MECHANICAL TESTING OF E-GLASS FIBER WITH EPOXY RESIN REINFORCED MATRIX

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***ABSTRACT**: Present research work is dedicated about the mechanical behavior of E-glass and crystal clear epoxy resin reinforced matrix. The E-glass fiber and crystal clear epoxy resin (LY556) materials with fiber orientation (0° and 30°) were fabricated by using hand layup method. The volume fraction of the E-glass fiber and crystal clear epoxy resin is 50%.The laminated composite material consists of 6 lamina. The fabricated laminate specimens were cut according to the ASTM standards for different tests. After testing the results of Tensile, Flexural, Compressive and impact were observed and compared each other with (0° and 30°) an orientation of fiber .This study is to be concluded with the best orientations of fiber-crystal clear epoxy resin reinforced matrix.*

Keywords: **E-glass Fiber, crystal clear epoxy resin, orientations (0° and 30°), Testing, lamina**.

1. INTRODUCTION

The term composite can be defined as a material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual materials being superior to the properties of individual material that make up the composite. Different materials can be combined on a microscopic scale, such as in alloying of metals, but the resulting material is, for all practical purposes, macroscopically homogeneous, i.e., the components cannot be distinguished by the naked eye and essentially act together. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are strength, fatigue life, stiffness, temperature-dependent behavior, corrosion resistance, thermal insulation, wear resistance and weight.

Composite materials are nowadays employed in many engineering structures such as helicopter and wind turbine rotor blades, boat hulls, and buildings, implying the application of variable loadings for long time spans. In this project the glass fiber is randomly arranged, flattened into a sheet (called a chopped strand mat), or woven into a fabric. Random fiber composites have dimensions that are approximately equal in all directions. A fiber has a length that is much greater than its diameter the length-to-diameter (l/d) ratio is known as the aspect ratio and can vary greatly Chopped strand mat glass fiber-reinforced polyester is widely used in chemical industry. Durability based design criteria for a chopped glass fiber automotive structural composite has been studied. Monotonic and tension-tension fatigue tests were carried out on E-GLASS chopped- strand mat/polyester composites, varying, the flexibility content by weight in the matrix in the range (0-50%). In this work, e-glass fiber and crystal clear epoxy resin is randomly arranged by hand layup procedure.

2. GLASS FIBER

Glass fibers are among the most versatile industrial materials known today. They are readily produced from raw materials, which are available in virtually unlimited supply. All glass fibers described in this article are derived from compositions containing silica. They exhibit useful bulk properties such as hardness, transparency, resistance to chemical attack, stability, and inertness, as well as desirable fiber properties such as strength, flexibility, and stiffness. Glass fibers are used in the manufacture of structural composites, printed circuit boards and a wide range of special-purpose products. Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time, all glass fiber had been manufactured as staple (that is, clusters of short lengths of fiber).

The basis of textile-grade glass fibers is silica, SiO_2. In its pure form it exists as a polymer, $(SiO_2)_n$. It has no true melting point but softens up to 1200 °C, where it starts to degrade. At 1713 °C, most of the molecules can move about freely. If the glass is extruded and cooled quickly at this temperature, it will be unable to form an ordered structure. In the polymer it forms SiO_4 groups which are configured as a tetrahedron with the silicon atom at the center, and four oxygen atoms at the corners. These atoms then form a network bonded at the corners by sharing the oxygen atoms.

2.1 General-purpose glass fibers: (E-glass variants) , which provides an in-depth discussion of compositions, melt properties, fiber properties, methods of manufacture, and significant product Glass fibers and fabrics are used in ever increasing varieties for a wide range of applications that covers all commercially available E-glass fibers, whether employed for reinforcement, filtration, insulation, or other applications. It lists all manufacturers, their sales offices, agents, subsidiaries, and affiliates, complete with addresses, and telephone and fax numbers. And it tabulates key properties and relevant supply details of all E-glass fiber grades that are available in the market today.

2.2 Special-Purpose Glass Fibers: S-Glass, D-Glass, A-Glass, ECR-Glass, ultrapure silica fibers, hollow fibers, and trilobal fibers are special-purpose glass fibers. Selected special-purpose glass fibers are discussed in the subsequent section of this article. That section reviews compositions, manufacture, properties, and applications to an extent commensurate with their commercial use A companion data book is available that covers all commercially available high strength glass fibers including S-glass and, all silica or quartz glass fibers, including astro-quartz and Quartzel. It also lists a wide range of woven fabrics that are commercially available in the market of today, ranging from S-glass/aramid, S-glass/carbon, silica/aramid, and silica/carbon yarns to silica/boron yarns. In addition, it covers all commercially available carbon, ceramic, boron, and high-temperature polymer fibers and yarns. This data book also lists all yarn counts, fabric constructions, fabric weights, and commercial sources.

