

Processing Of Titania Filled Epoxy- Glass Fiber Composites

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Abstract: The present work describes the development and characterization of a new set of hybrid polymer composites consisting of glass fiber reinforcement, epoxy resin and TiO₂ particulate fillers. The newly developed composites are characterized with respect to their mechanical and erosion wear characteristics. Experiments are carried out to study the effect of fiber content impact velocity, impingement angle, stand-off distance and erodent size on the solid particle erosion behavior of these glass fiber epoxy based hybrid composites. Then the significant control factors and their interaction predominantly influencing the wear rate are identified by using taguchi method. The study reveals that the fiber content in the composites, impact velocity, impingement angle and erodent size have substantial influence in determining the rate of material loss from the composite surface due to erosion. Also, artificial neural network (ANN) technique has been use to predict the erosion rate based on the experimentally measured database of composites. The morphology of eroded surfaces is examined by using scanning electron microscopy (SEM) and possible erosion mechanisms are discussed.

Keyword: composite material, epoxy resin, electron microscopy , artificial neural network

1. INTRODUCTION

The development of composite materials and related design and manufacturing technologies is one of the most important advances in the history of materials, Composite multifunctional materials having unprecedented mechanical and physical properties that be tailored to meet the requirements of a particular application. Many composites also exhibit great resistance to high-temperature corrosion and oxidation and wear.[1] These unique characteristics provide the mechanical engineer with design opportunities not possible with conventional monolithic (unreinforced) materials. Composites technology also makes possible the use of an entire class of solid materials, ceramics, in applications for which monolithic versions are unsuited because of their great strength scatter and poor resistance to mechanical and thermal shock. Further, many manufacturing processes for composites are well adapted to the fabrication of large, complex structures, which allows consolidation of parts, reducing manufacturing costs.[1,2]

1.1 What is Composite Material .

Composite materials are engineering materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component, There are two categories of constituent materials: matrix and reinforcement. [3] composite means material having two or more distinct constituent materials or phases. It is only when the constituent phases have significant different physical properties and thus the composite properties are noticeably different from the constituent properties. [4]

1.2 Classification of Composites .

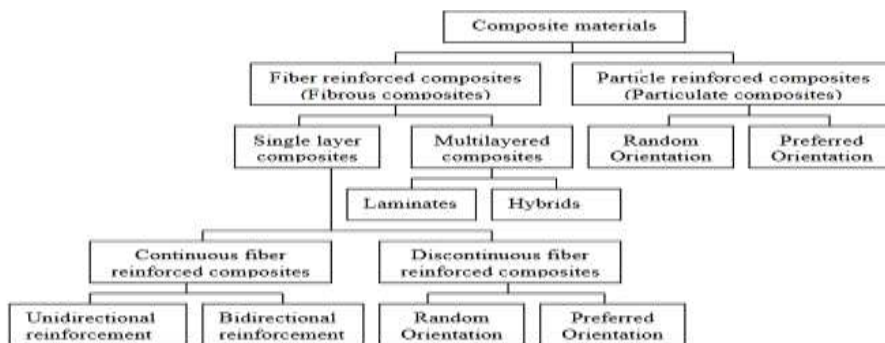


Figure 1.1. Classification of composite materials[4,5]

1.3 Structure of Composite

Structure of composite material determines its properties to a significant extent

Properties:

Nature of the constituent material (bonding strength)

The geometry of the reinforcement (shape, size)

The concentration distribution(vol. fraction of reinforcement

orientation of the reinforcement(random or preferred)

1.4 Advantages of composites

composite over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as strength-to-weight ratio.[6]

1.5 applications of composite

applications of composite material in different industry such as Aircraft , Aerospace, Automotive, Chemical and Construction. [7]

2 .MATERIALS AHD METHODS

procedures followed for their This chapter describes the details of processing of the composites and the experimental characterization. [8]

2.1 MATERIALS

E-glass fiber

TiO 2 filler

Epoxy resin

2.2 METHODS

2.2.1 Specimen preparation

E-glass fibers (360 roving taken from Saint Gobian) are reinforced with Epoxy LY 556 resin chemically belonging to the 'epoxide' family is used as the matrix material.[9] Its common name is Bisphenol A Diglycidyl Ether. The low temperature curing epoxy resin (Araldite LY and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight as

The epoxy resin and the hardener are supplied by Ciba Geigy India Ltd.[10]

