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Experimental Investigation on Mechanical Properties of Jute Glass Fibrere in forced Epoxy Resin Hybrid Composite

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Abstract: Due to their eco-friendly nature and sustainability, natural fiber reinforced composite are more popular nowadays. Artificial fiber reinforced composite are becoming more valuable due to their better properties. NFPCs are more valuable due to their low cost and availability,but someof thedrawbacks of NFPCs like more water absorption, poor mechanical properties and low resistant to fire limited its applications. In order to improve the properties of natural fiber, itcan be combined with artificial fiber to form hybrid composite. In this study, the properties of jute fiberis improved by combining it with glass fiber with the help of epoxy resinand its mechanical properties tensile, compression, impact strength and flexural strength is found out and compared.

Key words: Hybrid composite · Bi-directional ply · Hand lay-up method · Fiber reinforced polymer composites (FRP) · Natural fiber reinforced polymer composites (NFPCs) · Universal testing machine (UTM)

INTRODUCTION

Natural fiber reinforced polymer composites (NFPCs) got considerable attention in numerous applications because of low weight, low cost, biodegradability and minimum health hazards but some of the drawbacks of NFPCs mentioned above make it unsuitable for certain applications. Natural fiber modifications cause reduction of moisture absorption of natural fibers which lead to an excellent enhancement incompatibility between fiber and polymer matrix [1]. The properties of natural fiber reinforced composites can be enhanced by combining it with synthetic fiber and making it hybrid polymer composite.The bamboo-glass fiber reinforced polymer composites(BFRP) showed better mechanical properties like hydro thermal ageing and tensile strength [2]. The epoxy resin reinforced with glass fiber and filled with bamboo leaf derived SiC improves tensile and flexural strength of the composite [3]. The flexural fatigue strength of the glass fiber reinforced polymer composite can be enhanced by incorporating it with E-Glass epoxy laminates and making it hybrid polymer composite [4]. The property of anisotropy of the GFRP (Glass Fiber Reinforced Plastic) material is dominant on the fatigue strength [5]. The applications of NFPCs are growing fastlyin engineering fields. The different kinds of natural fibers reinforced polymer composite have played a great role in automotive applications by many automotive companies such as Audi, BMW, Volkswagen, Daimler and Mercedes etc., Beside the auto industry, the applications of natural fiber composites have also been found in construction industry, sports, aerospace etc., [6].

Selection of Material and Fabrication Process

Material: In this study, the natural fiber jute and the synthetic fiber glass are incorporated with epoxy resin.

Epoxy: Epoxy resins are the mostly used resins. They are a low molecular weight organic liquids which contains epoxide groups. Epoxide has three members in its ring, 1. Carbon and 2.Oxygen atoms. The reactions of Epichlorohydrin with aromatic amines or phenols amines make most epoxies. Filler, Hardeners and plasticizers are also added to produce epoxies with a wide range of properties of impact, viscosity, degradation, etc. Although epoxy is a costlier one than other polymer matrices, PMC is mostly used. More than two thirds of the polymer matrices which is used in aerospace applications is epoxy based type.

- Chemical name- Diglycidyl ether of bisphenol
- Type used - Araldite- LY556.

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Fig.1: Epoxy resin

Table 1: Properties of epoxy

Specific gravity	1.2
Tensile strength	35-130 Mpa
Poisson's ratio	0.37
Compressive strength	100-200 Mpa
Elongation	1-8.5%
Co-effof thermal expansion	45-70 10^{-6}/°C
Water absorption	0.1-0.4%

Catalyst: Hardener such as an organic peroxide, or similar compound which is mixed with anacceleratorinitiates the polymerization process of the resins. Catalyst is available as a paste or liquid.

- Chemical name – TriethaTetramine.
- Type used – Aradur-HY951

Glass Fibers: E-Glass fiber is used in the form of chopped strand mat. These materials are limited to low temperature applications where strength is considered as a major factor without the need for high rigidity

Glass Fiber Orientation: Glass fiber are available in two orientation. Based on the application the orientation areselected. The two types of orientations/ply of glass fiber are

- Uni-directional ply
- Bi-directional ply

Composition: E-Glass is a low alkali glass with a composition of14wt%of Al_2O_3, 54wt%of SiO_2, 22wt%of CaO+MgO, 10wt% of B_2O_3 and less than 2wt%. ofNa_2O+K_2O.Some other materials may also be present.

