Investigation of the Tribological Properties of Journal Bearing under Wear Test

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***Abstract* — Occurrence of the friction and wear at machine parts of rotating system which run together, affects the efficiency of machine negatively. Because of its simplicity, low of cost and efficiency journal bearings are used widely in industry. It is difficult to accurately predict the component life due to wear and friction. This attempt is to study the influencing parameters like load, speed and temperature, friction coefficient during wear test. The main objective to the paper is to study wear rate of Babbitt journal bearing. The Babbitt metal is tested in lubricated condition using 20W40 oil under Pin-on-Disc Tribometer. Results found that, metals prone to wear at considered operating conditions due to change in frictional coefficient at contact surface.**

***Index Terms*— Babbitt metal, Journal Bearing, Pin-on-Disc, Power loss, Nano-particles, Wear test.**

I. INTRODUCTION

Journal Bearing is that supports and positions the rotating journal. It uses the rotation of the journal to pressurize a lubricant that is supplied to the bearing to eliminate surface-to-surface contact to bear the external load. During the rotation of a journal in an impregnated bearing, the temperature rises because of friction development and lubricant material is drown out of porosities due to the rise of coefficient of the lubricant compared to the bearing material. As soon as the journal stops, the oil gets absorbed by capillary action.

Annual study says global engineering consumption by transportation vehicles (heavy-duty vehicles) are ranking on the second place behind light-duty vehicles even before aviation, buses, marine and rail vehicles. Considering heavy-duty vehicles, 26% of the fuel energy is needed to overcome the frictional losses [1]. Friction reduction is an effective method to increase the fuel efficiency beside drivetrain and auxiliary electrification. Journal bearings are also contributes for the total frictional power losses in engine which is used in a large number of critical positions in automotives internal combustion engine [5]. For heavy-duty bearings, an extra oil reservoir may be provided outside of the bearing for supplementary lubrication.

Bearing performance depends upon the operating conditions, parameters and its mechanical properties which exhibit the service life. Journal bearing should have properties such as high load bearing capacity, low friction coefficient, wear and corrosion resistance. These properties directly affect the fatigue and performance life of the bearing. Wear resistance is one of the important properties that journal bearings should possess. The researchers investigate friction and wear behavior of different materials due to the adverse effect observed in the performance and life of the components [2-4, 6].

For efficient operation and long service life, journal bearings should possess several requirements. Non-Ferrous Founders' Society (NFFS) have made the following requirements for journal bearing which must be satisfied simultaneously.

- Position and support a shaft or journal and permit motion with minimum energy consumption
- Support a fixed load and be able to withstand occasional shock loads
- Run quietly and suppress externally generated vibrations
- Act as a guide to support reciprocating or oscillating motion
- Withstand temperature excursions
- Accommodate some degree of shaft misalignment
- Accommodate dirt particle strapped in the lubricant
- Resist corrosion — under normal service conditions as well as during storage or extended down-time
- Provide easy maintenance

Three critical performance parameters in journal bearings can be expressed as the following:

- Friction coefficient
- Wear coefficient, which reflects material loss during the sliding
- Local bearing temperature, which is an important parameter in seizure

High-speed journal bearings are always lubricated with oil. Grooves in the bearing shell are used to distribute the oil throughout bearing. The viscosity grade required is dependent upon bearing speed, oil temperature and load. Higher the bearing speed, the lower is the oil viscosity required, while higher the operating temperature; higher is the oil viscosity required. Another method of determining the proper viscosity grade is by applying minimum and optimum viscosity criteria to a viscosity temperature plot. A generally accepted minimum viscosity of the oil at the operating temperature for journal bearings is 13 CentiStoke (cSt), although some designs allow for an oil as thin as 7 or 8 cSt at the operating temperature. The optimum viscosity at operating temperature is 22 to 35 cSt, for moderate speed bearings if no shock loading occurs. The optimum viscosity may be as high as 95 cSt for low speed, heavily loaded or shock loaded journal bearings [13].

If oil has low viscosity, the heat generated due to insufficient film thickness causes direct contact between journal and bearing surface. If oil has high viscosity, heat generates due to the internal fluid friction created within the oil. Selecting oil, which is too high in viscosity, can also increase the likelihood of cavitations **[10]**. The high and low-pressure zones, which are created within the oil on each side of the area of minimum film thickness, can cause oil cavitation in these bearings. Cavitation is a result of expansion of dissolved air or a vapor (water or fuel) in the low-pressure zone of the bearing. The resulting bubble implodes causing damage as it passes through the high-pressure portion of the bearing. If the implosion or collapse of the vapor bubble occurs next to the metal surface this can cause cavitation-pitting damage to the metal. If the implosion of the bubble occurs within the oil, a micro hot spot or micro dieseling can occur which may lead to varnishing within the system.

A. Objective:

The nature and consequences of interactions that takes place at interface controls its friction, wear, and lubrication behavior. So, this is considered as prima to study. The objective of the paper is to-

- Find out the behavior of the material from wear and friction point of view at the various sliding speed and loads.
- Study the tribological properties and its effect on the bearing material under wear test.
- Find the wear of Babbitt metal using Pin-on-Disc Tribometer for varying operating load and speed.

