PROCESSING AND CHARACTERIZATION OF GLASS FIBER AND CARBON FIBER REINFORCED VINYL ESTER BASED COMPOSITES

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Abstract

Composites materials are used in almost all aspects of the industrial and commercial fields in aircraft, ships, common vehicles, etc. Their most attractive properties are the high strength-to-weight ratio.Polymer composites are used because overall properties of the composites are superior to those of the individual polymers. The aim of this experimental study has targeted to investigate the mechanical strength of glass fiber & carbon fiber reinforced vinyl ester resin composites. The laminated specimens were fabricate using Hand lay-up technique. and the specimens are subjected to the investigated as per the ASTM standards. The tensile tests, compression tests, flexural tests were carried out on the laminated specimen for the determination of its mechanical properties.

Keywords: *commercial, attractive, polymers, reinforced, vinyl ester, specimens,*

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1. INTRODUCTION

Polymeric based composites materials are being used in many application such as automotive, sporting goods, marine, electrical, industrial, construction, household appliances, etc . Polymeric composites have high strength and stiffness, light weight, and high corrosion resistance. This kind of composite is used in the greatest diversity of composite applications due to its advantages such as low density, good thermal and electrical insulator, ease of fabrication, and low cost. The properties of polymer matrix composites are mainly determined by three constitutive elements such as the types of reinforcements (particles and fibres), the type of polymer, and the interface between them. Polymers are divided into two categories such as thermoplastics and thermosets. Thermoplastic are in general, ductile and tougher than thermoset materials. They are reversible and can be reshaped by application of heat and pressure. Thermoplastic molecules do not cross-link and therefore they are flexible and reformable. Thermoset materials are brittle in nature and offer greater dimensional stability, better rigidity, and higher chemical, electrical, and solvent resistance. The most common resin materials used in thermoset composites are epoxy, polyester, phenolics, vinyl ester, and polyimides

In recent times, E-glass fiber and vinyl ester resin based composites have foundextensive use in naval structures.Composites results in the potential for a limitless number of new material systems Having unique properties that cannot be obtained with any single monolithic material.[1] Compared to non-reinforced polymers most fiber-reinforced polymers are stiffer and less susceptible to fatigue failure and have lower hysteretic heating effects [2]. Fatigue properties of a short fiber reinforced polymers depend on fiber volume fraction, fiber orientation, matrix properties, fiber-matrix interfacial strength bonding, and fiber aspect ratio (*lf /df*).

The work reported in this paper was a part of an overall project with the goal of determining the mechanical behavior of the vinyl ester polymer and its carbon nanofiber reinforced composite. Extensive experimental work other than fatigue tests consisted of tensile, flexure, and creep tests, while analytical efforts included modeling deformation, creep, and stress-strain behavior of these materials. Experimental data considering strain rate and temperature effects as well as stress-strain and creep models are reported elsewhere
[3-6].

In the present work investigate the mechanical behavior of the vinyl ester based laminated specimens of glass fibre and carbon fibre reinforced polymer composites.

2. MATERIALS AND METHODS

Fig-1: Glass fiber Carbon fiber

Fig-2: Vinyl ester resin Promoter, Accelerator & Catalyst

2.1. Fiber Material

Fiber is the reinforcing phase of a composite material. The present research work, glass fiber and carbon fiber is taken as the reinforcement in the vinyl ester matrix to fabricate composites. Fiberglass is often used for secondary structure on aircraft, such as fairings, radomes, and wing tips. There are several types of fiberglass used in the many industry. Electrical glass, or E-glass, is identified as such for electrical & marine applications. It has high resistance to current flow. E-glass is made from borosilicate glass. S-glass and S2-glass identify structural fiberglass that have a higher strength. Advantages of fiberglass are lower cost than other composite materials, chemical or galvanic corrosion resistance and electrical properties (fiberglass does not conduct electricity).

Carbon fibers are very stiff and strong, these are used for structural aircraft applications, such as floor beams, stabilizers, flight controls,and primary fuselage and wing structure. Advantages include its high strength and corrosion resistance. Carbon fiber is gray or black in color and is available as dry fabric and prepreg material. Carbon fibers have a high potential for causing galvanic corrosion when used with metallic fasteners and structures.