E glass fiber and epoxy resin has modulus of 72.5 GPa and 3.42GPa respectively and possess density of 2590 kg/m³ and 1100kg/m³ respectively. The filler material TiO 2 (density 4.2 .gm/cm³) is provided by NICE Ltd India sieved to obtain particle size in the range 70-90 μm

2.2.2 Composites of three different

compositions such as 30wt%, 40wt% and 50wt% glass fiber are made and the filler content (weight fraction of TiO 2 in the composite) is kept at 10% for all the samples and the designations of these composites are given in Table 3.1. The castings are put under load for about 24 hours for proper curing at room temperature. Specimens of suitable dimension are cut using a diamond cutter for physical characterization and erosion test.[9]

Composites	Compositions
C ₁	Epoxy (60wt%)+Glass Fiber (30wt%)+TiO ₂ (10wt%)
C ₂	Epoxy (50wt%)+Glass Fiber (40wt%)+TiO ₂ (10wt%)
C ₃	Epoxy (40wt%)+Glass Fiber (50wt%)+TiO ₂ (10wt%)

Table 3.1. Designation of Composites

3. Characterization of the Composites

3.1 Density

The theoretical density of composite materials in terms of weight fraction can easily be obtained as for the following equations given by Agarwal and Broutman

$$\rho_{ct} = \frac{1}{(W_f/\rho_f) + (W_m/\rho_m)}$$

Where, W and ρ represent the weight fraction and density respectively. The suffix f, m and ct stand for the fiber, matrix and the composite materials respectively

The composites under this investigation consists of three components namely matrix, fiber and particulate filler. Hence the modified form of the expression for the density of the composite can be written as

$$\rho_{ct} = \frac{1}{(W_f/\rho_f) + (W_m/\rho_m) + (W_p/\rho_p)}$$

Where, the suffix 'p' indicates the particulate filler materials. The actual density (ρ_{ce}) of the composite, however, can be determined experimentally by

simple water immersion technique. The volume fraction of voids (V_v) in the composites is calculated using the following equation

$$V_v = \frac{\rho_{ct} - \rho_{ce}}{\rho_{ct}}$$

3.2 Tensile Strength

The tension test is generally performed on flat specimens as shown in Figure (3.1). The most commonly used specimen geometries are the dog-bone specimen and straight-sided specimen with end tabs. A uni-axial load is applied through the ends.[10] ASTM standard test

recommends that the specimens with fibers parallel to the loading direction should be 11.5

bone type and having dimensions -mm wide. Length of the test section should be 100 mm. The test-piece used here was of dog according to the standards. The tension test was performed on all the three samples as per ASTM D3039-76 test standard.[7]



Figure 3.1. Experimental set up for three point bend test

3.3 Impact strength

Low velocity instrumented impact tests are carried out on composite specimens. The tests are done as per ASTM D 256 using an impact tester (Figure 3.3).

The pendulum impact testing machine ascertains the notch impact strength of the material by shattering the V-notched specimen with a pendulum hammer, measuring the spent energy, and relating it to the cross

section of the specimen.[10] The standard specimen for ASTM D 256 is 64 x 12.7 x 3.2 mm and the depth under the notch is 10.2 mm as indicted in Figure (3.3)

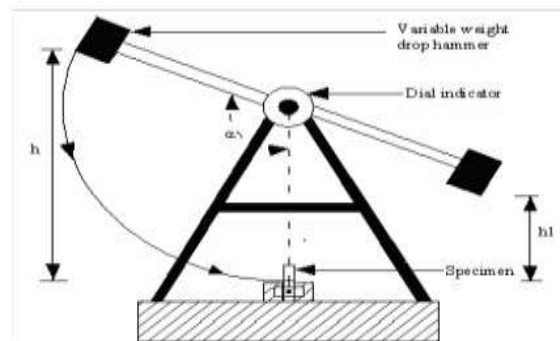


Figure 3.3. Schematic diagram of an impact tester

6. Conclusions

successful fabrication of a glass fiber reinforced epoxy composites filled with micro-sized TiO₂ is possible by simple hand lay-up technique

It is noticed that there is significant improvement in the mechanical properties of the composites with the increase in fiber $\frac{3}{4}$ loading.

7. Recommendations

Solid particle erosion study of other types of glass fiber E-glass fiber reinforced with

polyester resin composites filled with ceramic r has been a less studied area

There is a very wide scope for future scholars to explore this area of research.

8. References

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