Research Paper

ENHANCED MECHANICAL PROPERTIES OF EPOXY/GRAPHITE COMPOSITES

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ABSTRACT-

Particulate polymer composites comprise of polymer as matrix and variety of micro or nano fillers. The main objective behind inclusion of filler material in polymer matrix is to improve the various properties as well as make the composite economically viable. In the present work, graphite (size less than 75 μm) is taken as micro filler for preparation of epoxy composites. Experimental study has been carried out to study the effect of addition of fly ash at different weight percentage i.e 3wt%, 6wt%, 9wt% and 12wt% on the mechanical properties of epoxy composites. Mechanical properties such as Impact strength, Flexural strength, Flexural modulus and Fracture toughness are studied as per ASTM standards. Specimens are prepared using open mould casting. The results showsthe enhancement in Impact strength, fracture toughness, Flexural strength and Flexural modulus is by 100% and 50.96%, 73.5% and 19% at 12wt% of graphite in epoxy composites as compared to pure Epoxy.

KEYWORDS- Graphite, Epoxy Polymer, Composites, Flexural properties, Impact properties, Fracture toughness etc.

1. INTRODUCTION

Composite materials consist of multiple phases composed of continuous matrix phase and dispersed phase as reinforcing material. Matrix material may be metal, inorganic nonmetallic or polymer matrix composites.Reinforcing material usually material of micro or nanosize. Composite materials are manufactured to produce a material with better characteristics and enhanced mechanical, thermal or electrical properties [1].

Polymer matrix composite consist of organic polymer as matrix and micro or nano filler as reinforcement. Mechanical properties of filler material is much higher than the base matrix material. Filler material can act as main load bearing component and transfer load effectively, however matrix material act as adhesive[1].

Various applications of Composite materials includes manufacturing of aircraft components, electronic parts, packaging, surgical or medical equipment, thermal management and structural etc. due to the advantages such as high strength, light weight, corrosion resistance, easy processing.

Shape, size and characteristics of filler materials is the important parameter while selecting a filler for specific application. Particulate composite is the combination of coarse or small particles, chopped fibres, platelets etc. in the matrix. A polymer is a very high molecular weight compound composed of many small molecules (known as monomers) synthesized via polymerization. Epoxy resin is a thermoset polymer containing more than one epoxide groups. Epoxy resins have excellent electrical properties, good adhesion, low shrinkage, resistance to thermal and mechanical shock and can be used as high performance coatings, adhesives, electrical insulation and encapsulation purpose. Mechanical properties of epoxy composites can be enhanced by adding various micro fillers such as Graphite [2-6], TiO_2 [7-10], Clay[11-14], Granite [15-18], Fly ash [19-22] and nanofillers such as graphene [23-28].

Graphite is a black, soft, allotropic form of carbon in hexagonal crystalline form can be used as filler material for various composite materials. Graphite consists of layers hexagonal rings of carbon atoms connected to each other by strong covalent bonds also called as benzene rings. These hexagonal plates or rings connected to each other by weak van der waals forces of attraction as shown in fig. 1. In this work mechanical properties (flexural strength, flexural modulus, and impact and fracture toughness) of Epoxy/graphite composites are studied as per ASTM standard, which is further useful for various application.

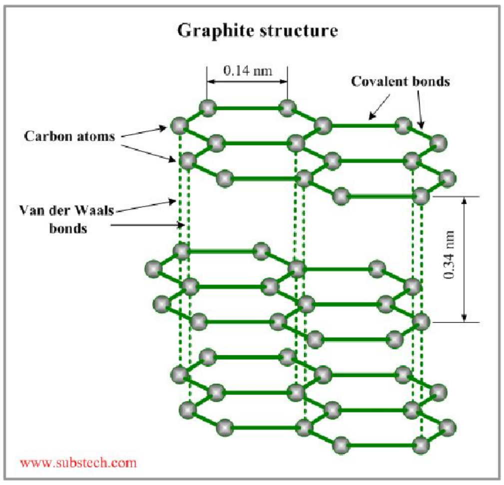

Fig. 1. Structure of Graphite [29]

2. MATERIALS

Epoxy resin is chemically named Diglycidyl Ether of Bisphenol A (DGEBA) (epoxy resin AW-106). A room temperature hardner HV-953 IN supplied by S.Ganesh & Co. Kothrud, Pune; is used as the matrix material. It is a medium viscous fluid at room temperature. The specific gravity of cured neat resin, as given by the supplier is 1.17 g/cm3. Graphite powder was supplied by S.Ganesh & Co. Kothrud, Pune.

3. PREPARATION OF EPOXY/GRAPHITE COMPOSITE

Graphite powder of less than 75 µm size was used as micro filler. Open Glass moulds are prepared for the fabrication of composites. Figure 2. Shows preparation of Epoxy/Graphite composites.

The predetermined weight percentage of graphite powder and Epoxy resin are weighed using microbalance and mixed manually. Hardener is then weighed at (10:1) ratio with Epoxy, poured slowly in mixture and stirred uniformly and gently for 10 min to avoid the formation of bubbles.