II. Literature Review

Journal bearing is used in almost every critical position of ICE as well as axles, supporting shaft and rods. Considering power losses, friction gives almost 26% of the total loss [5]. Thus, referring the literature intends to study the behavior of bearing at different operating conditions and also its tribological properties of different bearing material at different parameters.

Christoph Knauder et al. [1] investigated heavy-duty Diesel engine of 13 liter-class, HTHS-viscosity (Dynamic viscosity of lubricant at 150ºc) limitations are determined which indicate that the use of lubricants with further reduced HTHS-viscosity would require engine and/or journal bearing modifications to be able to maintain the high service life of the engine. He compared between the investigation of friction reduction in highly loaded journal bearing using ultra-low viscosity lubricant (0W20) and work from literature. He found that ultra-low viscosity 0W20 lubricant achieved friction reduction of about 8% with HTHS-viscosity of 3.6 mPa-s.

Harbansh Singh [2] examined the friction and wear always occur at machine parts which run together which affects the efficiency of machines negatively. He studied the influence of wear parameters like load, speed, type of lubricant used, temperature, and viscosity of lubricant. The main objective of the study is to evaluate the wear rate of different journal bearing materials (brass and white metal) under similar conditions. The materials are tested in dry and wet lubrication under similar operating conditions. For this purpose we use Pin-on-disc apparatus. It was found that the wear rate of both materials is more in dry conditions compared to lubricated conditions (when tested under similar working conditions). We also found that wear rate of white metal is more as compared to brass and higher frictional force is observed in case of brass material**.**

S. Baskar et al. [3] examined the friction and wear behavior of journal bearing material (brass) using Pin-on-Disc wear tester with three different lubricating oil i.e. synthetic lubricating oil (SAE 20W40), chemically modified rapeseed oil (CMRO), chemically modified rapeseed oil with Nano CuO. He founds that bearing material lubricated with CMRO + 0.5 wt.% nano CuO has the lowest friction coefficient of 0.073, that of CMRO is 0.13 and SAE20W40 is 0.09.Thus, lubricating oil contain nano CuO preferred for the lubrication in journal bearing application.

M. Bhuptani [4] described the tribological behavior analysis for the conventional materials i.e. Brass and Gunmetal as well as New non metallic material Cast Nylon. Friction and Wear are the most important parameters to decide the performance of any bearing. He studied major tribological parameters for three material and try to suggest better new material compared to conventional existing material. It could help us to minimize the problem of handling materials like Lead, Tin and Zinc etc. After Test on wear machine he found that Cast Nylon compared to Brass and Gunmetal for the same operating and lubricating condition, have less value of coefficient of friction which help us to minimize power lost due to friction and assist in increasing overall engine efficiency of the engine.

H. Allmaier [5] studied that journal bearings are used in a large number of critical positions in automotive internal combustion engines (ICE) and contribute a major contribution to the total friction power losses in these engines. Due to the worldwide effort to reduce CO2 emissions, automotive manufacturers investigate the remaining potential for friction reduction also in the journal bearings, which leads to severe operating conditions due to the lower viscosity lubricants. He investigated the lubrication of journal bearings in detail starting from an extensive thermo-elastohydrodynamic (TEHD) simulation, which yields important insights into the thermodynamical behavior of journal bearings. From these results a powerful isothermal elastohydrodynamic (EHD) simulation model using a simple approach to calculate equivalent temperature is derived. The capabilities of the presented simulation methods are compared to extensive experimental measurements performed on a journal bearings test-rig, which show excellent agreement.

B. S. Ünlü et al. [6] studied the tribological and mechanical properties of the journal bearings made of tin and lead based alloy. A special bearing wear test rig has been designed to examine the wearing behavior of bearing materials and the shaft together. Therefore, it is possible to investigate different bearing and shaft materials and the effects of heat treatment on these materials. Tensile, compressive, notch impact, three-point bending, radial fracture, and hardness tests were to obtain mechanical properties. At the end of wear test he concluded that, the highest friction coefficient and temperature of the bearing were observed for pure Cu bearings. Pure Sn, Pb, and Cu metal bearings get worn to journal more than the

SnPbCuSb white-metal bearings. The lowest friction coefficient and wear losses of the bearing and journal occurred in SnPbCuSb alloyed bearings. The highest wear losses of the bearings took place for pure Pb. The maximum journal wear occurred for pure Sn bearings.

Erol Feyzullahoglu et al. [7] analyzed the tribological properties of 4 different aluminum alloys using pin-on-disc Tribometer. Friction coefficient and weigh losses were carried out for specimens for different operating conditions. Results shows that, the friction and wear behavior of the alloys have changed according to the sliding conditions. Al-Si and Al-Sn alloys which includes the Si and Sn can be preferred, among the aluminums alloys that will works under lubrication, as the bearing material.

