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Sliding wear characteristics of Biaxial Glass Fiber with Epoxy/Al_2O_3/Sic hybrid Composites for journal bearing liner using Sea Water Lubricant

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Abstract: Composite journal bearings are becoming more popular now a day because they eliminate the possibility of seizure failure to the bearings. The major drawback of the metal bearings is the seizure failure. This failure is depends upon friction and lubricant used. To overcome this problem, the composite journal bearings are widely used by the industries. Hence, this paper presents the wear behaviour of Biaxial glass fiber reinforced with silicon carbide (SiC) and aluminium oxide (Al_2O_3) composite using sea water as lubricant. The test specimens are prepared and tested as per ASTM standard. The experiments are conducted by using a pin on disc wear tester. The results indicated that the wear resistance of the hybrid composite is better than that of the glass fiber. The fracture surface of composites shows the ductile tear ridges and cracked SiC and Al_2O_3 particles indicating both ductile and brittle fracture mechanism.In this study, different combinations based composite materials were comparatively investigated under actual loading, sliding distances and time frame to configure best suitable bearing materials. The hybrid composite are proven for clean functioning and shows remarkable life.

Keywords: Hybrid composite; sea water, reinforced fiber;wear rate; Sliding wear, friction.

1.Introduction

The sliding metal-to-metal contact wear can be observed in cams, gears, bearings, clutches and other applications involving sliding contact or rolling contact [1]. Composites is widely used in many automobile, aerospace and mineral processing components because of their excellent combination of low density and high thermal conductivity [2]. However, they suffer from poor wear properties. To overcome this, hard reinforcement phases, such as particulates, fiber, and whiskers (short fiber) which are well known for their high-specific strength, have been uniformly distributed [3]. Here the good ductility of the matrix material is retained while the modulus and strength of the composites have increased because of the reinforcement phase. Composite material structures are a synergistic combination of two or more reinforcements (constituents) that differ in physical form, chemical combination and are insoluble in each other. The objective of havingtwo or more reinforcements is to take advantage of the superior properties of both materials without compromising on the weakness of either [4]. In most cases, hard ceramic particulates such as Zirconia, alumina (Al2O3) and silicon carbide (SiC), have been introduced intoaluminium-based matrix in order to increase the strength, stiffness, wear resistance, corrosion resistance, fatigue resistance and elevated temperature resistance. Among these reinforcements, SiC is chemically compatible with aluminium (Al) and forms an adequate bond with the matrix without developing inter-metallic phase and has other advantages such as excellent thermal conductivity,high machinability, good workability and low cost [5–8].

The demand for lightweight, inexpensive and energy efficient materials has led to the development of aluminium matrix composites containing hard ceramic dispersed [9,10]. The results fromthe previous studies indicated that wear increases with the applied load. The composites failed under certain combination of load and speed. The load that caused failure during sliding is not fixed at a particular critical value but varied with respect to speed [11]. Sahin [12] indicated that the introduction of SiC particle into the aluminium exert a greater effect on wear, followed by applying load. The sliding distance is found to have a much lower effect. In addition, the interactions of SiC reinforcement/applied load and SiC reinforcement/sliding distance had a moderate influence on the abrasive wear while the interactions of reinforcement/ abrasive size, applied load/abrasive size, applied load/sliding distance and abrasive size/sliding distance had no significant effect.

2. Experimental

Fabrication Process

1. The major component of biaxial glass fiber is Epoxy LY556 (Resin).
2. Hardener HY951 is used for hardening and support.
3. Resin + Hardener are mixed in the ratio of 10:1 and the mixture made up is called MATRIX.
4. Glass cloth Bi-directional –(300GSM grams/meter sq.) 0.29mm thickness is used.
5. Tool is prepared by standard method.
6. Apply the matrix on glass cloth which is wrapped around the mandrel.
7. Ensure proper weighing is done.
8. Clamp the tool die for 2 hrs at ambient temperature condition.
9. The sample is then furnace heated at 100celcius for 2 hrs for hardening.
10. Take out and cool the specimen until room temp. is achieved.
11. Flash is removed from the sample.
12. Demoulding i.e. clamp is removed from the specimen.
13. Cut to appropriate dimension as per experimental needs
14. Emery paper of grade 60 is used to provide necessary surface finish.

The Figure1, Figure 2 and Figure 3 shows the biaxial glass fiber, mould cavity and hot air oven for preparing specimen.

