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The Wear & Friction Characteristics of Glass-Epoxy Composites for Coal Handling Parts in Thermal Power Plants

Bharathi V*, Ramachandra M*, Srinivasa S*, Sampathkumaran P**,
Vynatheya S** and Seetharamu S**

The comparative performance of plain Glass-Epoxy (G-E) system with graphite(2.5wt.%) as filler has been reported for slide wear and friction behavior using pin-on-disc setup under varying loads and sliding velocities. This material is intended for use in coal handling systems. Besides slide wear and coefficient of friction (μ) measurements, examination of worn surface features by scanning electron microscope has been carried out to support the slide wear data. The slide wear data reveal that with increase in sliding speed, wear loss of both G-E composite and G-E plain system increase. Further it is seen that the G-E graphite filled system shows the least wear loss compared to plain G-E system. This trend is observed for all the three loads employed in this work. It is observed that the graphite bearing and plain G-E samples display a rise in the value of μ, when both load and sliding velocity are increased. The coefficient of friction of graphite G-E shows the least compared to plain G-E system irrespective of the load and the sliding velocity employed.

Keywords *Glass-epoxy (G-E), Pin-on-disc, Sliding wear, Graphite filler, SEM observations*

1.0 INTRODUCTION

The epoxy resin being a liquid thermo-set variety exhibit low viscosity easy curing, low shrinkage, high adhesive strength, high mechanical properties, high electrical insulation, good chemical resistance and versatility. On the other hand solid epoxy resins exhibit air curing, low shrinkage, high resistance to chemical attack, good aging and damping characteristics, high resistance to wear and heat, low flammability and co-efficient of friction, low susceptibility to stress crack formation and high strength to tensile and vibrational loading [1].

Some functional additives are added to the epoxy resins in various forms to enhance the performance. They include curing agents like thinners, flexibilizer, coolants, fillers etc. G-E resin contains organic or inorganic fibers in the form of chops, woven cloth, paper or laminars in addition to the functional additives [2]. The epoxy resins find their extensive application as varnishes for electrical and electronic equipment. Besides this, the low wear resistance and friction offered bypolymer composite system makes it suitable for thermal power plants application especially in coal handing equipments.

They are employed in motors, generators, transformers, switchgear, bushings and insulators [3]. The epoxy resins have excellent electrical insulting properties and protect the electrical components from short circuiting, dust and moisture. In the electronics industry, epoxy resins are primarily used for molding integrated circuits, transistors and hybrid circuits and making printed circuit boards. The epoxy resins are used to bond

*Department of Mechanical Engineering, BMS College of Engineering, Bangalore-560019. India. E-mail: vb_niharika@yahoo.co.in
**Materials Technology Division, Central Power Research Institute, Bangalore – 560 080. India. E-mail: psampathkumar29@yahoo.com

copper foil to circuit board substrates, and they form a component of the solder mask on many circuit boards.

The GE based polymer composites finds its use in thermal power plants as liner materials in coal hoppers/chutes/feeders/bunkers as they possess low friction and low wear rate. This would aid smooth flow of coal and also improve the wear characteristicsin coal handing parts compared to conventional material namely carbon steel. Continuous usage of coal in thermal power plants calls for durability and effective performance of coal handling parts.

Many researchers have reported on the wear and friction aspects of G-E composites and they have employed various fillers viz., organic, inorganic, ceramic materials in improving the sliding wear resistance of the G-E composites. The published information on the effect of fillers such as carbon fibers, silicon dioxide and silicon carbide particles on sliding wear behaviour in G-E composites have shown improved wear resistance over unfilled ones. Some of the research work carried out by others was concentrated on the effect of more than one type of filler on the slide wear performance in hybrid G-E composites[4-8]. It is known that the organic filler i.e., graphite employed in epoxy matrix with glass fibers as reinforcement material gives raise to good tribological properties as graphite is known to be good solid lubricant. Hence the present work focuses on the influence of graphite filler in G-E system on the wear & friction characteristics in comparison with G-E sample without filler addition.

