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RESEARCH ARTICLE

DRY SAND ABRASIVE WEAR BEHAVIOR OF CARBON EPOXY COMPOSITES WITH AND WITHOUT MOS_2 FILLER.

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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 dry sand abrasive wear behavior of carbon fiber reinforced epoxy composites with and without MoS_2 filler. From the experimental result, it is very clear that MoS_2 filled composites showed optimum results when compared with unfilled one.

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 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 behavior 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.

The influence of SiO_2 fillers on sliding wear resistance and mechanical properties of compression moulded glass epoxy composites was investigated by B. Shivamurthy et al. [9]. Increase in filler content in the GE composite enhanced the young’s modulus, flexural strength, surface hardness and brittleness. Sliding wear loss and specific wear rate were strongly influenced by the applied load for unfilled GE composite and 3% SiO_2 particulate filled GE composite when compared with other GE composites.

S.Basavarajappa et al. [10] carried out investigation to show the influence of adding filler to glass epoxy polymer matrix composites on dry sliding wear behaviour of polymer matrix composites. They used Taguchi approach and found that the inclusion of SiC and graphite as filler material in glass epoxy composites increased the wear resistance of the composite greatly.

Asit Kumar Khanra et al. [11] conducted a study on Microstructure and mechanical properties of magnesium substituted hydroxy apatite (Mg-HAP) composites. From the experimental study, they found that the compressive strength of composite was increased with the addition of HAP.

Material and methods:-

Specimen preparation

The steps involved in preparation of carbon fiber reinforced epoxy composites laminates by layup technique is as follows:

Step 1

The rectangular box of dimension 100mm×170mm is cleaned with soft brush using acetone to remove the dust. A layer of releasing agent is coated on the cleaned surface for the easy removal of the laminate after curing. Carbon fiber strand is cut to fit rectangular box.

Step 2

The epoxy resin is weighed to a ratio of 3:2 with that of weight of reinforcement material taken and is poured in to a bowl. Hardener HY 951, which is 2%-6% of the weight of epoxy resin is added to the bowl containing epoxy and stirred uniformly

Step 3

The first layer of epoxy resin is coated on the releasing agent, on which a single strand of carbon fiber is placed. Again a layer of epoxy is coated on which the carbon fiber strands is placed. To clean away the entrapped air and to obtain uniform distribution of epoxy over the carbon fibers of the mat, hand operated rollers are rolled under constant pressure throughout the mat surface. Same procedure is repeated until the desired thickness is obtained. Alternate layers of epoxy and carbon fiber are placed.

Step 4

On the top most surface of the carbon fiber a flat plate with same dimensions of laminate is placed. The pressure is applied manually for the extra epoxy resin to squeeze out from sides of the laminates.

Step 5

The laminate is cured under light pressure for 2 hrs, followed by curing at room temperature for 24 hrs. By following the same procedure as said above, composite laminates having filler composition of 4% and 8% is prepared. The mechanical properties and wear behaviour of all the composite laminates are tested subsequently.

Table1. Composite selected for study

Material	**Matrix**	**Filler**
Carbon –Epoxy (C-E)	40	-
MoS_2 Filled(C-E1)	36	4
MoS_2 Filled(C-E2)	32	8

Dry sand abrasion test:-

Dry sand abrasive wear studies were carried out on a dry sand rubber wheel abrasion test rig as shown in fig.1. The schematic of which is shown in fig 2. The abrasives are introduced between the test specimen and rotating wheel (chlorobutyl rubber tire). The test specimen is pressed against the rotating wheel at a specified force by means of lever arm while controlled flows of grit abrade the test surface. The rotation of wheel is such that its contact face moves in the direction of grit flow. The pivot axis of the lever arm lies within a plane, which is approximately tangential to the rubber wheel surface and normal to the horizontal diameter along which the load is applied. The tests were carried out for different loads of 11N, 23N and 32N and sliding distance varied in steps from 300m to 1200m. The rubber wheel was rotating at a speed of 200rpm. Abrasive used was silica of ASF grade 60 and was angular in shape with sharp edges. Sand flow rate between rubber wheel and specimen was 250 ± 5 g/min. The specimens were prepared according to ASTM G65 and the same is shown in figure 3. At the end of set test duration, the specimen was removed, thoroughly cleaned and again weighed (final weight). The difference in weight before and after abrasion was determined. At least three tests were performed and the average values so obtained were used in this study. In all the above tests, wear was measured by loss in weight, which was then converted to wear volume using density data. The specific wear rate was calculated using equation (6.4). The specimen before and after the wear test is shown in fig.4