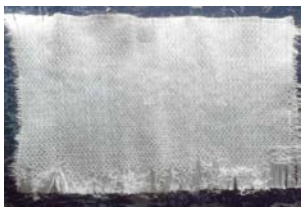

Fig. 2: Uni-Directional ply

Fig. 3: Bi-Directional ply

Jute Fiber: Jute is a soft, long, shiny plant fiber that can be spun into course, strong threads. Jute fiber is 100% bio-degradable.

Fabrication Process: For fabrication of composite, the bi-directional chopped strand mat E-Glass fiber and the jute fiber are incorporated into epoxy resin by hand lay-up method.

Hand Lay-up Method: Hand lay-up is a simple and cheaper method for production of composite. Unless the composite is to be joined directly to another structure, a mould must be used for hand lay-up parts. Before laying-up, the mould was prepared with a release agent to avoid the adhering of the part with the mold. Reinforcement fibers was cut and laid in the mould. It is the designer's choice to decide the type, direction of the fibers and the amount being used. Then required amount of resin is added to the fibers. A roller and brushes can be used to impregnate the fibers with the resin. The main methods used for joining metallic parts, adhesive fastening and mechanical fastening are also applicable to composites, provided care is taken to allow for the characteristics of composites.

Fig. 4: Fabrication set-up for Hand lay-up method

Fig. 5: Jute-Glass fiber hybrid composite

Experimental Work: In this study, the mechanical properties (tensile, compression, flexural and impact strength) of jute-fiber reinforced polymer matrix hybrid composite were checked. The work material to be checked for a particular test is cut to the required dimension for the corresponding test.

Testing of the Specimen in UTM Machine: Tensile test, Compression test of the hybrid composite was done by using UTM machine. The FRPCs was cut to the required dimension (5.14mm thickness and 13.22 mm width) by a cutting machine. The tensile specimen is placed in the universal testing machine. The specimens are loaded step by step up to failure under tensile loading along the material longitudinal axis. A continuous record of load and deflection is obtained by a digital data acquisition system.

Fig. 6: Loading of specimen in UTM

Fig. 7: Specimen after tensile testing

Impact Test: The toughness of the jute fiber hybrid composite was determined by Chirpy test. Chirpy test is also called as Chirpy V-Notch test. As per ASTM standard, the specimen of size 10X10 cross-section and length 55mm was cut and tested in a impact testing specimen.

Fig. 8: Impact testing machine

Fig. 9: Specimen after impact testing

Bending Test: The bending strength of the hybrid fiber composite was tested by universal bending testing machine. It was cut to the required dimension and the test was conducted.

Fig. 10: Universal bending machine

Fig. 11: Specimen after bending failure

RESULT AND DISCUSSION

All the tests for the jute glass fiber composite were taken in omega laboratory, Guiney, Chennai. The results for each test are as follows.