M. O. A. Mokhtar et al. [8] studied the location of the wear within the bearing was caused entirely by the sliding which occurred during starting and that no significant contribution to the wearing process was made during stopping. He used multi-diameter measuring technique enabled an accurate assessment of the local wear and the greatest increase in the bearing's diametral clearance to be deduced. He concluded that during the first 1,000 cycles of operation, measurements showed rapid improvements of the surface finish of the bearings accompanied by a relatively high rate of increase of clearance in the worn area ,while the extent of the worn area also increased rapidly particularly in bearings with relatively low initial diametral clearance.

Ertuğrul Durak et al. [9] used a rotational experimental system to investigate the variation of the friction force according to the velocities and loads in journal bearings and displayed the results of reduction ratio in the friction coefficient for lubricating oil, which was formed by adding commercial additives (A, B, C) oil at determined ratios of concentration (vl 3 per cent) to engine oil and compared with engine oil at both 25 and 100ºC. He founds that Additive A added to engine oil was more effective in reducing the friction coefficient in the journal bearing under static loading. At the same time, additive A of friction modifying performance was higher in particularly in the higher temperature and at even higher loads.

Ming Feng [10] investigated the friction and wear characteristics of two typical hydrodynamic bearings for hard disk drive (HDD) spindle motors (SPM), i.e., the herringbone groove and multi-taper bearings, during start-up and shut-down transient operation. The friction characteristics are calculated by a lubricated friction model which is an extension of Kogut and Etsion’s dry friction model (a modified version of the CEB model), while the wear characteristics are qualitative ly evaluated in non-dimensional form by the semi-analytical wear model proposed by Holm–Archard. The average flow Reynolds equation and the pressure-compliance relationship of elastic– plastic roughness contact are used together to consider the combined effects of partial lubrication and asperity contact occurring during start-up and shut-down and then friction and wear characteristics are caluculated.

Mustafa Duyar et al. [11] studied the elasto-hydrodynamic lubrication (EHL) approach which resulted in improvement in the performance and durability of bearings. In this lubrication regime, hydrodynamic pressure is sufficiently high that a significant elastic deformation of the interacting surfaces is caused and also film thickness is slightly influenced by the elastic moduli of surfaces. Developed model is used along with the Archard law to predict the wear rate. Prediction shows that using more conforming bearing material and cooling the lubricant which increases the viscosity results in better design.

M. Priest et al. [12] reviewed that there has been relentless pressure in the second half of the 20th century to develop ever more fuel efficient and compact automobile engines with reduced environmental impact. From the viewpoint of the tribologist this means increasing specific loads, speeds and temperatures for the major frictional components of the engine, namely, the piston assembly, the valve train and the journal bearings, and lower viscosity engine oils with which to lubricate them. Inevitably, this leads to decreasing oil film thicknesses between the interacting surfaces of these components and a more crucial role for the topography and surface profile of the two surfaces in determining tribological performance. Key areas for future research and the implications for design are highlighted.

A. Ramamohana Rao et al. [13] studied the factors influencing the wear of carburized plain carbon steel like-pair journal bearings operating under mixed-lubrication conditions. A comprehensive set of experiments employing Taguchi’s technique was carried out to establish wear characteristics under varying combinations of different parameters, i.e. load, surface velocity, surface roughness of journal and bush, surface hardness pairing of mating members, clearance ratio of bearing, and frequency of starts and stops.

J. Archard [14] recommended that the interpretation of certain phenomena occurring at nominally flat surfaces in stationary or sliding contact is dependent on the assumed distribution of the real area of contact between the surfaces. He concluded that, (a) The electrical contact resistance depends on the model used to represent the surfaces; the most realistic model is one in which increasing the load increases both the number and size of the contact areas. (b) In general, mechanical wear should also depend on the model. However, in wear experiments showing the simplest behavior, the wear rate is proportional to the load, and these results can be explained by assuming removal of lumps at contact areas formed by plastic deformation; moreover, this particular deduction is independent of the assumed model. This suggests that a basic assumption of previous theories, that increasing the load increases the number of contacts without affecting their average size, is redundant.

III. MATERIAL MANUFACTURING

A. *Genuine Babbitt*

Babbitt used as bearing metal for axles and crankshafts, based on the tin alloy invented in 1839 by Isaac Babbitt for use of steam engine. Modern Babbitt provides low friction lining for bearing shells made of stronger metals such as cast iron, steel or bronze. Babbitt alloy classified mainly by composition Tin-based and Lead-based.

Different Babbitt alloys are available according to purpose and graded differently by societies such as ASTM, SAE etc. Genuine Babbitt tin-based alloy composed of Sn-89%, Sb-7.5%, and Cu-3.5%. Babbitt metal is available in ingot form of 6-40lbs and in wire for flame spraying application. Babbitt Ingot cast in square bar of 13.5x13.5x500 cm dimension. For testing, we required Babbitt pin in cylindrical c/s which is then test across the EN-31 steel disc to calculate the wear rate. For that square bar is turned on the Lathe machine and formed in as shown in fig. 1.