Figure 1. Biaxial Glass Fiber

Figure 2. Mould Cavity

Figure 3. Hot Air Oven

Experimental Setup

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disc test rig shown in Figure 4. Materials are tested in pairs under nominally non-abrasive conditions. A pin on discis an instrument that measures tribological quantities, such as coefficient of friction, friction force, and wear volume, between two surfaces in contact.

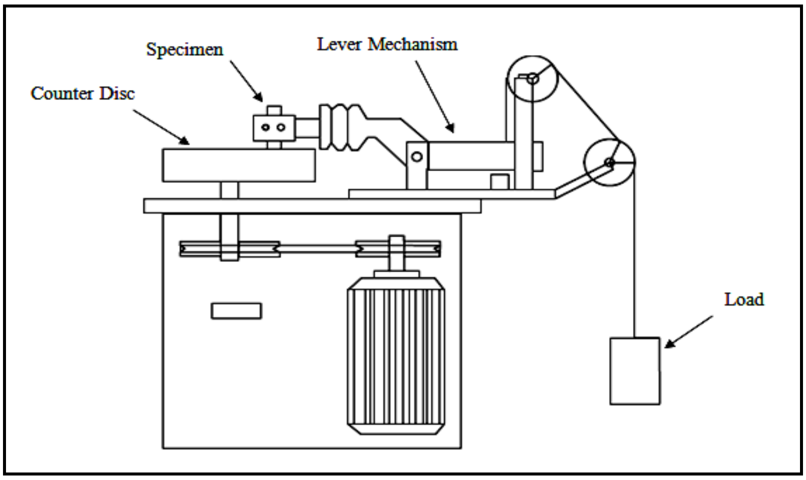

Figure 4.Pin-on-Disc Test Rig

Table 1 Test Rig Parameters

S.No	Description	Details
1	Speed	Min 200 rpm, max 2000 rpm
2	Normal Load	200N max
3	Frictional Force	200N max
4	Wear	± 2mm
5	Wear Track Diameter	Min 50mm, max 100mm
6	Sliding Speed	Min 0.3m/sec, max 10m/sec
7	Preset Timer	99/59/59 hr/min/sec
8	Specification Size (Pin)	Ø3,4,5,6,8,10 & 12mm
9	Wear Disc Size	Dia 165mm X 8mm Thick, EN-31 Hardened To 60hrc, Ground To Surface Roughness 1.6Ra
10	Environmental Chamber	This chamber prevents oil spillage and collects debris after test
11	Software	Winducom 2010
12	Software Interface	Comport

Procedure

A pin-on-disc test setup was used for slide wear experiments. The surface of the sample (5mm X 5 mm) glued to a pin of dimensions 10 mm diameter and 30 mm length comes incontact with a hardened disc of hardness 60 HRC. The counter surface disc was made of En31 steel having dimensions of 165 mm diameter, 8 mm thick and surface roughness (Ra) of1.6 µm. The test was conducted on a track of 115 mm diameter for a specified test duration,load and velocity. Prior to testing, the test samples were rubbed against a 600-grade SiCpaper. The surfaces of both the sample and the disc were cleaned with a soft paper soaked inacetone before the test. The pin assembly was initially weighed using a digital electronicbalance (0.1 mg accuracy). The test was carried out by applying normal load (50 N to 150 N)and run for a constant sliding distance (5000 m) at different sliding velocities. At the end of the test, the pin assembly was again weighed in the same balance. A minimumof three trials was conducted to ensure repeatability of test data. The friction force at thesliding interface of the specimen was measured at an interval of 5 minutes using a frictionalload cell. The coefficient of friction was obtained by dividing the frictional force by theapplied normal force.Experiments were done in two groups. The aim in the first group is to investigate the effect ofload and velocity on tribological behaviours while the aim in the second group is toinvestigate the effect of sliding distance and sliding time.The bearing velocities are kept in between 2.5-3 m/s and the bearing loading upto150N. The Figure 5. shows the sliding test with sea water lubricant.

