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Tribological Wear Behaviour of Journal Bearing on PEEK Composites.

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Abstract- **The present experimental study work is aimed at developing a new material for industrial application from product quality and identification surveying sugar factory from nearby areas. In the present investigation the effect of surface texturing on tribological properties of PEEK composite material considering various texture patterns so as to observe the comparative friction and wear behaviour of PEEK composite with surface texturing on mating surface at dry lubrication condition by using a pin-on-disc Tribometer. The wear resistance can be significantly improved by texturing & addition of some filler materials. Therefore in the present investigation the effects of square surface texturing pattern with 10%, 20% & 30% dimple density on AISI SS 304 disc is studied at varying load & sliding velocity by using TR20LE Tribometer. The results show that the coefficient of friction varies considerably with surface texture density (10%-30%), load (13.63kg-17.51kg), velocity (0.070m/s-0.1.2m/s). It is concluded that minimum wear obtained at dimple density 30% for material A at velocity- 0.102 m/s & load- 17.34Kg, similarly for material B dimple density 20% at velocity- 0.086 m/s, load- 15.48Kg.**

Index Terms--**Wear, Friction, Journal Bearing, dimples, PEEK Composite**.

I. INTRODUCTION

Composite materials are used in large volume in various engineering structures including spacecrafts, airplanes, automobiles, boats, sports' equipments, bridges, buildings and Industry. Widespread use of composite materials in industry is due to the good characteristics of its strength to density and hardness to density. If methods has raised application range of these materials. Application of composite materials was generally use at manufacturing industry. Meanwhile, the automotive industry considered as a mother one in each country, has benefited from abilities and characteristics of these advanced materials. Along with progress in technology, metallic automotive parts are replaced by composite ones. A Properly installed and maintained, journal bearing should have infinite life. It permits a relative motion between the contact surfaces of the members, while carrying the load with little loss of power due to friction. In order to reduce the frictional resistance and wear, and to carry away the heat generated, a layer of fluid which is known as lubricant has to provide to the bearing. Materials used in tribological applications are, for the most part, common materials used for general engineering applications. There are some materials designed specifically for bearings characterised by high loads, low sliding velocities and large contact area. Polymers are used for dry sliding applications where the soft materials aid for self-lubricating properties. Polymers with such capabilities should be evaluated for precise tribological characteristics such as friction and wear rate. The friction and wear rates are commonly obtained from small scale pin-on-disc mechanical tests are preferred due there low cost or time and easy handling of the test specimens. These methods provide fundamental information about friction and wear mechanisms and are useful for preliminary material classification. However, the global characteristic of material in real scale is unknown unless the commencement of failure in real components.

Surface texturing technology has been newly explored technique in the tribology community is a method of improving the friction and lubrication performance of various mechanical components. The several researches and investigations on surface texture presents the potential benefits of modifying the surface topography such as reduce coefficient of friction and leakage problems in mechanical seals, improve load carrying capacity of journal and thrust pad bearing, as well as reduces the metal to metal contact and decreased surface damage. The presence of surface textures may also benefit because it works as a lubricant reservoir and storing and supplying the lubricant directly to the contact zone and reduce friction and wear problems.

II. LITERATURE REVIEW

Dinghan Xiang et al. [1] undertook an extensive review work on composite of PTFE and alloy steel and composite of PTFE and bronze. *David L. Burris* [2], this paper presents a PEEK filled PTFE composite that exhibits low friction and ultra-low wear. *Yunxia Wang etl*. [3], have done the