Wear loss calculation:-

Wear Loss (g) = **Initial Weight – Final weight** ……………….. (1)

Volume loss, mm^3 = **[mass loss (g)/ density (g/cm^3)] * 1000** …….. (2)

Specific wear rate, mm^3/Nm = $[\Delta V/Ld]$ …… (3)

ΔV = volume loss, L = load in Newton's

d = sliding distance in meters

Fig 1. Three body abrasion tester

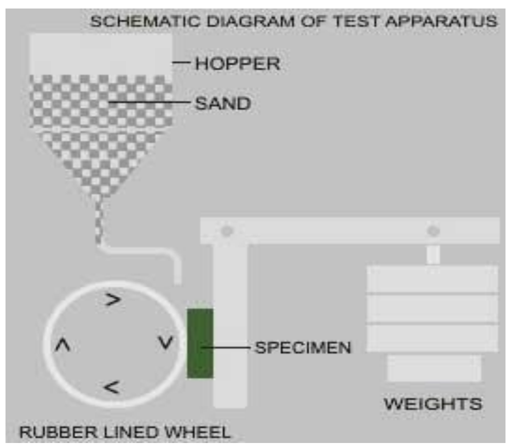

Fig 2. Three body abrasion tester

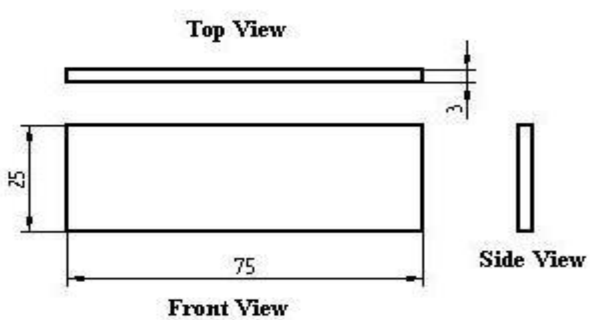

Fig 3. Three body Abrasive wear test specimen

(a) 

(b) 

Fig 4. (a) Specimen before test (b) specimen after test

Result and discussion:-

Figures 5, 6 and 7 show the weight loss in grams as a function of sliding distance for C-E composites with and without MoS_2 filler. It is observed that weight loss is increasing with increased abrading distance and amount of wear has seemed to decrease with increase in MoS_2 filler content. C-E composites without MoS_2 filler showed maximum weight loss of 0.8218g for an abrading distance of 1200m at a load of 35N whereas C-E composite with 8% MoS_2 filler content showed the least weight loss of 0.0213g at a load of 11N and an abrading distance of 300m.
This suggests that addition of filler has altered the wear behavior characteristics of C-E composites and addition of filler has resulted in improved wear resistance. From the graph it is clear that the carbon fiber reinforced epoxy composites with 4% MoS_2 filler showed the best wear characteristics than C-E composite without and with 8% MoS_2 filler.

