Characterization of Viscose Staple and E-Glass Fiber Hybrid Composites

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Abstract

The study of light weight with high strength application of the composites in automobile industry has been popular. The present work is synthesizing four different compositions of hybrid composites made of viscose staple fibre and E-Glass fibre reinforced with epoxy resin. The specimens were fabricated by hand layup technique investigated the best hybridization effect of viscose staple fibre on the mechanical properties. Mechanical tests were carried out, 15% of viscose staple fibre hybridization shows the optimum results than the other three composites.

Key Words: Viscose Staple fiber, E-glass fiber, Epoxy resin, Hybridization, Mechanical Properties.

1. Introduction

The automobile industry has shown increased interest in the replacement of steel components parts with composite components due to high strength to weight ratio. Composites are combination of two or more materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets or particles and are embedded in the other materials called matrix phase. The reinforcing and the matrix materials can be metal, ceramic, or polymer. Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. Fiber matrix interactions play a crucial role in determining the properties of their relative composites [1]. To meet the needs of natural resource conservation and energy economy, the automobile manufacturers have been attempting to reduce the weight of vehicles in recent years [2]. Fiber reinforced polymers are making in many on road applications, principally because of the potential for weight saving. Other advantages of using fiber reinforced polymers instead of steel are the possibility of reducing noise, vibrations and ride harshness (NVH) due to their high damping factors the absence of corrosion problems, which means lower maintenance cost, and lower tooling cost, which has favorable impact on the part of manufacturing cost [3].

1.1 Hybrid Composites

Hybrid composites, the plies can include fibers of two, or may be more types, e.g., carbon and glass, glass and aramid and so on. Hybrid composites provide wider possibilities to control material stiffness, strength and cost. A promising application of these materials is associated with the so-called thermostable structures that do not change their dimensions on heating or cooling. Designers prefer the usage of hybrid composites that combines different types of matrix/reinforcement forms to achieve greater efficiency and reduce cost [4]. The foregoing sections of this work concern the properties of unidirectional plies reinforced with fibers of a certain type - glass, carbon, aramid, viscose staple fibre (VSF) etc.

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2. Materials and Method

The material selection criteria are so much important in fabrication of hybrid composite specimens. It is depends on the parameters such as high strength, cost, versatility and flexibility, corrosion resistance, weight advantages of material.

Proposed material for hybrid composite specimens:

- Epoxy resin with hardener.
- Bi-directional (BD) E-Glass fiber (woven fabric)
- Viscose Staple Fibre (VSF).
- Polyvinyl Alcohol (PVA) mold releasing agent.

Properties of composite material:

2.1 Properties of E-Glass

E-glass thread is the most used, whether in the textile industry or for composites, its share reaching 90% of reinforcements. A high-end fibre, it is characterised by its resistance to continuous high temperatures of up to 550°C and its excellent electrical insulation properties, can withstand the main chemical agents and remains dimensionally stable, even under intense variations of humidity and temperature. The properties of E-Glass fibre shown in table 1.

Table.1 : Properties of E-Glass fibre

Shear modulus	15 GPa
Fiber strength	3.45 GPa
Elongation	4.88%
Tensile modulus	81.4 GPa
Density	2.6 g/cc

2.2 Properties of Viscose Staple Fibre

Grasim is India's pioneer in Viscose Staple Fibre (VSF), a man- made, biodegradable fibre with characteristics akin to cotton. Extremely versatile and easily blended with other fibres, VSF is widely used to manufacture fabrics for both woven and knitted garments. Aditya Birla Group is today the world's largest producer of VSF, commanding a 24% global market share and meeting over 98% of India's VSF requirements.

Table.2 : Properties of Viscose Staple Fibre

Tenacity	2.4 – 3.2 gm/den.
Density	1.64 – 1.54 gm/c.c.
Elongation at break	13%
Elasticity	Good.
Moisture Regain (MR%)	11 – 13%
Melting point	This fiber becomes weak when it heated above 150^{o}c.
Ability to protest friction	Less.

2.3 Types of specimens used in the precede prepared

The present work is synthesizing four different compositions of hybrid composites made of viscose vtaple fibre and E-Glass fibre reinforced with epoxy resin. The specimens were fabricated by hand layup technique. The different compositions of hybrid composites shown in table 3.

Table.3 : Different compositions of specimens

Specimen →	40:45:15 E:GF:VSF	40:30:30 E:GF:VSF	40:15:45 E:GF:VSF	50:50 E:VSF

Reinforcement Material	Glass fiber and Viscose staple fibre
Matrix material	Epoxy resin with its hardener (L12/K6)

2.4 Fabrication

The constant cross section (250 x 250 x 6 mm) is selected. In the present work, the hand lay-up process was employed. The templates (mould die) were made from wood shown in figure 1 according to the desired profile. The glass fibers and VSF were cut to the desired size, so that they can be deposited on the template layer by layer during fabrication. In the conventional hand lay-up technique, a releasing agent (PVA) was applied uniformly to the mould which had good surface finish. This is followed by the uniform application of epoxy resin over glass fiber. Another layer is layered and epoxy resin is applied and a roller is using for removing all the trapped air. Specimens are prepared with variation of constituent layers according to the calculated volume fraction. After the layers are laid up a teflon layer to which PVA is applied and kept on a steel plate. Further compaction pressure is applied and allowed for curing at atmospheric temperature for 18 hours then it is taken out as shown in figure 2.

