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EFFECT OF CERIUM OXIDE AS FILLER MATERIAL ON E-GLASS FIBER/EPOXY REINFORCED POLYMER COMPOSITES

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ABSTRACT

The present work describes the development and mechanical characterization of new polymer composites consisting of glass fibre reinforcement, epoxy resin and filler materials as cerium oxide. The newly developed composites are characterized for their mechanical properties. Experiments like tensile test and three point bending were conducted to find the significant influence of filler material on mechanical characteristics of GFRP composites. Morphological analysis of the fractured surface of the composites indicated good adhesion between the matrix polymer and the glass fibers.The tests result have shown that the composite C3 with cerium oxide as a filler material exhibited better tensile strength when compared to the other composition and on further addition it decreases, Similarly the composite C3 exhibited better flexural strength on further addition of filler material it decreases.

INTRODUCTION

Composite materials generally defined as the combinations of two or more materials that result in the different properties than that of parent materials. Fiber reinforced plastics have been widely used for manufacturing aircraft and spacecraft structural parts because of their particular mechanical and physical properties such as high specific strength and high specific stiffness. Another relevant application for fiber reinforced polymeric composites (especially glass fiber reinforced plastics) is in the electronic industry, in which they are employed for producing printed wiring boards. The use of polymer composite materials is becoming increasingly important. Therefore, studies on the mechanical properties of these composites are very important. Many studies have been published concerning the mechanical properties of the polymer composites with a variety of fillers including organic and inorganic fillers. Addition of silicon carbide, alumina, and titanium carbide improves hardness, strength and wear resistance of the composites (Amar Patnaik and Mahapatra, 2009 and Chauhan *et al*., 2009).

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Vithal Rao Chauhan *et al*., worked on the mechanical properties of glass/orthophthalicpolyster resin with hematite ore filled composites and observed that the inclusion of hematite ore in composites with increased tensile strength and flexural strength. Increase filler percentage till 6% weight fraction in composites got beneficial mechanical properties, further increase of filler material with matrix material improper bonding, interface and embrittlement of the composites causes detrimental effect, (Vithal Rao Chauhan, 2014). The addition of fly ash as filler material in glass polyester composite increased its mechanical characteristics (Manjunath Shettar *et al*., 2015). The impact strength of the epoxy laminated bamboo composite increased with addition of cenospher as a filler material (Hemalata Jena, Mihir, 2012). The addition of coal ash to glass fiber polymer matrix composites improved their mechanical strength (Naresh Kumar, 2013). In the present work an attempt is made to study the effect of cerium oxide as a filler material in epoxy glass fiber reinforced composites.

MATERIALS AND METHODS

Materials

Raw materials used in this experimental work are as follows:

- E-glass fiber plain weave mat (200GSM)
- Lapox resin, L12
- Hardener, K6
- Cerium oxide as filler material

Specimen Preparation

The method that is used in the present work for manufacturing the laminated composite plates is hand layup as shown in Figure.1 which is the oldest method that was used to get the composite materials. The type of Glass Fiber mat selected to make specimens was, Mat–200GSM. The matrix material used was a medium viscosity epoxy resin (LAPOX L-12) and a room temperature curing polyamine hardener (K-6), both manufactured by ATUL India Ltd, Gujarat, India. This matrix was chosen since it provided good resistance to alkalis and has good adhesive properties. Based on volume fraction the calculations were made for 60-40 (60% Glass Fiber – 40% Epoxy Resin) combination showed a better result. Filler materials i,e cerium oxide were added to different combination by keeping Epoxy percentage constant (40%). Based on literature survey the amount of filler added was 1, 2, & 3 % , the details are as shown in Table 1. After preparation of the specimen, the specimens were cutted according to ASTM standards for different test to obtain the strength of materials.

