Fillers on Mechanical Properties and Fracture Toughness of Glass Fabric Reinforced Epoxy Composites

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***Abstract*- Glass fabric reinforced epoxy this composite were filled with two types of fillers namely graphite, silicon carbide (each 15 and 20 weight) this composite was fabricated by hand lay-up method and compressed using hot press process. These composites were checked for their mechanical properties such as tensile, compression testings and impact strength as well as fracture toughness as per ASTM standards. Experimental results on mechanical properties indicate that the strength and the modulus in tensile and flexural mode. Selected failed samples under tensile, bending and fracture were tested. This application can be used in landing gear.**

Index Terms- G-E Composite, Fillers, Mechanical Properties, Fracture Toughness

1. INTRODUCTION

Fiber and particulate filled polymer matrix composites (PMCs) are used in very large quantities in almost all engineering applications and despite the overwhelming interest in advanced PMCs, considerable research and development is done on hybrid PMCs. Fillers improve stiffness and heat deflection temperatures, decrease shrinkage, voids and good appearance of the composites. Polymer composites offer additional energy-absorbing damage modes, making them attractive for lightweight, impact resistant applications.

Indeed for use in conventional armor systems, composites have enabled a significant increase in toughness. Composites would offer engineers more flexibility in designing transparent laminates.

Based on the cited literature, it was found that combined constituents namely fiber and filler in thermoset polymer study showed improved mechanical properties and in some cases improved the fracture toughness. This study aims to investigate the role of hard filler and lubricating filler (SiC and graphite) in E-glass woven fabric reinforced epoxy (G-E) composite. The static mechanical properties and mode-I fracture toughness of these composites were studied. Furthermore, the main goal of this research work is to recommend the best hybrid reinforced G-E composite for structural applications.

2. EXPERIMENTAL AND METHODS MATERIAL

Plain weave woven glass fabrics made of 360 g/m2 containing E-glass fibers of diameter of about 12 μm have been employed. The epoxy resin (LAPOX L-12) was mixed with the hardener (K-6, supplied by ATUL India Ltd., Gujarat, India). Two different fillers namely SiC and graphite (each 15 and 20 wt%) were used in the present work. These fillers were silanated and have an average particle size of about 25 μm. Silicon carbide material was supplied by (Fibro Plasa, Coimbatore, India) and graphite powder was supplied by (Coimbatore metals, Coimbatore, India.)

2.1 Graphite

It is a crystalline form of the element carbon with its atoms arranged in a hexagonal structure. It occurs naturally in this form of carbon under standard conditions. Crystal class Dihexagonal dipyramidal Crystal habit- Tabular, six sided foliated masses, granular to compacted masses Tenacity – Flexible non – elastic, sessile .Other characteristics – Strongly anisotropic, conduct electricity, greasy feel, readily marks

Graphite

2.2 Silicon carbide

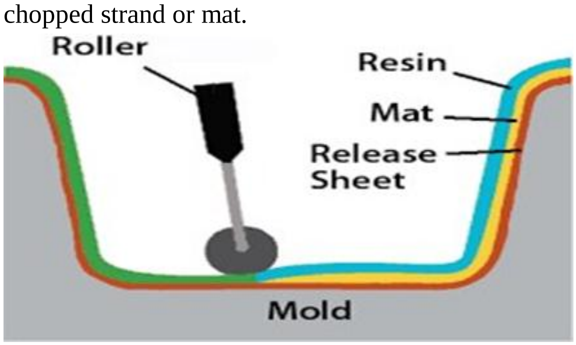
It is also known as carborundum is a semi conductor containing silicon and carbon.It occurs in nature as an extremely rare mineral moissanite.SIC powder use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests.

Silicon Carbide

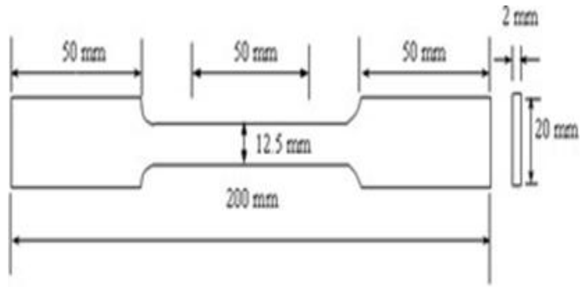
3. METHOD

3.1 Lay-up method

Hand lay-up is a molding process where fiber reinforcements are placed by hand then wet with resin. The manual nature of this process allows for almost any reinforcing material to be considered, chopped strand or mat.



4.SPECIMEN



5. Fabrication

E-glass plain weave woven roving fabric which is compatible to epoxy resin was used as the reinforcement. The epoxy resin was mixed with the hardener in the ratio 100:10 by weight ratio. A hand lay-up method was used to for lay-up of lamina consolidation. Later, the consolidation was compressed and cured using hot press under 0.5 MPa pressure and temperature of 70˚C. In all the composites the amount of glass fiber was 55 wt%. Eight and thirty three layers of fabrics were used to obtain laminate of thickness 2 mm respectively. Further, to prepare the particulate filled G-E hybrid composites, selected filler with a known quantity was mixed in the epoxy resin. The details of the G-E hybrid composites manufactured were listed

6. MECHANICAL CHARACTERIZATIONS

The tensile and bending tests were carried out on a fully automated machine connected to a computer, which was aided by Kalpak- software. A 100/10-kN load cell was used and load versus deformation/deflection curves were collected for all the measurements. The tensile tests were performed according to ASTM D638 standard. The tensile test was performed at crosshead speed of 5 mm/min (quasi-static). Tensile modulus was evaluated from the stress- strain diagram. Flexural testing under three- point bending mode was conducted. The span length was performed at crosshead speed of 5 mm/min .Tensile modulus was evaluated from the stress-strain diagram. Flexural testing under three-point bending mode was conducted. The span length was set at about 60 mm. Flexural modulus was evaluated from the load- deflection curves. Izod impact strength was performed according to impact testing machine at the striking rate of 3.46 m/s. At least five samples were tested for each composite type for all the studies and the average value was recorded and snapped.