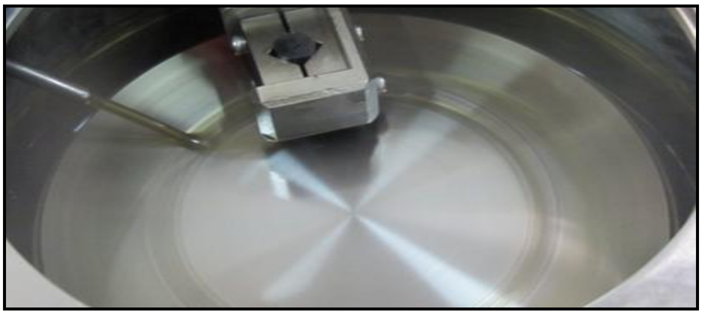

Figure 5. Sliding Test with Sea Water Lubricant

3. Results and Discussion

Results Related To Friction

1. At the beginning, the friction coefficient increases with the operating time, but after some time it reaches a stable value and this does not change considerably.
2. With increasing sliding distance,the friction coefficient values changes in close periphery and values lies in higher order for dry conditions.
3. Friction coefficient increases as working load increases, but this increase slows down as load increases.
4. Friction coefficient increases as the velocity increases. But this increase in the friction coefficient slows down as the velocity increases. The time needed to reach a stable value of friction coefficient does not depend on bearing pressure.
5. For dry testing conditions, coefficient of friction value ranges within 0.5 to 0.8 for different loading conditions and sliding distances.

Results Related To Wear

1. At the beginning of operation, wear increases quickly with the operating time. These times corresponds respectively 4.610 km sliding distance.
2. Under lubricated testing condition wear pattern increases considerably with sliding distanceWear rate increases as working load increases, but this increase is not gradual as load increases.
3. Wear increases as the velocity increases. But this increase in the wear rate slows down as the velocity increases.
4. For lubricated testing conditions, wear value ranges up to 210µm for different loading conditions.

The Figure 6, Figure 7 and Figure 8show that as the load increases, the wear with respect to time also increases. The wear is more for Glass fiber with Epoxy(GE) when compared to GE filled with Al_2O_3 and SiC.

