ISSN (e): 2250 – 3005 || Volume, 05 || Issue, 09 ||September – 2015 ||
International Journal of Computational Engineering Research (IJCER)

MECHANICAL CHARACTERIZATION OF BIO-FIBRE AND GLASS FIBRE REINFORCED POLYESTER COMPOSITE LAMINATE JOINTS

S.Rameshkumar*
*Asst.proffesor/Department of Mechanical Engineering , Mahendra college of Engineering, Tamilnadu, India.

Abstract

Composites are versatile and convenient in diverse application such as automotive and aeronaut industry, constructional materials, civil and military applications and many more. Natural fiber composites are currently being used in mostly non-structural applications [1]. Natural fibers are being widely used to substitute artificial glass and carbon fibers in polymer composites. The aim of present work was to focus on the hybridization of natural fiber (jute) and synthetic fiber (E-glass) with polyester resin for applications in the aerospace industry [1]. The mechanical properties such as tensile, impact, flexural test and water absorption rate of hybrid glass/jute fiber reinforced polyester composites were determined. Laminates were fabricated by hand lay-up technique [2]. Then the mechanical properties of lamina prepared with different compositions of natural and synthetic fibers are compared. Total fiber weight fraction was maintained at 50%. Specimen preparation and testing was carried out as per ASTM standards [1], [2].

Key words: *natural fiber, synthetic fiber, polyester resin & fiber weight fraction 50%.*

I. Introduction

A hybrid composite which has more than one fiber as a reinforcement phase embedded into a single matrix phase. Hybridization provides the designers with an added degree of freedom in manufacturing composites to achieve high specific stiffness, high specific strength, enhanced dimensional stability, energy absorption, increased failure strain, corrosive resistance as well as reduced cost during fabrication Composites made of a single reinforcing material system may not be suitable if it undergoes different loading conditions during the service life. Hybrid composites may be the best solution for such applications. Normally, one of the fibers in a hybrid composite is a high- modulus and high-cost fiber such as carbon, boron and the other is usually a low-modulus fiber such as E-glass, Kevlar. The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies [3-5]. High-modulus fibers such as carbon, boron are widely used in many aerospace applications because of their high specific modulus. However, the impact strength of composites made of such high-modulus fibers is generally lower than conventional steel alloys or glass reinforced composites. An effective method of improving the impact properties of high-modulus fiber composites is to add some percentage of low-modulus fibers like E-glass [6]. Most composite materials experience time varying internal disturbance of moisture and temperature during their service life time which can cause swelling and plasticization of the resin, distortion of laminate, deterioration of fiber/resin bond etc. Because of the high performance laminates and composites especially in aerospace, the effect of moisture/temperature environment has become an important aspect of composite material behavior. In this project work the behavior of glass and jute hybrid composites with polyester resin was described.

II. MATERIALS, METHODS AND PREPARATION OF COMPOSITE

This paper describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The raw materials used in this work are

1. Glass fiber
2. Jute fiber
3. Polyester resin

2.1. GLASS FIBER

Glass fiber is commonly used as an insulating material. It is also used as a reinforcing agent for many polymer products; to form a very strong and light fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as "fiberglass". Glass fiber has roughly comparable properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle. The glass fiber is shown in figure.

Glass Fiber

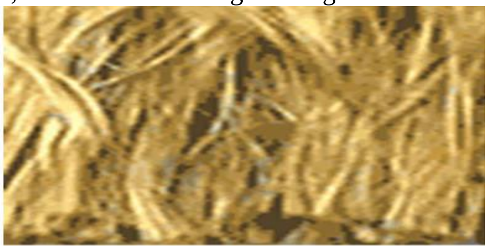
Glass-reinforced plastic (GRP) is a composite material or fiber-reinforced plastic made of a plastic reinforced by fine glass fibers. Like graphite-reinforced plastic, the composite material is commonly referred to as fiberglass. The glass can be in the form of a chopped strand mat (CSM) or a woven fabric. As with many other composite materials (such as reinforced concrete), the two materials act together, each overcoming the deficits of the other. Whereas the plastic resins are strong in compressive loading and relatively weak in tensile strength, the glass fibers are very strong in tension but tend not to resist compression [7-17]. By combining the two materials, GRP becomes a material that resists both compressive and tensile forces well. Manufacturers of glass-fiber insulation can use recycled glass. Recycled glass fiber has up to a 40% recycled glass.