2.0 MATERIALS AND METHODS

A hand layup procedure was adopted for making plain and graphite bearing G-E composites [9]. The reinforcement material used was a 7 mil E glass plain woven fabric with epoxy compatible finish. LY 556 epoxy resin with HY 951 grade room temperature curing hardener with diluent DY 021 (both supplied by Hindustan Ciba Geigy) was used as the resin mix for the matrix material. The layup procedure consists of placing the glass fabric on a release agent coated base plate over which resin smearing was done. The upper and lower faces had a surface matte to have smooth surface finish. Use of spacers helped in obtaining laminates of the required thickness. The procedure was common for making both plain and graphite bearing G-E composites. The procedure used for graphite bearing G-E laminate was to employ a 300 mesh, 99.99 purity graphite powder and the 2.5 wt. % of the same is used to smear on two chosen layers while making the layup. These were roughly ¼th and ½ thickness positions. Both the plain and graphite bearing laminates were pressed in a compression unit at about 60 psi (0.4 N / mm^2). The curing time was well over a day. These two materials have been designated as follows.

1. Glass – Epoxy plain system : G-E
2. Glass – Epoxy with 2.5 wt.% graphite filler : G-E + g

The laminates were cut using a diamond tipped cutter to yield smaller sized and smooth finished surface test samples of size 6mm X 6mm X 3mm for performing the slide wear tests on pin-on-disc machine.

2.1 Test set up and wear runs

The slide wear test set up used in this investigation is a pin-on-disc machine [10]. The sample under investigation is glued using suitable adhesive to a grooved pin of size 6 mm diameter and 25 mm length. The sample size used is 6 x 6 x 3 mm. The sample assembly is fixed to the holder and it is dead weight loaded. The samples were made to rotate over hardened alloy steel disc (count face) of hardness HRC 62 with surface finish 10 µm.

The coefficient of friction is determined by dividing the frictional load by the normal load applied to the sample. The mounting arrangement of the G-E sample is made in such a way that the thickness side of the laminate containing the lay-up consisting of glass fiber with epoxy resin system is made to come in contact with the disc. The initial weight of the pin assembly is noted in each test using a sensitive electronic digital weighing balance. The test is conducted for the load of 30, 50 and 70 N, sliding velocity of 2, 3 and 4 m/s and sliding distance adopted in the range of 0.5 – 5 km. Following the completion of the test, the pin assembly is weighed accurately again using the same balance. The weight changes, due to wear runs of the sample were recorded.

3.0 RESULTS AND DISCUSSION

Figures 1 and 2 show the slide wear loss for G-E and G-E+g systems for varying sliding velocity respectively. Figures 3 and 4 show the coefficient of friction for G-E and G-E+g systems for varying load and sliding velocity respectively. Figures 5,6 and 7 show the slide wear features of G-E system for varying loads. Figures 8, 9 and 10 show the slide wear features of G-E+g system for varying loads.

3.1 Slide wear

Figures 1 and 2 show the slide wear characteristics of G-E and G-E+g systems respectively. It is observed that the slide wear loss increases with increase in load from 30-70 N and sliding velocity 2-4m/s. Further, it is observed that G-E+g sample exhibits the least wear loss irrespective of the load and sliding velocity adopted. The slide wear data gets good support from the SEM worn surface features. The percentage of increase in slide wear resistance of G-E+g system for 30N load and 2m/s is 70% and for the G-E system the decreases in slide wear resistance at 70 N load and 4m/s sliding velocity is 41%. The low wear rate displayed by G-E+g will be a promising material which finds suitability as liners for wear resistance application in coal fired power stations.

3.2 Coefficient of Friction

Figures 3 and 4 display the coefficient of friction in respect of G-E and G-E+g systems for different loads (30, 50 and 70N) and sliding velocities (2,3 and 4 m/s). It is again observed that with the increase in load and sliding velocity, both the G-E and G-E+g systems show increase in coefficient of friction. However the G-E + g exhibits lower coefficient of friction compared to G-E for all loads and sliding velocities. Thus low friction exhibited by G-E+g may be appropriate as liner material.

3.3 SEM observations

The Figures 5 – 7 and Figures 8 – 10 show the worn surfaces of G-E and G-E+g samples for 30, 50 and 70 N loads respectively. When the Figures 5 and 8 arecompared, G-E+g shows less debris formation, less fiber exposure and less fiber breakage compared to G-E. As the load is increased from 30 to 50N, because of more heat and friction G-E sample exhibits higher matrix distortionas well as agglomeration of debris (Figure 6). Further, increase in load up to 70N caused greater amount of breakage of fibers and soft matrix deformation.Debris formed turn into masses due to increased heat and friction. This finally results in delamination in G-E system compared to G-E+g system (Figure 7)

Thus in summary, the graphite filler addition to G-E has contributed to lower coefficient of friction and lower wear loss. The SEM pictures featuring worn surfaces of G-E and G-E+g support the slide wear data displayed in Figures 1 and 2 respectively.