Fig.1: Babbitt Pin Manufactured for Testing

B. Nano-fluid

i. The concept of nano-fluid

Recent reviews of research programs on nano-technology in the U. S., China, Europe, and Japan show that nanotechnology will be an emerging and exciting technology of the 21^{st} century and this is at a similar level of development as computer/information technology was in the 1950s. Solids have higher thermal conductivities than those of conventional heat transfer fluids (Figure). For example, the thermal conductivity of metal and oxides of metal at room temperature is about 3000 times greater than that of the engine oil. Thus, solid particles in fluids are expected to enhance the thermal conductivities of fluids. Numerous studies are presented for effective thermal conductivity of dispersions that contain solid particles. Since, Maxwell's theoretical work was published more than 100 years ago (Maxwell, 1873).

iii. Advantages of Nano-fluids

Nano-fluids offer different advantages those are enlisted below:

- *Simple manufacturing methods*: The availability of simple manufacturing methods gives to produce nano-fluid that meet the needs of a wide variety of current and future applications. Researchers can choose the most appropriate material to be added to a fluid currently in use.
- *Can use many particle materials*: One can choose from a variety of nano-particle materials, which is most compatible with existing base fluid. One can use non-metals and oxides of metals and can enhanced the stability of metal nano-particles.
- *Works with a variety of base fluids*: This enables existing fluids can be easily improved instead of being replaced. For examples, radiators that use an ethylene glycol/water mixture and thermal systems that use synthetic fluids.
- *Does not require dispersants*: Nano-fluids remain stable almost indefinitely without the use of dispersants and eliminates any time, cost, or effort that would be associated with using dispersants.
- *Does not settle rapidly*: Stability is a requirement for enhancing the properties of lubricant. Particles also need to stay suspended to ensure that the properties of the fluid do not change. If particles settle, more particles need to be added to replace them; this involves extra time, expense, and effort.

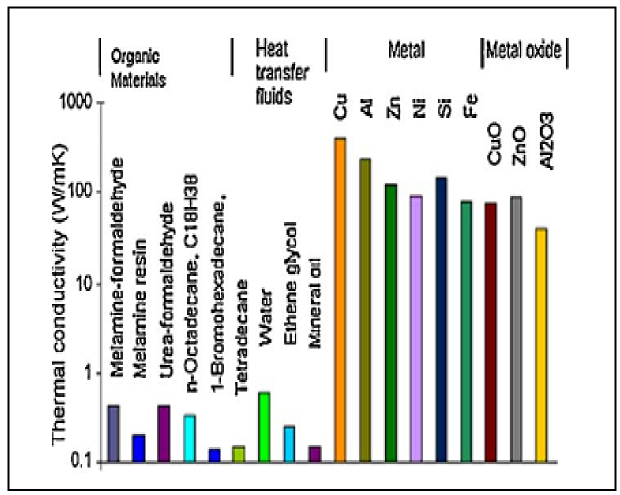

Fig.2: Thermal conductivity of typical materials

iv. Preparation of Nano-fluid

Nano-particles TiO_2 are added to refrigeration system by adding them into the lubricant SAE 20W40. The preparation and stability of this mixture is very important. The lubricant SAE 20W40 is in a liquid state so it is difficult to mix the nano-particles in lubricant. Procedure for adding nano-particle in the lubricant is given below:

1. Find out the amount of lubricant SAE 20W40 is circulated in the bearing i.e. the requirement of lubricant
2. Weigh the mass of TiO_2 nano-particles on a digital electronic balance for 0.1% of weight of refrigerant.
3. Vibrate the mixture by using an ultrasonic vibrator for 3 hrs and get the well-dispersed TiO_2 nano-lubricants.
4. Repeat the above steps for preparing the dispersion of 0.2%, 0.3%, nano-particles in lubricant SAE 20W40.

The conclusion can be obtained that the prepared nano-fluid with the ultrasonic processing has better dispersion than the mixture without the ultrasonic processing.

Fig.3: Ultrasonic Vibrator

The nano particles of TiO_2 and SAE 20W40 mixture was prepared with an ultrasonic vibrator for 3 hours to fully separate the nano-particles and to prevent any clustering of particles in the mixture to obtain proper homogenization. No surfactant is added in this work as there may be any influence in reduction of thermal conductivity and performance.

v. Particle concentration in Lubricant

Nano-particles with 0.1%, 0.2%, 0.3% concentration of TiO_2 in the lubricant prepared.