TUE—CN—400

Model after Testing

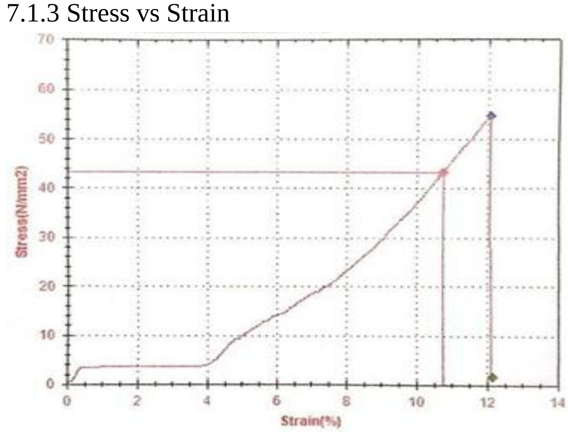
7. RESULTS AND DISCUSSION

Mechanical Properties The mechanical test data for unfilled G-E and particulate filled G-E hybrid composite are presented. From this it is clear that the introduction of SiC and graphite fillers in G-E composite system increased the strength as well as modulus under tensile and flexure mode.

7.1 Tensile testing 7.1.1Input Data
Specimen shape: Flat
Specimen type : FIBER
Specimen Description: Composite Material Specimen
Width: 13.53 mm
Specimen Thickness: 2.41 mm
Initial G.L. For % elong: 50 mm
Pre Load Value: 0 kN
Max. Load: 30 kN
Max. Elongation: 1000 mm

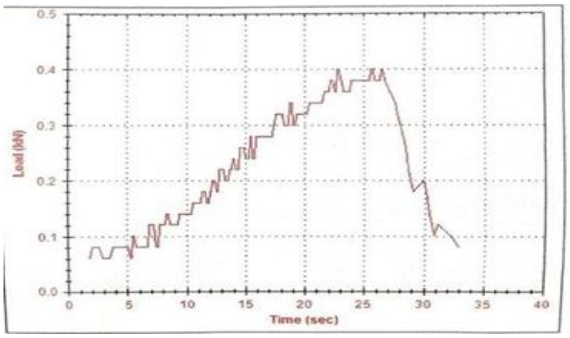
7.1.2Output Data
Load At Yield: 1.437 kN
Elongation At Yield: 6.857 mm
Yield Stress: 44.079 N/mm²
Load at Peak: 1.799 kN
Elongation at Peak: 7.421 mm
Tensile Strength: 55.184 N/mm²
Load At Break: 0.041 kN
Elongation At Break: 7.574 mm
% Elongation: 0.72 mm
Specimen Type: Fiber
Specimen Description: Composite Material
Specimen width: 3.01 mm
Specimen Thickness: 28.36 mm
Pre Load Value: 0 kN
Max. Load : 400 kN
Specimen C S Area: 85.36 mm²

7.1.3 Stress vs Strain



7.2 Compression Testing
7.2.1 Input Data
Specimen Shape :Flat
SpecimenCross
Section Area: 32.607 mm²
Final Gauge length: 50.36 mm

7.2.2 Output Data
Load at Peak : 0.400 kN
C.H. Travel at peak : 3.770 mm
Shear Strength : 4.686 N/mm²



8. CONCLUSION

In this work, an experimental investigation has been made to evaluate the mechanical properties and fracture toughness of unfilled and particulate filled G-E hybrid composites. The results show that it is possible to fabricate successfully, multi-component hybrid composites (three different constituents) for structural applications. The following conclusions can be drawn from this study. Hard and lubricating fillers viz. SiC and graphite particles modify the mechanical properties of G-E composite. Addition of filler loading (15 to 20 wt%) led to an increase in tensile and flexural properties. Particulate filled G-E hybrid composites show that the large difference between fiber-matrix interfacial bonding and the type of filler can influence the complex stress concentrations around the fibers. In this work, SiC filled G-E hybrid composites exhibit significant improvement in tensile and flexural properties. The impact resistance depends on the complex energy dissipation mechanisms, in which the interface properties and the complex stress concentration of the type and size of particles and geometry of the fibers play an important role on the control of the composite fracture. Both fillers did not show improvement in the impact strength of G-E composite. The fracture energy of the G-E composites has been improved by both SiC as well as with lubricating graphite particles. Rigid nature of SiC particles leading to effective relief of crack- tip triaxial stress, small scale yielding of epoxy matrix and stretching of SiC particles were facilitated in the crack tip region leading to improved fracture toughness of G-E hybrid composite. Furthermore, the hard SiC particles in G-E, the fracture toughness is marginal. On the contrary, the lubricating filler additions, graphite into G-E, show the maximum fracture energy. By considering the overall mechanical performance, G-E composite modified with lubricating graphite particles demonstrates the superior performance and the same composition may be utilized for fabrication of structural load bearing components. SEM micrographs reveal features like bending of transverse fibers, fiber pullout, fiber breakage, and fiber-matrix de-bonding.

9. FUTURE WORKS

This specimen with huge dimensions can be used in landing gear sectors. Which is have a great application which is based on flexibility, and strength.

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