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experimental work to study tribological behaviour of transfer films of PTFE/ bronze composites. . H. Unal a, A. Mimaroglu b, U. Kadıoglu a, H. Ekiz.[3]The influence of test speed and load values on the friction and wear behaviour of pure polytetrafloureoethylene (PTFE), glass fibre reinforced (GFR), bronze and carbon filled PTFE polymers. Jayashree Bijawe, Sukanta Sen [4] Increase in PTFE content though adhesive and LAOW performance increased substantially, it was at the cost of deterioration in all mechanical properties and abrasive wear performance. *W.Wieleba* [8], has studied the effect of role of internal friction in the process of energy dissipation during PTFE composite sliding against steel. *G. Theiler etl.* [11], have studied tribological behaviour of PTFE composites against steel at cryogenic temperature. Tribological performances of polymers depend significantly on the temperature at the friction contact. *J.R. Vail, B.A. krick etl.* [13], this work uses high tenacity expanded polytetrafluoroethylene (ePTFE) filaments as both a fiber reinforcement and a reservoir for solid lubricants. The wear rates obtained from the inclusion of expanded PTFE filaments were better than conventional powder filled PTFE–PEEK composites reaching values as low as $K=7\times10^{-8}mm^3/Nm$ and showed stable friction coefficients below = 0.125 for over 2 million cycles.

III. EXPERIMENTAL METHODOLOGY

A pin-on-disc Friction and Wear Monitor TR-20LE is used to investigate wear characteristics of PEEK composites as per ASTM G 99-95 standards. The disc of material AISI SS 304 stainless steel plate of the square surface Texturing for counter surface 160 mm track diameter and 8 mm thick. Complete arrangement of experimental Set Up is shown in Figure .1

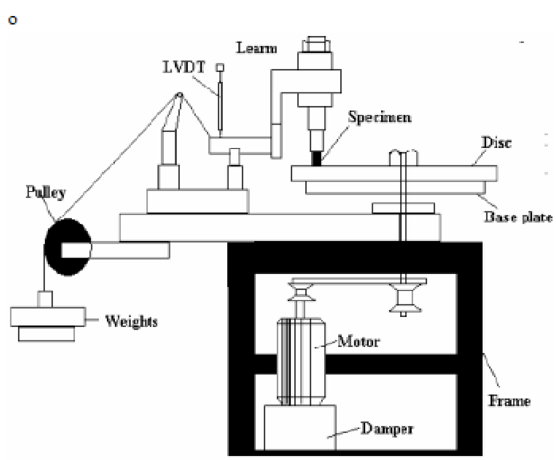

Fig. 1. Experimental setup of Pin on Disc Tribometer.

The TR-20LE Pin on disc wear testing is advanced regarding the simplicity and convenience of operation, ease of specimen clamping and accuracy of measurements, both of wear and frictional force along with lubrication and environmental facility.

The machine is designed to apply loads up to 20 kg and is intended both for dry and lubricated test conditions. It facilitates study of friction and wear characteristics in sliding contacts under desired test conditions within machine specifications. Sliding occurs between the stationary pin and a rotating disc. Normal load, rotational speed and wear track diameter can be varied to suit the test conditions. Tangential frictional force and wear are monitored with electronic sensors and recorded on PC. These parameters are available as a function of load and speed.

IV. PREPARATION OF SPECIMEN

PEEK composite material is in the form of cylindrical rod with dimensions 10 mm diameter and 105 mm length. The test specimens (pins) of 10 mm diameter and 30 mm length are cut. The disc of material AISI SS 304 stainless steel plate of the surface i.e. for disc is the surface texture patterns were made on the SS 304 plate by the Lasers surface technology (LST). The size of the dimple is taken 450*450 Micrometer & dimples densities are varied as 10%, 20%, 30%. The no. of dimples for the 3 tracks is as follows:

Track No.1: 10% Dimple Density

Track No.2: 20% Dimple Density

Track No.3: 30% Dimple Density

For the preparation of pinion First PEEK, PTFE, CARCON FIBER & BRONZE, Second PEEK, PTFE, CARCON FIBER & MoS2 were mixed with different proportion as mention in table 1. For accurate weighing digital weighing balance are used with accuracy 0.0001gm for uniform mixing were done by compounding of raw materials.

Table 1. Material Composition.