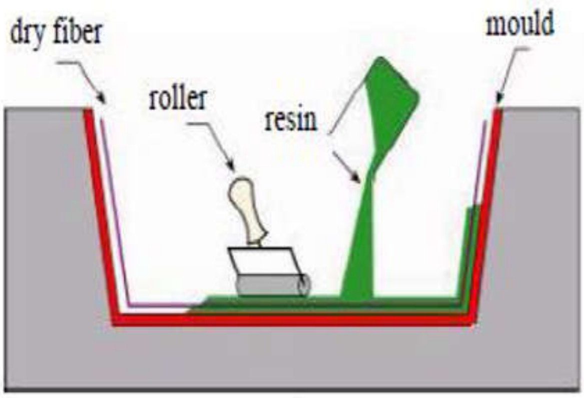

Fig. 1. Hand lay-up Technique

Table 1. Nomenclatures of composite material fabricated

Sl. No	Specimen code	Glass fiber content %	Epoxy	Filler content in %
1	C1	60	40	---
2	C2	59	40	1
3	C3	58	40	2
4	C4	57	40	3

Table 2. ASTM Standards

Test specimens	ASTM	Size
Tensile test specimens	D-3039	250x25x3 mm
Bending test specimens	D-790	127x12.7x3 mm

Experimental Setup

Following tests were conducted in the present work;

- Tensile test
- 3-point bending test
- SEM

Tensile strength

The specimen is prepared according to the ASTM D3039 standard. The testing is carried out in tensile testing machine with displacement velocity at 2 mm/min. Initially the breadth and width of specimen is observed and the area of cross section is calculated. The output result is a stress strain curve, from this the ultimate stress, elongation percentage, yield stress and break load is calculated. Three specimens are tested for each fiber resin composition ratio.

Fig. 2. Tensile testing

Flexural strength

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. The stresses induced by the flexural load are a combination of compressive and tensile stress.

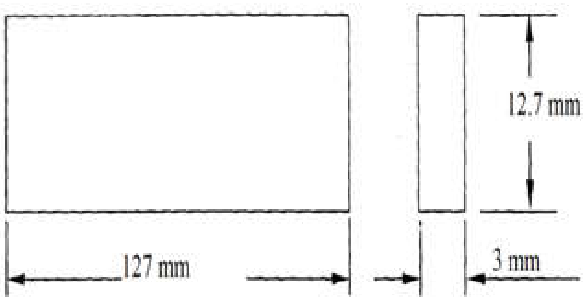

Fig. 3. Flexural Test Under ASTM Standard D790

Fig. 4. Flexural testing setup

The flexural properties were investigated using Universal testing machine (UTM, capacity 1–100 kN). Three-point bending test was performed at a crosshead speed of 2 mm/min considering a beam span of 50 mm. The output result is a load Vs displacement curve, from this result the ultimate stress and break load is calculated. Three specimens are tested for each fiber resin composition ratio.

Scanning Electron Microscopy

The morphology and fracture surface of the blends were studied using scanning electron microscope at an accelerating voltage of 5kV. The specimens were sputtered with gold before taking the micrographs.

RESULTS AND DISCUSSION

Mechanical Properties

Mechanical properties of these type of composites depend on matrix, dispersed powder and as well as on interface between fibre and matrix. The mechanical properties are also influenced by other factors like type of filler, amount of filler, distribution of filler in the matrix, processing parameters and kind of bonding between matrix and filler. From the fabricated composites, the test specimens are prepared as per ASTM standards and are tested to evaluate their tensile and flexural strength. The results obtained by conducting these tests are given below.

Tensile Strength

The effect of cerium oxide content on the tensile strength of the composite is shown in figure. It is observed that the tensile strength varies from 100.54MPa to 131.08MPa. The tensile strength increases for the composite C3 and thereafter it decreases. The increase in tensile strength with the increase in cerium oxide can be attributed to the good interfacial bonding between the cerium oxide and the matrix. As the filler content is further increased the composite transforms into brittle and hence the tensile strength decreases.