4.0 CONCLUSIONS

The important findings that emerge from this work are given below.

- The graphite addition of 2.5% by wt. to G-E system has significantly contributed to lower slide wear loss compared to G-E sample. This is true for all loads and sliding velocities employed.
- The coefficient of friction also shows a trend similar to the slide wear loss data emphasizing the fact that the co-efficient of friction is always lower for G-E+g system compared to G-E system irrespective of load or sliding velocity adopted.
- It is desirable to use the graphite filler in G-E system to reduce the wear loss and coefficient of friction as it enhances the life of liners in coal hoppers/chutes/bunkers in thermal power generation. The higher graphite (greater than 3 %) addition in G-E system influencing wear and friction requires further experimental investigation.

- Thus selection of liner material for coal handling parts in thermal power plants plays a major role in the direction of reducing friction and sliding wear rate. Ultimately material properties govern the performance and hence reflect their importance.

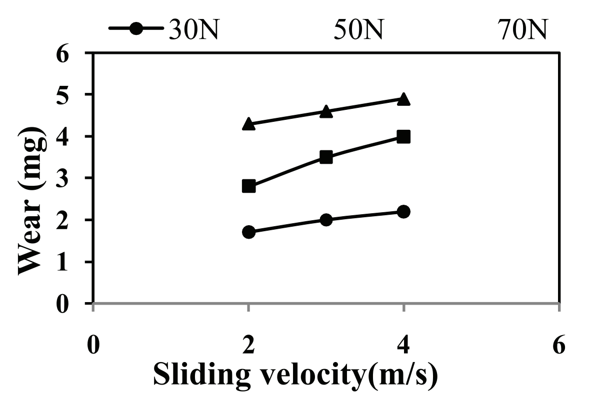

FIG. 1 PLOT OF SLIDE WEAR LOSS V/S SLIDING VELOCITY FOR G-E SYSTEM

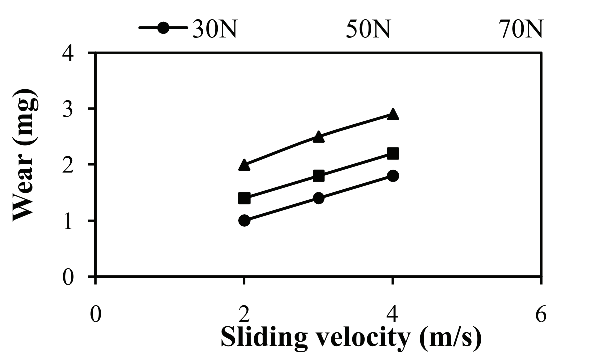

FIG. 2 PLOT OF SLIDE WEAR LOSS V/S SLIDING VELOCITY FOR G-E + G SYSTEM

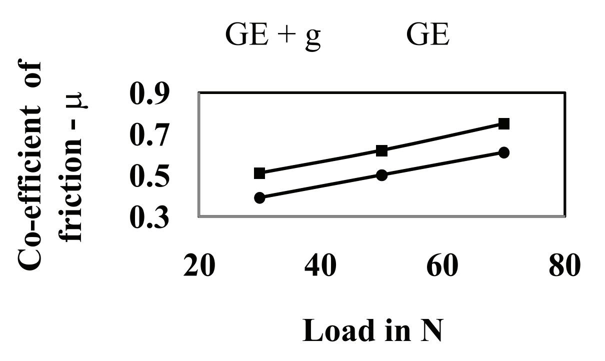

FIG. 3 PLOT OF CO-EFFICIENT OF FRICTION V/S LOAD FOR G-E AND G-E+G

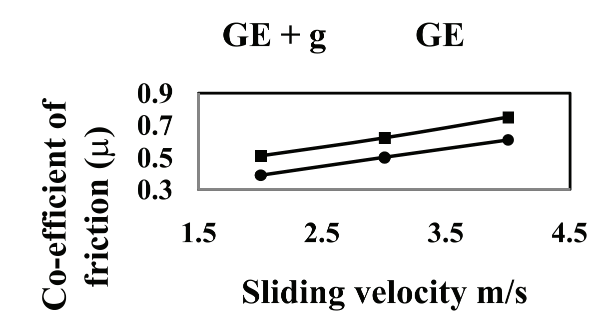

FIG. 4 PLOT OF CO-EFFICIENT OF FRICTION V/S SLIDING VELOCITY FOR G-E AND G-E+G

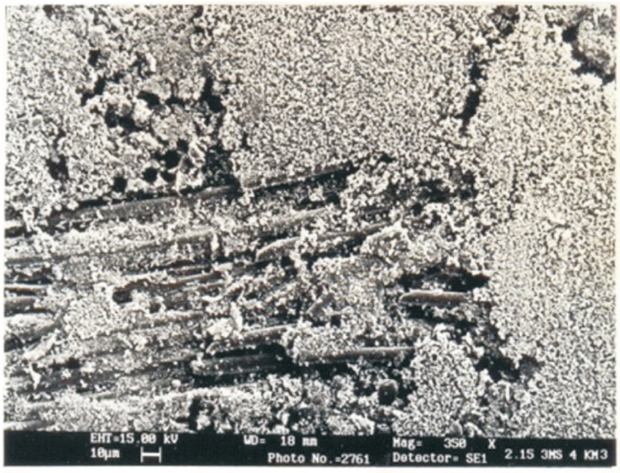

FIG. 5 SLIDE WEAR FEATURES OF G-E SYSTEM FOR 30 N LOAD

FIG. 6 SLIDE WEAR FEATURES OF G-E SYSTEM FOR 50 N LOAD

FIG. 7 SLIDE WEAR FEATURES OF G-E SYSTEM FOR 70 N LOAD

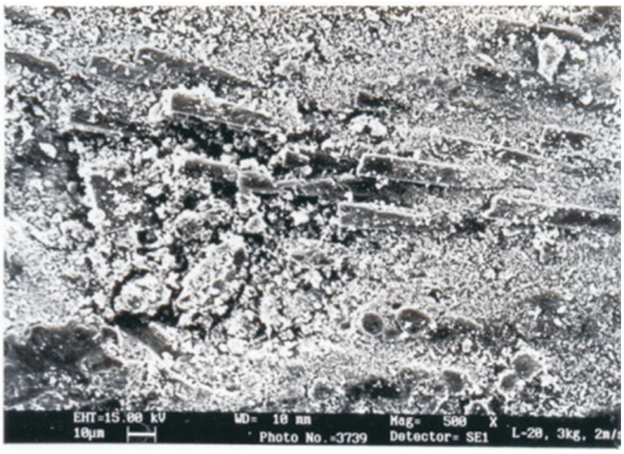

FIG. 8 SLIDE WEAR FEATURES OF G-E + G SYSTEM 30 N LOAD

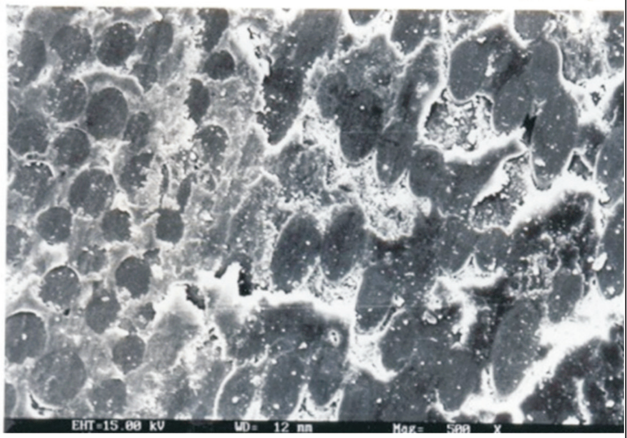

FIG. 9 SLIDE WEAR FEATURES OF G-E + G SYSTEM 50 N LOAD

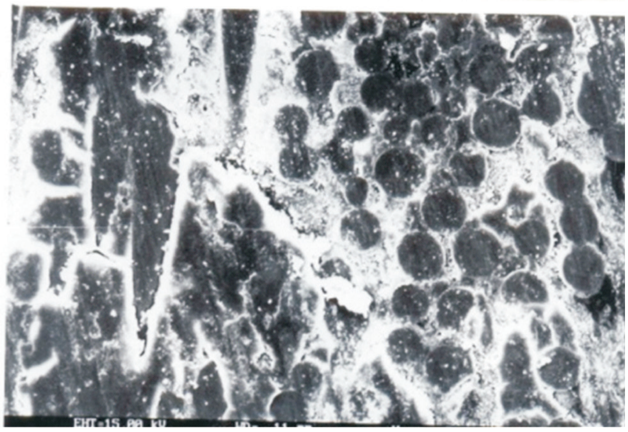

FIG. 10 SLIDE WEAR FEATURES OF G-E + GSYSTEM FOR 70 N LOAD

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