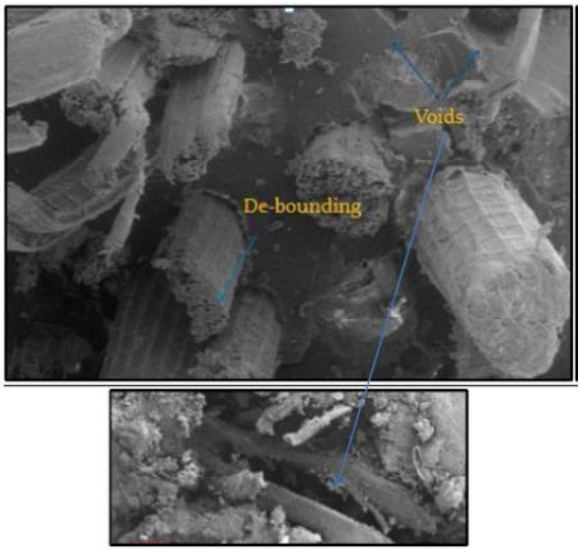


Fig: 8SEM micrograph (200 µm scale) of fractured [$0^0/90^0$] composite testspecimen.

The SEM image of fractured surface (Fig:8) of tensile specimen show that the major factors behind failure isthe de-bonding at fiber and matrix interface andthe crack growth due to nucleation of voids. Also the micrographs show the shearing fibers which again add to lowering the strength of composites. The interfacial gap between the matrix and fiber could be been minimized by applying the coupling agent. Shearing of some jute fibers is also seen in these images.

3.2 Charpy impact test

The results of Charpy impact test have been plotted in Fig:9. The composite with [$0^0/90^0$] orientation is found to have higher impact strength than itscounterpart. Overall in general the impact strength of natural fiber reinforced polymer matrix composite is very much less than that of metals and alloys.The reason being natural fiber contains higher cellulose content and lower micro fibril angle that results in higher work of fracture in impact testing.

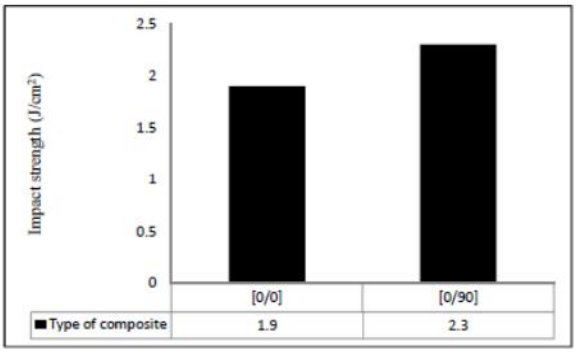


Fig: 9 Comparison graph of impact strength for different composite.

CONCLUSIONS

- Manual Hand layup technique can be effectively used to fabricate the woven mat

epoxy composite laminates with reasonably good surface finish.

- The composite with $[0^0/0^0]$ orientation of fibers exhibited higher tensile strength than that of composite with $[0^0/90^0]$ orientation of fibers this could be because of the reason that the fibers are stronger in the longitudinal direction than in lateral direction.
- The composite with $[0^0/90^0]$ orientation of fibers had higher energy absorbing capacity than the other orientation pattern.
- The reason for lower impact strength of the fabricated composite is that the natural fiber (jute and sisal in the present study) contains higher cellulose content and lower micro fibril angle that results in higher work of fracture in impact testing.
- Debonding at the fiber matrix interface and the void nucleation are found to be the major factors for lower tensile strength of the composites.

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