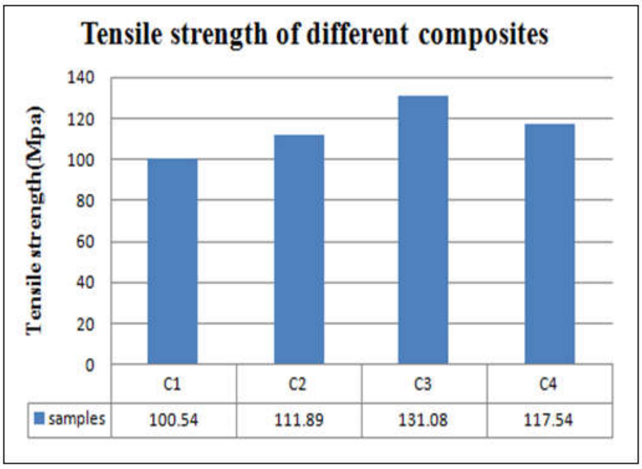

Chart 1. Comparison of Tensile strength for different composites

Flexural Strength

The flexural strength of the composite is determined from 3-point bend test. The flexural strength for various composites is shown in figure. The flexural strength of the composites varies from 271.795MPa to 360.09 MPa and the maximum value is obtained for composite C3 on further addition of cerium filler material in the epoxy matrix, the flexural strength decreases.