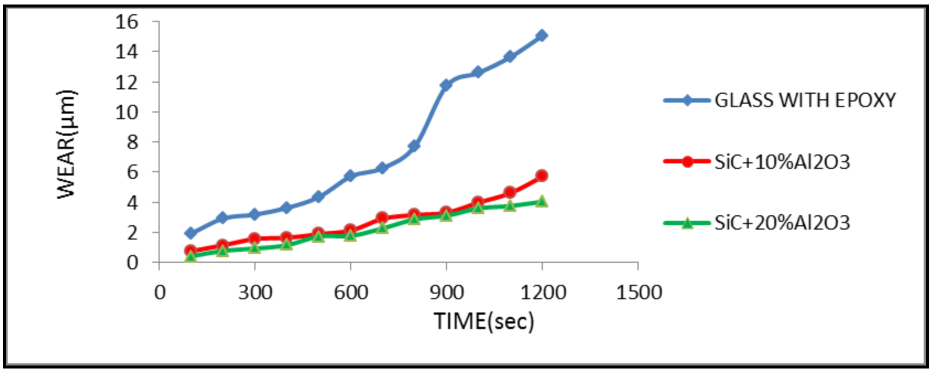

Figure 6.Lubricated, Load - 50 N, Speed - 572 Rpm, Duration - 20 Min

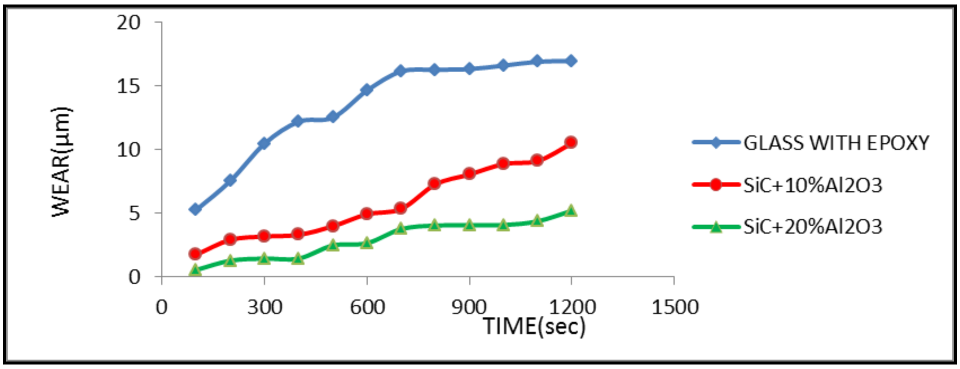

Figure 7.Lubricated, Load - 100 N, Speed - 572 Rpm, Duration - 20 Min

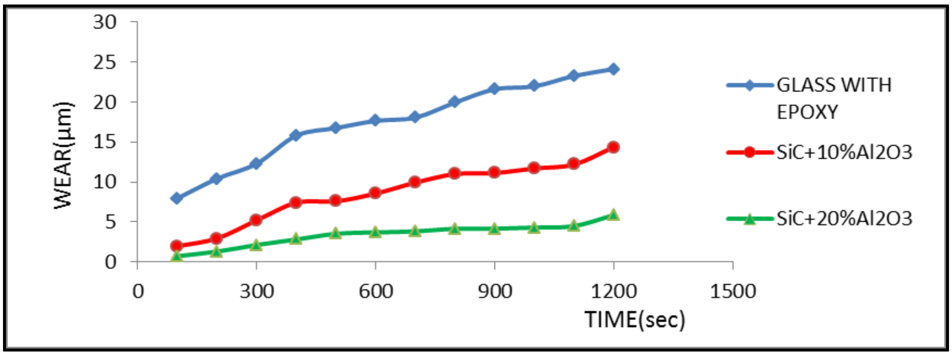

Figure 8.Lubricated, Load - 150 N, Speed - 572 Rpm, Duration - 20 Min

The Figure 9, Figure 10 and Figure 11 show that as the load increases, the coefficient of friction with respect to time also increases. But, the wear is more for glass fiber with epoxy when compared to GE filled with 10% of Al_2O_3 and SiCand 20% of Al_2O_3 and SiC. This shows that as the composition increases wear and coefficient of friction are get decreased.