Mass of Lubricant: 3428grams

Mass of 0.1% of nano-particles: $3428 \times \frac{0.1}{100} = 3.428$ grams

Mass of 0.2% of nano-particles: $3428 \times \frac{0.2}{100} = 6.856$ grams

Mass of 0.3% of nano-particles: $3428 \times \frac{0.3}{100} = 10.284$ grams

IV. EXPERIMENTAL TESTING

The wear is the loss of material due to relative contact between two components, which is relatively small in most of the machinery and engineering tool [14]. For measuring wear, we are using some apparatus and instruments, which give results about the wear rate in tools and machinery

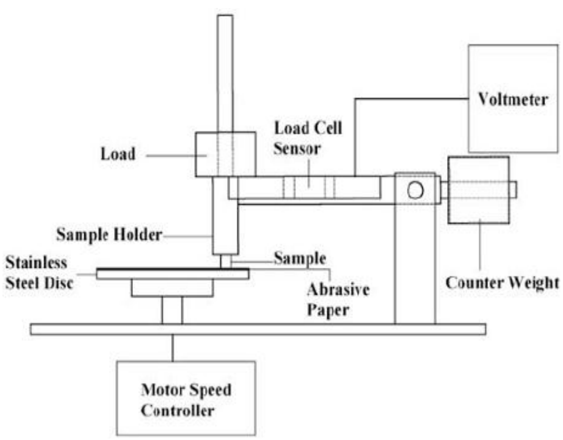

Fig. 4: Pin-on-Disc Test rig Block Diagram

The Pin-on-Disc (POD) is common test rig used to evaluate the tribological properties of materials. It consists of an arm to which the pin is attach, a fixture that accommodates disks of EN-31 steel. Pin is made of material that is under investigation in order to find the consequences of wear and friction under different conditions, such as dry, lubricant and lubricant with different additives for different loading and sliding speed. Cylindrical Pin specimens tested at range from 2 to 10 mm diameter and from 20 to 30mm height. Specimen can be tested across the load weighing range from 0.5Kgf to 20Kgf with speed ranges from 100 rpm to 2000 rpm [15].

A pre-determined Hertzian pressure is automatically applied to the pin using a system of weights, which gives sliding wear as well as a friction force. Users simply specify the speed, the load, and any other desired test variables such as work duration and temperature limit. Designed for unattended use, a user need only place the test material into turntable fixture and specify the test variables. Software included with this model provides for quick calculation of the Hertzian pressure between the pin and disk. A sink provided which permits the use of liquid lubricants during a wear test (optionally). An electronic sensor (PID) for measuring the friction force, coefficient of friction, wear and temperature. Computer software (on Lab view platform) for displaying the parameters, printing, or storing data for analysis.

Table – 1: Pin-on-Disc Tribometer specification

Tribometer Model: **TR: 20LE-CHM-PHM400,DUCOM** Made in India	
Pin Size	3 to 12 mm diameter
Length of Pin	30 mm
Disc Size	165mm diameter x 8mm thick
Wear track diameter (mean)	50mm to 100mm
Pitch circle diameter	155mm
Disc rotation speed	100-2000 rpm
Normal load	0-200N
Friction force output	0-200N digitally recorded
Wear measurement range	0-4 micron
Surface roughness	0.02 micron
Material of disc	EN31 Steel Disc
Hardness of disc material	58-62 HRC
Lubricant used	20W40 (HP)
Accessories	
Electronic Controller	
Chamber Heating (ambient to 600°c)	
Pin Heating (Ambient to 400°c)	
Environmental Chamber	
Lubricant re-circulation System	
Standard Data Acquisition System	

DUCOM's Pin-on-Disc (POD) Tribometer is used to evaluate the tribological properties of Babbitt material (ASTM B23 Grade-2) with 20W40 lubricant oil. Material tested at variable operating conditions. Babbitt Pin of 10 mm circular cross-section with length 30mm placed normal to a fixture that accommodates disks of EN-31 steel of 165 mm in diameter & 8 mm thick. Different operational condition is tabulated in table -2.

Table – 2: Experimental operating conditions

Sr. No.	Sample ID	Load	Speed	Sliding Distance
1	1-1	5 Kg	300 rpm	100 mm
2	1-2	12 Kg		
3	1-3	20 Kg		
4	2-1	12 Kg	600 rpm	
5	2-2	20 Kg		
6	3-1	12 Kg	1000 rpm	

Ertugrul Dural [9] proposed the behavior of journal bearing from start-up to shut-down. He founds that, bearing prone to wear during start-up and shut-down i.e. for lower speed. During start-up journal climbs with insufficient lubrication causes direct contact with bearing surface which gives the wear at start. Similarly for the shutdown, journal slips down during rest which gives corresponding wear for bearing [10].

For this reference, lower speed with varying load are considered as operating conditions which gives the corresponding wear and friction coefficient . Test results are tabulated in table-3.