2.2 Matrix Material

Among different types of matrix materials, polymer matrices are the most commonly used because of cost efficiency, ease of fabricating complex parts with less tooling cost and they also have excellent room temperature properties when compared. Polymer matrices can be either thermoplastic or thermo set. The most commonly used thermoset resins are epoxy, vinyl ester, polyester and phenolics. vinyl ester resins are being widely used for many advanced composites due to their many advantages such as excellent adhesion to wide Variety of fibers, corrosion resistance, good performance at elevated temperatures and superior mechanical and Electrical properties.

2.3 Hand Lay-Up Method

In the present study the composite laminate specimen's are prepared using the hand layup technique and the specimen are subjected to the investigation is carried out as per the ASTM standards. The simplest manufacturing technique adopted involved laying down bidirectional type fibers over a polished mould surface previously treated with a releasing agent: after this, a liquid thermosetting resin is worked into the reinforcement by hand with a brush or roller. The process is repeated a number of times equal to the number of layers required for the final composite. Resin and curing agents are pre-mixed and normally designed to cross-link and harden at room temperature. The major advantage of this manufacturing process is its great flexibility, meaning that it suits most common mould sizes and complex shapes. it can be re-used for several runs and the actual cost of the raw materials make this process economically feasible.

Fig- 3: Preparation of Laminated Specimens

3. RESULTS AND DISCUSSION

3.1 Tensile Test

The Tensile test generally performed on flat specimen.Tensile test of composite sample is carried out in ASTM D3039 test standard. In tensile test, a uniaxial load was applied through both the end. The tensile test specimen of bidirectional glass fibre reinforced vinyl ester composites is shown in Figure, In each case 3 samples were tested and their mean values were reported. Figure: 4 shows the experimental setup and loading arrangement of specimen for tensile test.

Fig- 4: Experimental Set Up

Fig-5: Before Tensile Test

Fig-6: After Tensile Test

Table-1: Tensile properties on Glass & Carbon reinforced vinyl ester composites

Fiber	Glass	Carbon
Sample Thickness	3	3
Force, N	6025.5	12375
Tensile Strength, N/mm2	321.4	660.1
Ext @ Max Load, mm	8.427	7.094
Young's Modulus, N/mm2	8303	21060

In the above tensile test the following observations are made

1) As compare to glass fibre reinforcement carbon fibre shows better Tensile strength with more force sustained

2) Extension is minimum in case of carbon fibre and maximum in case glass fibre.

3) With the same thickness of specimen Young's modulus is increases in carbon fibre and decrease in glass fibre

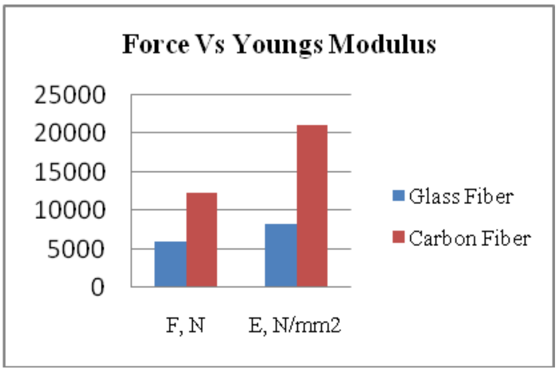

Chart -1: Bar chart for tensile properties of Glass & Carbon reinforced vinyl ester composites for Force and Young's modulus

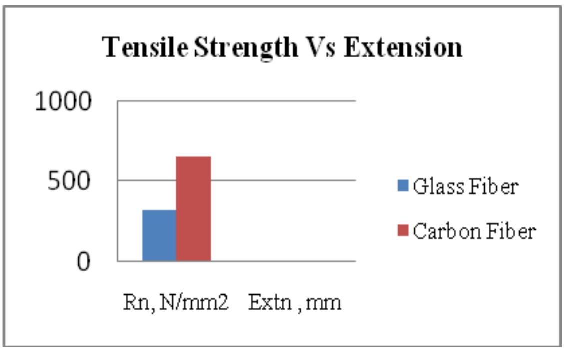

Chart-2: Bar chart for tensile properties of Glass & Carbon reinforced vinyl ester composites for Tensile strength and Extension at max. load

3.2 Flexural Test

Flexural test is to determine the capability of a material to withstand the bending before reaching the breaking point. Flexural test of composite sample is carried out in ASTM D7264 test standard. In each case 3 samples were tested and their mean values were reported. Figure:7 shows the experimental set up and loading arrangement of the specimens for flexural test respectively.