Glass fibers are the most common fiber of all reinforcing fiber for polymeric matrix composites (PMC).The fig 1 shows different forms of glass fibers. The glass fiber forms

- Roving
- Chopped stands
- Yorns
- Mats

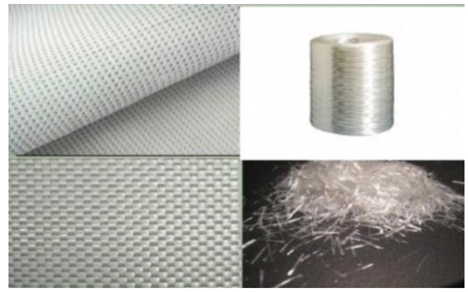


Fig 1: Different forms of glass fiber

2.3 E-GLASS FIBER

E-Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass. Fiberglass is a lightweight, extremely strong, and strong material. E-CR-glass Electrical/chemical Resistance; alumino-lime silicate with less than 1% alkali oxides, with high acid resistance E-Glass is a low alkali glass with a typical nominal composition of SiO_2 54wt%, $Al_2O_3$14wt%, CaO+MgO 22wt%, B_2O_3 10wt% and Na_2O+K_2O less than 2wt%. Some other materials may also be present at impurity levels.

FIBERS	**Tensile Strength (MPa)**	**Young's modulus(GPa)**	**Density (g/cm^3)**
E-Glass	2000	80	2.55
S-Glass	4750	89	2.49
Kevlar 29	2750	64	1.44
Kevlar 49	3700	136	1.44
Alumina	1950	297	3.28
Carbon	2900	525	2.00

Table2: The glass fiber properties

3. EPOXY RESIN

Epoxy Resins (monomers or oligomers) can be powders, or they can be thick, clear or yellow liquids. Some common epoxy resins are: the diglycidyl ether of bisphenol A (DGEBA), novolac resins, cycloaliphatic epoxy resins, brominated resins, epoxidized olefins, Epon^{R}and Epikote Epoxy resins are available in liquid and solid forms and are cured into the finished plastics by a catalyst. They are cured at room temperature as well as elevated temperatures of about 275°. The resin grade LY-556 was used of density 1.1-1.2gm/cc at 298k has been used as the matrix material.

Epoxies tend to be stronger than other resins, certainly much less brittle on their own than polyester in other words, they have very good flexural strength! They come as two parts which are commonly mixed in ratios ranging 2:1-4:1 resin to hardener by weight. Also compared to others, epoxy resin generally has a very long pot-life (working time) i.e. even a 'fast' epoxy resin will still give c.15mins working time before it starts gelling whereas a regular/slow can take 100mins or more (the average would seem to be 40mins). A 'fast' epoxy may be demouldable in 8hrs and sandable after 12-18 hrs whereas a 'slow' may need 30hrs before it can be removed from the mould. Full cure generally takes 5-7 days.

4. METHODOLOGY

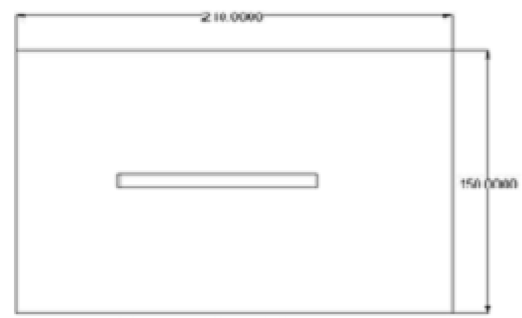
4.4 MATERIAL PREPARATION

4.1.1 Die preparation

The mold box was made with the dimension of 210 mm (L) ×150 mm (W) ×3.0mm (T) mm, the matrix was prepared by mixing the hardener to epoxy resin. The epoxy and hardener ratio was maintained at 1:0.5. To get the well-cured and a standard-quality specimen, the epoxy and hardener must be mixed smoothly and slowly. Initial layer of the mold was filled with epoxy resin mixture and then the appropriate quantity of fibers was placed such that epoxy mixture completely spread over the fibers. Before applying compression, efforts were made to remove all bubbles with roller. Finally, the compression pressure was applied evenly to achieve the uniform thickness of 3 mm and cured for 24 h at room temperature. The obtained composite plates are of the size (210 ×150×3) mm^3.