Fig.5: Actual Test Rig

V. Results & Discussions

Tribological properties of journal bearing metal such as coefficient of friction, wear and temperature are studied on Pin-on-Disc Tribometer and results are plotted as following:

Table – 3: POD Test Results

Sr. No.	Sample ID	Load Kg	Speed	Coefficient of Friction	Wear µm
1	1-1	5	300 rpm	0.0001	+16
2	1-2	12		0.001	+22
3	1-3	20		0.001	+48
4	2-1	12	600 rpm	0.003	+11
5	2-2	20		0.021	-7
6	3-1	12	1000 rpm	0.024	-6

A. Load: 5Kgf Speed: 300 rpm

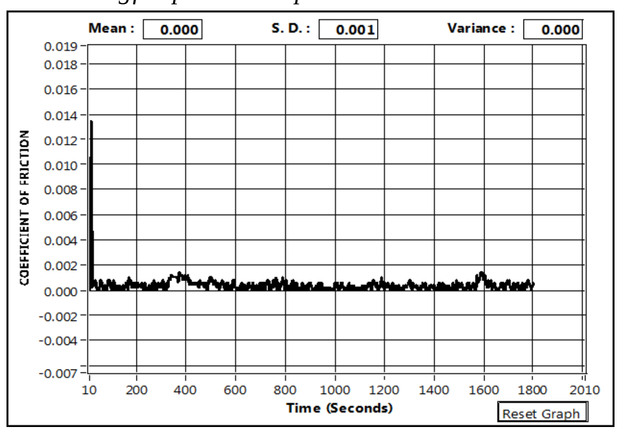

Fig.6: Coefficient of Friction Vs Time (Sample:1-1)

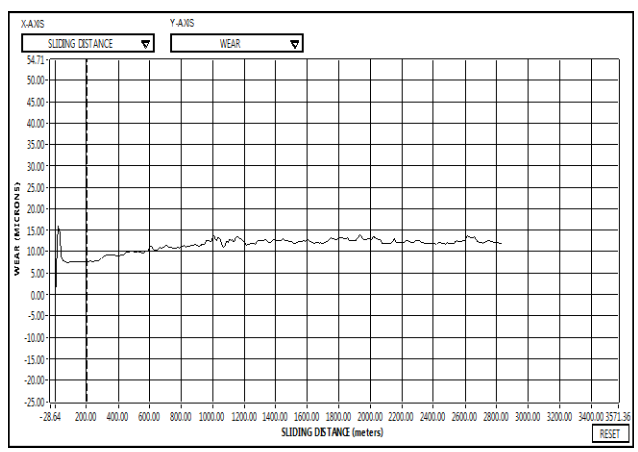

Fig.7: Wear Vs Sliding Distance (Sample:1-1)

For 5Kgf load and 300 rpm start-up speed, wear is found to be as +16µm for 60 min duration across the 0.0001 mean friction coefficient gives corresponding wear upto thin oil film formation after 30th second.

B. Load: 12Kgf Speed: 300 rpm

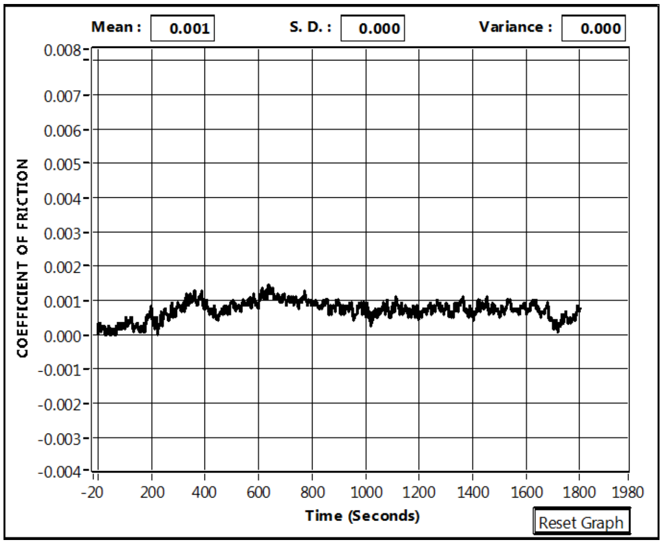

Fig.8: Coefficient of Friction Vs Time (Sample:1-2)

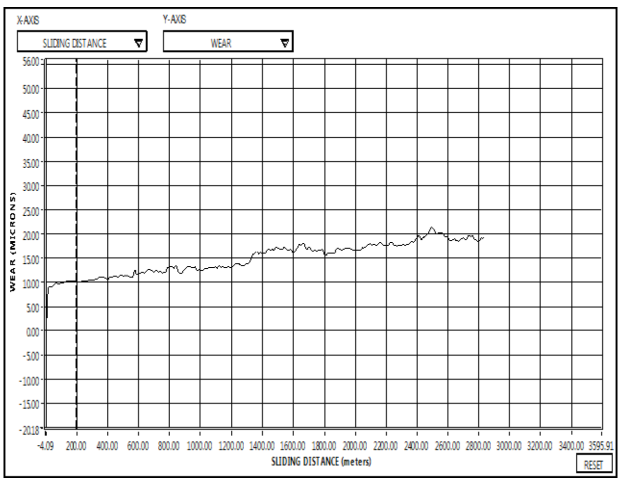

Fig.9: Wear Vs Sliding Distance (Sample:1-2)

For 12 kgf load & 300 rpm start-up load, wear found as +22µm along 0.001 mean friction coefficient for 60 min test duration.

