Mechanical Properties of Short Sisal Fiber Filled Polyester Composites

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Abstract-In present work, anew class of polymer composites is developed with thermoset resin polyester as matrix material and a natural fiber, short sisal fiber as reinforcing material.Hand lay-up method are used for fabrication of composites. The effect of fiber content on mechanical properties of such fabricated samples are investigated and presented in this work. The various property evaluated are tensile strength,compressive strength and flexural strength of the fabricated samples. From the experimental results, it is found that compressive strength and flexural strength increases with fiber content and tensile strength decreases with fiber content.

***Keywords: Polymer matrix composites, Polyester, Sisal fiber, Mechanical properties*.**

I.INTRODUCTION

Natural fiber-reinforced polymer composites are important components in the field of research and innovation [1]. Plants or animals are the main source of natural fibers. Out of these two, plants fibers find more potential application in polymer composites. Natural fibers obtained from plants are harvested from renewable resources and readily available at low prices. Their specific properties are comparable to synthetic fibers that are traditionally used as reinforcing phases in polymer based composite materials [2]. The plant, which produces cellulose fibers can be classified into bast fibers (jute, flax, ramie, hemp and kenaf), seed fibers (cotton, coir and kapok), leaf fiber (sisal, pineapple and banana), grass and reed fibers (rice, corn and wheat) and core fibers (hemp, kenaf and jute) as well as all other kinds (wood and roots) [3].

Such composites are in great use because of the good properties and superior advantages of natural fiber over synthetic fibers in terms of its relatively low weight, low cost, less damage to processing equipments, good relative mechanical properties, improved surface finish, renewable resources, being abundant, biodegrability and minimal health hazards [4].

Among the different types of natural fibers, sisal fibers are a promising reinforcement for use in composites. Maurya et al. [5] worked on epoxy reinforced with short sisal fiber and evaluated the mechanical properties of the composites as a function of fiber length. They used four different length fiber ranging from 5 mm to 20 mm with an increment of 5 mm and kept the fiber loading constant to 30 wt. %. In their analysis, they found that the flexural strength increases with increase in the length of the fiber whereas tensile strength decreases with increase in length of fiber. Gupta et al. [6] used epoxy matrix with sisal fiber and fabricated the composite. They studied the effect of fiber content and types on various mechanical properties of the composites. In their analysis, they found to achieve maximum tensile strength and flexural strength with maximum fiber content of 30 wt. %. Zhou et al. [7] et al. used combination of short sisal fiber with high density polyethylene matrix and fabricated the composites using twin screw extruder. They fabricated two sets of composites with 10 wt. % and 20 wt. % fiber and found that the tensile and flexural strength increases for 10 wt. % fiber and decreases for 20 wt. %. When, sisal fibers were incorporated in polypropylene polymer, Hasmi et al. [8] observed continuous increasing trends in all the mechanical properties under investigation.

Incorporation of sisal fiber enhances mechanical properties Further improvement in properties can be achieved by using surface modified sisal fiber. Fiore et al. [9] modified the surface of sisal fiber with baking soda. In their study, they found that flexural strength and flexural modulus increases with treatment hour upto 120 hours and later decreases when treatment time increases to 240 hours. They explained the phenomenon as surface modification enhances the property of fiber and adhesion between fiber and matrix. As treatment time increases, adhesion properties also increase but once the treatment time increases beyond critical time, it starts to break the fiber internally and reduces the strength of the fiber results in overall decrement in the value to flexural properties. Naushad et al. [10] also used the combination of PP and sisal fiber and they used NaOH with maleic anhydride grafted PP and found that the tensile and flexural properties increase. MAPP supported the increment in properties. When they evaluated the mechanical properties of the material by reinforcing 40 wt. % of untreated fiber in PP matrix, they not found noticeable increment in mechanical properties. Against this background, an attempt has been made in this research work to develop short sisal fiber (SSF) based polyester composites using simple hand lay-up technique and to study their mechanical properties i.e. tensile strength, flexural strength and compressive strength with varying sisal fiber content in polyster composites.

II.MATERIAL CONSIDERED

Unsaturated isophthalic polyester supplied by Ciba-Geigy India Ltd. is taken as the matrix materials in the present investigation. Polyester is a category of polymer which contains the ester functional group in their main chain. The term unsaturated polyester resin is generally referred to the unsaturated (means containing chemical double bonds) resins formed by the reaction of dibasic organic acids and polyhydric alcohols. Polyester resin is also known as a thermosetting plastic, which implies the plastic sets at high temperatures. Polyester resin composites are cost effective because they require minimal setup costs and the physical properties can be tailored to specific applications.