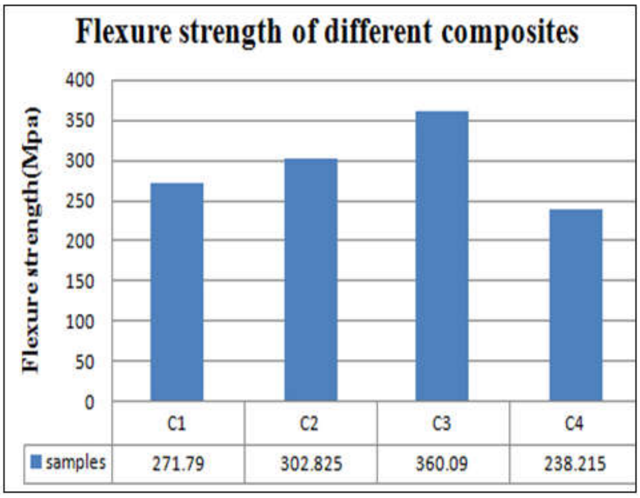

Chart 2. comparison of Flexure strength for different composites

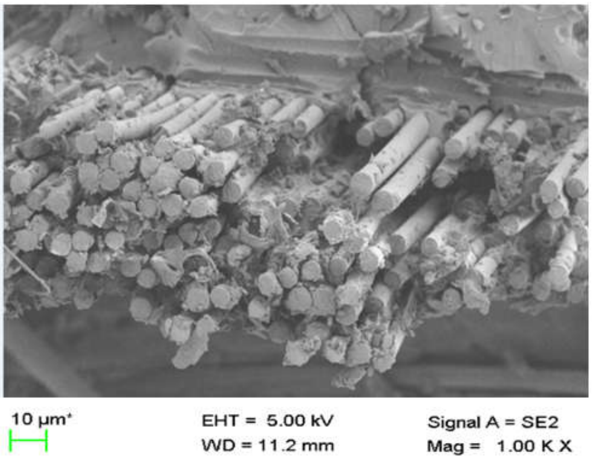

Fig. 5. For composite C1 Tensile specimen

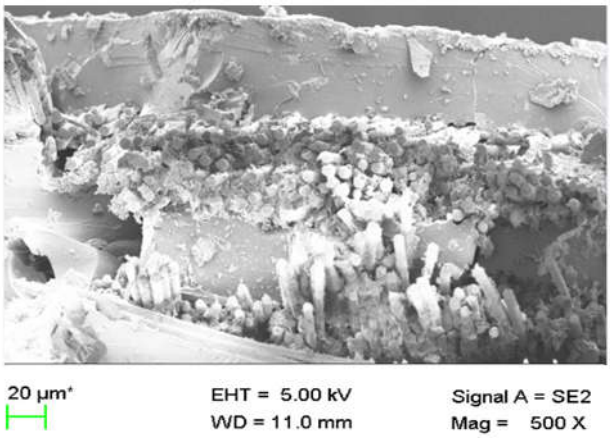

Fig. 6. For composite C2 Tensile specimen

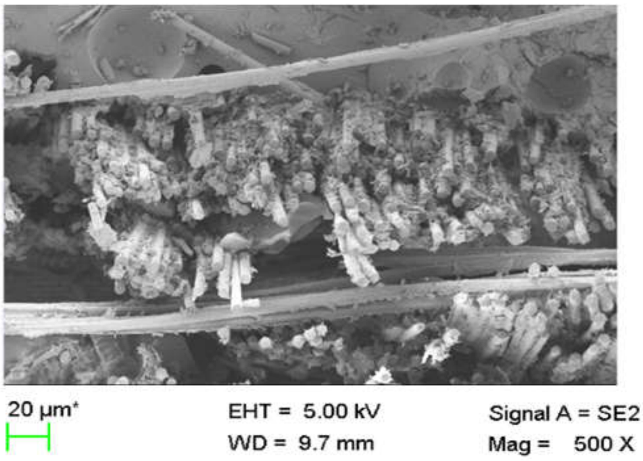

Fig. 7. For composite C3 Tensile specimen

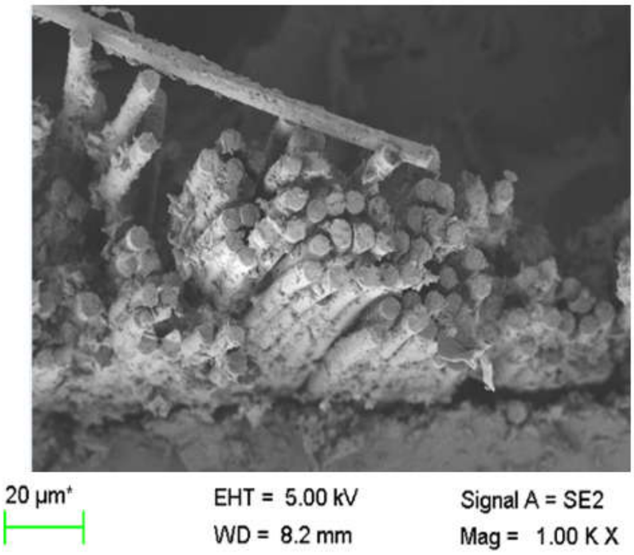

Fig. 8. For composite C4 Tensile specimen

Morphological Analysis

The structural analysis of tensile test specimens was done using scan electron microscopy. From the figure we can clearly see the fiber breakage at the end. From Figure. 5,6,7,8 it is found that fracture is due to fiber breakage at the surfaces and de-lamination of the fibers. De-lamination of the fiber may be found due to weak bonding between the fibers. From the above figures it is revealed that it has good surface finish and has more surface area for interaction. There is good dispersion of matrix and filler in the filled composites. The interaction between the matrix and filler is also good as shown in SEM images.

Conclusion

In the present work glass fiber reinforced with cerium oxide as fillers were used for preparation of sample laminates by using hand layup technique. The flexural strength and tensile strength were tested. The conclusions drawn from the present work are.

- The tensile strength of the composites varied from 100.54MPa to 131.08MPa and the maximum is obtained for composite C3 with cerium oxide as filler material.
- The flexural strength of the composite varies from 271.795 to 360.09 MPa. The maximum flexural strength is obtained for the composite C3 with cerium oxide as filler material.

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