Mechanical Properties of Epoxy Based Hybrid Composites Reinforced with Sisal/SIC/Glass Fibers

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Abstract - Development of the Polymer Composites with natural fibers and fillers as a sustainable alternative material for some engineering applications, particularly in aerospace applications and automobile applications are being investigated. Natural fiber composites such as sisal, jute, hemp and coir polymer composites appear more attractive due to their higher specific strength, lightweight and biodegradability and low cost. In this study, sisal/glass/Sic fiber reinforced epoxy composites are prepared and their mechanical properties such as tensile strength, flexural strength and impact strength are evaluated. Composites of silicon carbide filler (without filler, 3, 6 & 9Wt %) sisal fiber and glass fiber are investigated and results show that the composites without filler better results compared to the composites with silicon carbide filler.

Key words - Sisal fiber, Glass fiber, Silicon carbide, epoxy, polymers, Hand layup, Mechanical property,

1. INTRODUCTION

Development of polymer composites with natural fibers and fillers as a sustainable alternative material for some engineering applications, particularly in aerospace applications and automobile applications are being developed [1]. Natural fibers show superior mechanical properties such as stiffness, flexibility and modulus compared to glass fibers [2]. Some of the natural fibers are sisal, Jute, hemp, coir, bamboo and other fibrous materials [3]. The main advantages of natural fibers are of low cost, light weight, easy production and friendly to environment [4].Composite materials are intended to combine desired characteristics of two or more distinct materials. The reinforcement can be synthetic (e.g. glass, carbon, boron and aramid) or of natural sources (e.g. curaua, sisal, jute, piassava, hemp, coir, flax and banana). The main benefits of exploitation of natural fibers are: abundance and renewability, low cost, non-abrasiveness, simple process, non-toxicity, high flexibility, acoustic insulation and low density [1, 2]. On the other hand, there are some drawbacks such as their poor mechanical properties and high moisture absorption. The latter is due to their hydrophilic nature that is detrimental to many properties, including dimensional stability [3]. Nevertheless, some composite components (e.g. for the automotive sector), previously manufactured with glass fibers are now produced with natural fibers. Applications including door panels, trunk liners, instrument panels, interior roofs, parcel shelves, among other interior components, are already in use in European cars due to the more favorable economic, environmental and social aspects of the vegetable fibers [4]. N.Venkateshwaran et.al [5] reported Mechanical and water absorption behavior of banana/sisal reinforced hybrid composites. They observed that the effect of fiber length and weight percentage increases the flexural modulus and impact strength when increase in length of fiber and weight percentage of fiber. Leandro Jose da silva et.al [6] investigated on apparent density, apparent porosity and water absorption property on sisal fiber and silica micro particles, they concluded that the low level of volume fraction of fibers provided not only higher modulus of elasticity and mechanical strength under tensile and flexural loadings but also have values of apparent density, apparent porosity and water absorption. Kai Yang et.al [7] studied the thermal conductivity of epoxy nano composites filled with single filler system and hybrid filler system was performed. The applications of hybrid filler system not only obtain higher thermal conductivity of epoxy composites but also resistance the existence of big filler agglomeration.

The addition of filler consisting of a combination of Silicon and carbon black powders decrease the negligible amount residual free Silicon but increased the amount of internal reaction bonded SIC and filler reduced the flexural strength indicating damage to the fiber but it drastically improved the wear resistance characteristics of the composites [8].

