International Journal of Engineering Research ISSN: 2319-6890)(online),2347-5013(print)
Volume No.5 Issue: Special 6, pp: 1129 - 1254 20 May 2016

Effect/Influence of filler loading on erosive behavior of Glass –Epoxy Composites

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Abstract: In this study, an experimental investigation was carried out to study the effect of TiO_2 filled Glass epoxy composites in air-jet erosive situations. Erosive studies were carried out using an air jet erosion test rig. Silica sand particles of size ranging from 212-250 µm were used as abrasives. It observed that the inclusion of TiO_2 filler enhances the erosion resistance of the Glass-Epoxy composites. The worn out surfaces were analysed using scanning electron microscope.

Keywords: air jet erosion, Glass-Epoxy composites, SEM, TiO_2

I. INTRODUCTION:

The need for the use of newer material to combat erosive wear situations has resulted in the emergence of polymer based composite materials. Fiber reinforced polymeric composites are the most rapidly growing class of materials due to their good combination of high specific strength and specific modulus. They are widely used for a variety of engineering applications. The importance of tribological properties convinced many researchers to study the friction and wear behaviour to improve the wear resistance of polymeric composites.

The polymer and their composites find very useful applications in automotive components such as gears, cams, wheels, brakes, clutches, bearings and also in other engineering applications like conveyor aids, chute liners, power, mining, agriculture and other allied field.

N. Mohan et al. carried out a study on Investigation on Two-Body Abrasive Wear Behaviour of Silicon Carbide Filled Glass Fabric-Epoxy composites [1]. The wear loss of the composites was found increasing with the increase in abrading distances. A significant reduction in wear loss and specific wear rates were noticed after incorporation of SiC filler into GE composite.

B. Suresh et al. carried out a study on Mechanical and tribological properties of glass-epoxy composites with and without graphite particulate filler [2]. From the experimental investigation, they found that the tensile strength and dimensional stability of the G-E composite increased with increasing graphite content. The wear loss of the composites decreased with increasing weight fracture of graphite filler and increased with increasing sliding distance.

B Suresha et al. carried out Experimental studies using SiC instead of graphite as the filler material in E-glass reinforced thermoset composites [3]. From the experimental investigation, they found that tensile strength, flexural strength and hardness of the glass reinforced thermoset composite increased with the inclusion of SiC filler.

B. Shivamurthy et al. carried out experimental studies on Influence of SiO_2 Fillers on sliding wear resistance and mechanical properties of compression moulded glass epoxy composites [4]. Increase in filler content in the GE composite enhances the young's modulus, flexural strength, surface hardness, bitterness and decreases the tensile strength and flexural strength and elongation at break. SiO_2 particulate filled GE composites tensile strength and flexural strength follows very near the relation σuf=1.h2σut when compared to unfilled GE composites. The interlaminar shear strength improved after incorporation of fillers, 6% SiO_2 filler content GE composites exhibit maximum inter laminar shear strength (11 Mpa). Unfilled GE composite and 3% SiO_2 particulate filled GE composite sliding wear loss and specific wear rate strongly influenced by the applied load as composed to other GE composites.

S.Basavarajappal et al. carried out an investigation to show Effect of filler materials on dry sliding wear behaviour of polymer matrix composites-A Taguchi approach [5]. They found that the inclusion of SiC and graphite as filler materials in glass epoxy composites will increase the wear resistance of the composite greatly.

II. EXPERIMENTAL DETAILS:

Materials

Table 1. Composite selected for study

Material (Designation)	Matrix	Filler
Glass-epoxy (G-E)	40	0
TiO_2 Filled (GE-1)	35	5
TiO_2 Filled (GE-2)	30	10

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Specimen Preparation

A hand layup procedure was adopted for making G-E composites. The reinforcement material consists of bidirectional glass fabric yarn of about 8µm woven fabric with epoxy compatible finish. LY 556 epoxy was used as the resin for the matrix material with HY 951 grade room temperature curing hardener and diluent DY021. The layup procedure consisted of placing a glass surface mat to give smooth surface finish to the top and bottom layers of the cured composite. On this, a resin hardener mix prepared for this purpose was smeared. Over this, another layer of fabric was laid down and the resin was spread once again. The process was repeated till all the 8 layers of fabric (arrived at by trial experiments) made ready for the layup, were used up in the stacking arrangement. Use of spacers of about 3mm thickness helped in obtaining laminates of the required thickness following final curing. Air jet erosion test samples of size 50mmX50mmX3mm were prepared from the laminated using a diamond tipped cutter.

Air Jet Erosion Test

A schematic diagram of the solid particle erosion test rig, used in the present study is shown in fig. The rig consists of an air compressor, a particle feeder, an air particle mixing and accelerating chamber. Dry compressed air is mixed with sand particles, which are fed at a constant rate from a conveyor belt type feeder in to the mixing chamber and then accelerated by passing the mixture through a tungsten carbide (WC) converging nozzle of 4-mm diameter. These accelerated particles impact the specimen, which can be held at various angles with respect to the impacting particles using an adjustable sample holder. The feed rate of the particles can be controlled by monitoring the distance between the particle feeding hopper and belt drive carrying the particles to the mixing chamber. The impact velocity of the particles can be varied by varying the pressure of the compressed air. Square samples of size 50mm×50mm×3mm are cut from the plaque for erosion tests. A standard test procedure has been employed for each erosion test in accordance with ASTM G76. The samples have been cleaned and weighed to an accuracy of 0.1mg using an electronic balance, they eroded in the test rig for 4 min and weighed again to determine weight loss. The ratio of this weight loss to the weight of the eroding particles causing the loss (i.e. testing time x particle feed rate) is then computed as the dimensionless incremental erosion rate.