PROPERTIES OF E-GLASS FIBER:

Fiber type	**Tensile strength (MPa)**	**Compressive strength (Mpa)**	**Density (g/cm^3)**	**Thermal expansion µm/(m·°C)**	**Softening T (°C)**
E-glass	3445	1080	2.85	5.4	846

2.2. JUTE FIBER

The industrial term for jute fiber is raw jute. The fibers are off-white to brown, and 1–4 meters (3–13 feet) long. Jute is also called "the golden fiber" for its color and high cash value. Jute is a rain-fed crop with little need for fertilizer or pesticides, in contrast to cotton's heavy requirements. Production is concentrated in India, mainly Bengal, and mostly in Bangladesh. The jute fiber comes from the stem and ribbon (outer skin) of the jute plant [7-17]. The fibers are first extracted by retting. The retting process consists of bundling jute stems together and immersing them in slow running water. There are two types of retting: stem and ribbon. After the retting process, stripping begins; women and children usually do this job. In the stripping process, non-fibrous matter is scraped off, then the workers dig in and grab the fibers from within the jute stem.



Jute fiber

PROPERTIES OF JUTE FIBER:

- Density of 1.47 gm/cc.
- Average fineness-20 Denier (900 meters of filament).
- Average extension at break-1 .2%.
- Average toughness index-0.02.
- Average stiffness- 330 gm/denier.

2.3. POLYESTER RESIN

Polyester resins are the condensation products of dicarboxylic acid with dihydroxy alcohols. For example, terene or terylene or Dacron is saturated polyester formed by condensation of ethylene glycol and terephthaic acid. Polyester resin material is a three-component material. However, the manufacturer mixes the two reactive parts. At the time of application, a catalyst is added to start the reaction. Then the material is sprayed onto the roadway. Reflective beads are added using a separate gun located directly behind the paint gun.

COMPONENTS OF RESIN

Pigments

The material is composed of pigments that are very similar to those used in other pavement markings. The pigments are used to impart color, hiding and other desirable properties, like all other markings. However, these pigments are pre-ground prior to being blended into the resin.

Resins

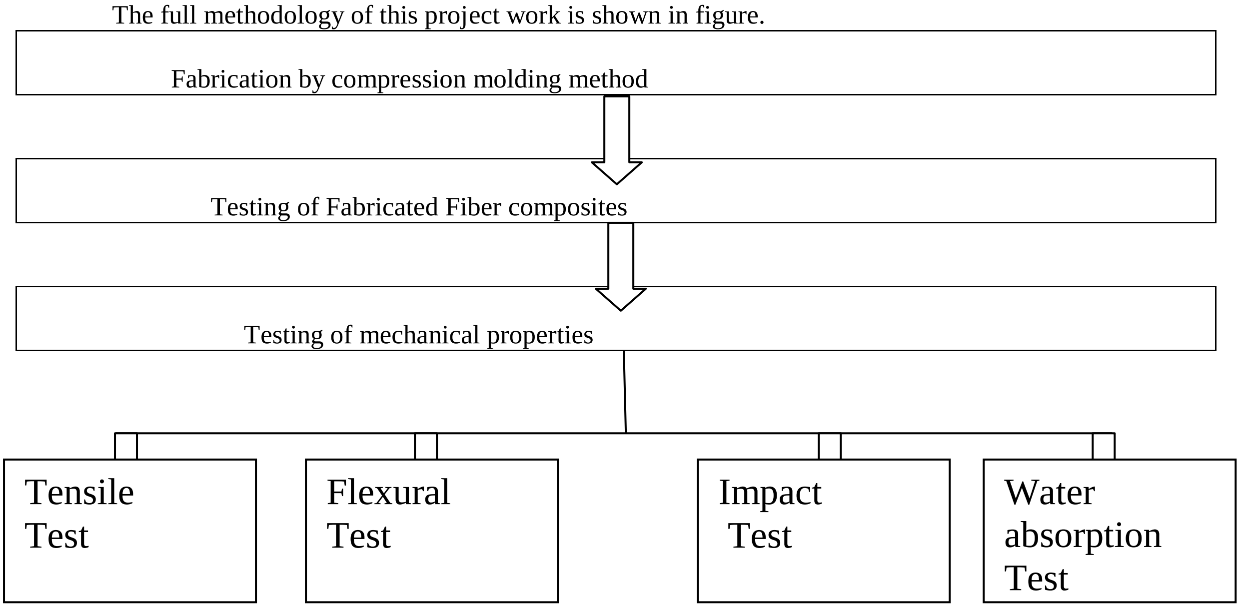
The marking has polyester resin that is mixed with a reactive solvent, a styrene compound. Normally, solvents are expected to evaporate and not participate in the setting up process. In addition to acting as a solvent, the styrene participates in the polymerization process. In order for this material to begin to react, a catalyst must be added to initiate the reaction.