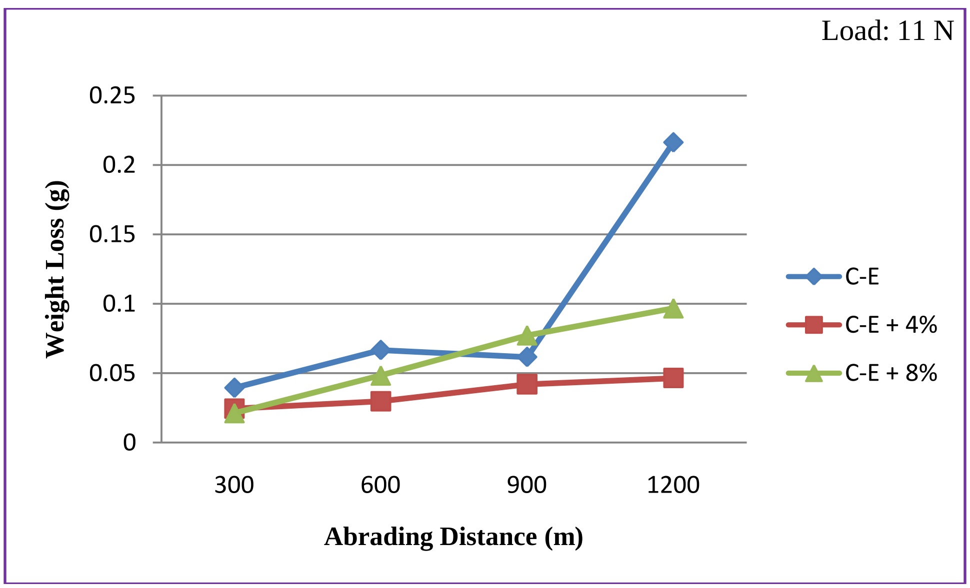

Fig 5. Weight loss Vs Abrading Distance at 11N Load for C-E Composites

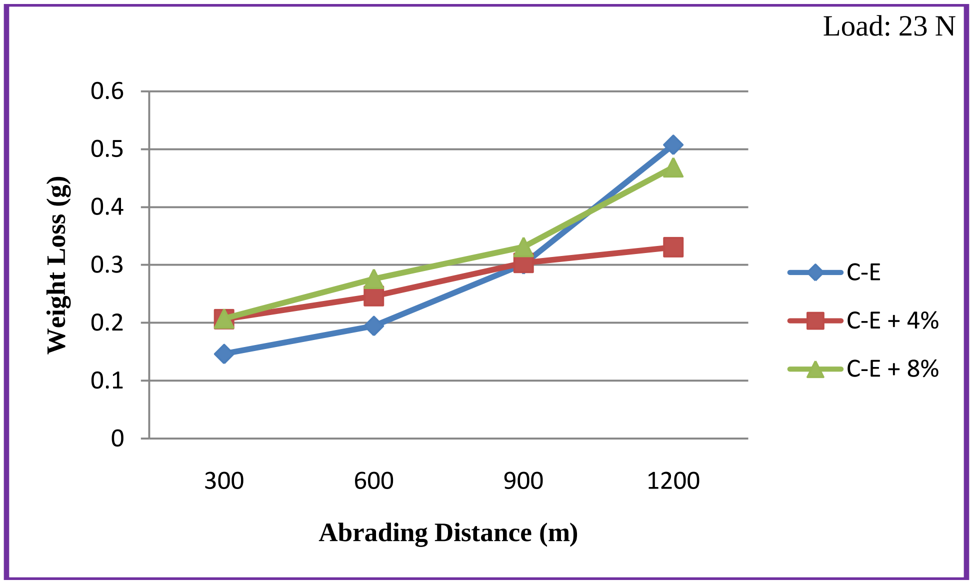

Fig 6. Weight loss Vs Abrading Distance at 23N Load for C-E Composites

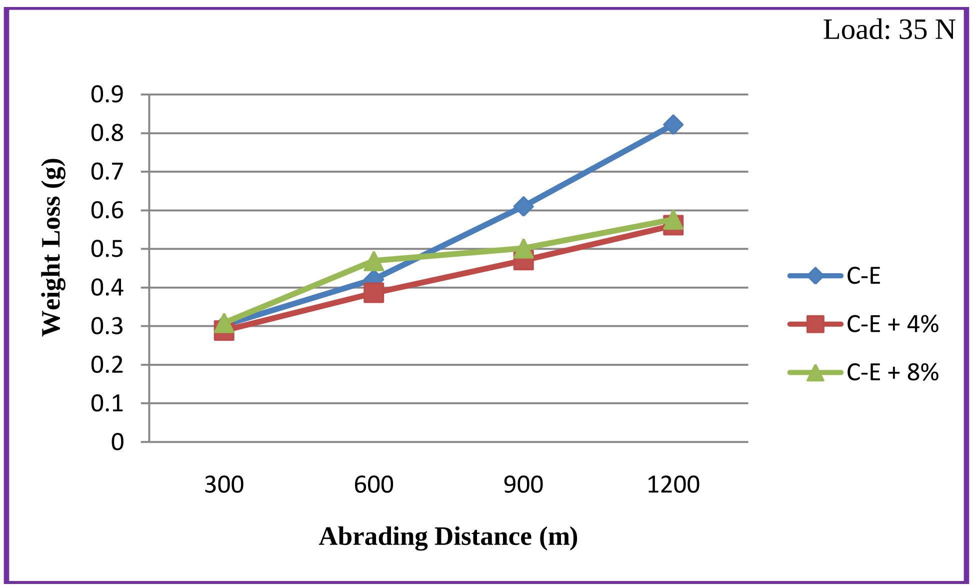

Fig 7. Weight loss Vs Abrading Distance at 35N Load for C-E Composites

Figures 8, 9 and 10 show the variation of specific wear rate as a function of abrading distance for C-E composites with and without filler. These figures indicate that the specific wear rate generally showed a decreasing trend with increased abrading distance. C-E composite with 8% filler showed maximum specific wear rate of 1.8234m^3/Nm for a load of 23N at an abrading distance of 300m, whereas C-E composite with 4% filler showed the least specific wear rate of 0.2135m^3/Nm at a load of 23N and an abrading distance of 1200m.

Also it can be observed that the specific wear rate for C-E composites without filler and with 8% MoS_2 filler showed no definite trend of variation with increased abrading distance, whereas specific wear rate for C-E composite with 4% filler marginally decreased with increased abrading distance for all the loads suggesting that 4% MoS_2 filled C-E composite showed stable wear characteristics as compared to other two.