Fig 2.1: Air Jet Erosion test rig

III. RESULTS AND DISCUSSION:

Fig shows the erosive weight loss of G-E composites as a function of impinging angle. It is observed that erosive weight loss is decreased with increase in impinging angle for all the composites. G-E composite with 5% additive resulted in least erosive when compared with other two. The erosive wear for G-E composite with 5% filler remained more or less same with increased impinging angle. This suggesting that this composite has stable erosive wear characteristics.

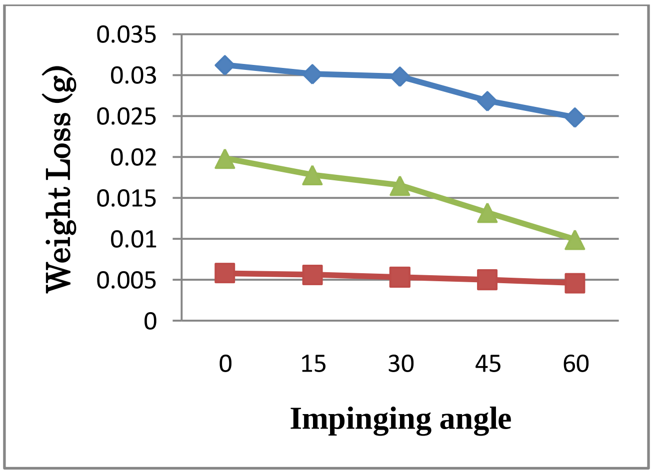

Fig 3.1: Weight loss vs Impinging angle

ISSN: 2319-6890)(online),2347-5013(print)
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VI. SCANNING ELECTRON MICROSCOPE

Fig. (a), (b) shows the surface morphology of G-E composite without filler and glass fiber reinforced epoxy composite with 5% TiO_2 additive respectively. These represents the worn surfaces after air jet erosion test at an impinging angle 15^0, abrasive particle size 60grade, grit size = 200-250 µm

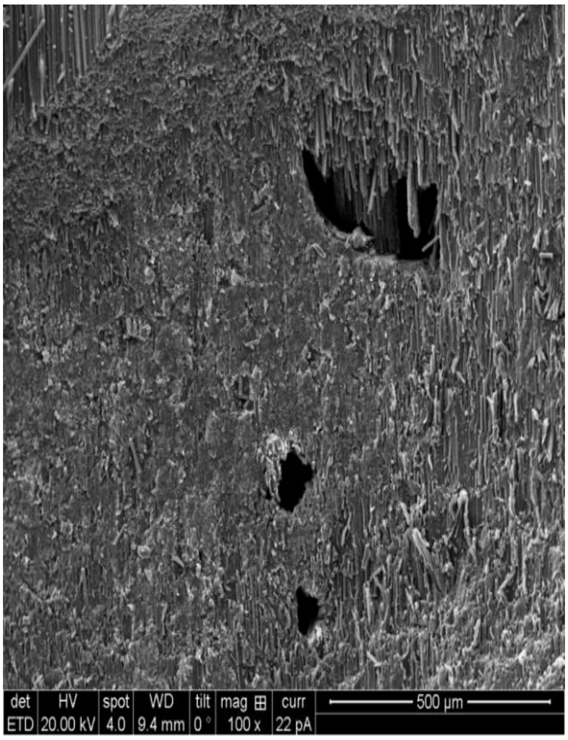

Fig 4.1. SEM Micrograph of 100X. (a): SEM Micrograph of the specimen without filler

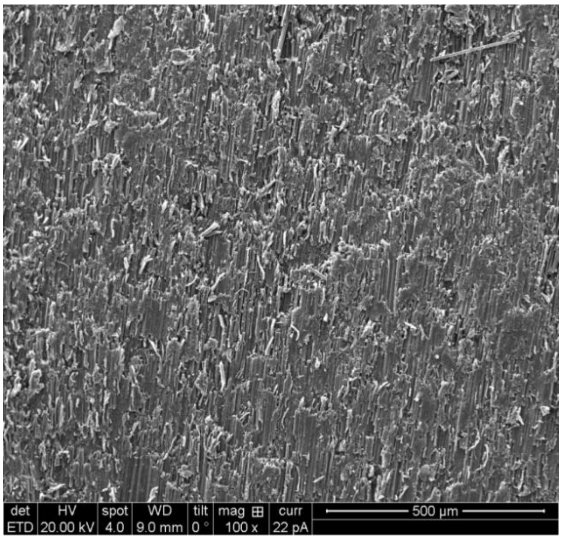

Fig 4.2. SEM Micrograph of 100X. (b): SEM Micrograph of the specimen with 5% filler

SEM Micrograph of the specimen without filler, [Fig. (a)] shows the cavities formed in the abrasion direction owing to less wear resistance. The SEM Micrograph of glass fiber reinforced epoxy with 5% filler Fig.[(b)] shows less furrows with discontinuous parallel lines. The damage to the matrix here is less due to the addition of filler.

V. CONCLUSIONS:

An experimental study of air jet erosion tests on glass fiber reinforced epoxy composite with and without TiO_2 filler at different impinging angle was carried out and the following conclusions are drawn:

- Weight loss of G-E composite during abrasion test was strongly dependant on the test parameter namely impinging angle. Comparative erosive wear performance of all the composites showed that wear loss decreased with increased impinging angle. G-E composites with filler showed better erosion resistance. Best erosive wear performance were seen for G-E composite with 5% filler.

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