Sisal /GFRP composites sample passes good tensile strength and Jute/GFRP composites specimen showed the maximum flexural load [9]. The maximum strength is achieved when the length of the fiber in the laminate is equal to the critical fiber length. The strength of short fiber composites depends on the type of fiber matrix, fiber length, fiber orientation, fiber concentration and the bonding between the fiber and matrix [10]. Thermal properties such as TGA and DSC were investigated by H.Ranganna et.al and they concluded that influence of change in fibre length (treated and untreated hybrid composites) shows significant improvement in tensile, flexural, and compressive strengths of the sisal/glass hybrid composite [11]. A.Gowthami et.al. studied on Effect of silica on sisal fiber reinforced polyester composites result shows that the tensile strength of composite with silica is 1.5 times greater than that of composite without silica and 2.5 times greater than that of pure resin. Tensile modulus of composite with silica is 1.809 GPa, whereas for composites without silica is about 1.67 GPa. The impact strength of composite with silica is 80% greater than that of matrix [12]. Hemalata Jena et.al. investigated on effect of bamboo fiber composite filled with cenosphere, result sow that the impact property of bio-fiber reinforced composite is greatly influenced by addition of cenosphere as filler and the impact strength is increased with addition of filler up to a certain limit and after which it is decreased on further addition [13]. Sandhyarani Biswas, et.al. investigated on effects of ceramic fillers on bamboo fiber they conclude that the incorporation of particulate fillers to the fiber tensile strengths of the composites are found to be decreased. Among the particulate filled bamboo-epoxy composites, least value of void content are recorded for composites with silicon carbide filling and for the composites with glass fiber reinforcement minimum void fraction is noted for red mud filling [14]. According to S.Husseinsyah et.al. Effect of filler content on properties of coconut shell filled polyester composites high filler content adversely affect the processability, ductility and strength of the composites. The effect of coconut shell content of polyester composites on mechanical properties swelling behavior and morphology was studied. The results show that the tensile strength, young's modulus and water absorption of polyester composites increased with the increasing polyester content but elongation at break decreased . Morphology studied indicates that the tendency of filler- matrix interaction improved with the increasing filler in polyester matrix [15].

2. EXPERIMENTAL

2.1 MATERIALS METHOD

In the present investigation Sisal fiber (Agave Sisalana), Glass fiber (woven mat form), silicon carbide fillers (240 mesh) are used. Sisal fibers were obtained from Dharmapuri District, Tamilnadu, Chennai, India. The Glass-Fiber Reinforced Polymers (GFRPs) used for the fabrication is of unidirectional mat having 360gs M/s supplied by Suntech fiber ltd. Bangalore. Silicon carbide supplied by M/s Mysore pure chemicals, Mysore, Karnataka, India. Commercially available epoxy (LY-556) and hardener (HY-951) supplied by M/s zenith industrial suppliers, Bangalore.

2.2 SISAL AND GLASS FIBER

In the recent two decades, there has been a dramatic increase in the utilization of natural fibers, for example, fiber extraction from sisal, jute, coir, flax, hemp, pineapple and banana for making another environment agreeable and biodegradable composite materials. A pack of fibers are mounted or braced on a stick to encourage isolation. Every fiber is divided as per fiber sizes and assembled appropriately. To bunch the fiber, each fiber is separated and knotted to the end of an alternate fiber manually. The partition and knotting is repeated until bundles of unknotted fibers are finished to structure a long persistent strand. This Sisal fiber could be utilized for making variety of products. E-glass variety of fiber is used as reinforcement in the FRP preparation which has the fallowing properties. Its bulk strength and weight properties are also very favorable when compared to metals. The plastic matrix may be epoxy, a thermosetting plastic (most often polyester or vinylester) or thermoplastic. Table 1, Table 2 and Table 3 shows the physical properties of sisal and glass fibers and silicon carbide.

Table 1. Physical properties of sisal fiber

Physical property	Sisal fiber
Density (kg/m^3)	1350
Elongation at break (%)	2-3
Cellulose content (%)	63-64
Lignin content (%)	5
Tensile strength (MPa)	54
Young's modulus (GPa)	3.4878
Lumen size (mm)	5

Table 2. Physical properties of Glass fiber

Properties	Glass fiber
GSM	360 gsm
Orientation	plain-woven fabric
UTS	40 Gpa
Modulus	1.0 Gpa
Density	1.9 g/cc

Table 3. Properties of silicon carbide

Physical property	Silicon carbide
Density (gm/cc)	3.1
Flexural strength (Mpa)	550
Elastic Modulus (Gpa)	410
Compressive strength(Mpa)	3900
Hardness (kg/mm^2)	2800