Fig-7: Experimental Set Up

Fig-8: Before Flexural Test

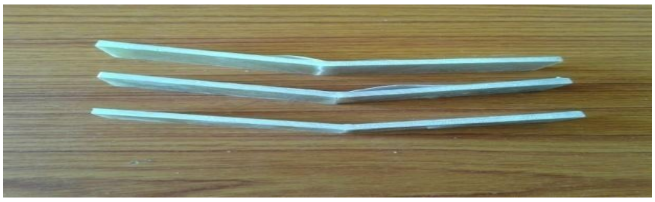

Fig-9: After Flexural Test

Table-2: Flexural properties on Glass & Carbon reinforced vinyl ester composites

Fiber	Glass	Carbon
Sample Thickness	3	3
Force, N	921.8	794.2
Flexural Strength, N/mm2	15.36	13.23
Def @ Max Load, mm	8.225	4.846
Young's Modulus, N/mm2	2967.3	3636.6
3 Point bending	384.06	330.93

In the above flexural test the following observations are made

1) As compare to glass fibre reinforcement carbon fibre shows better flexural strength with more force sustained
2) Deformation is minimum in case of carbon fibre and maximum in case glass fibre.
3) With the same thickness of specimen Young's modulus is decrease in glass fibre and increases in carbon fibre

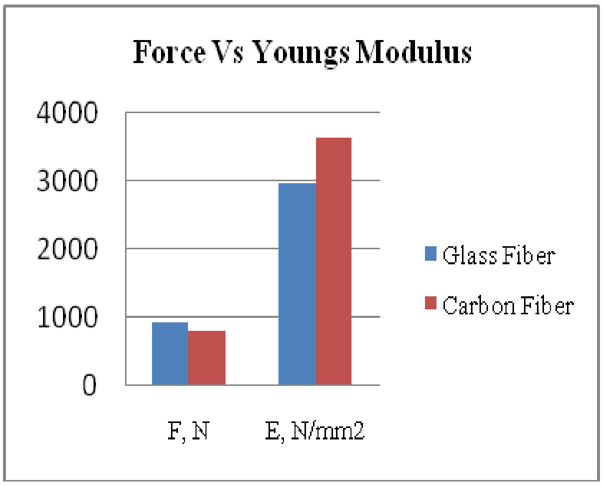

Chart-3: Bar chart for flexural properties of Glass & Carbon reinforced vinyl ester composites for Force and Young's Modulus

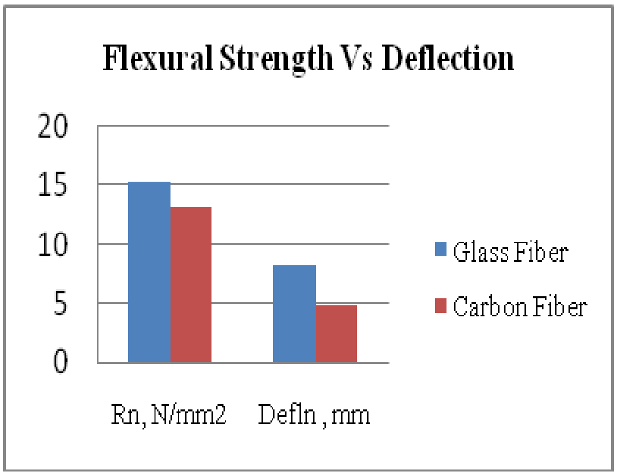

Chart-4: Bar chart for flexural properties of Glass & Carbon reinforced vinyl ester composites for Flexural Strength and Deflection at Max. Load

3.3 Compression Test

A compression test determines behavior of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. Flexural test of composite sample is carried out in ASTM D 3410 test standard. In each case 3 samples were tested and their mean values were reported. Figure: 10 shows the experimental set up and loading arrangement of the specimens for compression test respectively.