Additives

Driers are added to assist in the curing process. Beads are uniformly applied across the entire width of the marking by either a gravity or pressurized bead applicator located immediately behind the polyester spray gun. Beads are generally applied at a rate of 8 lb/gal.

III. METHODOLOGY

The full methodology of this project work is shown in figure.



IV. FABRICATION OF COMPOSITE MATERIALS

This topic deals with the fabrication stages carried out to obtain the composite material. The materials used in our fabrication process are as follows:

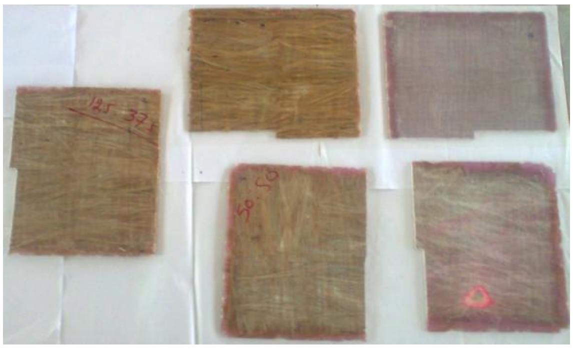
- E-glass fiber (250 g.s-m).
- Polyester (GP resin).
- Jute fiber.
- Hydrogen peroxide as Accelerator.
- Cobalt as catalyst.

HAND LAY-UP METHOD:

The composite laminate is fabricated using hand lay-up method. It is simple and mostly used method. The process of composite fabrication using hand lay-up process is listed below,

- Initially, the E-glass fiber mats are cut into 270 x 270 mm size and jute fibers are cut in the size of 150 mm.
- Then, prepare the matrix by mixing the polyester resin and Hardener in the ratio of 10:1

- Then the wax is applied and the some amount of polyester resin is applied in the die.
- Then the required amount of glass fiber and jute fiber is placed layer by layer in the square shaped die of dimension 300x300x3 mm.
- After placing the fibers the polyester resin is poured into the die and again the required amount of polyester resin is poured into the die.
- Then the die is closed for one hour and 70kg of weight is placed on the die.
- After one hour, the die is opened and the hybrid laminate of jute fiber and glass fiber is taken out.
- Utmost care has been taken to maintain uniformity and homogeneity of the composite. The fabricated specimen is shown in figure.



Composite Laminates

The composite laminate is fabricated for different fiber weight (%) that is shown in table

Composites	**Glass fiber Weight (%)**	**Jute fiber Weight (%)**	**Resin weight (%)**
S1	-	50	50
S2	50	-	50
S3	37.5	12.5	50
S4	25	25	50
S5	12.5	37.5	50

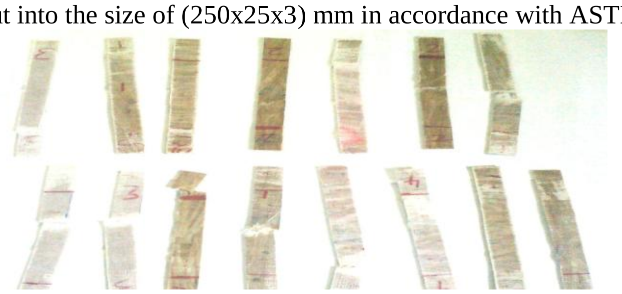
Designation of Composites

V. EXPERIMENT PROCEDURE

CUTTING OF LAMINATES INTO SAMPLES OF DESIRED DIMENSIONS:

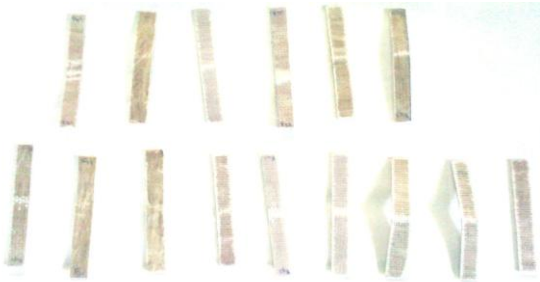
A WIRE HACKSAW blade was used to cut each laminate into smaller pieces, for various experiments and the sized specimens are shown in the following figures.

TENSILE TEST- Sample was cut into the size of (250x25x3) mm in accordance with ASTM standards D-638.



Tensile test specimen

FLEXURAL TEST- Sample was cut into flat shape (125x13x3) mm, in accordance with ASTM standards D-790.



Flexural test specimen

IMPACT TEST- Sample was cut into flat shape (65x13x3)mm, in accordance with ASTM standard D-790.

Impact test specimen

WATER ABSORPTION TEST-Sample was cut into flat shape (30x30x3) mm.

Water absorption test specimen

TENSILE TEST WITH BOLT JOINT- Sample was cut into the size of (102x25x3) mm in accordance with ASTM standard D-5868-01. Two plates are made up of for same size and made the single lab joint for testing the tensile strength. One hole is drilled at each plate at the size of 6mm diameter and the single lab joint is made with the help of 6mm bolt and nut.

Tensile test specimen with bolt joint

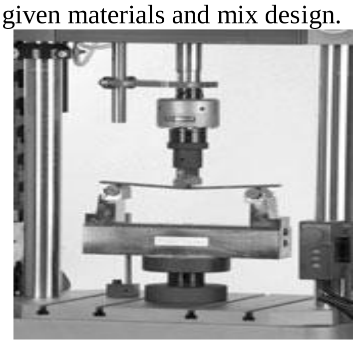
5.1. TENSILE TEST:

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250x25x3) mm, typical points of interest when testing a material include: ultimate tensile strength (UTS) or peak stress, peak load, elongation and break load [15-17]. The tensile test is performed in the universal testing machine (UTM) Instron 1195 and results are analyzed to calculate the tensile strength of composite samples.

Universal testing machine

5.2. FLEXURAL TEST:

Flexural strength is defined as a materials ability to resist deformation under load. The short beam shear (SBS) tests are performed on the composites samples to evaluate the value of inter-laminar shear strength (ILSS). It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conducted as per ASTM standard using UTM. The dimension of the specimen is (125x13x3) mm. It is measured by loading desired shape specimen (6x6-inch) with a span length at least three times the depth. The flexural strength is expressed as (MPa). Flexural strength is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. [15-17] However the best correlation for specific materials is obtained by laboratory tests for given materials and mix design.



Experimental setup for flexural test

5.3. IMPACT TEST:

Impact energy is the energy which is absorbed by the specimen when the impact load is applied. Here, the Izod impact test is carried out. Izod impact testing is an ASTM standard method of determining the impact resistance of materials. An arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact energy is determined. A notched sample is generally used to determine impact energy and notch sensitivity [15-17]. The test is similar to the Charpy impact test but uses a different arrangement of the specimen under test. The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three-point bending configuration. The impact specimen size is (65x13x3) mm.

Izod impact testing machine

5.4. WATER ABSORPTION TEST:

The water absorption test is used to find the water absorption rate. The effect of water absorption on jute and glass reinforced hybrid composites were investigated. The specimens were dried in an oven at 50^0C and then they were allowed to cool till they reached room temperature. The specimens were weighed to an accuracy of 0.1mg. Water absorption tests were conducted by immersing the composite specimens in distilled water in plastic tub at room temperature for 24 hours duration. Once in 24 hours, the specimens were taken out from the water and all surface water was removed with a clean dry cloth and the specimens were reweighed to the nearest 0.1 mg. From these two readings, the water absorption rate (%) was calculated. The specimen size is (30×30×3) mm.