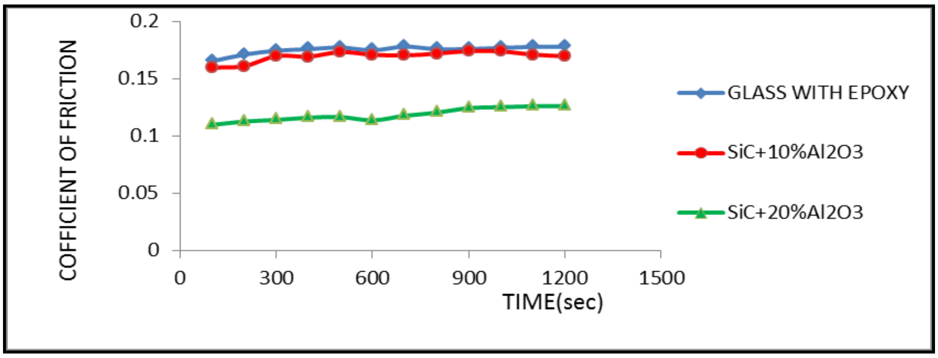

Figure 9.Lubricated, Load - 50 N, Speed - 572 Rpm, Duration - 20 Min

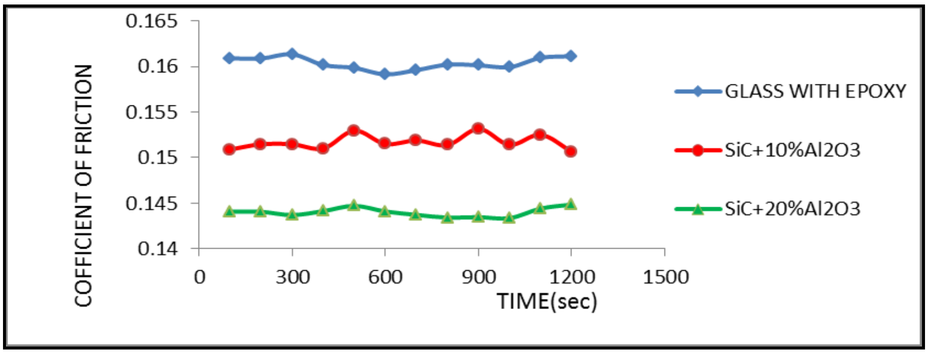

Figure 10.Lubricated, Load - 100 N, Speed - 572 Rpm, Duration - 20 Min

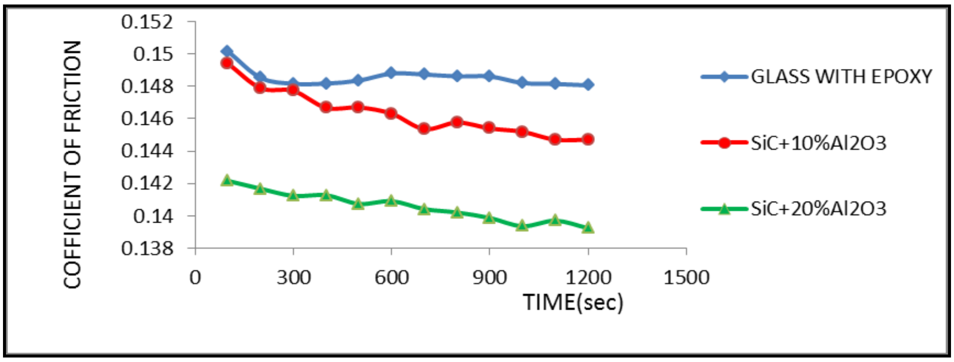

Figure 11.Lubricated, Load - 150 N, Speed - 572 Rpm, Duration - 20 Min

The Figure 12, Figure 13 and Figure 14 show that as the load increases, the wear with respect to time also increases. But, the wear is more for glass fiber with epoxy when compared to GE filled with 10% of Al_2O_3 and SiCand 20% of Al_2O_3 and SiC. This shows that as the composition increases wear is get decreased.

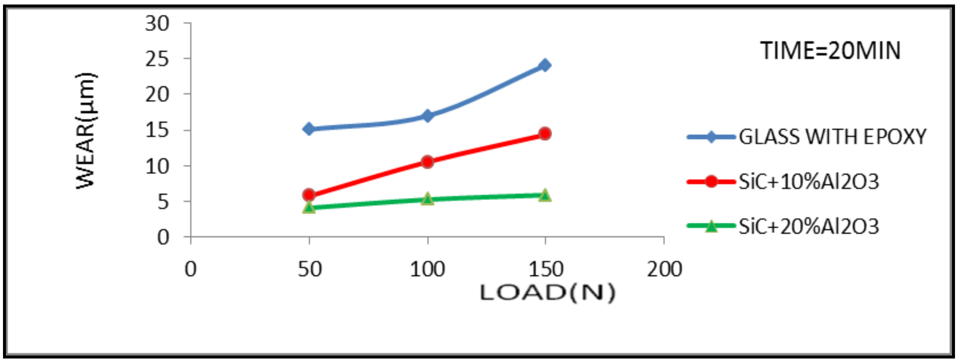

Figure 12.Lubricated, Speed - 572 Rpm, Duration - 20 Min

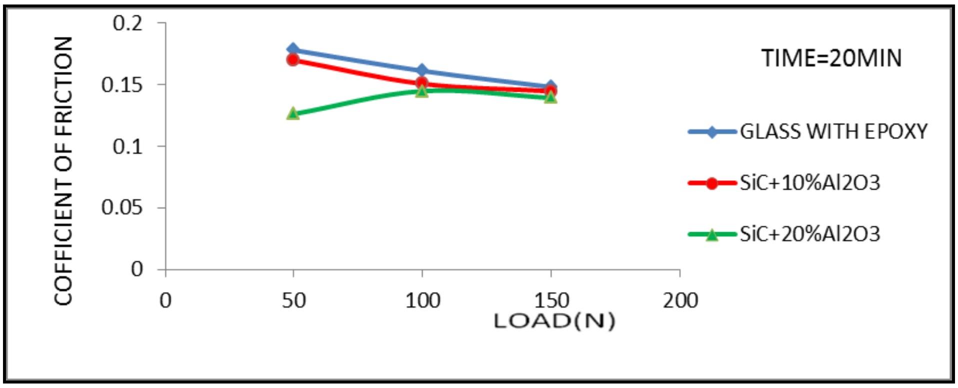

Figure 13.Lubricated, Speed - 572 Rpm, Duration - 20 Min

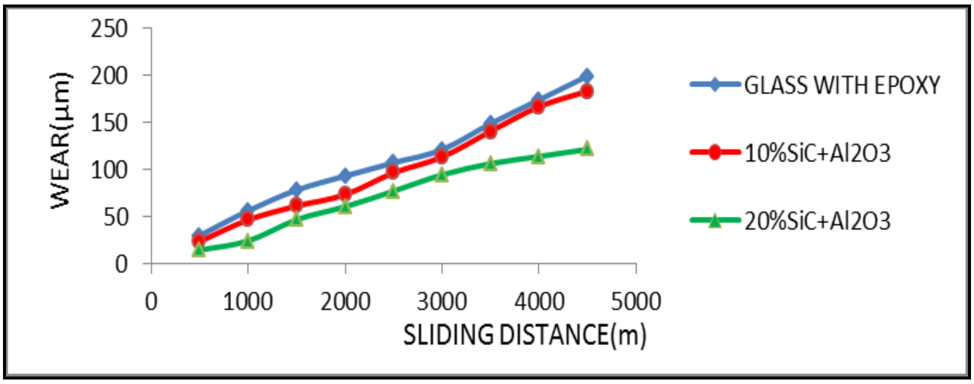

Figure 14.Lubricated, Load - 50 N, Speed - 572 Rpm, Velocity=2.9m/S

The Figure 15, Figure 16 and Figure 17 show that as the sliding increases, the wear also increases. But, the wear is more for glass fiber with epoxy when compared to GE filled with 10% of Al_2O_3 and SiCand 20% of Al_2O_3 and SiC. This shows that as the composition increases wear is get decreased.