2.3 PREPARATION OF COMPOSITE SPECIMEN

In the present investigation composite materials are fabricated by hand layup process. Sisal mat and glass fibers were cut into the dimensions of length and breadth is of 250×250mm was used to prepare the specimen. The composite specimen consists of totally 6 layers of glass fiber and 5 layers of sisal fibers for the preparation of different samples. A measured amount of epoxy is taken for different volume fraction of fiber and mixed with the hardener in the ratio of 10:1 and Silicon carbide filler is added into that mixer (3,6,9 wt.%) using tip ultrasonicator. The layers of fibers were fabricated by adding the required amount of epoxy resin. The glass fiber is mounted on the table and then epoxy resin is applied on it. Before the resin gets dried, the second layer of natural fiber is mounted over the glass fiber. The process is repeated till six layers of glass fiber and five layers of sisal fiber got over. The epoxy resin applied is distributed to the entire surface by means of a roller. The air gaps formed between the layers during the processing were gently squeezed out. The processed wet composite were then pressed hard and the excess resin is removed and dried. Finally these specimens were hydraulic pressed to force the air present in between the fibers and resin, and then kept for several hours to get the perfect samples. After the composite material dried completely, the composite material was taken out from the hydraulic press and rough edges were neatly cut and removed as per the required ASTM standards. Two types of composites were prepared one is with addition of silicon carbide filler (3, 6, 9 wt. %) and another one is without addition of silicon carbide filler.

3. RESULT AND DISCUSSION

In this study natural fiber are added to glass fiber and silicon carbide fiber and their effect on tensile, flexural and impact properties are evaluated. The different specimens used for tensile (Fig 1), flexural (Fig 2) and impact testing (Fig 3) is presented. The results for the tensile, flexural and impact testing of the hybrid composites samples are given in Table 4.

Fig. 1. Tensile test specimen.

Fig. 2. Flexural test specimen

Fig. 3. Impact test specimen

Table 4. Test results of specimens

Sample (Wt %)	Tensile strength [N/mm²]	Tensile modulus [N/mm²]	Flexural strength (Mpa)	Impact strength(KJ/m^2)
Without Sic	**158.167**	**2747.42**	**414.87**	**33.71**
3% Sic	**156.882**	**3620.66**	**558.6**	**32.0**
6% Sic	**114.81**	**1882.03**	**404.06**	**28.25**
9 % Sic	**91.331**	**1619.9**	**467.75**	**31.85**

3.1 TENSILE PROPERTIES

The composite samples were tested in the universal testing machine (UTM) and stress-strain curve was plotted. The typical graph generated directly from machine for tensile test for sisal/Glass composite without silicon carbide filler and sisal/glass with silicon carbide filler composites plotted in Fig 4, 5, 6 and 7.

The results indicate that the ultimate tensile strength for the composite without silicon carbide is higher than the composite with silicon carbide filler.