C. Load: 20Kgf Speed: 300 rpm

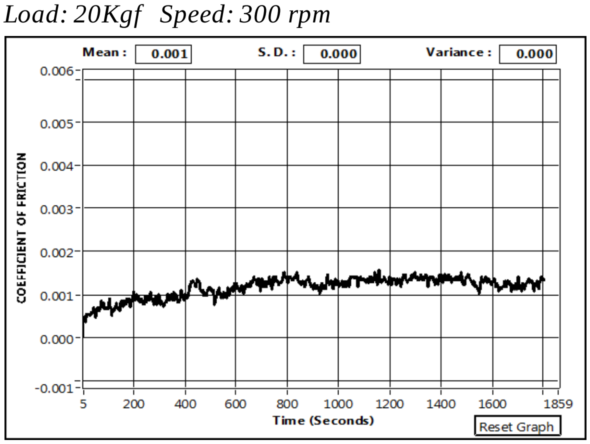

Fig.10: Coefficient of Friction Vs Time (Sample:1-3)

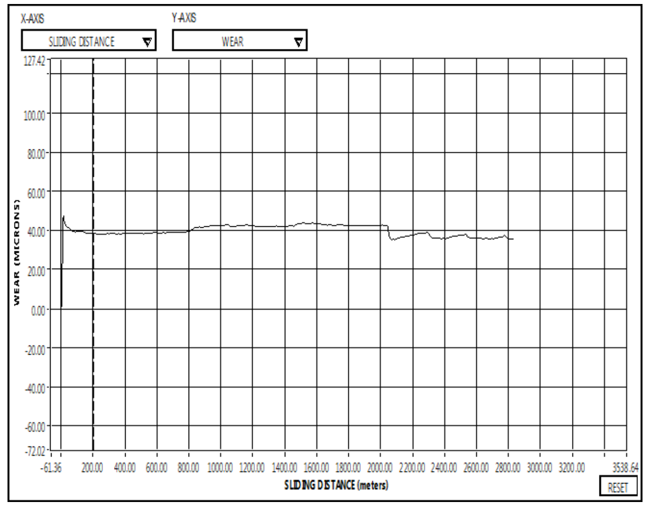

Fig.11: Wear Vs Sliding Distance (Sample:2-1)

For 20kgf full load & 300 rpm start-up spedd, wear found to be as +48µm. Results shows, load dominant for wear & for same low speed with successive increase of load at 5, 12, 20kg comparartive wear gives positive wear slope.

D. Load: 12Kgf Speed: 600 rpm

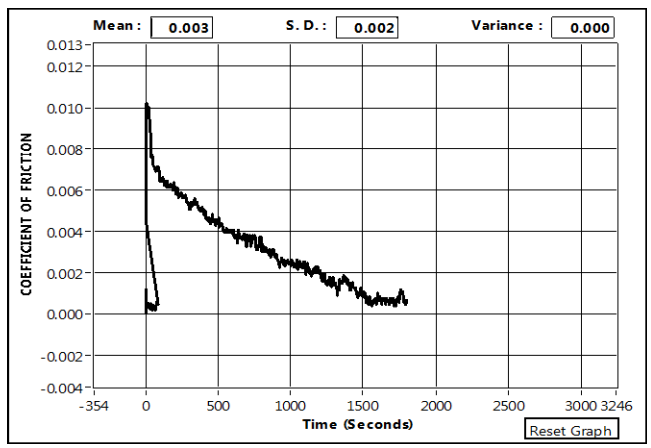

Fig.12: Coefficient of Friction Vs Time (Sample:2-1)

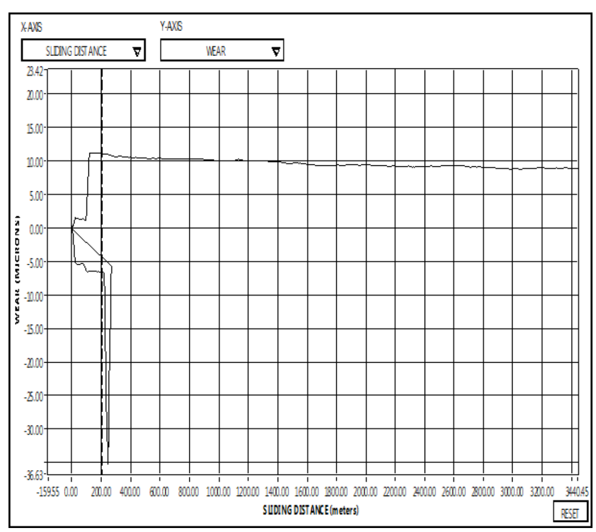

Fig.13: Wear Vs Sliding Distance (Sample:2-1)

For 12 kg Load and 600 rpm running-in speed the corresponding wear found to be as +11μm along the 0.003 friction coefficient.