The sisal fiber used in present work was extracted from the leaf of the plant Agave-Sisalana which is available in plenty

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in the Southern part of India. It is an herbaceous monocotyledonous plant from the Agavaceae family that consists of a rosette of sword-shaped leaves about 100–150 cm tall and 13–15 cm wide. A sisal plant has a 7 to 10-year life-span and produces about 200–250 leaves.When the plant completed two year of its growth, the fiber can be extracted from sisal leaf. By this this they reach a length of 80-100 cm. Among the various natural fibers, sisal fiber is chosen in present work because it is easily and cheaply available. Also, it possesses reasonably good physical and mechanical properties.

III.SAMPLE PREPARATION

In the present investigation, short fiber reinforced polyester composite is fabricated using simple hand lay-up technique. The fabrication of composite using hand lay-up method involves following steps:

1. The room temperature curing polyester and corresponding hardener methyl ethyl ketone peroxide (MEKP) are mixed in which hardener is added 2 % by weight as recommended.
2. Sisal fiber in its short form with approximate size of 3 mm will then added to the polyester-hardener combination and mixed thoroughly by hand stirring.
3. Before pouring the polyester/fiber mixture in the mould, a silicon spray is done over the mould so that it will be easy to remove the composite after curing. The uniformly mixed dough is then slowly poured into the mould so as to get the specimens as per ASTM standard for the entire characterization test.
4. The cast is than cured for 8 hours before it was removed from the mould. In this process exothermic reaction between the matrix and hardener occur which hardened the composite body in this specified duration.

Composites were fabricated with different weight fraction of filler ranging from 0 to 15 wt. %. The list of fabricated composites in present work is presented in table 1.

TABLE 1 LIST OF POLYESTER COMPOSITES REINFORCED WITH SHORT SISAL FIBER.

S.No.	Set	Composition
1	Set 1	Neat Polyester
2	Set 2	Polyester + 3 % by weight sisal fiber
3	Set 3	Polyester + 6 % by weight sisal fiber
4	Set 4	Polyester + 9 % by weight sisal fiber
5	Set 5	Polyester + 12 % by weight sisal fiber
6	Set 6	Polyester + 15 % by weight sisal fiber

IV.EXPERIMENTAL DETAILS

The tensile strength of the composites is measured with a computerized Instron 1195 universal testing machine in accordance with ASTM D638. Static uniaxial compression tests on specimens are carried out using the same computerized universal testing machine. The method by which the compression test is conducted is in accordance with ASTM D695. The flexural test measures the force required to bend a beam under three-point loading conditions. The three-point bend test was carried out in Universal Testing Machine (UTM) in accordance with ASTM D790 to measure the flexural strength of the composites.

V.RESULTS AND DISCUSSION

A. *Tensile strength*

The tensile strength of all the fabricated samples are measured by universal testing machine. The results obtained after the experimentation are plotted and shown in figure 1. From the figure it can be seen that the ultimate tensile strength of the fabricated composite decreases with increase in fiber content. The minimum tensile strength among the various fabricated samples was of sample with 15 wt. % of short sisal fiber. Its values were reported to be of 30.5 MPa which is an decrement of around 23.75 %. The reduction in tensile strength with increase in fiber reinforcement may be due to the weak chemical bond between fiber and the matrix body which is unable to transfer the tensile load.

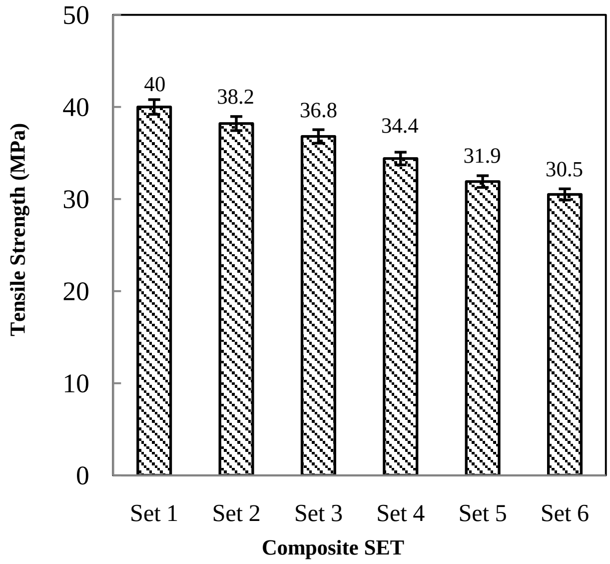

Fig.1 Tensile strength of polyester/short sisal fiber composites

B. *Compressive Strength*

The dependence of compressive strength of polyester composites reinforced with short sisal fibers with different fiber content shown in figure 2. It can be seen from the seen that with increase in fiber content, compressive strength of the composites increases. The compressive strength of neat polyester is 82 MPa which increases to 102.3 MPa at a loading of 15 wt. % of short sisal fiber. This is an appreciable increment of 24.75 %.