(a) (b) (c)

Fig. 1: (a) Bottom die used for square specimen (b) Upper die used for square specimen (c) fabricated hybrid composite specimen

Fig. 2: Fabricated specimen of varying composition

3. Mechanical Characterization

Mechanical tests have been done on the fabricated composite laminate specimens of different compositions for its characterization by the universal testing machine (UTM).

3.1 Tensile Property

According to ASTM D638, tensile test have been carried out. The test method covers the determination of the tensile behavior of reinforced polymers in the form of dog bone shaped test specimens. The dimension for the tensile specimen is 165 x 20 x 6 mm and the gauge length of specimen is 57mm are shown in figure 3.

Fig. 3: Tensile Test Specimens

A tensile testing machine is used to conduct the tension test under different loading conditions. The machine is fitted with 10kN load cell for detecting the load applied on the fabricated specimen. The uniform load was applied. The load and corresponding deflections during the test were noted.

3.2 Flexural Property (3-Point Bending)

This test is used to determines the flexural properties of fiber reinforced thermo set composites under defined condition. According to ASTM D790, flexural test have been carried out. Three point bending arrangement have been employed to carryout the flexural test. In this system, a centre loading is utilized on a simply supported beam. Each test specimen of 15mm width, length 80mm and thickness 6mm was used for the present investigation. The span (centre to centre distance between roller supports) for each specimen is 50mm. The flexural test specimen is shown in figure 4.

Fig. 4: Flexural Test Specimens

3.3 Inter Laminar Shear Strength

The inter-laminar shear strength (ILSS) is one of the most important parameters in determining the ability of a composite to resist delamination damage. An accurate prediction of its value, therefore, is important and a number of tests have been developed for evaluation. Standardized test methods are the threepoint-bending tests according to ASTM D2344 for Apparent Inter-laminar Shear Strength of Parallel Fiber Composites by Short-Beam-Shear (SBS). The main advantage of the SBS is its simplicity. The specimens are relatively easy to prepare and the test itself is simple to conduct and requires little fixturing. However, the SBS gives an accurate measure of ILSS value only if pure interlaminar shear failure takes place [5].

4. Moisture Absorption Property

Glass fiber reinforced unsaturated epoxy composites, which are commonly used in several applications, exhibited a very interesting relationship of their mechanical properties and their cost [6]. In automotive, aeronautical, and aerospace industries, the long term stability measured by their mechanical properties is of great interest. In these applications, they are in contact with liquids or vapors that affect the long-term properties of the material. Hence, in the use of composite materials, the environmental aspects have to be taken in to account [7]. Moisture absorption studies were performed according to ASTM D 570-98 standard test method for moisture absorption of specimens. The weights of the samples were taken and then dipped them to normal water.Weight change (percent) during water absorption was determined by using the following equation 1.

$$W\% = \frac{Wt - Wo}{Wo} \times 100 \quad \text{-------------------} \quad (1)$$

Where, ***Wt*** is the mass at a time ***t*** and ***Wo*** is the weight of the dry sample.

Fig.5. Specimens in water

5. Results and Discussions

5.1 Tensile test

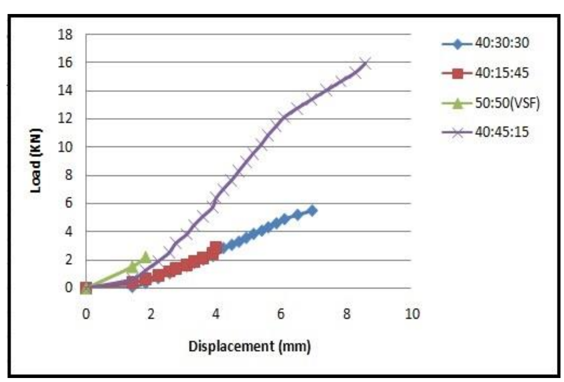

Fig. 6: Load vs Displacement

Figure 6 shows the Load vs Displacement values of the tensile tested specimens. Most of the specimens failed in the specified gauge length. The highest youngs modulus and Ultimate Tensile Strength (UTS) values are observed in 40E:45GF:15VSF specimen and the lowest youngs modulus and UTS is observed 50E:50VSF reinforced composites. In the present work, the hybridization effect over 15% volume fraction of VSF shows the optimum characteristic properties than other three specimens.

