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Experimental Analysis of Fiberglass Reinforced Epoxy Matrix Composites with Increasing Fiber Content

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ABSTRACT

In the field of composites, composites having polymeric matrix are used in nearly nineteen cases out of twenty. Neat polymers are reinforced to get improved mechanical properties. Application specific polymers composites can be produced by using different material combinations of reinforcement and matrix materials. Glass fibers and epoxy are used as reinforcement and matrix material in polymer composites in majority of cases. Polymer composites thus produced are light in weight, have more strength and stiffness, easy to fabricate, economical and have better corrosion resistant than bare polymers. Amount of fiber is also affects the flexural strength and other mechanical properties of different polymer composites. In the present paper, fiberglass reinforced epoxy based composites are prepared and effects of variation in the content of fiberglass on the mechanical properties of the epoxy based polymeric composites has been studied. Results show that flexural strength of fiberglass reinforced epoxy based composites increases with increase in fiber content.

Keywords: Fiberglass, epoxy, flexural strength, hand lay-up method, fiber content

1 INTRODUCTION

Polymer matrix composites have been grown nicely in the past few decades. Polymer composites have almost became the synonym of composites as these make more than 90% applications of composites. Polymer composites have their applications in aircrafts, sports equipment, space, medical devices, marine and other commercial applications. Polymer composites are lighter in weight, have more stiffness and strength, easy to fabricate, economical and have better corrosion resistant than bare polymers, metallic or ceramic composites. Strength-weight ratio of polymers is more than metals and ceramics. These characteristics lead to wide use of polymers as matrix materials. Improvements in the properties can be achieved by reinforcing the polymers. Further, application specific polymer composites can be produced. Glass fibers are one of the best options for reinforcement of polymer composites because of their high strength and stiffness than plastics. Also, these are economical and easy to fabricate. Fiberglass or ‘E’ glass, ‘S’ glass, ‘C’ glass, ‘E-CR’ glass, ‘A-R’ glass etc. are commonly used types of glass fibers. Due to high mechanical strength and good adherence to glasses and metals, epoxy resins are most commonly used matrix material. Epoxy has a low molecular weight. Most epoxies are formed due to reaction of epichlorohydrin with phenols or aromatic amines. In epoxies, range of properties can be increased by addition of hardeners, fillers or plasticizers. In the present research work, fiberglass reinforced epoxy based composites are prepared and mechanical properties (flexural strengths) are evaluated by varying the content of fiberglass in epoxy resin. Specimens are prepared with 0%, 5% and 10% fiber content and their flexural strengths are compared.

A lot of research work has been done on polymer composites and effects of different parameters and properties of reinforcement and matrix on composites have been studied.

T. Hojo, Y. Yang, Zhilan XU&H. HAMADA have studied the tensile properties of composites reinforced with bamboo, kenaf and jutemat and compared the fatiquebehavior of the three with glass. Results show that tensile modulus of jute and bamboo is similar but lower than kenaf. Also, ultimate strength of kenaf is found to be higher than the two. The modulus of three composites does not vary much during low cycle fatique test. A. Gopinath, S. Kumar M & Elayaperumal A have studied the mechanical properties of polyester and epoxy resin composites reinforced with jute fiber. It is concluded that the jute-epoxy composites shows better tensile and flexural strength than jute-polyester composites. Hardness and impact strength are also better. Hakim S., Sultan Aljibori & W.P. Chong studied the Load-displacement behavior of glass fiber epoxy composites under compressive loading. Results show that ultimate load is highest for cross ply laminated plates than plates with other angular orientations. In this paper, efforts are made to study the effects of increase in fiber content on flexural strength of the composite specimens.

2. EXPERIMENTATION

Experimental work performed can be described simply by the diagram given in fig. 2.

Materials

The different materials used to prepare specimens in the present study are:
Reinforcement: glass fiber (fiberglass or 'E' glass fiber)
Matrix: epoxy resin
Hardener: Perkadox
Catalyst: Styrene
Perkadox and styrene, content of each is 1%.