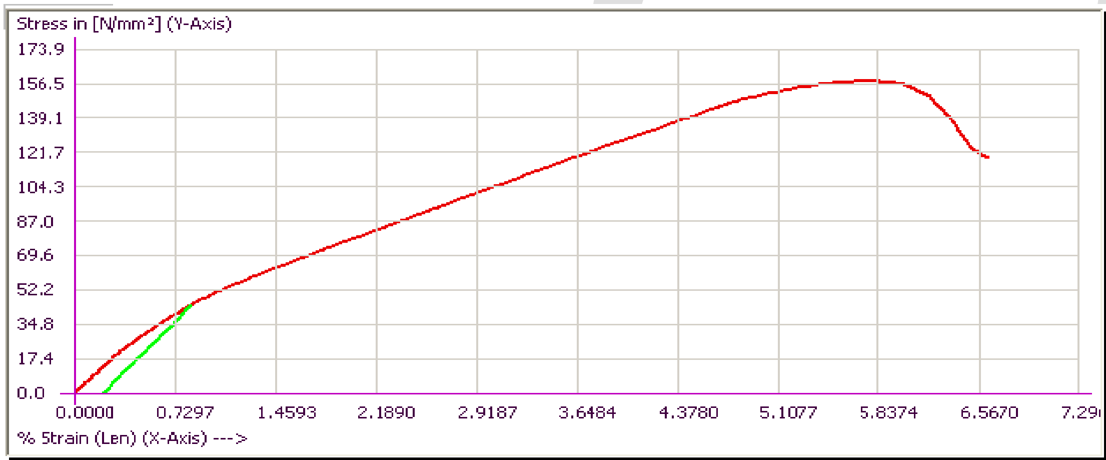

Fig. 4. Stress-strain curve of sample without Sic

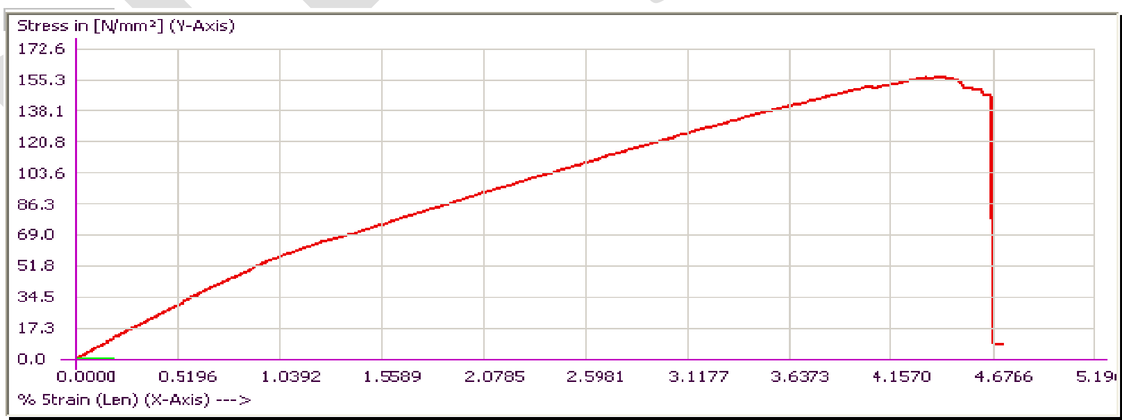

Fig. 5. Stress-strain curve of sample with 3% Sic

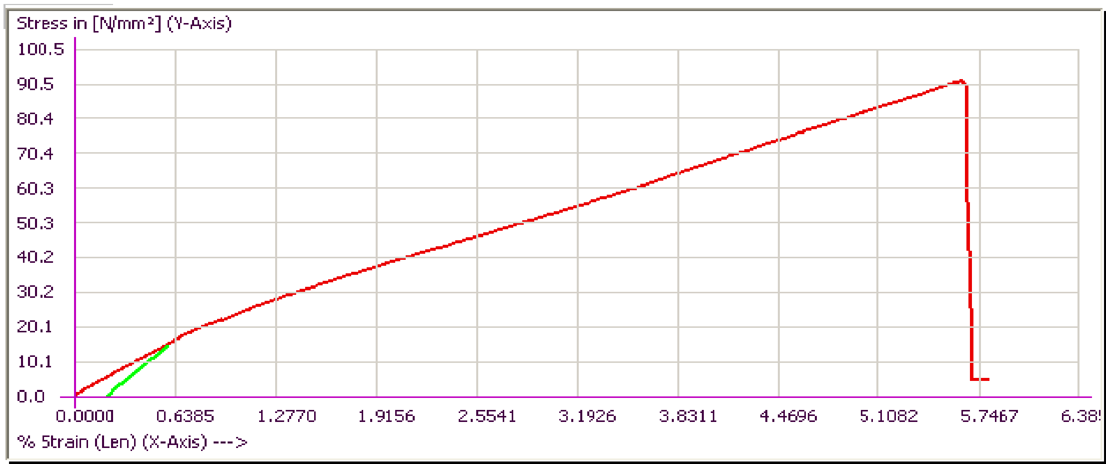

Fig. 6. Stress-strain curve of sample with 6% Sic

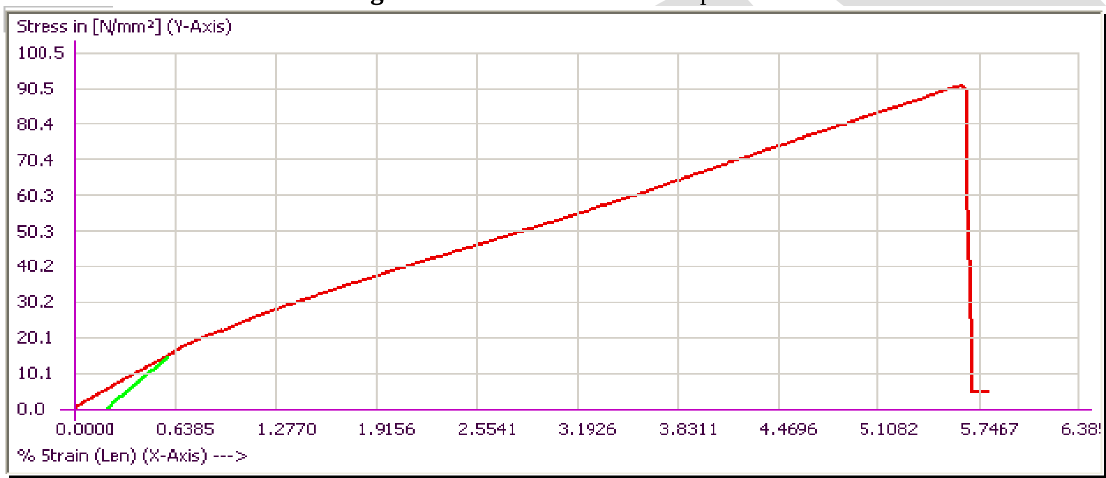

Fig. 7. Stress-strain curve of sample with 9% Sic

3.2 FLEXURAL PROPERTIES

The composite samples are tested in the universal testing machine (UTM) and stress-strain curve is plotted. The typical graph generated directly from machine