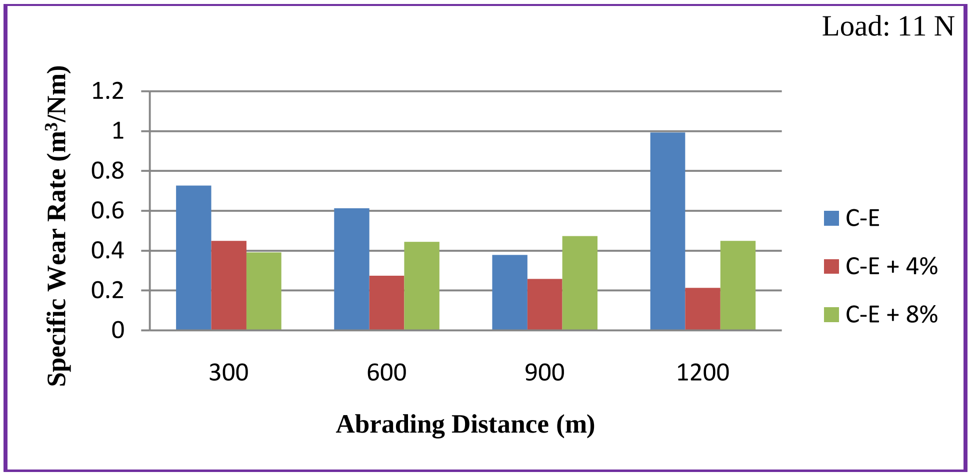

Fig 8. Specific Wear rate Vs Abrading Distance at 11N Load for C-E Composites

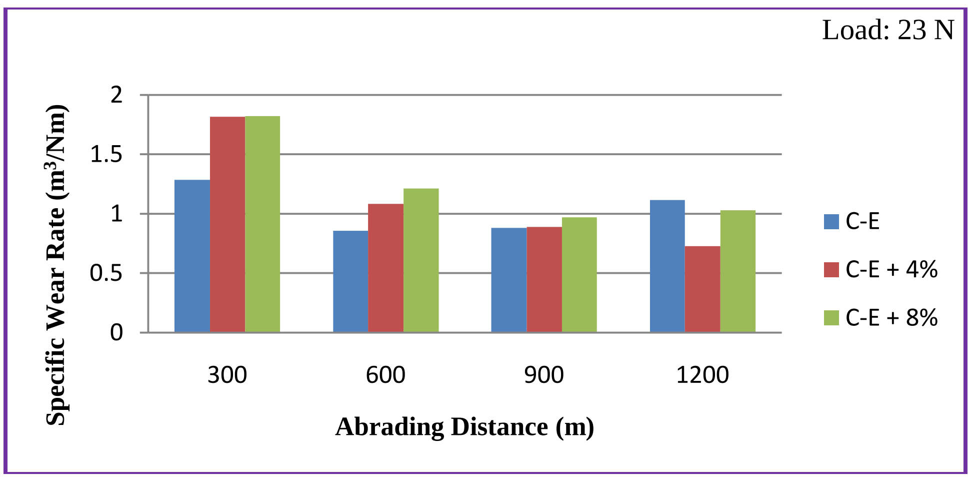

Fig 9. Specific Wear rate Vs Abrading Distance at 23N Load for C-E Composites

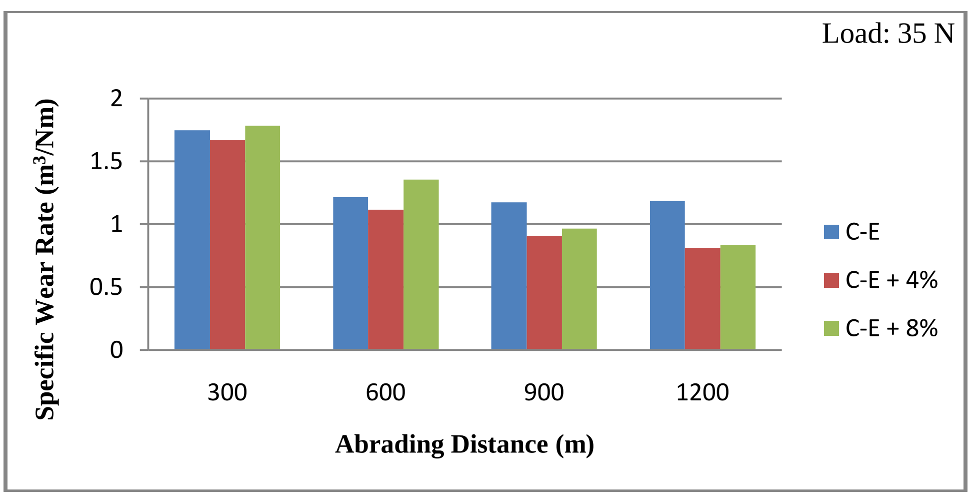

Fig 10. Specific Wear rate Vs Abrading Distance at 35N Load for C-E Composites

Conclusion:-

The primary reason for reinforcing fibers and adding fillers to polymer are to improve their wear characteristics. An experimental study of dry sand abrasive wear test on the carbon fiber reinforced epoxy composite with and without MoS_2 filler at different loads and sliding distance revealed the following characteristics:

Abrasive wear of carbon fiber reinforced epoxy composite was strongly dependant on the test parameters such as load and sliding distance. Comparative wear performance of different composites showed increased weight loss and decreased specific wear rate with increased load and abrading distance. MoS_2 filler provided better abrasion resistance to composite as compared to unfilled ones. Also wear rate decreased with increased filler content. Best abrasive wear characteristics were obtained for the C-E composite with 4% MoS_2 filler

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