VI. MECHANICAL CHARACTERISTICS OF COMPOSITES

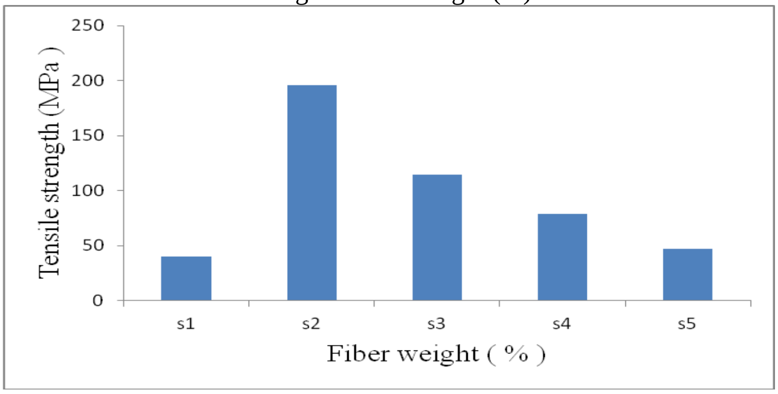
The characterization of the composites reveals that the fiber weight (%) is having significant effect on the mechanical properties of composites. The properties of the composites with different fiber weight (%) under this investigation are presented in Table

Composites	Tensile strength (MPa)	Tensile strength with bolt (MPa)	Flexural strength (MPa)	Impact Energy(J)	Water absorption (%)
S1	40.05	23.946	122.784	0.833	13.37
S2	195.857	44.187	247.545	2.106	0.24
S3	114.126	34.897	155.220	1.933	1.79
S4	78.395	35.864	66.153	1.733	5.59
S5	46.643	35.856	132.65	2	5.74

Mechanical properties of the composites

6.1. EFFECT OF FIBER WEIGHT (%) ON TENSILE STRENGTH

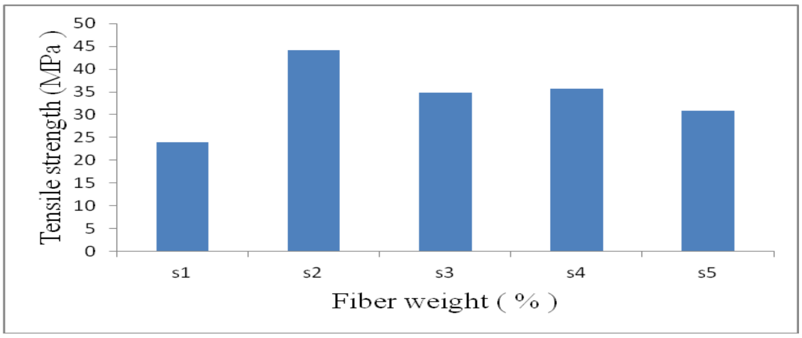
The test results for tensile strength are shown in Figure. The sample 1 and 2 shows the pure jute and pure glass reinforced composites and in this composites, pure glass shows high tensile strength. The sample 3, 4 and 5 shows the tensile strength of hybrid composites and in this hybrid composites, the sample 3(i.e 37.5% of glass and 12.5% of jute fiber) shows the better tensile strength. From the results it is seen that the tensile strength of the composite increases with increase in glass fiber weight (%).