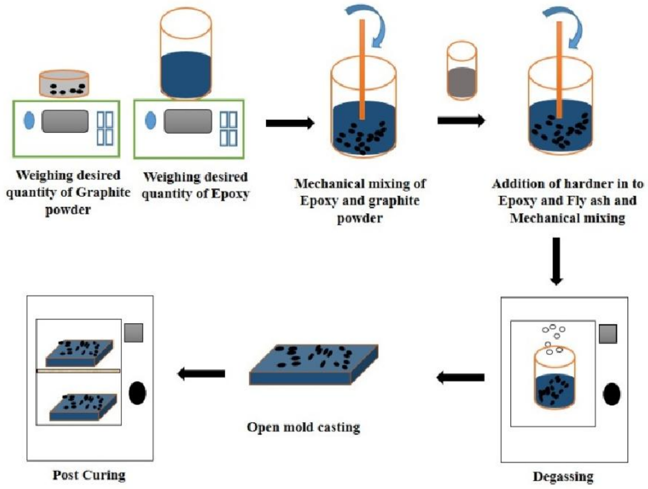

Fig. 2. Schematic for preparation of Epoxy/Graphite composites

Due to stirring, curing reaction starts, which can be experienced by exothermic reaction. The prepared mixture is gently poured inside the open glass mould. The specimens were allowed to cure for 24 hours in the mould at room temperature for curing.

Once the solidification is completed, the test samples were removed from the pattern and kept in electrically controlled hot air oven at 70 ºC for 7 hours for post curing process. Samples are further cut and polished as per ASTM standard and kept in plastic bags. Plastic bags are to prevent the moisture absorption by samples. Similar procedure is adopted for various concentration of Graphite i.e. 3 wt%, 6wt % , 9 wt% and 12wt%.

4. MECHANICAL TESTING OF EPOXY/ FLYASH COMPOSITES

4.1 Impact Test

Impact test is conducted to study the resistance of a material to sudden fracture, where load is suddenly applied. Energy required to produce rupture in the material is determined to study the tendency of brittleness. Generally Charpy and Izod tests are conducted to study Impact properties. In this work samples are prepared as per ASTM E23. Sample size is as shown in figure 3. In case of polymer composites unnotched samples are tested.

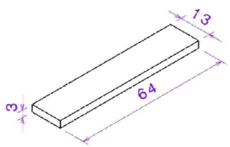

Fig. 3. Specimen dimensions for Charpy Test

4.2 Three Point Bend Test

The three point bending or flexural test is conducted as per ASTM D790 to determine the values of modulus of elasticity in bending, flexural stress, flexural modulus, flexural strain and flexural stress-strain response of the composite material. Sample size is as shown in figure 4.

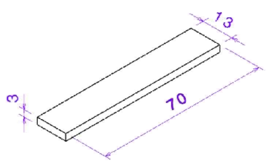

Fig. 4. Specimen Dimensions for Three Point Test

4.3 Fracture Toughness

Fracture Toughness is very important properties of material as it is difficult to avoid the occurrence of flaws during fabrication, processing or service of a material and component. Flaws may be in the form of voids, cracks, weld defects, metallurgical inclusions, design discontinuities or combination two or more of these. Fracture Toughness is the ability of a material to resist the fracture which already contains a crack. The standard test method i.e. ASTM D5045 is used to determine the fracture toughness of composites in terms of critical stress intensity factor (KIC) at the initiation of fracture. Sample size is as shown in figure 5.

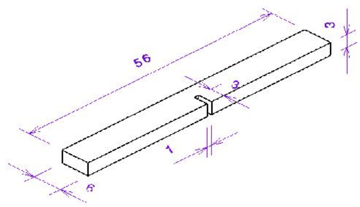

Fig. 5. Specimen Dimensions for Fracture Toughness Test

5. RESULTS AND DISCUSSION

Fig. 6 (a,b) shows the microstructure of graphite powder and its distribution. Particles are observed in spherical shape. Size of the particles ranges approximately from 1μm to 75 μm. Some of the particles are in cluster, irregularly shaped and some are separately distributed on substrate observed as shown in fig. 5 (a and b).

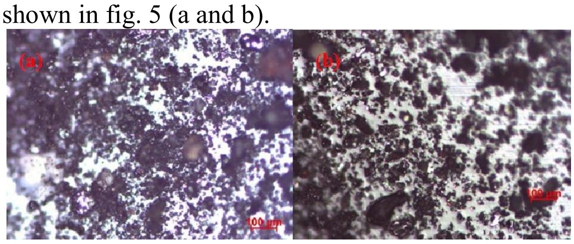

Fig. 6 (a,b). Microstructure of Graphite Podwer

Fig. 7 shows the results of charpy impact test conducted on Epoxy/graphite composites with different weight percentage of graphite, it is evident that there is an enhancement in impact toughness with increased percentage of Graphite powder. Referring from above graph, the impact toughness value of Pure Epoxy sample is 0.2 Joule. When percentage of Graphite powder is increased to 12% in Epoxy content, the Impact toughness value obtained is 0.4 Joule. I.e. total 100% enhanced in Impact Toughness.

