Dry Sliding Wear of Coconut Shell Powder Filled Glass Fiber Reinforced Polymer Composites

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Abstract - *—This paper presents the friction and wear behavior of GFRP (glass fiber reinforced polymer) composites fabricated by vacuum bagging process (glass fiber reinforced with Ly 556 epoxy resin). Composites were experimentally investigated under dry sliding environment. Wear tests conducted on a pin on disc type tribometer and EN3I steel as counter body sliding under dry environment ,the loads and sliding velocities varied from 20 N to 60 N and 3 m/s to 5 m/s respectively. A complete distance of 1 km and 3 km was attained. Experimental results depict that coefficient of friction and rate of wear increases with increase in velocity and normal loads for dry environment. Results also shows wear rate increases with increase in sliding distance. SEM analysis of the worn surfaces reveals that the high wear in dry environment results from an easy separation of fibers from the polymer matrix under high friction which leads to bending of fiber at the end.*

Keywords*:* **Tribology, Sliding Wear, Polymer Matrix Composite, Wear resistance.**

1.INTRODUCTION

There is tremendous use of composite materials since ancient times. Almost in every industry composite plays an important role ,it is mainly used in automobile and aircraft industries for manufacturing of various products [1] and some of these do require an understanding of their tribological characteristics also. Composites are more preferred over other materials due to their higher strength to weight ratio and other characteristics.

Epoxy when reinforced with glass fiber and mixed with hardener enriches the properties of epoxy, yet the glass-fiber- reinforced polymer (GFRP) category needs more and more research for enhancing its usage in light of its promise in terms of engineering application capabilities. Being comparatively of lower density and easily shapeable these may be prepared into different sequences of stacking to attain high strength and stiffness for heavy loadings(2-3) . Some additional mechanisms noted are fiber pull out, pealing of the resin, matrix wear associated to fiber separation, deformation of the edges of the wear track and shear deformation of the fibers(4-6). Prior research by other investigators has shown that when the polymer resins are reinforced with glass, carbon or any other fiber, the wear rate depends on various parameters like size, shape, materials

2.EXPERIMENTAL DETAILS

2.1 Composite fabrication

Composite specimens were prepared using glass fibers and epoxy resin matrix material, (Epoxy resin Ly-556 , Hardener K-6 and coconut shell powder). GFRP is a good engineering material with high impact strengths; moldable, high strength to weight ratio and that is also desirable in commercial applications due to lower cost.

The GFRP epoxy resin composite plates having dimensions 300mm*300mm*3mm were prepared by the vacuum bagging process . To attain 3 mm nominal thickness, eight layers of glass fabric were used. We used a stacking sequence, $[0°/ \pm45°/ 90°]_s$. During wear and friction experiments the surface which was in contact with steel disc having a 0° fiber orientation.

2.2 Experiment

Sliding Friction and wear tests were performed using pin on disc apparatus .Counter disc used was steel disc of EN31 hardened to 60HRC having Ra values between 0.2 to 0.3.The loads and sliding velocities varied from 20N to 40N and 3m/s to 5m/s respectively. A complete distance of 1km and 3km was attained with two different speeds and track diameter. All sets of experiments were conducted two times in the same manner and average weight loss was taken for calculation of specific wear rate.

Wear loss and coefficient of friction for different load were tabulated in table (Table 1 &2)

2.3Wear and friction properties

GFRP specimen N=955 rpm T=10 min,track dia = 100 mm, v=5 m/s

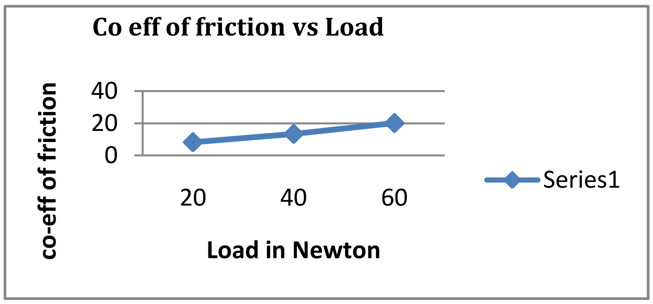
Table 1

Load (N)	Sliding distance (m)	Wear loss (mg)	Coefficient of friction
20	3000	1	8.2
40	3000	2	13.38
60	3000	4	20.15

