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An Investigation on the Mechanical Properties of Glass Fiber – Epoxy Based Composite

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Abstract: *Fiber reinforced plastics have gained utmost importance in the aerospace, automotive, marine and construction industries because of their particular mechanical and physical properties. Nowadays, glass fiber reinforced polymer combined with certain additives to form hybrid composites have gained more importance in fusion reactors and nuclear applications as this material gives outstanding desirable properties thus befitting them in various operating conditions. In the present work, composite laminates were fabricated using S glass fiber reinforced in epoxy matrix and a detailed study of the mechanical properties of the composite, such as tensile strength, flexural strength and impact strength was undertaken to evaluate the mechanical properties.*
Keywords: *S Glass fiber,Epoxy, impact strength, Tensile strength, flexural Strength.*

I. Introduction

Over the past few decades the use of composite materials for various applications have shown unprecedented growth. The provision for inducing tailor made properties by combining two or more distinct materials has led to the emergence of material properties never witnessed before. Brittle materials like ceramics are reinforced into soft metal matrix showing high strength with moderate toughness. Polymer matrices are gaining importance because of their ease in fabrication processes. As for reinforcement, Glass fibres are commonly used because of cost effectiveness and availability in various forms such as long fibres, short fibres, chopped strand mat, woven roving, yarns, fabrics etc. Glass fibre reinforced plastics (GFRP) possess several advantages over traditional materials such as high specific strength, high specific stiffness, chemical resistance, ease of fabrication etc. Their applications are in electronics, aviation, automobile industries, oil and gas industries etc.

Recently Epoxy resins as matrix has gained considerable acceptance over its use in insulation systems of superconducting magnets in low temperature conditions[2].Epoxies are a class of thermoset materials of particular interest to structural engineers owing to the fact that they provide a unique balance of chemical and mechanical properties combined with wide processing versatility[3]. When reinforced with Glass fibre it provides improved strength/stiffness ratio, strong ageing and fatigue performance, high electrical and thermal insulation and high chemical resistance.It was found that more the glass fiber areal weight and the layer number were used as reinforcement in epoxy composite, more its tensile strength increased [4].

In this work the mechanical characteristics of S glass fibre reinforced with Bisphenol-A based Epoxy resin, is studied and discussed.

II. Experimental

A. Material

S glass fiber biaxial roving mat was used as reinforcement.This type of glass contains alumino silicate with high MgO content that provides hightensile strength.Epoxy resin used was Araldite GY 250, general purpose high viscosity unmodified basic liquid epoxy resin based on bisphenol-A. The details of the material used are listed in Table 1.

Material	Details
Glass Fiber	S Glass Fiber Woven Roving Biaxial mat. 180 gsm
Epoxy resin	Resin: Epoxy Araldite GY 250 Epoxy equiv. 183 – 189 g/Eq Viscosity at 25 deg Centigrade: 10000 – 12000 mPa S Hardener: Epoxy Aradur 140 Viscosity at 25 deg Centigrade: 300 –

	600 mPa S Typical mix ratio: 50 g/100g Gel Time: 120 minutes

Table 1 Details Of Materials

B. Specimen Preparation

The test specimens were fabricated in the form of 1ft x 1ft laminates of 3.2 mm thickness with a fiber volume fraction of 0.18. Epoxy resin was applied in between alternate layers of pre-cut S-glass fiber biaxial mat as per hand layup technique procedure. The specimen was left to cure for 48 hrs after which it was cut according to ASTM standards required for corresponding tests.

1) Impact test

Test specimens were cut from the fabricated laminate as per ASTM D256 specification, with dimensions 64mm x12.7 mm x 3.2 mm. The test was performed on notched specimens using an ASTM D256 Impact Testing machine with an impact speed of 3.46 m/s.

2) Tensile test

Generally, tensile test is performed on flat specimens of dog-bone specimen shape or straight-sided specimen with end tabs. A uni-axial load is applied through the ends. The test specimen used in the present study was of dog- bone type, havingdimensions according to ASTMD638-10 standard. The test was performed on Universal tensile testing machine at a speed of 5 mm / min. Figure 1 depicts the fabricated tensile test specimens.