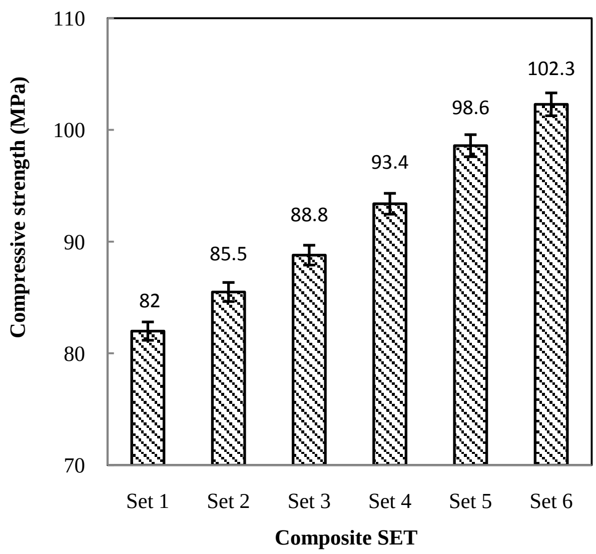

Fig.2 Compressive strength of polyester/short sisal fiber composites

The improvement in compressive strength with fiber addition is mainly because of the high compressive strength of fiber material. Also, the increase in compressive strength with increased fiber content is due to the favorable deformation processes facilitated by the presence of fiber in the matrix. Under a compressive loading situation, the fiber apparently aids the load bearing capability of a composite, rather than acting as stress raiser as is the case in tensile loading. Further, the fact that in a compression test, any crack or flaw introduced by dispersion of the fiber will, if at all, get healed (closed) and made ineffective, contrary to the crack opening mechanism occurring in a tensile loading situation.

C. Flexural Strength

In the present work, the variation of flexural strength of polyester-based composites reinforced with short sisal fiber with respect to the content of sisal fiber is shown in figure 3. It is observed from the figure that there is a gradual increase in the value of flexural strength with increase in short sisal fiber content in polyester resin. The maximum value of flexural strength for polyester composite with sisal fiber is reported to be 67.8 MPa for 15 wt. % of fiber. This is an increment of 50.6 % over neat polyester resin. It can be seen that the flexural properties of the samples can be explained on the basis of the changes in chemical interaction at the fiber-matrix interaction. This results in the improvement of flexural properties of the composites and increases the value of the developed material.

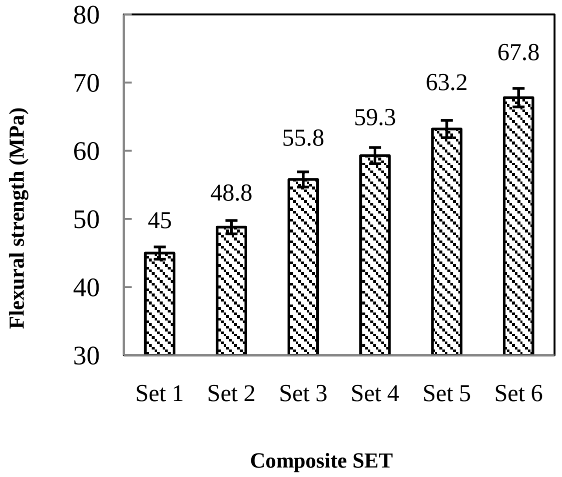

Fig.3 Flexural strength of polyester/ short sisal fiber composites

VI. CONCLUSIONS

This experimental investigation on short sisal fiber reinforced polyester composites has led to the following specific conclusions:

1. Tensile strength of the developed material decreases with increase in fiber content. Tensile strength of neat polyester is 40 MPa which reduces to 30.5 MPa for maximum filler content of 15 wt. %.
2. The compressive strength of the polyester composites reinforced with sisal fiber increase with increase in fiber content. The maximum value of compressive strength is obtained with 15 wt. % of sisal fiber. The compressive strength of neat polyester is 82 MPa which increases to 102.3 MPa for a fiber content of 15 wt. %.
3. The flexural strength increases with increase in fiber content. The maximum value of flexural strength for polyester/sisal fiber composite is obtained with 15 wt. % sisal fiber. The value obtained is 67.8 MPa against 45 MPa for neat polyester.

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