LOAD (N)	Sliding distance (m)	Wear loss (mg)	Coefficient of friction
20	3000	3	7.78
40	3000	2	16.98
60	3000	8	19.7

Coconut shell powder (csp) filled GFRP specimen, N=955 rpm, T=10min, v=5m/s

Table 2



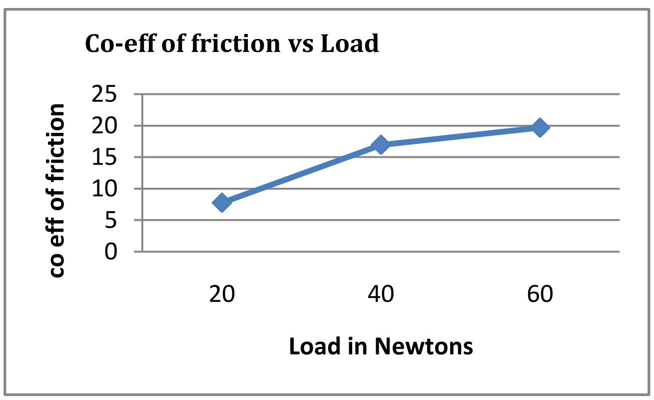


Chart1(a): Coefficient of friction v/s Load of GFRP composite

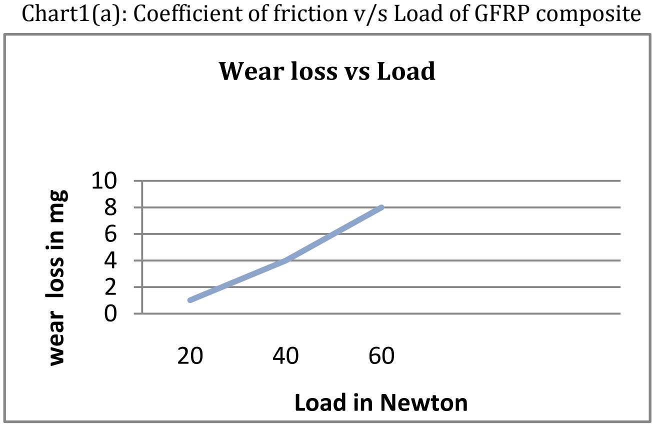


Chart1(b): Coefficient of friction v/s Load of GFRP composite

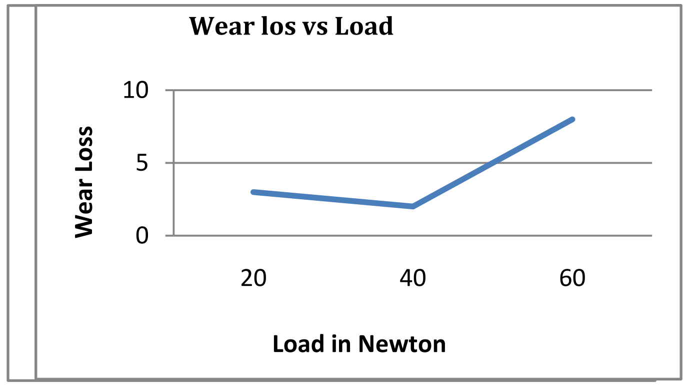


Chart2(a) wear loss v/s Load of (GFRP+CSP) composite

Chart2(b) wear loss v/s Load of (GFRP+CSP) composite

3. RESULTS AND DISCUSSION

Wear loss: Normal load, sliding distance and velocity of sliding are the main variables affecting the weight loss and friction. The weight loss in GFRP composite specimens was measured at 3 m/s and 5 m/s speeds and under 20N-40 N loads on dry environmental condition. The wear loss for all the composite specimens normally increased with the increase of normal loads at both of the constant sliding speeds of 3 m/s and 5 m/s, when the values of normal loads were increased from 20 to 40 N as can be easily seen from Fig.1(a) and 2(a)

During experiment it was observed that the specimen temperature had also increased with increase in normal load. Glass fibers embedded got more easily separated from the surface of the samples, and as a result, the weight loss increased with an increase in load and sliding speeds.