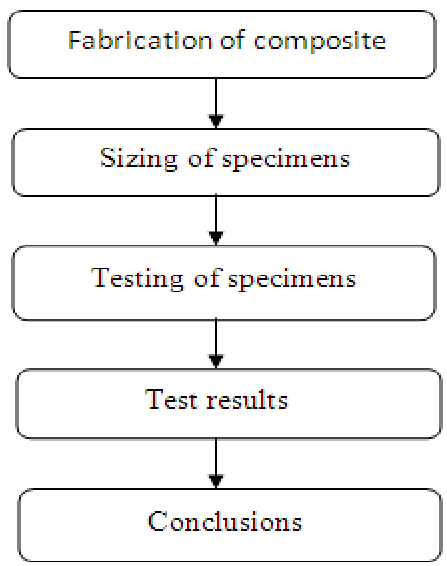

Fig 1: Experimental method

Fabrication of specimens

Composite specimens are prepared by a very simple method, Hand Lay-up Method. A mould is prepared first, whose size corresponds tosheets of 300mm*300mm and specimens of size 125mm*12.7mm*3.2mm are cut from these sheets.

Fig 2: Test specimen

Hand Lay-up Method: It is a very simple method of production of polymer composites. A mould or die is prepared for hand lay-up method. Dimensions of mould correspond to polymeric sheets of 300mm*300mm and specimens of size 125mm*12.7mm*3.2mm are cut from these sheets. Gel coating is given to mould which serves as decorative and protective surface. Coating of plastic films (release agent) is given to reduce sticking. Premeasured glass fibers are taken and placed inside the mould manually. Epoxy resin mixed with hardener, is applied using brush such at it fills the gaps of reinforcement. Epoxy resin is taken in liquid form and is mixed with curing agent before applied against the fiberglass. Fiberglass are placed over a layer of epoxy resin followed by layers of epoxy applied with brush up to required thickness of composites.

Dimensions of specimens:

Length of specimens- 125 mm
Width of specimens- 12.7 mm
Thickness of specimens- 3.2 mm

For each type of composites, five specimens are tested.

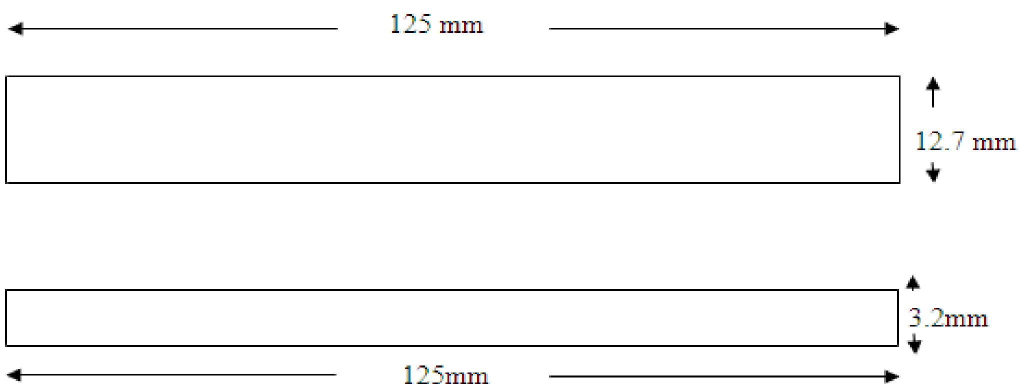

Fig 3: Dimensions of specimens

Experiment and conditions

Experiments are performed on 0%, 5% and 10% specimens on Universal Testing Machine (U.T.M.) for checking the flexural strengths. Flexural strength of specimens is analyzed by three points bending method using ASTM D790. In this method, test specimens are properly placed on two supports. Then load is applied at midway on the specimen or we can say, supports, by loading nose. A ratio of 16:1 is used for support span and depth. Due to application of load, the test specimens undergo deflection. This deflection continues until, either the value of maximum strain reaches 5.0 % or break occurs in specimen. Test is stopped when either of two conditions occurs. Specimen thickness, temperature and atmospheric conditions affect the flexural properties. Test specimens are conditioned at 23°C with a tolerance of 2°C and relative humidity is 50 with tolerance of 5% and tests are performed at the same conditions.