Fig-10: Experimental set up

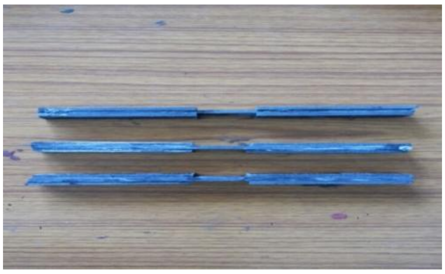

Fig-11: Compressive Test Specimens

Table-3: compression properties on Glass & Carbon reinforced vinyl ester composites

Fiber	Glass	Carbon
Sample Thickness	3	3
Force, N	4251.5	5700.5
Compression Strength, N/mm2	94.47	126.7
Def @ Max Load, mm	5.826	3.4075
Load @ high yield, N	339.2	1293.6
Young's Modulus, N/mm2	2688.5	4343.5

In the above compression test the following observations are made

1) As compare to glass fibre reinforcement carbon fibre shows better compression strength with more force sustained
2) Deformation is maximum in case glass fibre and minimum in case of carbon fibre
3) With the same thickness of specimen Young's modulus is decrease in glass fibre and increases in carbon fibre
4) Carbon fibre shows more load at high yield point and less in glass fibre

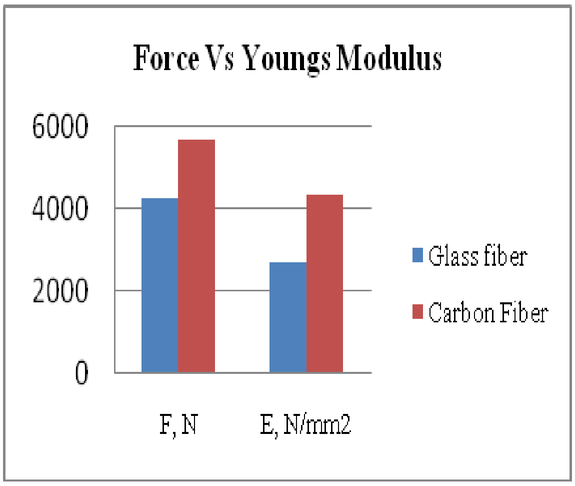

Chart-5: Bar chart for Compressive properties of Glass & Carbon reinforced vinyl ester composites for Force and Young's Modulus

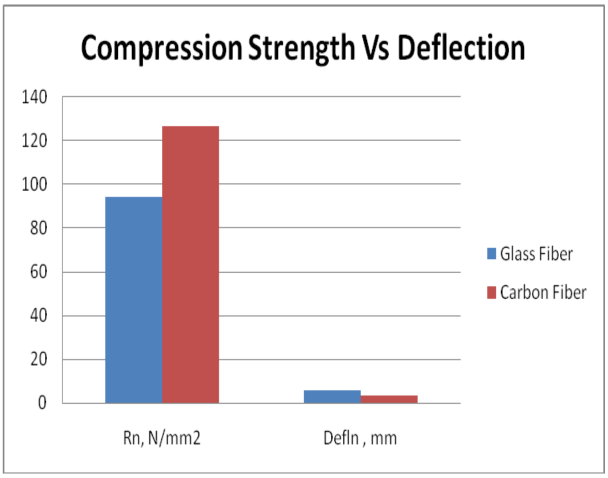

Chart-6: Bar chart for Compressive properties of Glass & Carbon reinforced vinyl ester composites for Compression Strength and Deflection at Max.Load

4. CONCLUSION

The mechanical behaviour of glass fibre and carbon fibre reinforced vinyl ester composites was studied. From the results it is observed that the carbon fibre & resin of vinyl ester with mixture of Promoter, accelerator, catalyst showed better Mechanical properties. It is concluded that shortest fibers have good adhesion with the vinyl ester resin for tensile properties.

The conclusions are made from the experimental investigation of tensile test; flexural test & compression test on laminated polymer composite materials are as follows:

- Tensile strength & compression strength is more in carbon fibre and less in glass fibre
- Flexural strength is more in glass fibre and less in carbon fibre
- Extension is minimum in case of carbon fibre compared to glass fibre
- Deformation is maximum in glass fibre and minimum in carbon fibre
- Carbon fibre shows more in young's modulus and less in glass fibre
- Maximum load at high yield point shows in carbon fibre and minimum in glass fibre

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