The wear mechanism of GFRP composite has two modes: the polymer matrix wear, which include matrix plastic deformation and cracks in the matrix and the fiber wear, which involve fiber sliding wear, fiber cracking, fiber rupture, and fiber pulverization.

Coefficient of friction: The obtained results of coefficient of friction are plotted in Fig. 1(b) and 2(b). The figure shows the deviations of coefficient of friction (average value at each experimental situation) with load and velocity of sliding under dry environmental conditions. Generally the coefficient of friction always increases if there is an increase in both load and sliding velocity. In dry sliding the relative motion of the mating surface does not permit the released soft debris (as in the inert gas sliding) to move out of the contact area. Up to a certain extent it allows a consecutive gathering of these wear debris over the contact surface of the GFRP laminate. Such wear debris is entrapped in between successive layers of composite.

3.1 SEM analysis of worn surface

Worn surfaces of composite samples were studied by SEM analysis primarily to understand and get insights into the process of wear. The effect of normal load and sliding velocity were seen from the microscope and the level of damage was analyzed. Fiber and matrix damage increased with increase in normal load on fibers and could be well correlated with wear performance. It could be observed systematically that how wear thinning of fibers (which is responsible for wear resistance of composites) diminished with increase in normal load and how fiber fracture and random dispersion of fiber debris increased with increase in normal load.

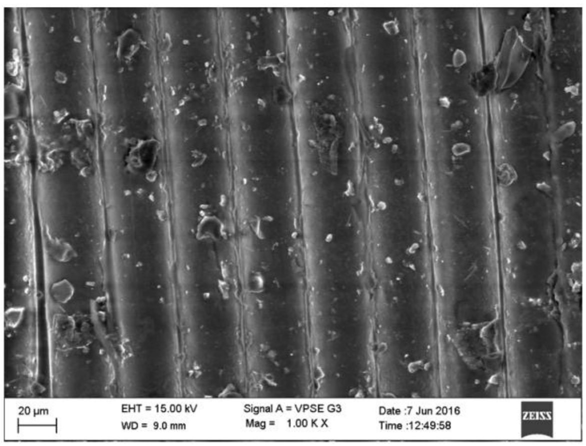


Fig: 1. SEM image of worn surface unreinforced glass epoxy composite

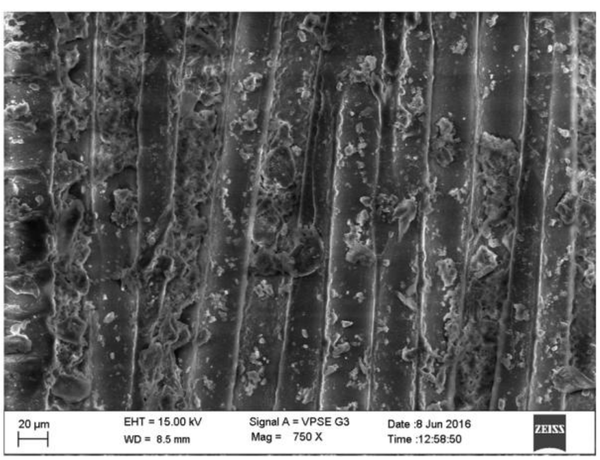


Fig: 2. SEM image of worn surface of coconut shell powder reinforced glass epoxy comp

4. CONCLUSION

After observing all the results obtained out of friction and wear experiments for the glass fibre reinforced polymer (GFRP) composite taken into the experiments, the following conclusions can be drawn:

1.The coefficient of friction of the composites tested was in the range of 7-20 sliding against steel under three stated environmental conditions.

2.Friction and wear behavior of a GFRP composite material is highly affected by the normal loads, sliding velocity and distance covered. The greater wear rates obtained in this case also are due to the significant role of the softened component of epoxy re

3.In dry sliding the values obtained for coefficient of friction are lying in between the other two medium options. These are obtained because of a consecutive deposition of soft debris resulting to soften the process of rubbing. The fibers undergo a slight bending at ends resulting in an easy shear effect. As a consequence, lower values for wear rate are obtained.

4.Microscopic analysis of the worn surfaces reveals that the high wear rate results from an easy separation of fibers from the polymer matrix under high friction.

5.An increment in normal load and velocity of sliding has invariably led to increased wear rate due to higher heat generation

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