Material Type	Composition material in volumetric %
Material A	PEEK60%+PTFE15%+C.F.15%+BRONZE10%
Material B	PEEK60%+PTFE15%+C.F.15%+$MoS_2$10%

Testing Parameters

Sr. No.	Velocity (m/s)	Load (Kg)	Time (min)	Dimple Density
1.	0.070	13.63	60	10%
2.	0.086	15.48	60	20%
3.	0.102	17.34	60	30%

V. OBJECTIVE OF EXPRIMENTS

Following are the objective,
1. To study the wear behavior of the selected materials and the effect of various speeds, load and time on wear.
2. To study the relationship between coefficient of friction, frictional force, time, speed and load.
3. To find the effect of dry sliding on wear rate and coefficient of friction.

VI. OBSERVATION TABLE.

1. Experimental Parameter-
Material Type- Material A, Velocity- 0.070 m/s, Speed- 70 RPM, Time- 60 min. Duration, Load- 13.63Kg, Dimple Density 10%, Track Dia-20 mm. Dry Condition.

Table 2. Experimental data of dimple density 10%.

Sr. No.	Time min.	Wear in micrometer (µm)	Frictional Force (N)	Coefficient Of friction (µ)
1	5	13	12.6	0.0942
2	10	16	12.8	0.0957
3	15	18	12.7	0.0949
4	20	19	12.6	0.0942
5	25	20	12.4	0.0927
6	30	21	12.1	0.0905
7	35	22	12	0.0897
8	40	23	11.8	0.0882
9	45	24	11.8	0.0882
10	50	25	11.6	0.0867
11	55	25	11.5	0.086
12	60	26	11.4	0.0852

2. Experimental Parameter-
Material Type- Material A, Velocity- 0.086 m/s, Speed- 45 RPM, Time- 60 min. Duration, Load- 15.48Kg, Dimple Density 20%, Track Dia-40 mm. Dry Condition.

Table 3. Experimental data of dimple density 20%.

Sr. No.	Time min.	Wear in micrometer (µm)	Frictional Force(N)	Coefficient Of friction (µ)
1	5	7	12.5	0.0823
2	10	9	12	0.079
3	15	11	11.9	0.0784
4	20	13	11.9	0.0784
5	25	13	11.9	0.0784
6	30	17	11.7	0.0771
7	35	19	11.7	0.0771
8	40	19	11.7	0.0771
9	45	21	11.7	0.0771
10	50	23	11.7	0.0771
11	55	23	11.7	0.0771
12	60	26	11.8	0.0777

3. Experimental Parameter-
Material Type- Material A, Velocity- 0.102 m/s, Speed- 35 RPM, Time- 60 min. Duration, Load- 17.34Kg, Dimple Density 30%, Track Dia-60 mm. Dry Condition.

Table 4. Experimental data of dimple density 30%..

Sr. No.	Time min.	Wear in micrometer (µm)	Frictional Force (N)	Coefficient Of friction (µ)
1	5	0	17.1	0.01
2	10	0	17.1	0.01
3	15	1	17.3	0.0101
4	20	1	17.5	0.0105
5	25	2	17.7	0.104
6	30	2	17.9	0.1052
7	35	3	17.11	0.1005
8	40	3	17.12	0.1006
9	45	4	17.14	0.1007
10	50	4	17.17	0.1009
11	55	5	17.19	0.1011
12	60	6	17.2	0.1012

4. Experimental Parameter-
Material Type- Material B, Velocity- 0.070 m/s, Speed- 70 RPM, Time- 60 min. Duration, Load- 13.63Kg, Dimple Density 10%, Track Dia-20 mm. Dry Condition.

Table 5. Experimental data of dimple density 10%.

Sr. No.	Time min.	Wear in micrometer (µm)	Frictional Force (N)	Coefficient Of friction (µ)
1	5	4	11.5	0.086
2	10	6	11.6	0.0867
3	15	6	11.8	0.0882
4	20	7	11.9	0.0889
5	25	8	12	0.0897
6	30	8	12.2	0.0912
7	35	9	12.4	0.0927
8	40	9	12.5	0.0934
9	45	11	12.5	0.0934
10	50	13	12.6	0.0942
11	55	15	12.8	0.0957
12	60	17	12.9	0.0964

5. Experimental Parameter-

Material Type- Material B, Velocity- 0.086 m/s, Speed- 45 RPM, Time- 60 min. Duration, Load- 15.48Kg, Dimple Density 20%, Track Dia-40 mm. Dry Condition.