Each measurement is taken using untested specimens. Dimensions of the specimen are measured carefully and correctly providing suitable tolerances (0.03 mm). The measurements remade in accordance with Test Methods ASTMD 790.Support span is determined and is set within 1 % of the determined value. The two supports and the loading nose are aligned in such a manner that their cylindrical surfaces have their axes parallel to each other. Loading nose is adjusted such that it is equidistant from the supports. Place the test specimen such that its longitudinal axis is at right angle to the supports and loading nose. Calculations are made for crosshead rate and load is applied gradually recording the load-deflection data at the same time. Deflection can be measured using a gage. Flexural strength can be determined by plotting Load-deflection curves. Seating and indentation of the test specimens and machine deflections are corrected by performing toe compensation. When either of condition of the maximum strain (5% or 5mm/mm) occurrence of break, is achieved, stop testing procedures.

3. RESULTS AND DISCUSSION

Specimens are tested on Universal Testing Machine (U.T.M.) for checking the flexural strengths.
Results are shown in three parts:

1) For specimens with 0% fiber content or neat polymer.
2) For specimens with 5% fiber content.
3) For specimens with 10% fiber content.

1) Specimen with 0% fiber content

Test

Name	Maximum force	Maximum stress	Maximum strain
Units	N	MPa	%
1-1	27.6875	42.4212	4.38883
1-2	24.4375	38.6726	7.12218
1-3	28.7813	43.9387	3.41712
1-4	29.1250	42.8938	5.91975
1-5	29.9688	41.2652	4.09750
mean	27.6000	41.4383	4.98908

Specimen no. 1:

Maximum value of force=27.6875N, Maximum value of stress=42.4212MPa
Maximum value of strain (%) =4.38883

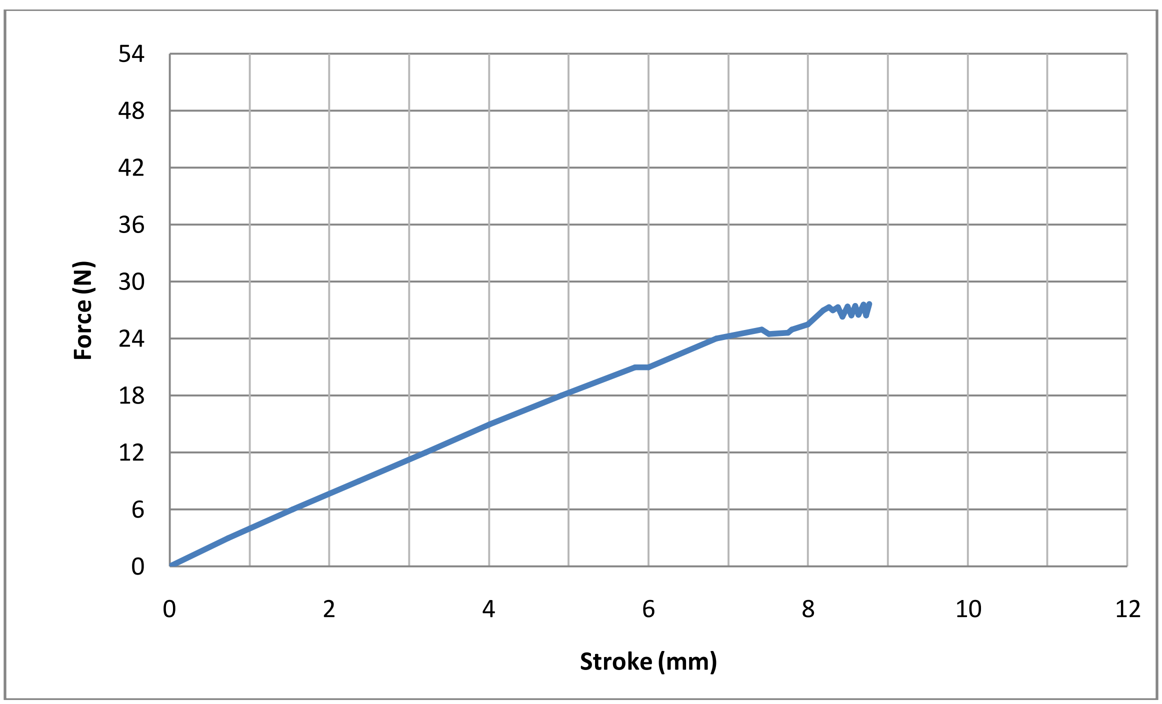

Figure 4: Force vs Stroke graph for specimen no. 1 (0% composition)