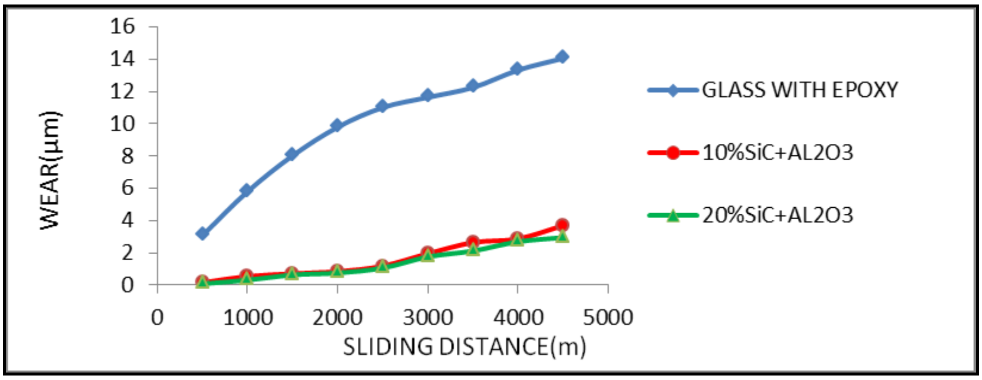

Figure 15.Lubricated, Load - 50 N, Speed - 572 Rpm, Velocity=2.9m/s

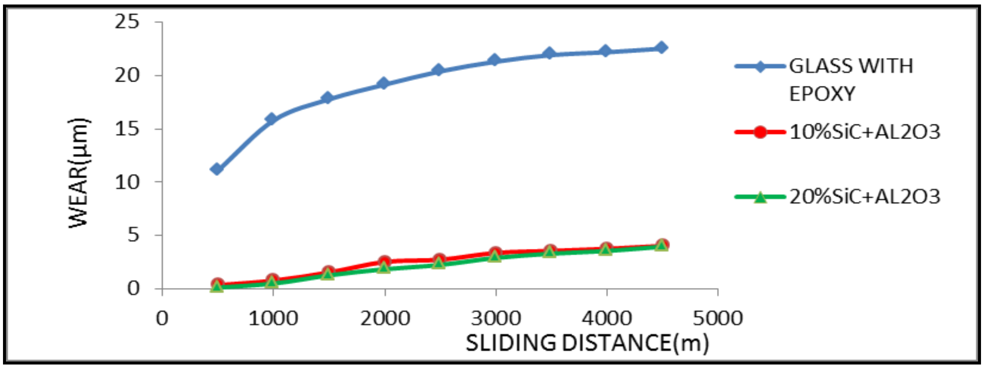

Figure 16.Lubricated, Load - 100 N, Speed - 572 Rpm, Velocity=2.9m/s

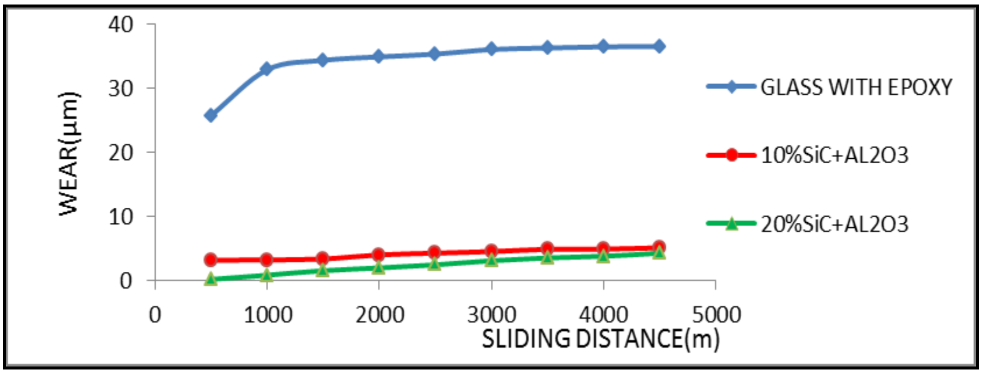

Figure 17.Lubricated, Load -150 N, Speed - 572 Rpm, Velocity=2.9m/s

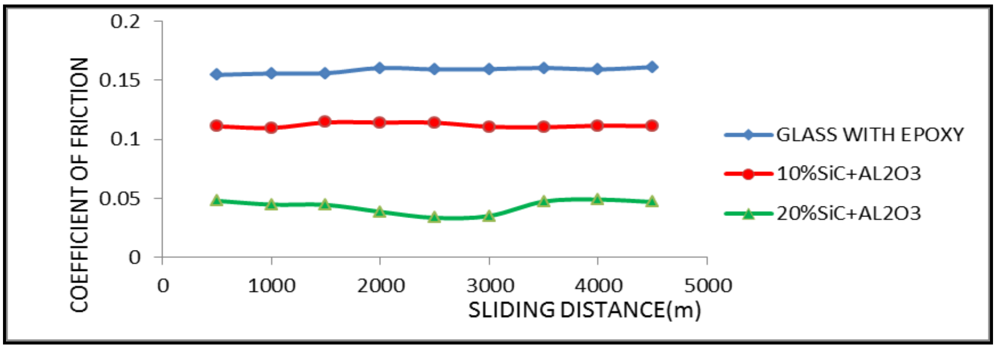

Figure 18.Lubricated, Load -50 N, Speed - 572 Rpm, Velocity=2.9m/s

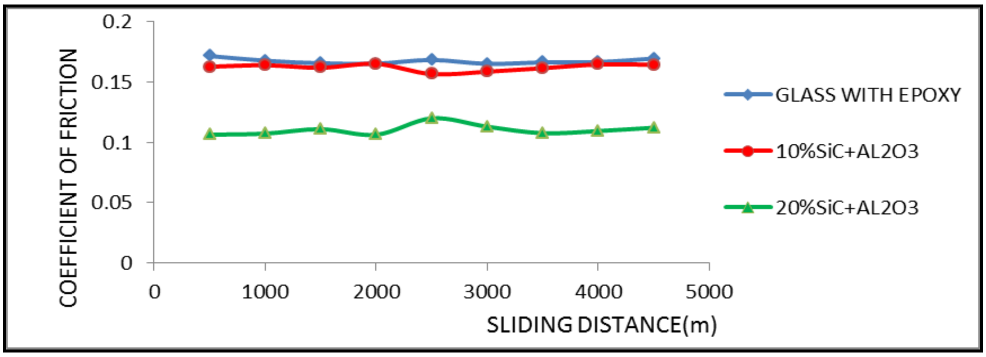

Figure 19.Lubricated, Load -100 N, Speed - 572 Rpm, Velocity=2.9m/s

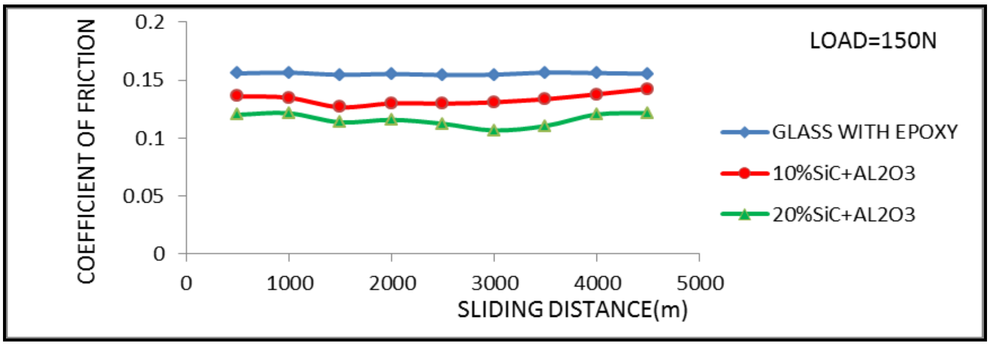

Figure 20.Lubricated, Load -150 N, Speed - 572 Rpm, Velocity=2.9m/s

The Figure 18, Figure 19 and Figure 20 show that as the sliding distance increases, the coefficient of friction with respect to load also increases. But, the wear is more for glass fiber with epoxy when compared to GE filled with 10% of Al_2O_3 and SiCand 20% of Al_2O_3 and SiC. This shows that the composites having excellent self-lubricating property.

The Figure 21 Shows 3D Plot of Wear Vs Volume Fraction Vs Sliding Distance and Figure 22 Shows 2D Plot of Wear Vs Volume Fraction Vs Sliding Distance. From the plots, it finds that wear is less, when the volume fraction is increased.