E. Load: 20Kgf Speed: 600 rpm

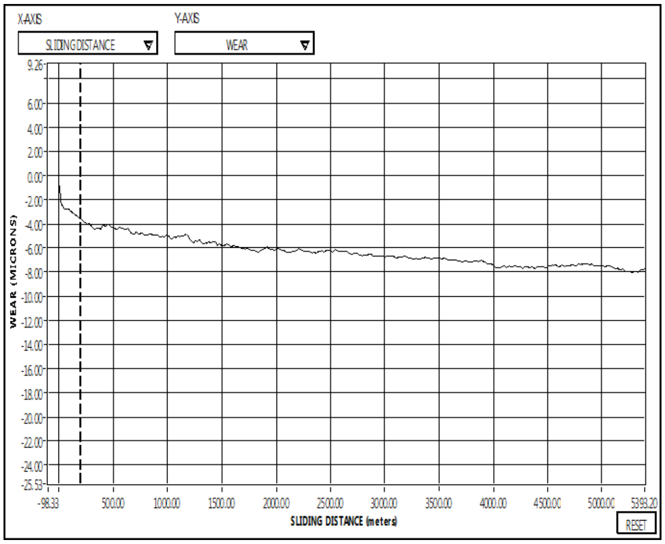

Fig.14: Coefficient of Friction Vs Time (Sample:2-2)

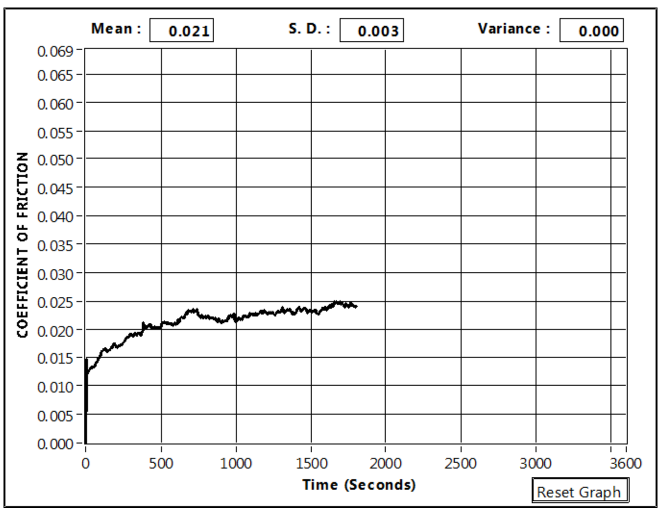

Fig.15: Wear Vs Sliding Distance (Sample:2-2)

For 20 kg full load & 600 rpm running-in speed the corresponding wear found as -7 μm along 0.021 friction coefficient due to film lubricaion. Results shows with the increase of speed from 600 to 1000 rpm along same load of 12 kg and 20 kg, crresponding lower wear found at 600 rpm. Increase of speed lowers the viscosity which gives corresponding reduced shear thinning in lubrication due to rise of friction coefficient at contact surface.

F. Load: 12Kgf Speed: 1000 rpm

For 20 kg full load & 1000 rpm high speed wear found as -6 μm aling 0.024 friction coefficient.

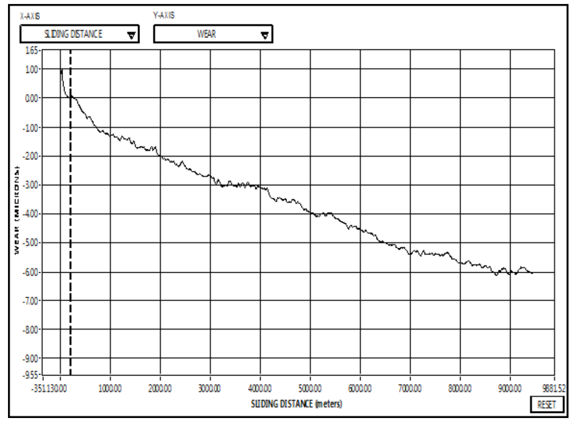

Fig.16: Wear Vs Sliding Distance (Sample:3-1)

VI. CONCLUSION

In the paper, the tribological properties of journal bearing were studied. Genuine Babbitt of grade ASTM B23 Grade-2 used in tests at different working conditions. Conclusions are summarized as below:

1) Tribological properties of bearing metal such as coefficient of friction, wear, frictional force and temperature were studied at different load and rotating speed and results of the tests indicate that, bearing load and rotational speed dominates to changes its tribological properties during considered time period.
2) Babbitt material have high wear rate at low speed and varying high loads. This shows for lower speeds due to high shear thinning in oil film because of high viscosity gives wear at contact area with minimal friction coefficient.
3) At higher speed, due to low viscosity the effect of shear thinning is minimum which causes the increasing friction coefficient with almost no wear due to film formation.
4) At 12 kg of load with varying speed of 300, 600, 900 rpm gives the wear of +22, +11, -6 μm respectively with 0.001, 0.003, 0.024(increasing) friction coefficient respectively. Increase of speed reduces the shear thinning due to decreasing viscosity because of temperature rise.
5) Test with 300 rpm speed with step increase in loads from 5, 12, 20 kg gives successive rise in the wear and frictional coefficient at due to the boundary lubrication region at contact surface.
6) Result of the test specimen at speed 600 and 1000 rpm gives the successive increase of friction coefficient for higher loads. Due to oil film lubrication the wear is not even for higher load.

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