Table 6. Experimental data of dimple density 20%.

Sr. No.	Time min.	Wear in micrometer (µm)	Frictional Force (N)	Coefficient Of friction (µ)
1	5	3	11.7	0.077
2	10	4	12.1	0.0796
3	15	4	12.3	0.081
4	20	5	12.5	0.0823
5	25	7	12.6	0.0829
6	30	7	12.7	0.0836
7	35	8	12.9	0.0849
8	40	9	12.9	0.0849
9	45	11	13	0.0856
10	50	14	13	0.0856
11	55	17	13.1	0.0862
12	60	19	13.2	0.0869

6. Experimental Parameter

Material Type- Material B, Velocity- 0.102 m/s, Speed- 35 RPM, Time- 60 min. Duration, Load- 17.34Kg, Dimple Density 30%, Track Dia-60 mm. Dry Condition.

Table 7. Experimental data of dimple density 30%.

Sr. No.	Time min.	Wear in micrometer (µm)	Frictional Force (N)	Coefficient Of friction (µ)
1	5	5	15.2	0.089
2	10	7	15.4	0.0905
3	15	9	15.6	0.0917
4	20	11	15.7	0.0922
5	25	16	15.8	0.0928
6	30	19	15.8	0.0928
7	35	21	15.8	0.0928
8	40	24	15.9	0.0934
9	45	27	16	0.094
10	50	31	16.1	0.0946
11	55	33	16.1	0.0946
12	60	36	16	0.094

VII. RESULTS & DISCUSSION.

a. Wear of the material A square dimple at dry condition.

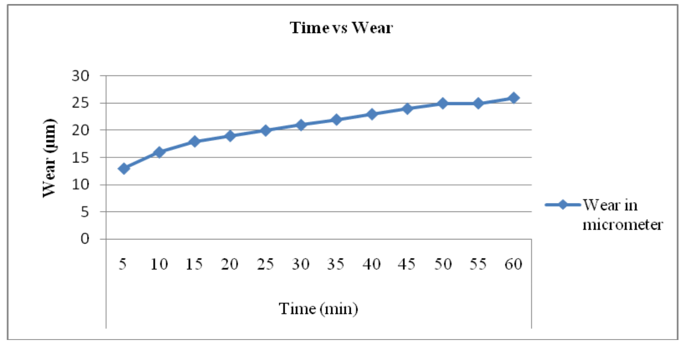

Fig. 2: Time vs Wear when dimple density 10% dry condition.

Above Fig. 2 in square dimple density 10% wear rate slowly increase at constant load & speed.

b. Wear of the material A square dimple at dry condition.

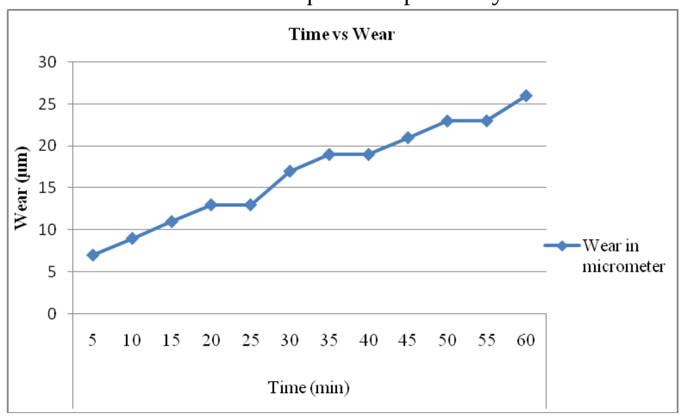

Fig. 3: Time vs. Wear when dimple density 20% dry condition.

Above Fig. 3 in square dimple density 20% wear rate slowly increase at constant load & speed similar TO 10% dimple density condition of dry lubrication.

c. Wear of the material A square dimple at dry condition.