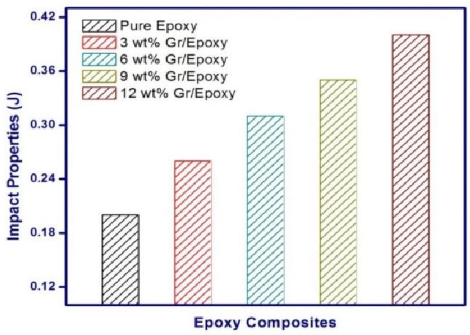

Fig.7. Impact Properties of Epoxy/graphite composites

Fig. 8,9 shows the flexural properties of Epoxy/graphite composites with different percentage ratios, it is evident that there is an enhancement in Flexural Strength with increased percentage of Graphite powder. Referring from above graph, the Flexural Strength value of Pure Epoxy sample is 66.03 MPa. When percentage of Graphite powder is increased to 12% in Epoxy content, the Flexural Strength value obtained is 73.5 MPa. i.e. total 12% enhanced in Flexural Strength.

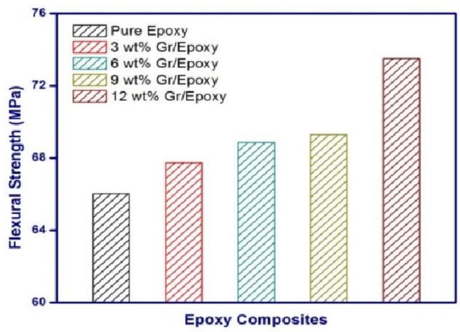

Fig. 8. Flexural Strength of Epoxy/graphite composites

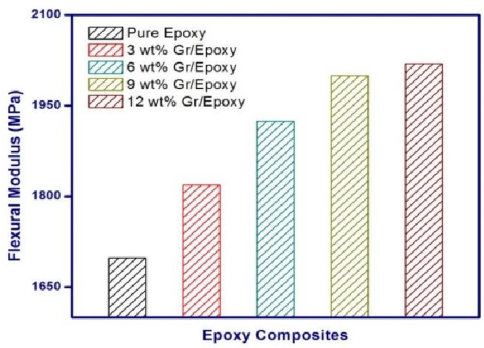

Fig.9. Flexural Modulus of Epoxy/graphite composites

Flexual modulus of pure epoxy and Epoxy/graphite composites is shown in fig.8,9. Flexural modulus of Epoxy/ graphite blended with different percentage ratios, it is evident that there is an enhancement in Flexural Modulus with increased percentage of Graphite powder. Referring from above graph, the Flexural Modulus value of Pure Epoxy sample is 1698 MPa. When percentage of Graphite powder is increased to 12% in Epoxy content, the Impact toughness value obtained is 2019. I.e. total 19% enhanced in Flexural Modulus.

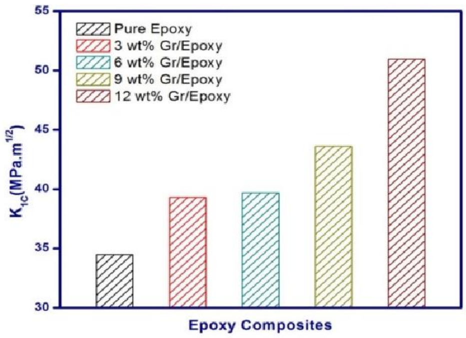

Fig. 10. Fracture toughness of Epoxy/fly-ash composites

Fracture Toughness of epoxy/graphite composites blended with different percentage ratios is shown in fig 10. The Fracture Toughness value of Pure Epoxy sample is 34.48 MPa. When percentage of Graphite powder is increased to 12% in Epoxy content, the Fracture Toughness value obtained is 50.96 MPa. I.e. total 48% enhanced in Impact Toughness.

6. CONCLUSION

We were fabricated the polymer reinforced particulate composites i.e. Epoxy/Graphite composites with different weight percentage of graphite powder using open mould casting technique. Samples were tested as per ASTM standards to study various mechanical properties such as Charpy Impact test, Flexural Strength, Flexural Modulus and Fracture Toughness test.

In present work it is observed that, with the addition of graphite (size less than 75 μm) in epoxy resin at different weight percentage such as 3 wt%, 6 wt% and 9wt% and 12 wt% mechanical properties got enhanced. This increased properties is due to uniform dispersion, better adhesion and strong interfacial interaction between graphite and epoxy resin. Graphite flakes resist the crack propagation and improves the flexural properties. Due to better harness it improves impact and fracture toughness properties of epoxy composites.

The enhancement in Impact strength, fracture toughness, Flexural strength and Flexural modulus is by 100% and 50.96%, 73.5% and 19% at 12wt% of graphite in epoxy composite. Epoxy/graphite composites have wide range of applications where cost of system needs to be cheaper.

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