Test Specimen no. 2:

Maximum value of force=24.4375 N, Maximum value of stress=38.6726 MPa
Maximum value of strain (%) =7.12218

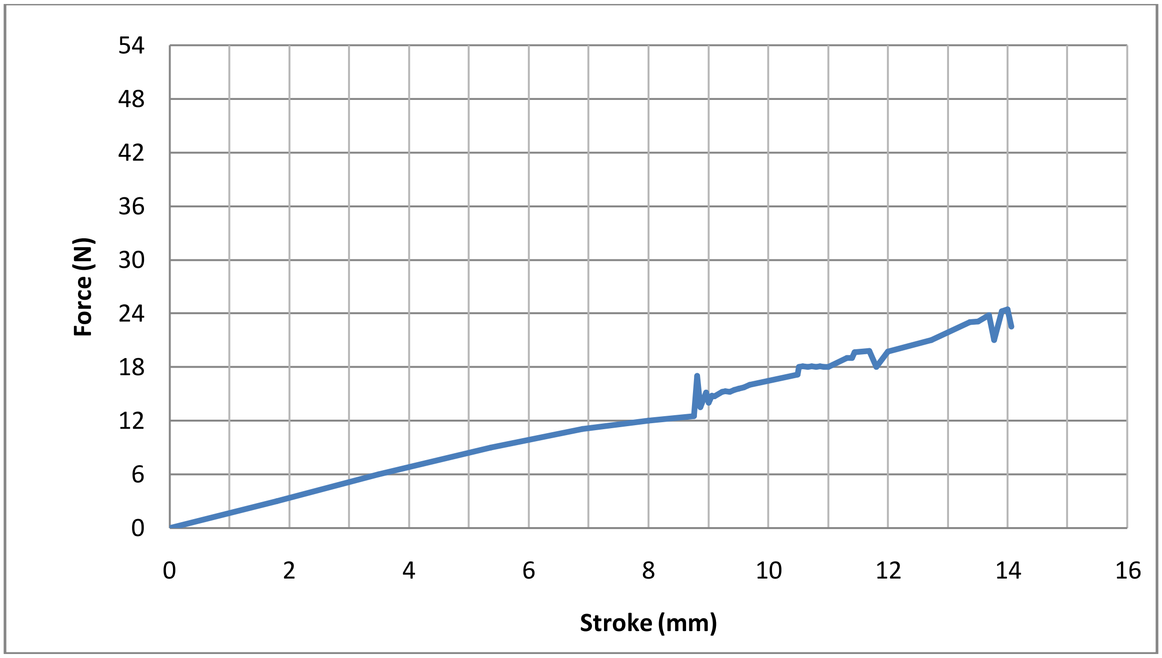

Figure 5: Force vs Stroke graph for specimen no. 2 (0% composition)

Test Specimen no. 3:

Maximum value of force=28.7813 N, Maximum value of stress=43.9387 MPa
Maximum value of strain (%) =3.41712

Figure 6: Force vs Stroke graph for specimen no. 3 (0% composition)

Test Specimen no. 4:

Maximum value of force=29.1250 N, Maximum value of stress=42.8938 MPa
Maximum value of strain (%) =5.91975

Figure 7: Force vs Stroke graph for specimen no. 4 (0% composition)

Test Specimen no. 5:

Maximum value of force=27.9688 N, Maximum value of stress=41.2652 MPa
Maximum value of strain (%) =4.09750

Figure 8: Force vs Stroke graph for specimen no. 5 (0% composition)