Effect of fiber weight (%) on tensile strength of composites

6.2. EFFECT OF FIBER WEIGHT (%) ON TENSILE STRENGTH WITH BOLT JOINT

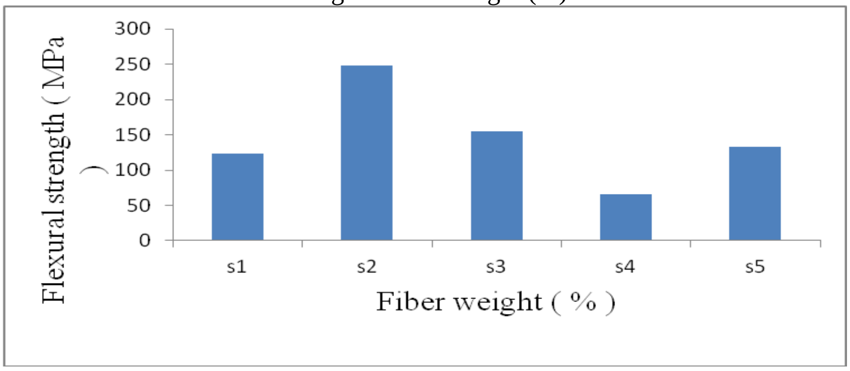
The test results for tensile strength are shown in Figure. The sample 1 and 2 shows the pure jute and pure glass reinforced composites and in this composites, pure glass shows high tensile strength. The sample 3, 4 and 5 shows the tensile strength of hybrid composites and in this hybrid composites, the sample 3(i.e 37.5% of glass and 12.5% of jute fiber) shows the better tensile strength. From the results it is seen that the tensile strength of the composite increases with increase in glass fiber weight (%).



Effect of fiber weight (%) on tensile strength of composites

6.3. EFFECT OF FIBER WEIGHT (%) ON FLEXURAL STRENGTH

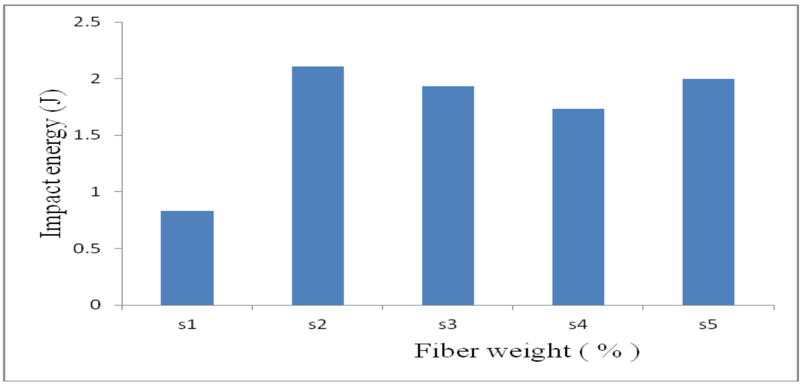
The test results for flexural strength are shown in Figure. The sample 1 and 2 shows the pure jute and pure glass reinforced composites and in this composites, pure glass shows high flexural strength. The sample 3, 4 and 5 shows the flexural strength of hybrid composites and in this hybrid composites, the sample 3(i.e 37.5% of glass and 12.5% of jute fiber) shows the better flexural strength. From the results it is seen that the flexural strength of the composite increases with increase in glass fiber weight (%).



Effect of fiber length on flexural strength of composites

6.4. EFFECT OF FIBER WEIGHT (%) ON IMPACT ENERGY

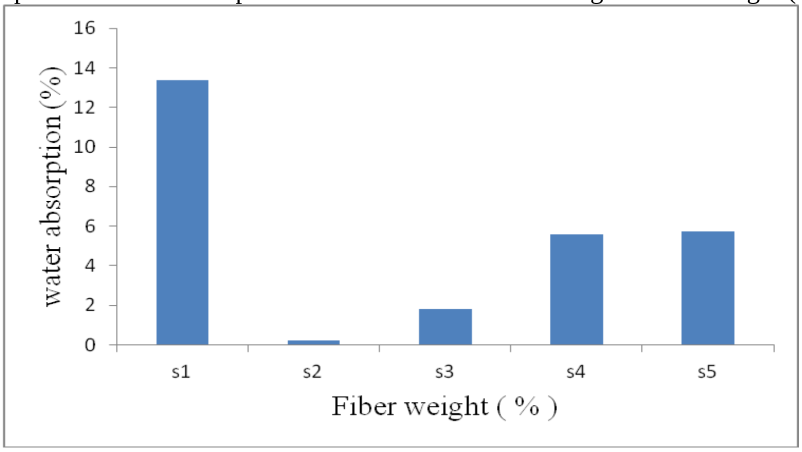
The test results for impact energy are shown in Figure. The sample 1 and 2 shows the pure jute and pure glass reinforced composites and in this composites, pure glass shows high impact energy. The sample 3, 4 and 5 shows the impact energy of hybrid composites and in this hybrid composites, the sample 3(i.e 37.5% of glass and 12.5% of jute fiber) shows the better impact energy. From the results it is seen that the impact energy of the composite increases with increase in glass fiber weight (%).



