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EFFECT OF AGEING ON EROSIVE WEAR BEHAVIOUR OF CARBON FIBER REINFORCED EPOXY COMPOSITES

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ABSTRACT

Fibre reinforced polymeric materials have been widely used due to their superior properties, low density, and manufacturing flexibility. Numerous applications have been allocated for these materials in aerospace and automotive industries such as gears, seals, bearings, cams etc. In order that these components satisfactorily perform under loading conditions, they should have good mechanical, tribological and machining properties.

In this paper, an experimental investigation was carried out to study the erosive wear behaviour of carbon fiber reinforced epoxy composites with and without MoS_2 filler under ageing conditions. From the experimental result, it is very clear that MoS_2 filled composites showed optimum results when compared with unfilled one.

Keywords: MoS_2 filler, Carbon fiber, Epoxy, Erosive wear, Ageing

1. Introduction

Fibre reinforced polymeric materials have been widely used due to their superior properties, low density, and manufacturing flexibility. Numerous applications have been allocated for these materials in aerospace and automotive industries such as gears, seals, bearings, cams etc. In order that these components satisfactorily perform under loading conditions, they should have good

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mechanical, tribological and machining properties. Number of scientists and researchers are carrying out work to develop newer material system and characterize them for their various properties so that they can be selected for specific end use. A brief review of the literature is presented below throwing more light on the above.

B. Suresha et al. [1] carried out a study on three-body abrasive wear behaviour of carbon and glass fiber reinforced epoxy composites. From the study, they found that specific wear rate increased with applied load at lower abrading distance and decreased with increased abrading distance. Carbon epoxy composite showed better abrasion resistance as compared with that of glass fiber epoxy composites.

A study on Erosive wear behaviour of epoxy based composites at normal incidence was carried out by A.P. Harsha et al. [2]. They found that the bi-directional glass fibre reinforced epoxy composites showed better wear resistance than unidirectional reinforced composites. The erosion behaviour of epoxy composites is controlled by the type of fibre and its arrangement. They also reported that the epoxy composites have shown peak erosion rate at 60^0 impingement angle at a velocity of 25m/s.

J. Stabik et al. [3] conducted a study on electrical and tribological properties of gradient epoxy-graphite composites. They concluded that the surface resistivity increased significantly with decreasing content of filler in composite.

J.K. Lancaster et al. [4] conducted a study on the effect of carbon fiber reinforcement on the friction and wear of polymers. They found that the wear rate can be reduced by the addition of a third component, such as graphite or bronze, although only with small sacrifice on the bulk strength. However, they felt that further investigations are required to determine the most effective additives and their proportions to obtain an optimum compromise in strength and wear properties.

A study on solid particle erosion of glass fiber reinforced fly ash filled epoxy resin composites was carried out by V.K. Srivastava et al. [5]. From the experimental investigation, they found that the inclusion of fly ash filler in the GFRP composite decreased the hardness, tensile strength and density. They also reported that GFRP without any filler showed the highest erosion rate. The influence of impingement angle on erosive wear of all composites under consideration exhibited semi ductile wear behaviour with maximum wear rate at 60° impingement.

N. Mohan et al. [6] carried out a study for investigating two-body abrasive wear behaviour of silicon carbide filled glass fabric-epoxy composites. 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. Suresha et al. [7] carried out a study on Mechanical and tribological properties of glass-epoxy composites with and without graphite particulate filler. Their investigation revealed that the tensile strength and dimensional stability of G-E composite increased with increasing graphite content. The wear loss of the composites decreased with increasing weight fraction of graphite filler and increased with increasing sliding distance. On further investigation using SiC instead of graphite as the filler material in E-glass reinforced thermoset composites [8], they found that tensile strength, flexural strength and hardness of the glass reinforced thermoset composite increased with the inclusion of SiC filler.

Substantial research work has been carried out to investigate the mechanical and tribological behaviour of fiber reinforced polymeric matrix composite with and without addition of fillers. Though number of fillers has been tried out, the effect of adding MoS_2 filler on the mechanical and tribological behaviour of fiber reinforced polymeric composites is not much reported. In this context, the present work is to carried out with the main objective of studying erosive wear behaviour of carbon fiber reinforced epoxy composites with and without the addition of MoS_2 filler and the same has analysed using artificial neural network.