2) Specimens with 5% fiber content

Name	Maximum force	Maximum stress	Maximum strain
Units	N	MPa	%
1-1	38.1250	58.4130	2.94700
1-2	38.0938	57.1661	3.22681
1-3	34.1563	52.1444	3.72557
1-4	38.6875	56.9770	3.67019
1-5	38.7188	57.1258	3.08930
mean	37.5563	56.3653	3.33195

Test Specimen no. 1:

Maximum value of force=38.1250 N, Maximum value of stress=58.4130 MPa
Maximum value of strain (%)=2.94790

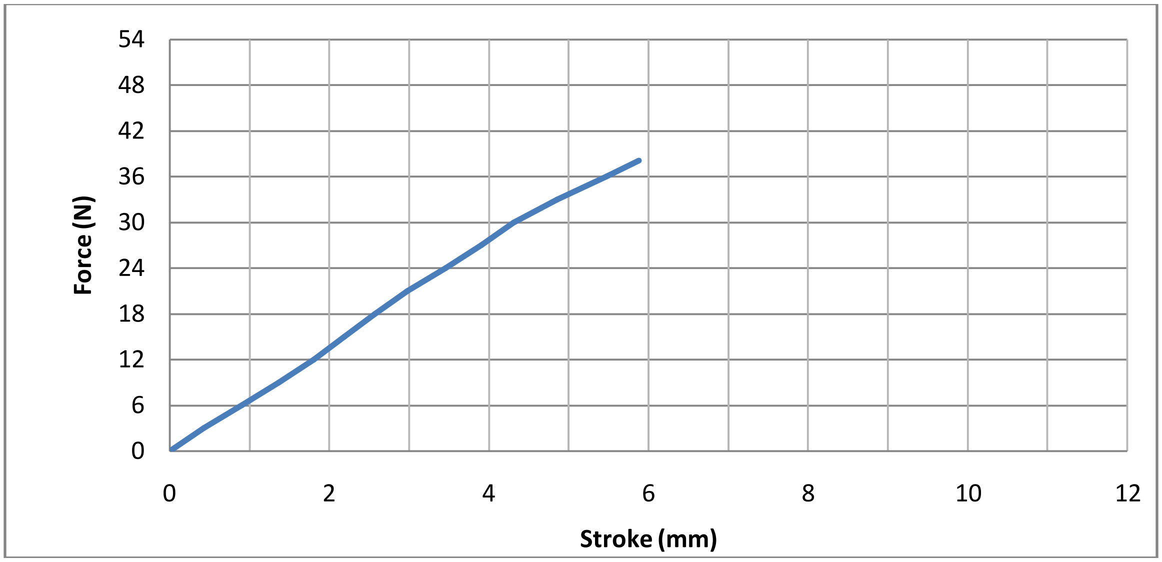

Figure 9: Force vs Stroke graph for specimen no. 1 (5% composition)

Test Specimen no. 2:

Maximum value of force=38.0938 N, Maximum value of stress=57.1661 MPa
Maximum value of strain (%) =3.22681

Figure 10: Force vs Stroke graph for specimen no. 2 (5% composition)

Test Specimen no. 3:

Maximum value of force=34.1563 N, Maximum value of stress=52.1444 MPa
Maximum value of strain (%) =3.72557