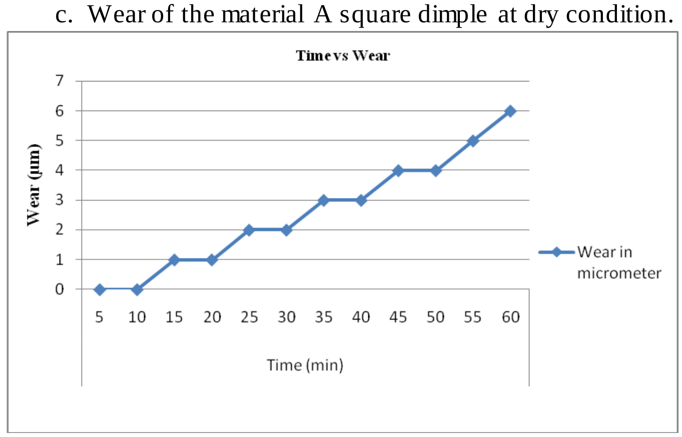

Fig. 4: Time vs.Wear when dimple density 30% dry condition.

Above Fig. 4 in square dimple density 30% wear rate is lower over the square dimple density 10% & 20%, minimum wear rate for dry lubrication condition.

d. Wear of the material B square dimple at dry condition

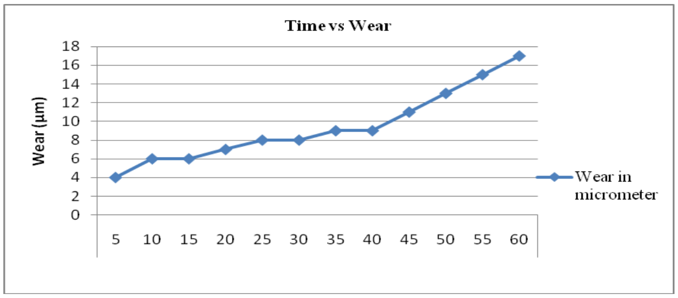

Fig. 5: Time vs Wear when dimple density 10% dry condition. Material B in the wear rate slowly increases after some time at constant load & speed.

e. Wear of the material B square dimple at dry condition.

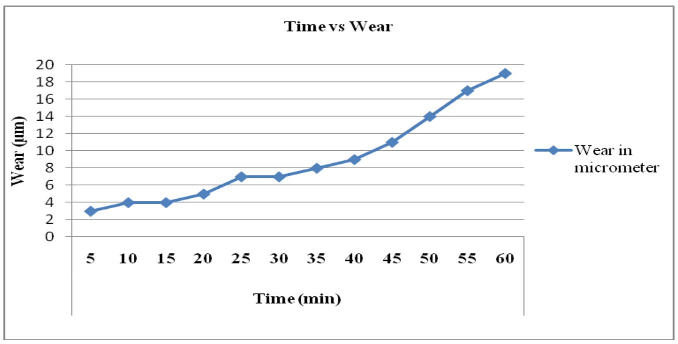

Fig. 6: Time vs Wear when dimple density 20% dry condition. Material B in the wear rate is high over then square dimple density 10% after some time at constant load & speed.

f. Wear of the material B square dimple at dry condition.

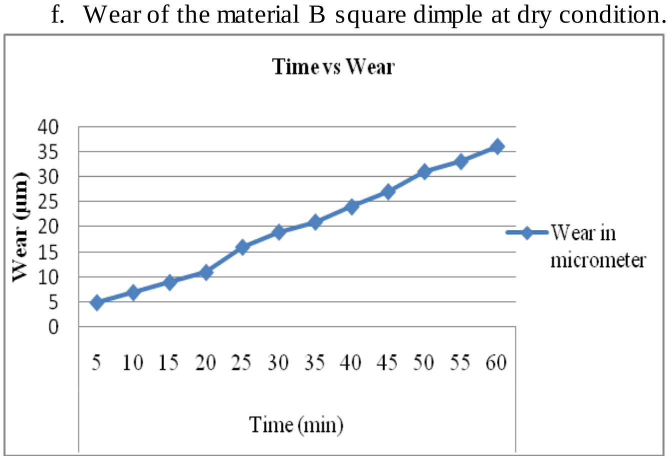

Fig. 7: Time vs Wear when dimple density 30% dry condition. Material B in the wear rate increase after some time in load & speed change on square dimple density 30%

g. C.O.F. of the material A square dimple at dry condition.