Effect of fiber length on impact energy of composites.

6.5. EFFECT OF FIBER WEIGHT (%) ON WATER ABSORPTION RATE

The test results for water absorption rate are shown in Figure. The sample 1 and 2 shows the pure jute and pure glass reinforced composites and in this composites, pure glass shows less water absorption rate. The sample 3, 4 and 5 shows the water absorption rate of hybrid composites and in this hybrid composites, the sample 3(i.e 37.5% of glass and 12.5% of jute fiber) shows the less water absorption rate. From the results it is seen that the water absorption rate of the composite decreases with increase in glass fiber weight (%).



Effect of fiber weight (%) on water absorption rate

VII. CONCLUSIONS

This experimental investigation of mechanical behavior of jute and glass fiber reinforced polyester hybrid composites leads to the following conclusions:

1. This work shows that successful fabrication of a jute and glass fiber reinforced polyester hybrid composites with different fiber weight (%) is possible by simple hand lay-up technique.
2. It has been noticed that the mechanical properties of the composites such as tensile strength, flexural strength, flexural modulus, impact strength and water absorption rate of the composites are also greatly influenced by the fiber weight (%).
3. It has been noticed that the mechanical properties of the composites are increases with the increases of glass fiber weight (%).

REFERENCES

[1] Kaw A.K.; Mechanics of composite materials, Chapter 1, CRC Press: Taylor & Francis Group, USA, 2006, 2nd ed. ISBN: 0-8493-1343-0
[2] Ghassemieh, E.; Nassehi, V. Polymer Composites. 2001, 22, 528. DOI: 10.1002/pc.10557
[3] Chandra, R.; Singh, S. P.; Gupta, K. Composite Structures. 1999, 46, 41. DOI: 10.1016/S02638223(99)00041-0
[4] Haldar, A.K.; Singh, S.; Prince. AIP conference proceedings. 2011, 1414, 211. DOI: 10.1063/1.3669958
[5] Malkapuram, R.; Kumar, V.; Negi Y.S. Journal of Reinforced Plastics and Composites. 2009, 28, 1169. DOI: 10.1177/0731684407087759
[6] Matter, M.; Gmur, T.; Cugnoni, J.; Schorderet, A. Computers and Structures. 2010, 88, 902. DOI: 10.1016/j.compstruc.2010.04.008
[7] Sun, W.; Lin, F. Journal of Thermoplastic Composite Materials, 2001, 14, 327. DOI: 10.1106/YKDM-PX8K-NF6Q-L7FK
[8] Gilchrist, M.D.; Kinloch, A.J. Composites Science and Technology, 1996, 56, 37. DOI: 10.1016/0266-3538(95)00126-3
[9] Ascione, F.; Feo, L.; Maceri, F. Composites Part B: Engineering. 2009, 40, 97. DOI: 10.1016/j.compositesb.2008.11.005
[10] Shokrieh, M.M.; Omidi, M.J. Composite Structures, 2009, 88, 595. DOI: 10.1016/j.compstruct.2008.06.012
[11] Haider, A.Z.; Zhao, X.L.; Riadh, A.M. Procedia Engineering, 2011, 10, 2453.
[12] Segurado, J.; LLorca J. Mechanics of materials, 2006, 38, 873. DOI: 10.1016/j.mechmat.2005.06.026
[13] Zhang, Y.X.; Yang, C.H. Composite Structures, 2009, 88, 147. DOI: 10.1016/j.compstruct.2008.02.014
[14] Kabir, M.R.; Lutz, W.; Zhu, K.; Schmauder, S. Computational Materials Science, 2006, 36, 361.DOI: 10.1016/j.commatsci.2005.09.004
[15] Goh, K. L; Aspden, R. M; Hukin, DWL. Composite Science and Technology, 2004, 64,1091. DOI: 10.1016/j.compscitech.2003.11.003
[16] Zhang, Y.; Xia, Z. CMC, 2005, 2, 213. DOI: 10.3970/cmc.2005.002.213
[17] Houshyar, S.; Shanks, R.A.; Hodzic, A. Express Polymer Letters, 2009, 3, 2. DOI: 10.3144/expresspolymlett.2009.2