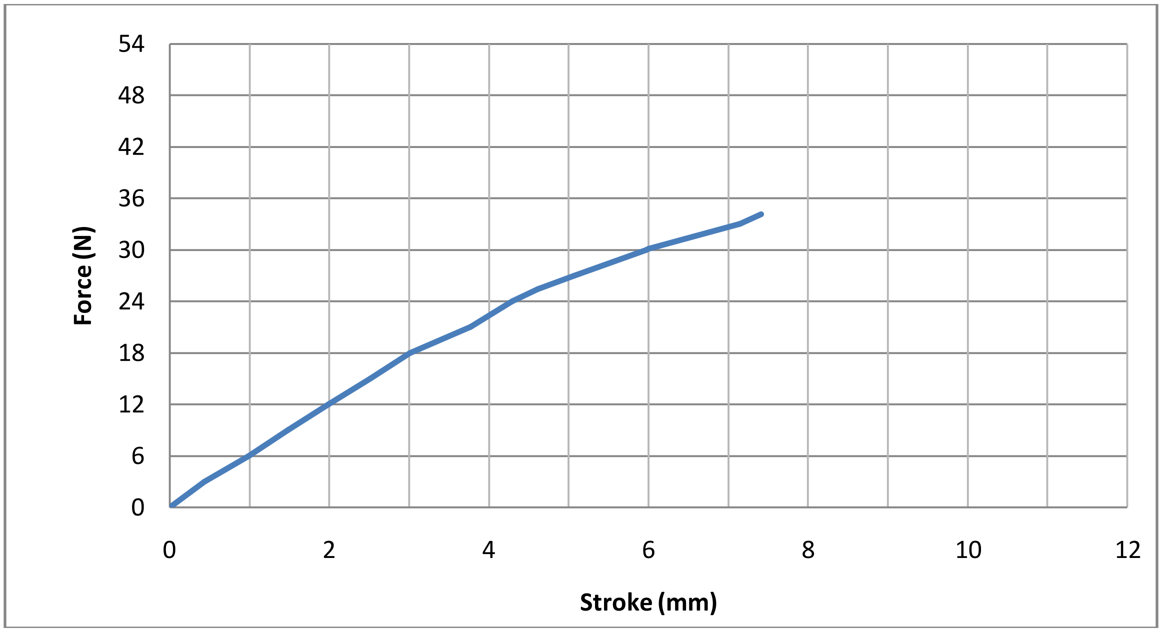

Figure 11: Force vs Stroke graph for specimen no. 3 (5% composition)

Test Specimen no. 4:

Maximum value of force=38.6875 N,   Maximum value of stress=56.9770 MPa
Maximum value of strain (%) =3.67019

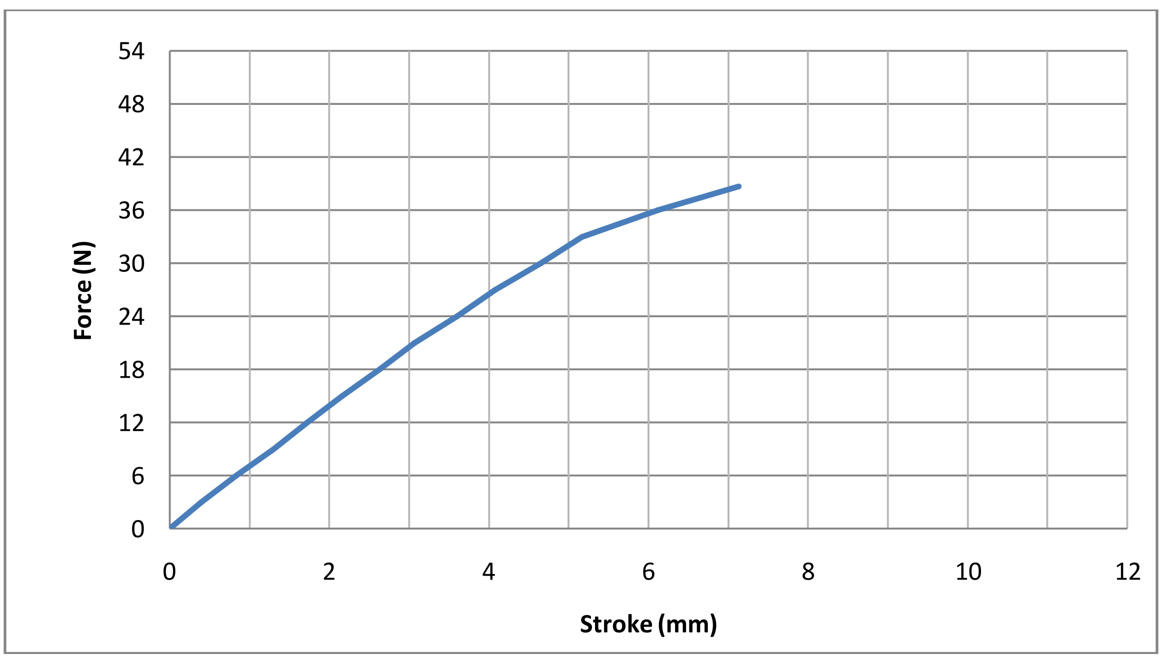

Figure 12: Force vs Stroke graph for specimen no. 4 (5% composition)

