Torsional and Longitudinal Tensile Behaviour of Polyester Shaft Reinforced With Unidirectional Sisal Fiber

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Abstract - Natural fibers are emerging as a replacement for glass fibers in reinforcing polymer due to their low cost, low density and eco-friendly nature. Sisal are abundantly found in several region of India which is rich in cellulose fibers which can be easily extracted from them. The main objective of this investigation is to determine the torsional and longitudinal behaviour of polyester composite rod reinforced by unidirectional sisal fiber.

Keywords: Natural fiber, sisal, unidirectional.

I. INTRODUCTION

Composite materials are the combination of two distinct materials to make use of their virtues while minimizing their drawbacks to some extent. The natural fiber composites have a potential to replace glass in many applications that do not require very high load bearing capability [1]. Natural fiber composites are becoming popular in automotive applications because, the lower weight components improve fuel efficiency and in turn significantly lower emissions during the use phase of the component life cycle [2]. Building materials constitute 60-70% of the total cost of construction; this cost could be reduced by efficient use of locally grown raw materials and moreover India is already a major producer of natural fibers, but not flax [3]. Longitudinally aligned fiber composites generally have higher tensile strength but lower compressive strength and transverse directed fibers undergo very low tensile strength, which is lower than the matrix strength [4]. When the fibers are completely separated, the fiber defects are distributed more homogeneously in all three material directions and are believed to result in stronger natural fiber composites [5]. The rule of mixture predicted and experimental tensile strength of different natural fibers reinforced HDPE composites were very close to each other [6]. Sisal fiber has been widely used as a reinforcing fiber in polymers due to its high tensile strength and stiffness. In addition, sisal, Agave sisalana, is locally planted in Thailand. [13]. Accordingly, extensive studies on the attractiveness of a plant based fiber reinforcement materials come from its low abrasion, multifunctionality, low density, unlimited availability, Eco friendliness, high specific mechanical performance, and renewability[14].

II. EXPERIMENTAL

2.1 Materials and chemical treatment

Sisal fibers were purchased from a local sisal processing unit, karur, Tamilnadu, India. These fibers were approximately 600mm in length.The fibers were immersed in 5% NaOH solution for 1h at atmospheric temperature. Chemical treatment on reinforcing fibers can reduce its hydrophilic tendency and thus improve compatibility with the matrix [4]. The fibers were then cleaned with distilled water several times and dried in sunlight for 1 day. It takes out a certain portion of hemicelluloses, lignin, pectin, wax and oil covering materials [4].Polyester resin was purchased from Arulkumaran metal, Karur, Tamilnadu, India. The properties of polyester resin and sisal fiber are shown in table 1.

TABLE 1. Properties of polyester resin& sisal fiber

Properties	Polyester resin	Sisal fiber
Density (g/cm^3)	1.2-1.5	1.45
Modulus (Gpa)	2-4.5	9.4 -22
Tensile strength (Mpa)	40-90	468-640
Elongation (%)	2	3 - 7

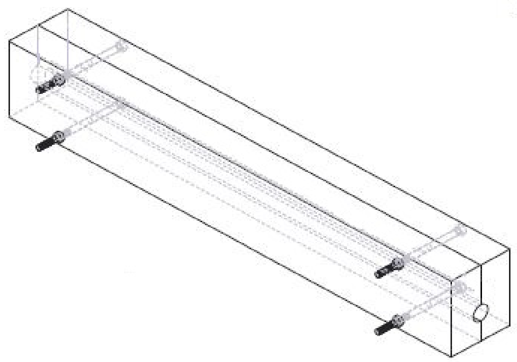

Fig. 2.1 Wooden die 3D diagram

2.2 Preparation of wooden mould

A wooden mould was made with a cavity of diameter 14mm throughout the entire length of the wood with the help of CNC machine as shown in Fig 2.1.

2.3 Preparation of unidirectional composite

Composite rod specimens were made at atmospheric temperature by aligning unidirectional continuous fibers with 30% volume fraction. Typical fiber volume fractions are only 20-40% for Natural fibers [7]. The volume fraction of fibers can be estimated by the rule of mixtures equation (1).

$$V_{fr} = V_f/V_c = V_f/(V_f+V_m) \quad (1)$$

Where V_f, Vm and V_c are the volume of fiber, matrix and composite.

2.4 Torsional properties of the composites

Torsional properties of unidirectional sisal fiber reinforced polyester composites were carried out according to ASTM2013a [8] of length 225mm with Torsion testing machine.

2.5 Tensile properties of the composite

Tensile properties of unidirectional sisal fiber reinforced polyester composites were carried out according to ASTM2008b [8] of length 250mm with Universal testing machine.

III. RESULTS AND DISCUSSION

3.1 Scanning Electron Microscopy

The Scanning Electron Microscopy (SEM) images are taken to observe the internal properties and internal structure of the composite material. All the specimens are coated with conducting material before observing the surfaces through SEM. Fig 3.1 shows the SEM micrograph of sisal fiber composite.