for flexural test for sisal/Glass composite without silicon carbide filler and sisal/glass with silicon carbide filler composites plotted in Fig 8, 9, 10 and 11.

Flexural properties of different composite samples are tested and results are plotted. The results indicate that the ultimate flexural strength for the composite with silicon carbide of 3% filer is higher than the other composite with silicon carbide filler and without silicon carbide filler.

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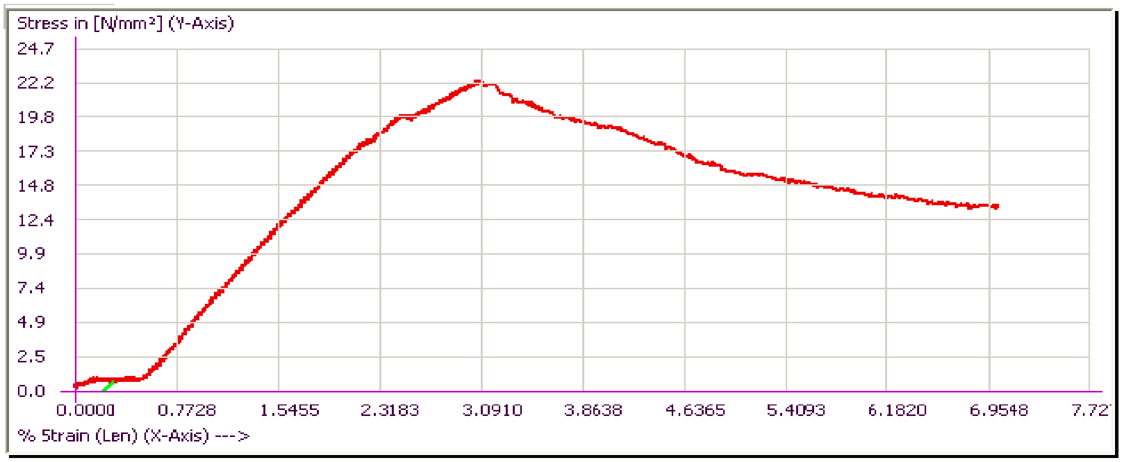