Die Size 210x150x5

Fig 3: Die without cover



cover plate dimension 210x150x5

Fig 4: Moulds for making composite plates

Fig 5 .Die cover covering plate

4.1.2. PREPARATION OF RESIN AND HARDENER

For the making of good composite the measurement of the samples should be accurate and the mixture should be very uniform. We take accurate amount of polymer which we have calculated earlier and 10% of its hardener. Then this mixture is stirred thoroughly till it becomes a bit deep. Bit extra amount of hardener is taken for the wastage in the process. Hardener should take very closely because little extra amount of hardener can spoil the composite.

(a)

(b)

Fig 6 :(a) HARDNER (HY 951) AND EPOXY RESIN (b) Both hander and epoxy are mixed a bowl

4.1.3. Manufacturing of composite by HAND LAY-UP METHOD

Hand lamination process is considered as one of the easiest method of fabricating any composites. Here the base plate is fixed inside the frame. For fabricating the glass fiber composites 60% of resin hardener mixture is used and the remaining is of glass fiber sheets. At first, the mixed epoxy is been applied as a base layer and on top of that the glass fibers were kept. The epoxy is kept as a base because it will prevent from any air gap that may affect the entire fabrication process. The roller is used to roll the mold and for making the layer even throughout the mold. Then the process is continued for multiple layers of fiber sheet and epoxy. The final layer of epoxy is been covered with the laminated sheet and has been kept in the dry place for 24 hours for the drying purpose. The simplest of the fabrication process is used in low volume products of large products.

Fig7: (a) Initial setup of mould frame

(b)During curing of the fiber plate

(c) Machined fiber plate

(d) Final limnate

5. TESTING PROCESS

The fabricated specimen has to be tested according to the ASTM (American Standard for Testing Materials) standards.

5.1 Tests to Be Carried Out

The tests that are to be carried out on the fabricated plate are:

- Tensile test.
- Water absorption
- Bending test.
- Impact test.

5.2 Tensile Test

The Tensile specimens were prepared as per the ASTM (D638) standard. Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined Young's modulus, passion's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. For anisotropic material, such as composite materials and textiles, biaxial tensile testing is required. This test method covers the determination of the tensile properties of unreinforced and reinforced plastics in the form of standard dumbbell-shaped test specimens when tested under defined conditions of pretreatment, temperature, humidity and testing machine speed.

5.3; Compression Test:

The compression specimen is prepared as per the ASTM D638 standard. A compression test involves mounting the specimen in a machine and subjecting it to the compression. The compression process involves placing the test specimen in the testing machine and applying compress to it until it fractures. The compressed force is recorded as a function of displacement. During the application of compression, the elongation of the gauge section is recorded against the applied force

0°

30°

Fig 9: Fabrication of Compressive Specimen

5.4 Flexural Test:

The Flexural specimen is prepared as per the ASTM (D7264) standard. Bending test provides values for the modulus of elasticity in bending, flexural stress, flexural strain and the flexural stress-strain response of the material. The main advantage of a bending flexural test is the ease of the specimen preparation and testing. However, this method has also some disadvantages the results of the testing method are sensitive to specimen and loading geometry and strain rate.

ASTM D7264 outlines testing of flexural properties of polymer matrix composites using a bar of rectangular cross section supported on a beam and deflected at a constant rate. The specimen is clamped into the pendulum impact test fixture with the notched side facing the striking edge of the pendulum. The pendulum is released and allowed to strike through the specimen. If breakage does not occur, a heavier hammer is used until failure occurs. Since many materials (especially thermoplastics) exhibit lower impact strength at reduced temperatures, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment.

5.5 IMPACT TEST:

The Impact test specimen is prepared as per the ASTM (D256) standard. Notched Izod Impact is a single point test that measures a materials resistance to impact from a swinging pendulum. Izod impact is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. Izod specimens are notched to prevent deformation of the specimen upon impact. The standard specimen for ASTM is 64 x 12.7 x 3.2 mm (2½ x ½ x 1/8 inch). The most common specimen thickness is 3.2 mm (0.125 inch), but the preferred thickness is 6.4 mm (0.25 inch) because it is not as likely to bend or crush. The depth under the notch of the specimen is 10.2 mm (0.4 inches).