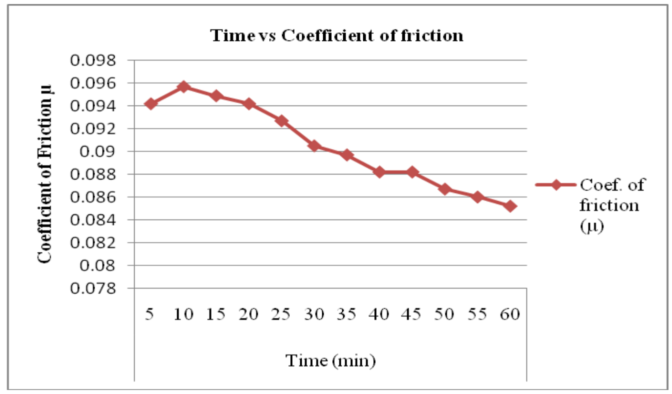

Fig. 8: Time vs C.O.F. when dimple density 10% dry condition.

At run on square dimple density 10% in constant speed & load decrease the C.O.F. rate.

h. C.O.F. of the material A square dimple at dry condition.

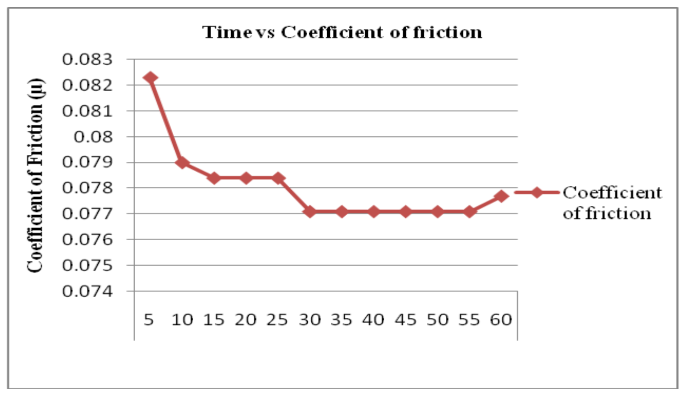

Fig. 9: Time vs C.O.F. when dimple density 20% dry condition.

Similarly, above fig.8 run on square dimple density 20% in constant speed & load decrease the C.O.F. rate

i. C.O.F. of the material A square dimple at dry condition.

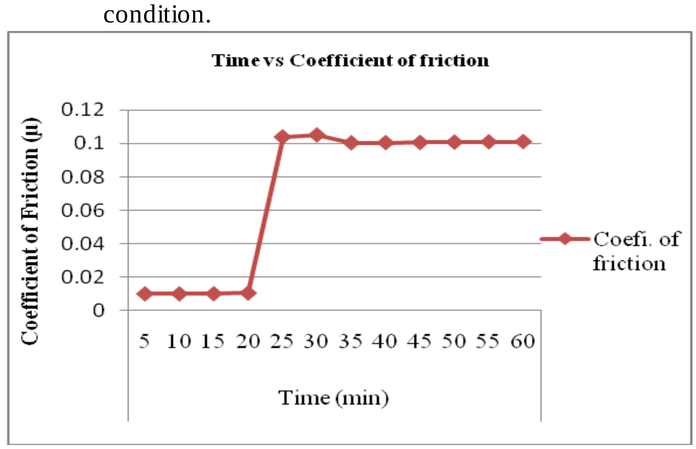

Fig. 10: Time vs C.O.F. when dimple density 30% dry condition.