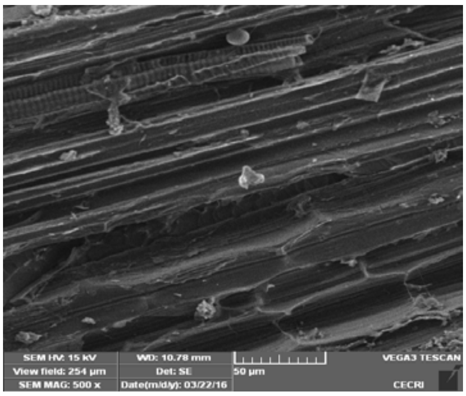

Fig. 3.1 SEM micrograph of sisal fibers composite

3.2 Field Emission Scanning Electron Microscopy

Field Emission Scanning Electron Microscopy (FESEM) shows the cross sectional view of sisal fiber composite. Fig 3.2 clearly shows a grove in the cross sectional fiber.

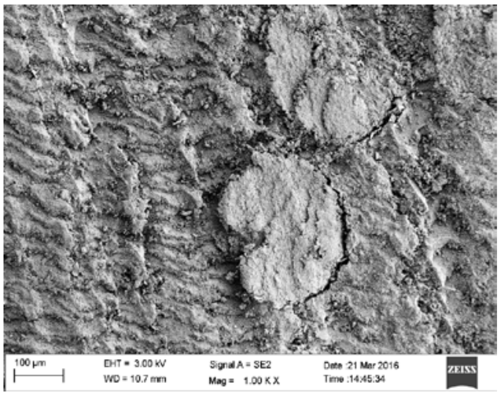

Fig. 3.2 FESEM micrograph of the cross-sectional image of single sisal fiber

3.3 Tensile test results

Figure 3.3 shows the Load vs displacement curve. The tensile test results are shown in table 3.1.

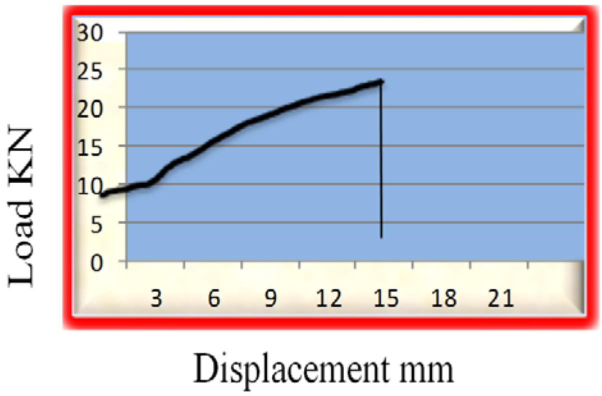

Fig. 3.3 Load vs displacement curve

TABLE 2. Tensile properties of composites

S.No	Tensile properties	Result
1	Maximum force (KN)	25.45
2	Maximum displacement (mm)	20.66
3	Tensile strength (KN/mm^2)	0.081
4	Elongation (%)	6.076
5	Yield load (KN)	14
6	Yield stress (KN/mm^2)	0.045

3.4 Torsion test result

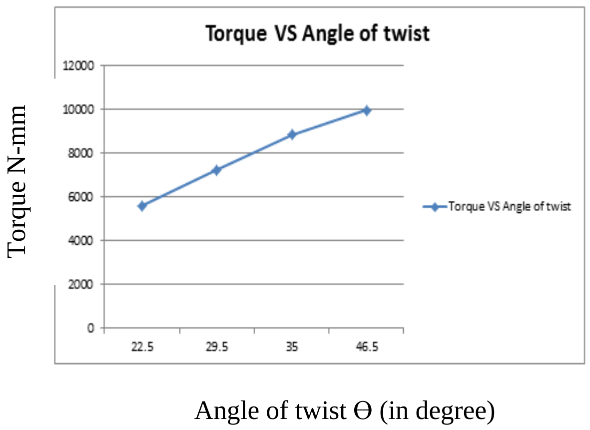

Fig 3.4 Torque VS Angle of twist

Figure 3.1 shows the behaviour of composite rod in torsion by depicting torque versus angle of twist.

IV. CONCLUSION

Unidirectional continuous composites were prepared by reinforcing NaOH treated sisal fibers. The SEM micrograph shows better interfacial bonding with fiber and matrix. The sisal fiber reinforced polyester composites were tested for its longitudinal tensile strength and torsional strength. The test results shows that naural fibers can be utilised as an alterate material for synthetic fiber as a reinforcing material for polyester with specific strength. Thus the composite shafts were made with a simple fabrication method at short period of time, low cost and can be utilised as transmission shaft facing torsional load between 5 to 10 N-m.

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