0°

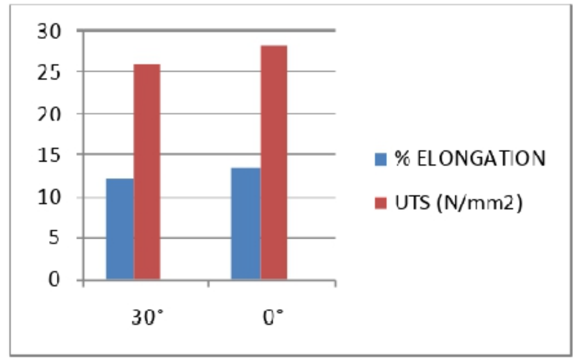
30°

Fig 11: Fabrication of impact Specimen

6. RESULTS AND DISCUSSION

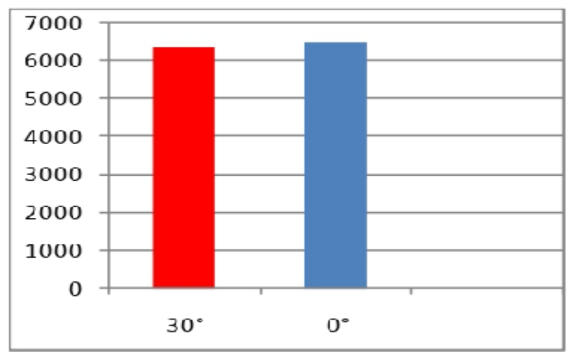
The Specimens are prepared and tested in the laboratory. The results all are show the performance of composite in different orientation in the comparison of (0°, 30°). the following tables all are shown the value after conducting the different kind of in test using universal testing machine and water absorption test .The graph show the different forms in the performance it will make help to understand the reality what happened in the part of the work There are the Tensile test, Compression test, Flexural test and Impact Izod test are listed below.

6.1 TENSILETEST



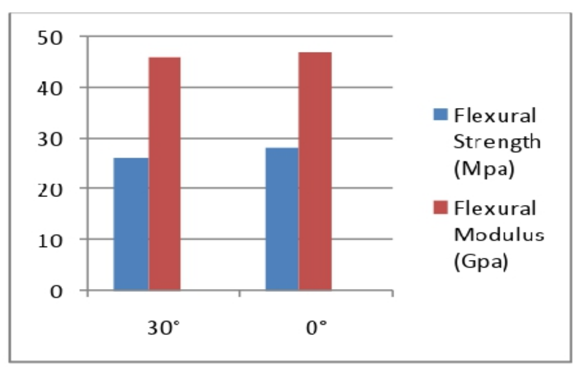
Grap 1: Peak load vs %Elongation and UTS

6.2: Compression Test



Graph 2: Peak load vs% Elongation and UTS

6.3: Flexural test



Graph3: Peak load vs Flexural strength and flexural modulus

Table 3: Tensile test

SAMPLE NO	CS AREA [MM^2]	ORIENTATION	PEAK LOAD [N]	% ELONGATION	UTS [N/MM^2]
1	85	30	6312.112	12.08	26.013
2	85	0	6412.002	13.523	28.223

Table 4: Compression test

SAMPLE NO.	CS AREA [MM 2]	ORIENTATION	PEAK LOAD [N]	FLEXURAL STRENGTH (MPA)	FLEXURAL MODULUS(GPA)
1	85	30°	258.125	26.32	46.001
2	85	0°	268.002	28.12	47.012

Table 5: Flexural test

SAMPLE NO	ORIENTATIO N	CS AREA [mm^2]	PEAK LOAD [N]	COMPRESSIVE STRENGTH [N/mm^2]
1	30^o	120	6342.235	44.253
2	0o	120	6452.223	46.221

7. CONCLUSIONS

Based on the above observation (E glass and Jute fiber) of the composite material were compared with each other. From the graph tensile (61 N/mm^2 for sample 1 E glass), flexural strength (129 N/mm^2 for sample 3 of jute fiber), water absorption (0.38 gm. for jute fiber) anodized

Impact value I (0.232j/mm^2) is higher. So we can use theses fibers for day today applications. From this we conclude that the usage of glass fiber composite will reduce the weight of the structure and it gives high strength. By the results obtained from the test carried out on the specimen it is clear that glass fiber composite material possesses greater strength to weight ratio that is why it mainly used in structural chambers in the helicopters, automobiles, aircrafts and other civil infrastructures.

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