2. Air Jet Erosion Test

Solid particle erosion test rig used in the present study. 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 (fig 2.1). 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. The test conditions are represented below.

a. Nozzle diameter (mm) = 3

b. Erodent velocity (m/s) = 30

c. Erodent feed rate (g/min) = 4.56

d. Abrasives = silica

e. Abrasive size (μ) = 200

f. Time period (mins) = 4

g. Impinging angle (ά) = 0°,15°, 30°, 45°, 60°

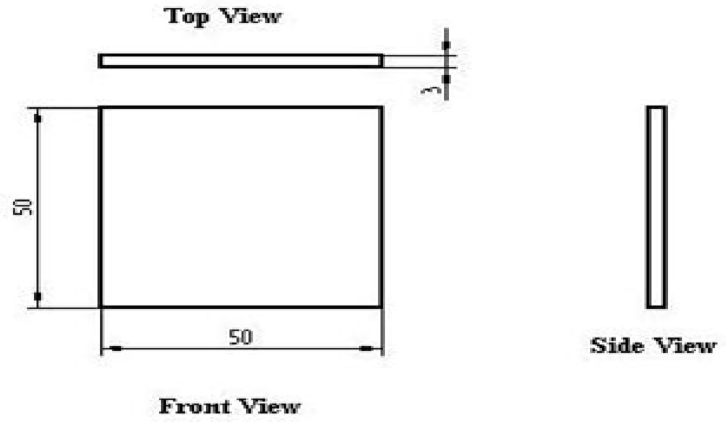

Fig 2.1. Air Jet Erosion Test Specimen

3. Results and Discussions

Air jet erosion tests were conducted using solid particle erosion test rig for carbon fiber reinforced epoxy composites with and without MoS_2 filler at different impinging angle in accordance with ASTM G76 for with and without ageing. The results are shown in table 3.1 and 3.2.

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Table 3.1. Results of air jet erosion test: without ageing

	IMPINGING ANGLE (α)				
COMPOSITION	α -0	α -15	α -30	α -45	α -60
	Weight Loss (g)	Weight Loss (g)	Weight Loss (g)	Weight Loss (g)	Weight Loss (g)
C-E	0.0312	0.0301	0.0298	0.0268	0.0248
C-E + 4% MoS_2	0.0058	0.0056	0.0053	0.005	0.0046
C-E + 8% MoS_2	0.0198	0.0178	0.0165	0.0132	0.0099

Table 3.2. Results of air jet erosion test: with ageing

	IMPINGING ANGLE (α)				
COMPOSITION	α -0	α -15	α -30	α -45	α -60
	Weight Loss (g)	Weight Loss (g)	Weight Loss (g)	Weight Loss (g)	Weight Loss (g)
C-E	0.0416	0.041	0.0368	0.0348	0.0338
C-E + 4% MoS_2	0.0067	0.0065	0.0061	0.0059	0.0054
C-E + 8% MoS_2	0.0297	0.0278	0.0275	0.0232	0.0165

Fig.3.1 shows the erosive weight loss of C-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. C-E composite with 4%MoS_2 additive resulted in least erosive when compared with other two. The erosive wear for C-E composite with 4% MoS_2 filler remained more or less same with increased impinging angle. This suggesting that this composite has stable erosive wear characteristics.

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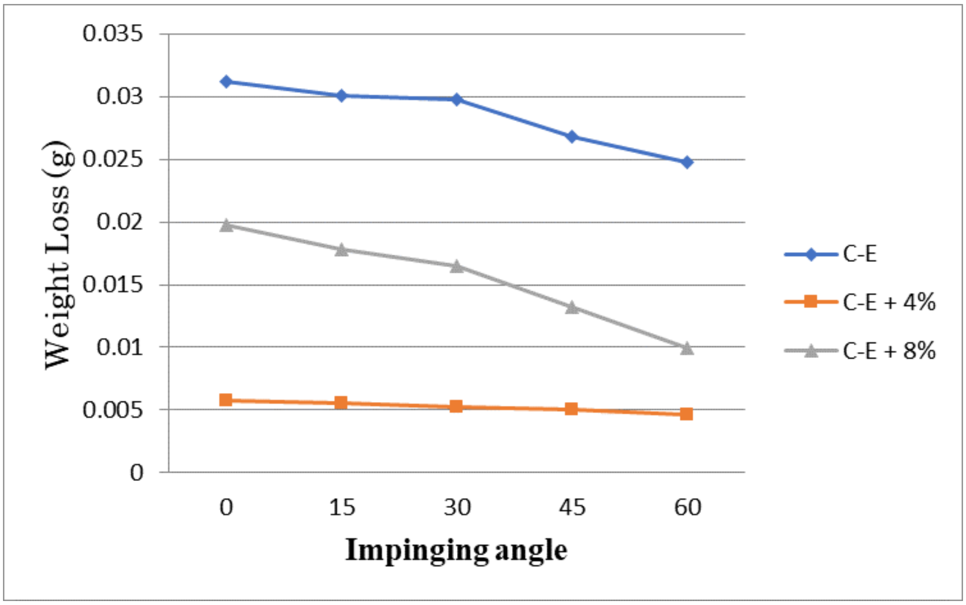

Fig 3.1: Weight loss Vs Impinging angle for C-E composites – Without ageing

Fig.3.2 shows the erosive wear loss as a function of impinging angle. It is observed that erosive wear decreased with increased impinging angle. C-E composite with 4%MoS_2 additive resulted in lesser erosive wear of 0.0054g compared with the other two. Also no significant variation of wear loss was observed. This shows that this composite with 4% MoS_2 filler showed stable wear properties even under ageing conditions.