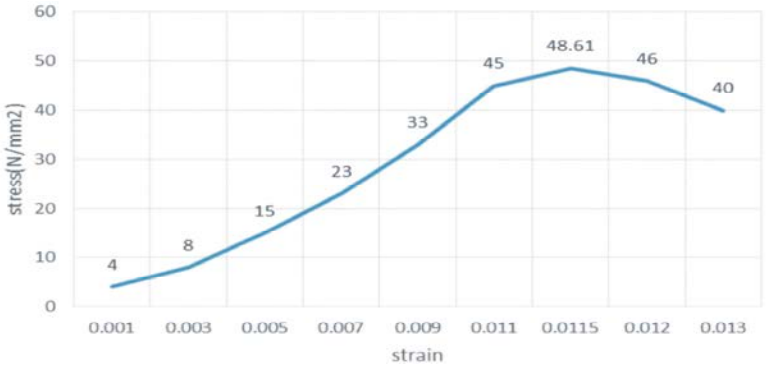

Fig. 12: Stress-strain curve for tensile test

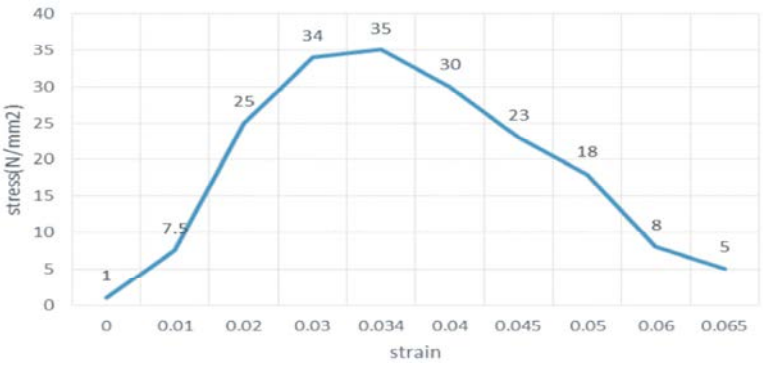

Fig. 13: Stress-Strain curve for compression test

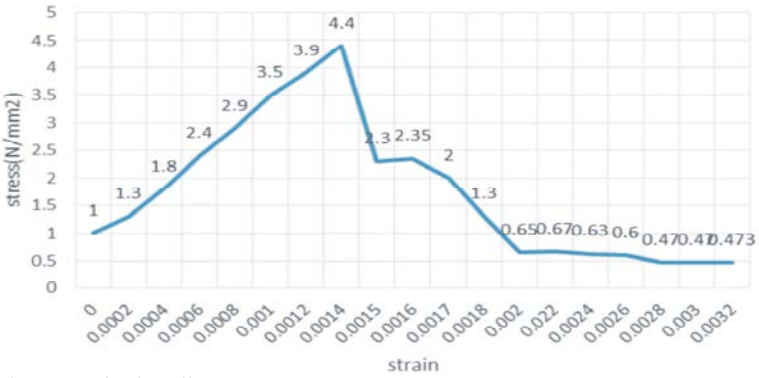

Fig. 14: Stress-strain curve for bending test

Tensile Test: Figure 12 shows the stress-strain curve when the specimen is loaded gradually in UTM. The size of the specimen taken for tensile test was of thickness 5.14mm and width 13.22mm. From the Figure.11, the ultimate strength was taken and is equal to 48.61 Map. Young's modulus of the composite in tension is equal to (48.61/0.0115)=4.226Gpa.

Compression Test: Figure 13 shows the stress-strain curve of the composite when the load is gradually applied in UTM during the compression test. The size of the specimen taken for compression test was 4.77mm thick and 51.10mm width. The ultimate compression strength was taken from the curve and is equal to 35 Map and the Young's modulus in compression is equal to (35/0.034) = 1.029Gpa.

Flexural Test: Figure 14 shows the stress-strain curve of the composite when the load is gradually applied during the bending test. The size of the specimen taken for bending test was 5.33mm thickness and 26.38mm width. From the curve, the flexural strength of the composite was taken and is equal to 4.40 Map and the young's modulus in bending is equal to (4.40/0.0014)=3.142GPa.

Table 2: Results of the impact test

Composite	Trial.1	Trial.2	Trial.3	Average (Joules)
Jute-Glass fiber hybrid composite	2	4	4	3.33

Table 3: Comparison of jute-glass-epoxy and jute-epoxy

Composite	Tensile modulus	Flexural modulus	Impact Strength
Jute-glass-Epoxy	4.22	3.14	3.53
Jute-Epoxy	1.064	3.08	2.63

Impact Test: The size of the specimens for impact test as per standard ASTM A370 is 55x10x10mm. Composites generally have low value of impact strength compared to the metals. The impact test was carried out by chirpy V-notch test and the results are shown in Table 2.

Comparison: The results of the jute-glass fiber reinforced polymer composite is compared with the results of the jute fiber reinforced polymer composite [7] and are shown in Table 3.

CONCLUSION

The strength of jute-fiber reinforced hybrid polymer composite in tension, compression, bending were found out by universal testing machine and its toughness was found out by a charpoy test. The results of the jute-glass-epoxy composite were compared with the results of jute epoxy composite. It was proved that when the natural fiber (Jute) as well as synthetic fiber (E-Glass) are incorporated with resin, it showed better strength than natural fiber (Jute) reinforced resin.

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