At run on square dimple density 30% in change speed & load increase the C.O.F. rate.

j. C.O.F. of the material B square dimple at dry condition.

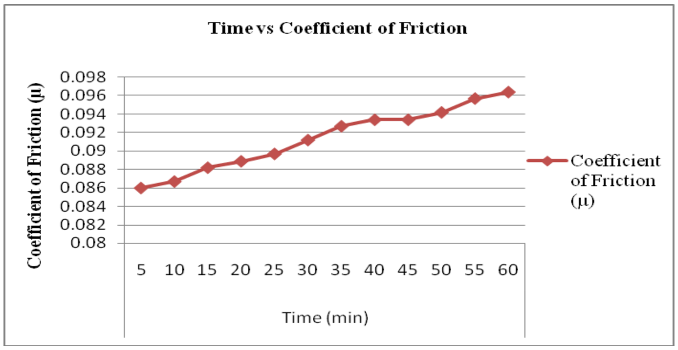

Fig. 11: Time vs C.O.F. When dimple density 10% dry condition.

At run on square dimple density 10% in constant speed & load slowly increase constant the C.O.F. rate.

k. C.O.F. of the material B square dimple at dry condition.

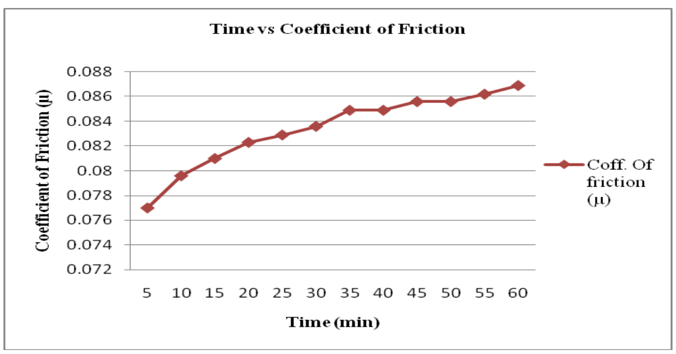

Fig. 12: Time vs C.O.F. when dimple density 20% dry condition.

Similarly run square dimple density 10% square dimple density 20% in constant speed & load slowly increase constant the C.O.F. rate

l. C.O.F. of the material B square dimple at dry condition

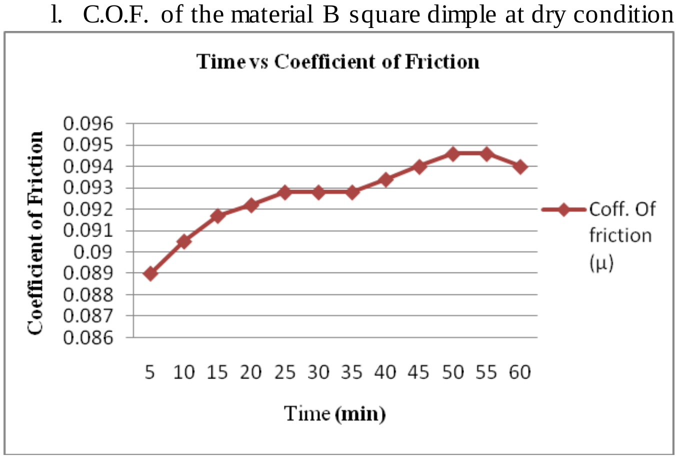

Fig. 13: Time vs C.O.F. when dimple density 30% dry condition.

At run on square dimple density 30% in constant speed & load slowly increase the C.O.F. rate & after some time constant C.O.F. rate, material B at 30% dimple density C.O.F. lower than 10% & 20% dimple density.

VIII. CONCLUSION.

The Tribological concepts have been successfully applied in developing a new design of the sugar mill journal bearing which was able to operate in mixed lubrication of the bearing as well as the journal from the analysis of the dry sliding wear of the PEEK composites.

1. It improves the mechanical efficiency & bearing life.
2. C.O.F. increases with density of the dimples.
3. PEEK has very low coefficient of friction but it subject to more wear which can be reduced by adding suitable filler combination.

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