5.2 Flexural test

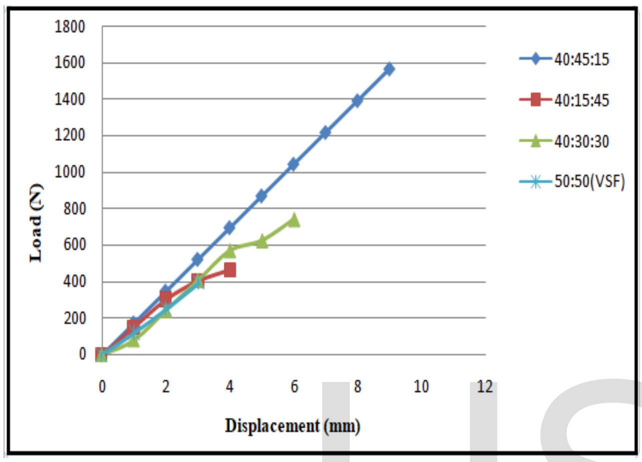

Fig. 7: Displacement vs Load

The flexural test (3-Point Bending) has been conducted by using bending test fixtures on computerized UTM. The Load v/s Displacement curves for the specimens 40E:45GF:15VSF, 40E:30GF:30VSF, 40E:15GF:45VSF, and 50E:50VSF has been plotted and shown in figure.8. The highest Maximum load and UFS values are observed in 40E:45GF:15VSF specimen and the lowest load and UFS is observed 50E:50VSF reinforced composites. In the present work, the hybridization effect over 15% volume fraction of VSF shows the optimum characteristic properties than other three specimens.

5.3 Interlaminar Shear Strength (ILSS) Test

The values of inter-laminar shear strength (ILSS) for the different composite laminate were obtained using the equation 2.

$$ILSS = \frac{0.75P}{bxt} \text{-----------------} \quad (eqn\ 2)$$

Where,
P = Maximum bending load,
b = Breadth,
t = Thickness.

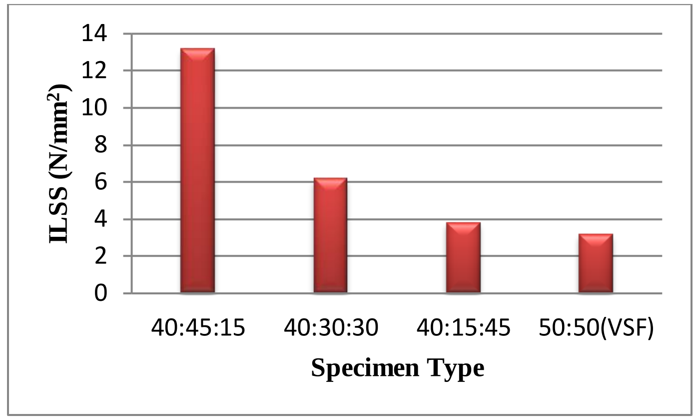

Fig. 8: Comparison of Interlaminar Shear Strength of different composition composite specimens

The composition 40E:45GF:15VSF has showed highest inter-laminar strength owing to 40E:30GF:30VSF, 40E:15GF:45VSF, and 50E:50VSF. The variation of the inter-laminar shear strength of the chosen specimens are shown in figure.8.

5.4 Water Absorption Test.

The effect of moisture absorption on the chosen composite materials can be best understood by considering the effect of water diffusion on the constituent specimens. The composition 40E:45GF:15VSF has showed lowest absorbed water owing to 40E:30GF:30VSF, 40E:15GF:45VSF, and 50E:50VSF. The variation of the water absorption chosen specimens are shown in figure. 9.

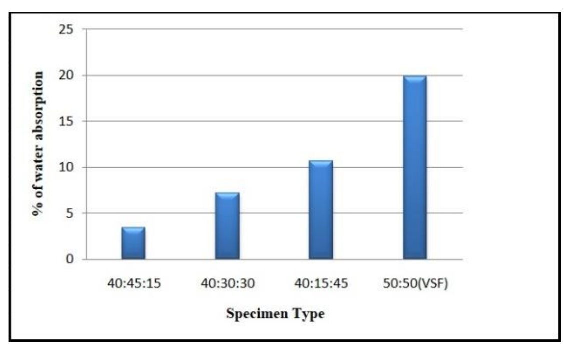

Fig. 9: Water absorption of different composition composite specimens

6. Conclusion

The experimental analysis of the four different variety of the hybrid composite specimens were synthesized and tested for mechanical characteristics; and the following conclusions are drawn from the work,

- Manual hand layup methodology is used to synthesize hybrid composite specimens effectively with minimum flaws.
- The present work infers that 40E:45GF:15VSF

yields best hybridization ratio.

- Flexural and tensile properties are better for 40E:45GF:15VSF composition.
- Investigation in to the water absorption properties of VSF/Glass fiber hybrid composites as a function of glass fiber content showed that resistance to moisture diffusion to the composites was increased with hybridization with glass fibers.

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