Test Specimen no. 5:

Maximum value of force=38.7188 N, Maximum value of stress=57.1258 MPa
Maximum value of strain (%) =3.08930

Figure 13: Force vs Stroke graph for specimen no. 5 (5% composition)

3) Specimens with 10% fiber content

Name	Maximum force	Maximum stress	Maximum strain
Units	N	MPa	%
1-1	43.4668	66.6004	3.82234
1-2	43.9375	65.9356	4.16147
1-3	41.8438	63.8805	4.42310
1-4	42.1875	62.1316	4.00043
1-5	44.4083	65.5171	3.95908
mean	43.1688	64.9130	4.07329

Test Specimen no. 1:

Maximum value of force=43.4668 N, Maximum value of stress=66.6004 MPa
Maximum value of strain (%) =3.82234

Figure 14: Force vs Stroke graph for specimen no. 1 (10% composition)

Test Specimen no. 2:

Maximum value of force=43.9356 N, Maximum value of stress=65.9356 MPa
Maximum value of strain (%) =4.16147

Figure 15: Force vs Stroke graph for specimen no. 2 (10% composition)

Test Specimen no. 3:

Maximum value of force=41.8438 N, Maximum value of stress=63.8805 MPa
Maximum value of strain (%) =4.42310

Figure 16: Force vs Stroke graph for specimen no. 3 (10% composition)

Test Specimen no. 4:

Maximum value of force=42.1875 N, Maximum value of stress=62.1316 MPa
Maximum value of strain (%) =4.00043

Figure 17: Force vs Stroke graph for specimen no. 4 (10% composition)

Test Specimen no. 5:

Maximum value of force=44.4083 N, Maximum value of stress=65.5171 MPa
Maximum value of strain (%) =3.95908

Figure 18: Force vs Stroke graph for specimen no. 5 (10% composition)

CONCLUSIONS

The work presented in this thesis deals with the preparation and testing of polymer composite materials. E-Glass fiber reinforced polymer composite having different fiber compositions with matrix of epoxy resin are prepared using hand lay-up method and mechanical behaviour is tested under flexural testing, with varying concentration of fiber content. Results lead to following conclusions:

1) E-Glass fiber reinforced polymer composite having different fiber compositions with matrix of epoxy resin are prepared successfully using hand lay-up technique.

2) Testing results show that flexural strength of 10% E-Glass fiber specimen is more than 5% E-Glass fiber specimen and neat epoxy specimen. Also, strength of 5% E-Glass fiber specimen is more than neat epoxy specimen.
3) Increasing the composition of E-Glass fiber in epoxy polymer composite results in increase in its flexural strength.

FUTURE SCOPES

Scholars have a wide future scope in the area of research on reinforced polymer composites. The work on E-Glass epoxy composites can be extended for evaluation of other mechanical properties like tensile strength, compression strength, shear strength, creep testing, fatique testing, etc. Other parameters like abrasion, wear, hardness behaviour, adherence, etc can be evaluated. Further, above work can be done for wider range of fiber compositions. Different fiber materials for different matrix materials can be used to prepare the composites and the results can be compared with each other on the basis of mechanical and other aspects. Comparison can be made between mechanical behaviour of specimen prepared by different production techniques. Also, researches can be made about the optimum values of fiber content in matrix up to which there is an increment in the mechanical properties of composite materials. Other potential materials for fabrication of composites can be tested and the results can be compared. Comparison in mechanical properties of different composites with same weight of specimen can be done and optimum combinations with lower weight and higher strength or other application specific composites can be selected. There is a wide area open to research scholars in the field of hybrid composites.

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