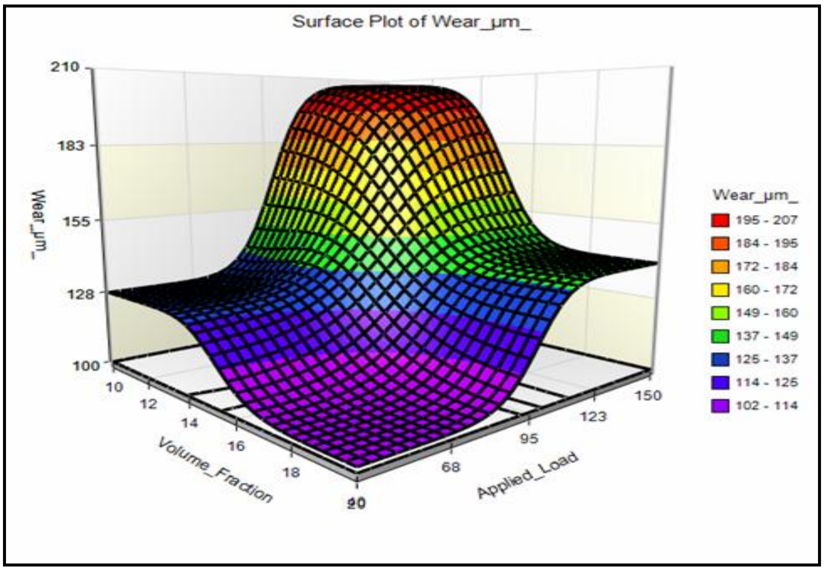

Figure 21.3D Plot of Wear V_s Volume Fraction V_sSliding Distance

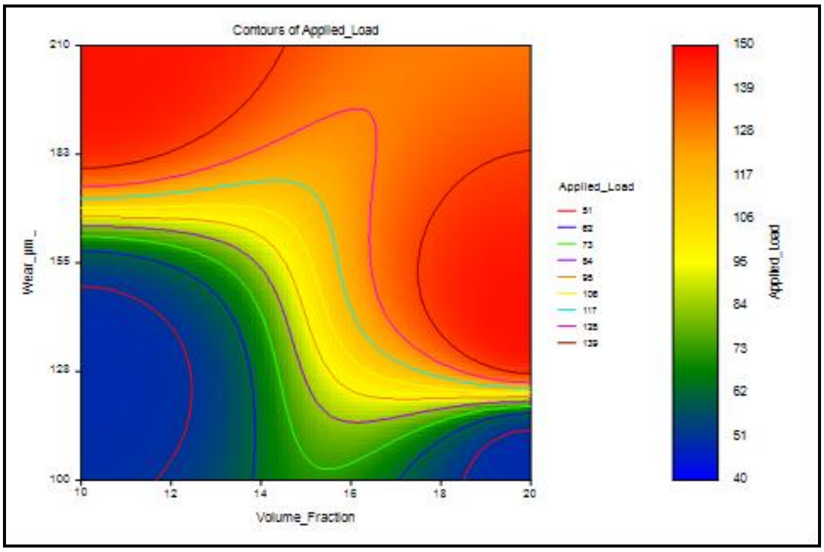

Figure 22. 2D Plot of Wear V_s Volume Fraction V_sSliding Distance

5. Conclusion

In this study, the biaxial glass fiber epoxy manufactured and tested under various conditions and the results are compared. The experiment is conducted to analyze the behavior of composite and it is suggested to be used for manufacturing of journal bearing liner. The various graphs among different parameters like coefficient of friction, sliding velocity, load which influences material performance are plotted. After the complete analysis of the results it was concluded that,the materials made of glass fiber with epoxy resin exhibits good performance. From the results it was observed that, the coefficient of friction was very less, and hence heat generation was also less.

The following points are drawn from the above study.

- Inclusion of Graphite, Al_2O_3 and SiC particulate fillers contributed significantly in reducing friction and exhibited better wear resistant properties.
- Al_2O_3 and SiC particulate carbide filled G-E composite shows higher resistance to slide wear compared to plain G-E composites.
- There has been an observed marked improvement in wear resistance as seen inAl_2O_3/SiC G-E composite sample compared to plain G-E sample.
- G-E composite shows highest coefficient of friction compared to the other two samples.
- Increased wear resistance and reduced coefficient of friction are positive traits, which make the composite suitable to be used as liners in bearings.

Hence, under the sea water lubricating conditions the composites showed the good tribological characteristics due to the good thermal property of epoxy resin and self-lubricating characteristics of glass fiber.

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