Fig. 8. Stress-strain curve of sample without Sic

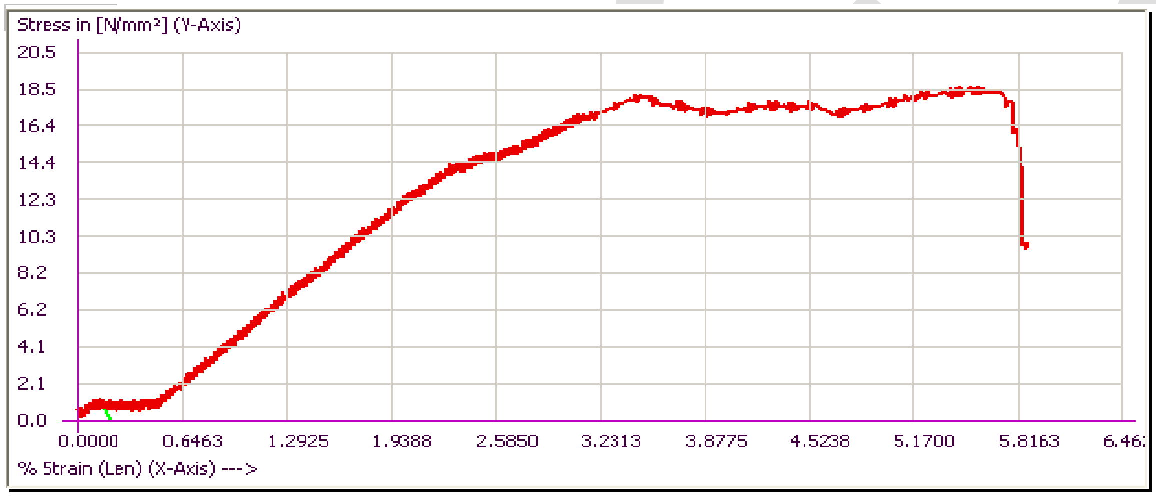

Fig. 9. Stress-strain curve of sample with 3% Sic

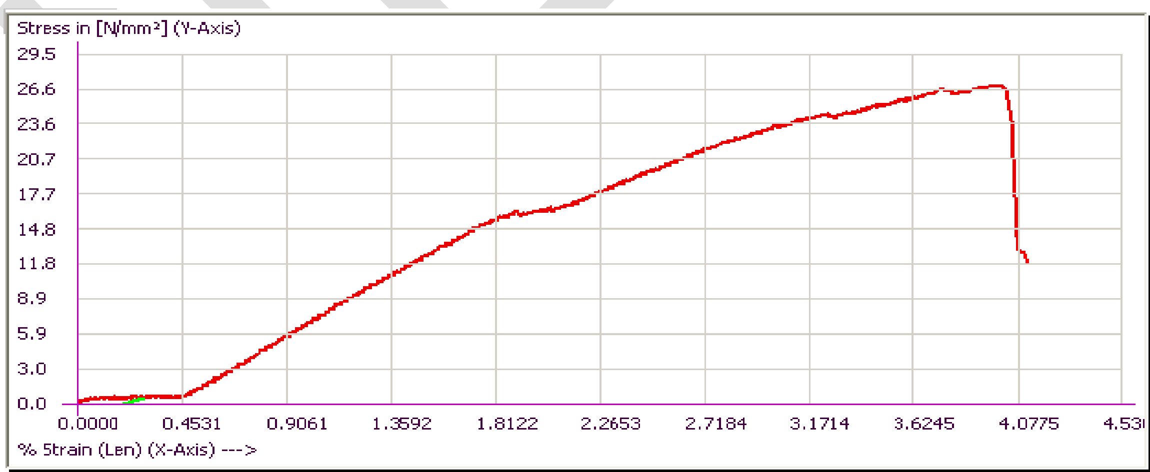

Fig.10. Stress-strain curve of sample with 6% Sic

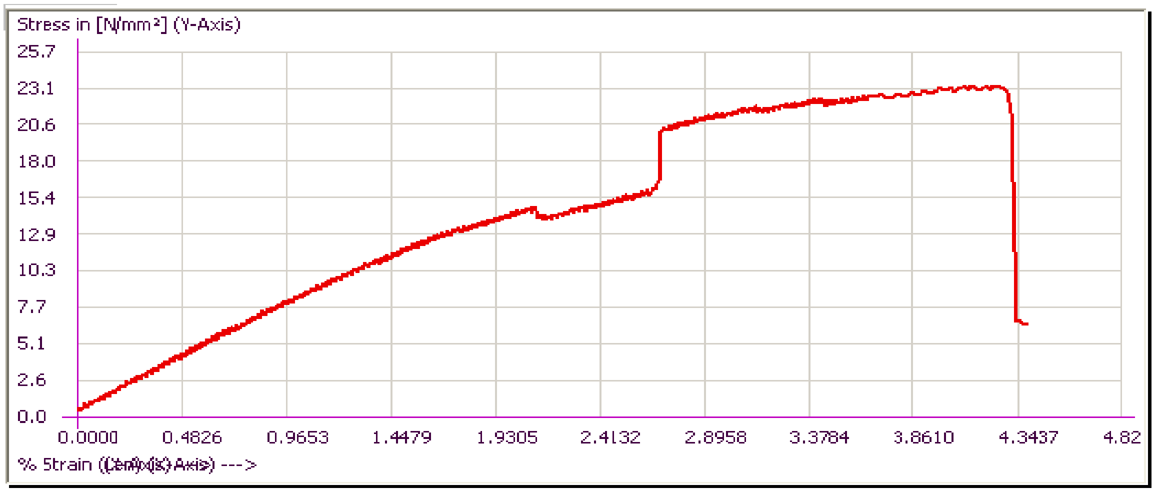

Fig.11. Stress-strain curve of sample with 9% Sic

3.3 IMPACT PROPERTIES

For analyzing the impact property of the different specimens an impact test is carried out. Impact test carried out for the present study is Charpy impact test. The energy loss is obtained from the Charpy impact machine. The impact response in Sisal/SIC/Glass composites of Charpy impact test is presented in Fig.12. The results indicated that the maximum impact strength is obtained for zero percent of silicon carbide of sisal/glass composites.

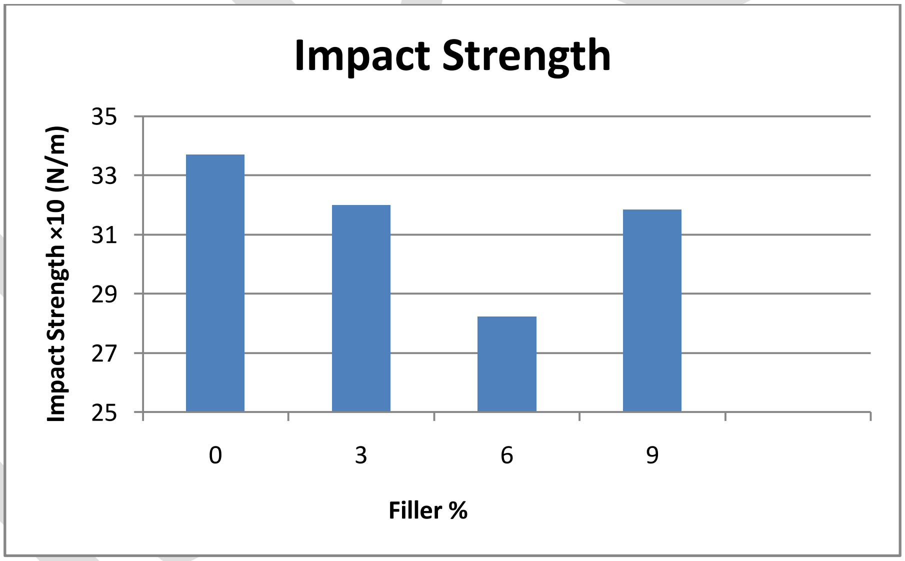

Fig.12. Impact load comparison of different composite materials.

CONCLUSION

The Sisal//SIC/Glass hybrid composite specimens are prepared and subjected to Tensile, Flexural and impact loadings.
From the experimental results following observations can be made.

- The sisal/Glass composite samples possess good tensile strength and can withstand the strength up to 158.167 N/mm².
- The sisal/Glass fiber filled with 3% of silicon carbide possesses good flexural strength and can withstand the strength up to 558.6 Mpa.

- The sisal/Glass composites possess good impact strength up to 33.71 KJ/m^2 compared to other composites filled with silicon carbide filler.
- From results it can be concluded that sisal/glass composites without filler showing good tensile strength and sisal/glass with 3% of silicon carbide filler showing good flexural strength compare to other composites and also the composites without filler of sisal/glass performing good impact strength compare to composites filled with silicon carbide filler.
- The performance of these natural fibers with glass fiber is more than that of composites with silicon carbide filler; it can be used in many applications which needed lower strength.

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