Fig. 1 Tensile test Specimens

3) Three-point bend test

Determination of flexural strength is an important characterization of a composite specimen. It is the ability of a material to withstand the bending before reaching the breaking point. Generally, the composite specimens are subjected to three-point bending test for finding out this material property. The strength of a material in bending is expressed as the stress on the outermost fibers of a bent test specimen, at the instant of failure. In a conventional test, flexural strength and in-plane shear strength is given by:

Flexural Strength = $3PL / 2bd^2$

Shear Strength = $3P / 4bd$

where P is the applied central load, L is test span of the sample b is the width of the specimen and d is the thickness of test specimen.

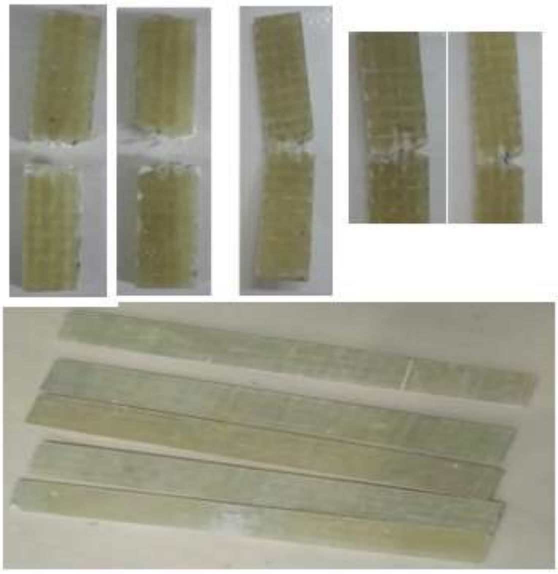

Fig. 2 Three-point bending test specimens

In the present study, specimens (shown in figure 2) were prepared with length 100 mm and width 12 mm and the flexural strength and in-plane shear strength were determined through three-point bending test as per ASTM D790 – 03.

III. Results And Discussions

The photograph of impact test specimen is presented in fig. 2 and the energy absorbed by the composite specimens is presented in table 2

Sample	Energy Absorbed	Impact Strength (KJ / m^2)
1	2.726 J	89.085
2	2.728 J	89.15
3	2.721 J	88.922
4	2.730 J	89.216
5	2.726 J	89.085
Mean	**2.7262 J**	**89.092**

Table 2 Impact Test Results

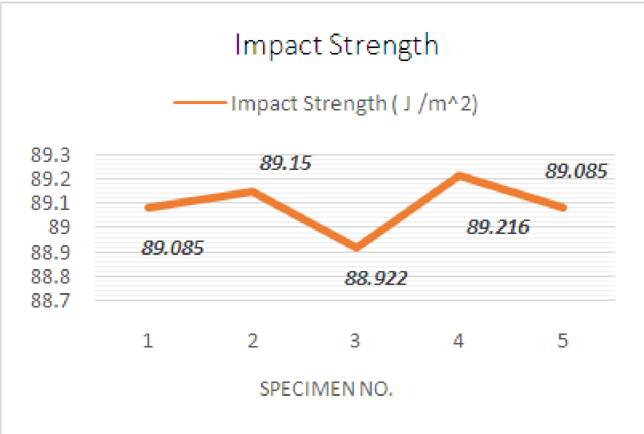

Fig. 3 Impact Test results

Since the fiber volume fraction is only 18%, the energy absorbed by the specimens before fracture was witnessed to be 2.726 J with an impact strength of 89 KJ / m^2. Thus, with an increase in fiber ratio the impact strength of the composite can be increased.

Fig.4Impact test specimens after test

Figure 5 and figure 6 depicts the results of the tensile test and the flexural test respectively. After performing the test, the average value of the Ultimate tensile strength of five samples of the insulation composite material was obtained to be 162 MPa and that flexural strength obtained was 130 MPa. The results that was obtained from these tests is comparatively less when compared with the required strength of the material used in a fusion reactor. In Fusion reactor, the Ultimate tensile strength and inter-laminar shear strength should be around 280 MPa and 60 MPa respectively [2], [7].