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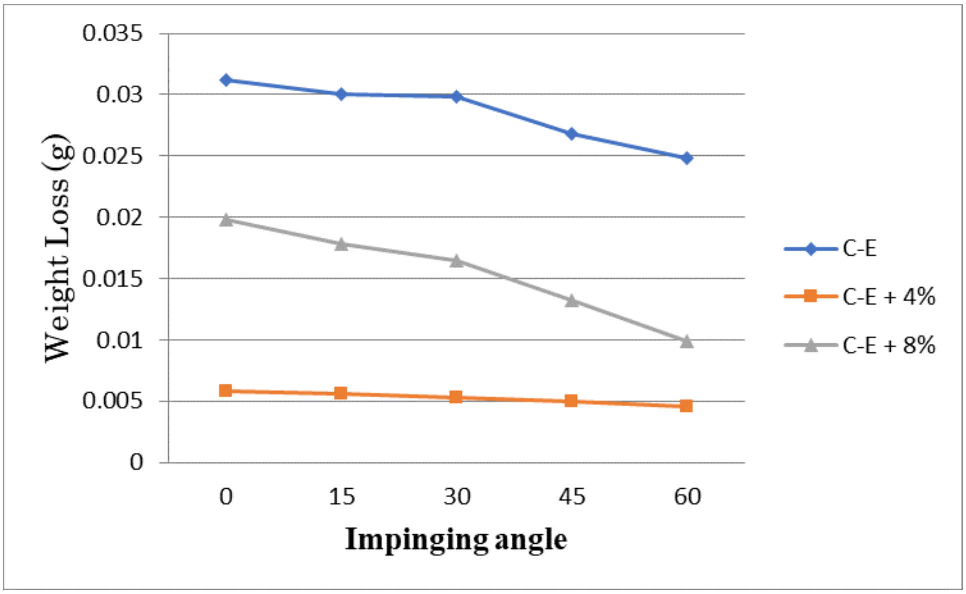

Fig 3.2: Weight loss Vs Impinging angle for C-E composites – With ageing

Comparison of Tribological Characteristics of Aged and Unaged C-E Composites

Fig.3.3 shows the erosive wear loss as a function of impinging angle. It is observed that erosive wear decreased with increased impinging angle. Carbon fiber reinforced epoxy composites without ageing shows better erosive wear resistance when compared with aged samples.

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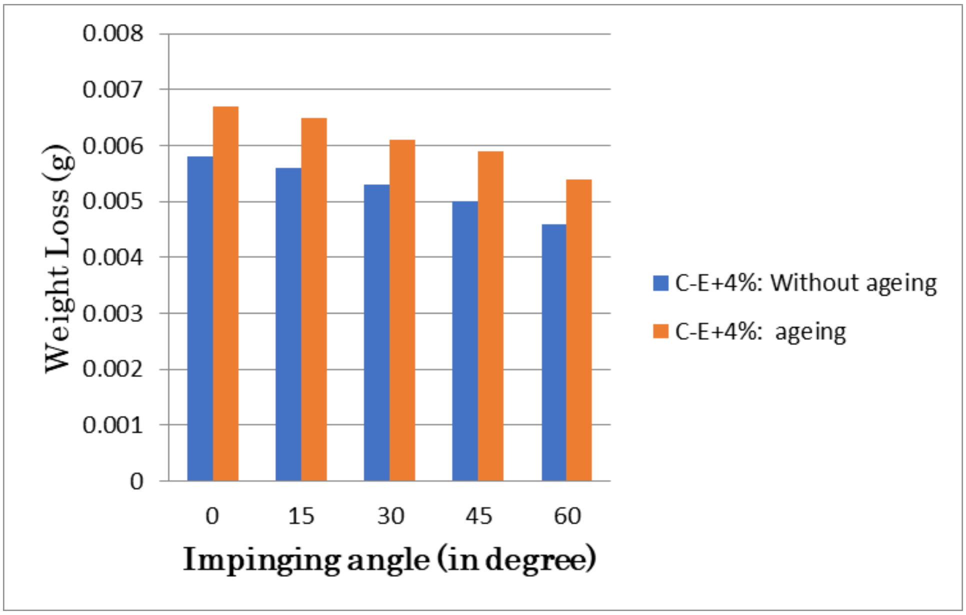

Fig 3.3: Comparison between aged and unaged C-E+4% filler composites: Air jet erosion test

4. Conclusion

An experimental study of air jet erosion tests on carbon fiber reinforced epoxy composite with and without MoS_2 filler at different impinging angle was carried out under ageing conditions and the following conclusions are drawn:

Weight loss of C-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. C-E composites with filler showed better erosion resistance. Best erosive wear performance were seen for C-E composite with 4% MoS_2 filler.

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