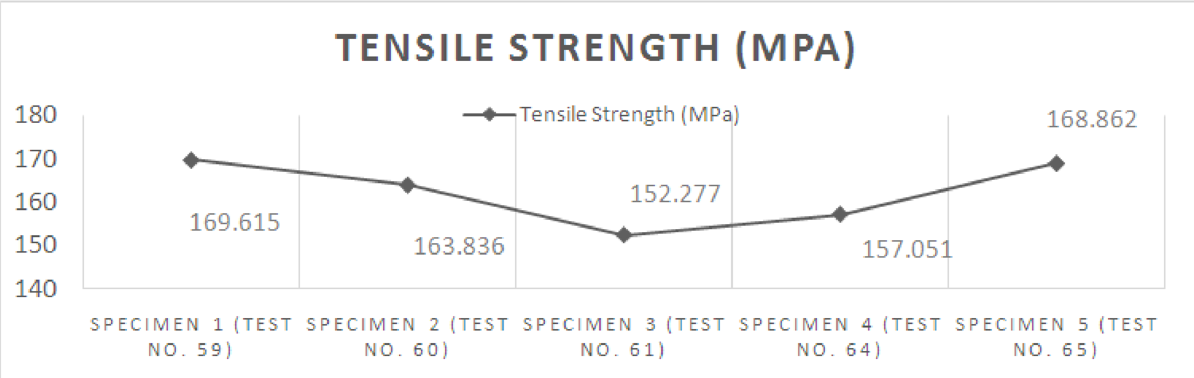

Fig. 5 Tensile test results indicating tensile strength

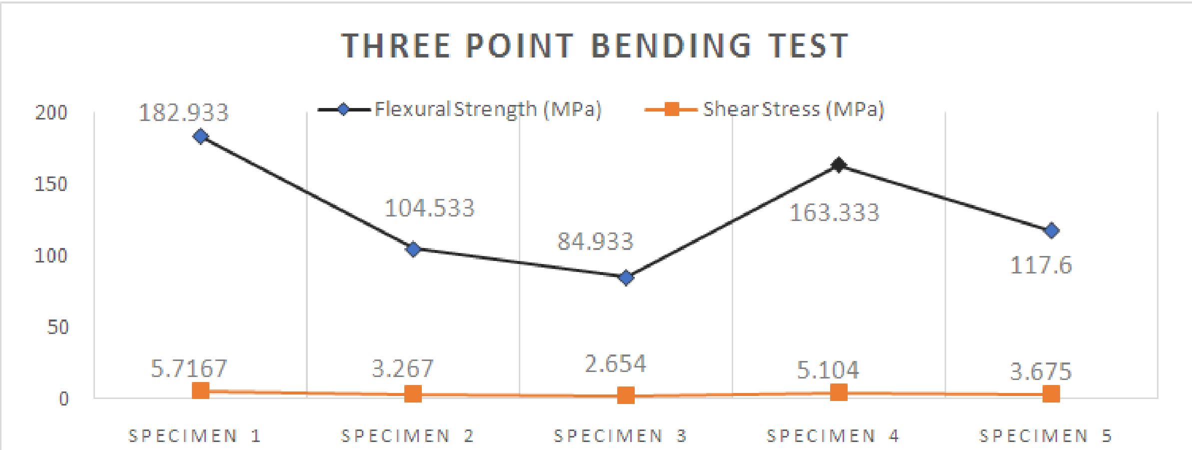

Fig. 6 Three-point Bend test results depicting flexural strength and shear stress

IV. Conclusion

The present investigation involved the fabrication of samples of the S glass fiber reinforced epoxy composite for carrying out all the tests to determine its mechanical properties. The result from the impact test indicate that the average energy absorbed by the test specimens was 2.72J. Howeverfew samples did not undergo catastrophic failure indicating that it possessed toughness and could withstand more impact energy. The values obtained from tensile tests have less variation indicating the average strength obtained is 162 MPa which is twice that obtained from ordinary glass fiberreinforcement.The possible reason in variation of the flexural test result might be due to uneven distribution of the resin between the outer surface of the composite material and in between layers of the fiber mat. Also complete removal of air bubbles while fabricating the composite with hand layup technique is inevitable and therefore might be the possible reason for non-homogeneity which led to variation in strength as can be seen from the fig 6. Nevertheless the overall result indicate good strength of the composite taking into account 20% of fiber volume fraction. The strength can further be increased by incorporating more S glass fiber mat layers.

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