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Tribological Investigation of PTFE, Tin Bronze and White Metal

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Abstract -*PTFE, Copper, tin, and lead based alloys are widely used as journal bearing materials in tribological applications. Tin bronze and White metals were widely used as journal bearing materials for copper based alloys and tin-lead based alloys respectively. Thus, the purposes of this study were to investigate the tribological properties of bearing alloys with different compositions used especially in heavy industrial service conditions. The specimens were fabricated using the powder metallurgy (PM) techniques. The wear and coefficient of friction of all these materials are tested using pin-on-disc tribometer with respect to sliding speed and bearing load. Tests were carried out in dry sliding conditions, since despite the presence of lubricant film, under heavy service conditions dry sliding may occur from time to time, causing local wear. As a result of local wear, bearing materials and bearing may be out of their tolerance limits in their early life time.*

Key Words: *Coefficient Of Friction, Journal Bearing Material, Pin-On-Disc Tribometer, PTFE, Tin Bronze, Wear, White Metals.*

1. INTRODUCTION

Bearing is one of the most important parts in rotating equipment's, which permits constrained relative motion between two rotating parts. It provides much easier movement between two rotating parts, which increases efficiency and reduces energy consumption. Bearings are used in any rotating parts such as fans, jet engines, automobile parts, industrial equipment's, and application. For efficient operation and long service life journal bearings have to meet several requirements. Three critical parameters in journal bearings can be expressed as the Friction coefficient, Wear rate, which reflects material loss during the sliding, local bearing temperature, which is an important parameter in seizure. Main causes for journal bearing failure can be Excessive loads, Overheating, Lubricant failure, Corrosion, Misalignment.

In the past few years, wood, iron and skin have been used as journal bearing materials. Moreover, PTFE, Tin bronze, white metal have also found some applications. Currently, in addition to these bearing materials, aluminum and zinc based materials are used as journal bearing materials. With technological improvements, self-lubricated sintered bearings are used where continuous lubrication is impossible and plastic materials are used in certain applications. Therefore, it is essential that the bearing material be chosen depending upon application area. Wear resistance is one of the most important properties that journal bearings should possess. There are several studies and investigations dealing with wear resistance improvements of these Materials.

PTFE is a high performance engineering plastics which is widely used in engineering field, medical field. It is used for manufacturing toys, small gears, wheels. Its use as sliding bearing material is now days increasing due to its properties such as low coefficient of friction, high resistivity against temperature, chemically neutral, self-lubricating, light weight etc. Its costs compared with metallic sliding bearing material are low. Again it provides clean operating environment which is the necessity of certain applications such as food industry. A liquid lubricants have many difficulties to use in sliding bearing, such as liquid lubrication sometimes requires complicated housing design with need for oil ways or nipples which increases overall cost, most of lubricants can be used in very limited operational temperature range. There are many certain applications where we cannot lubricate by liquid lubricants. Among the all polymeric materials PTFE which is high performance engineering Plastic widely used as a solid lubricant in engineering Industry. [3, 4, 5]

Copper based materials are widely used as bearing material because they have high thermal and electrical conductivity, self-lubrication property, and good corrosion and wear resistance. The effect of tin on wear in copper based materials is important. Copper based tin bronzes that include tin are used as bearing material to have a high wear resistance. Friction and wear properties of these materials can be improved by adding tin. The tin bronze (90% Cu and 10% Sn) is the most suitable bearing material under corrosive conditions, at high temperatures and high loads.

The effect of tin on wear in copper-based materials is important. Copper-based tin bronzes that include tin are used as bearing materials to get high wear resistance. Friction and wear properties of these materials can be improved by adding tin. The tin bronze (90% Cu and 10% Sn) is the most suitable bearing material under corrosive conditions, at high temperatures, and under high loads. The

effect of copper on the mechanical properties in tin-lead-based materials is important. Copper increases the mechanical properties of tin-lead-based materials. In addition, antimony increases the hardness and mechanical properties of tin-lead-based materials. It prevents shrinking in the course of solidification of tin-lead. Tribo-materials used for crankshafts in automobiles have embedding ability and high wear resistance. These bearings contain lead, tin, aluminium, and copper. [6, 7, 8]

Talat Tevruz et. al. [3] carried out study on "Tribological behaviors of carbon filled polytetrafluoroethylene (PTFE) dry journal bearing", Wear 221(1998) 61-68. In this paper a complete setup for testing a sliding bearing is given. A tribological behavior of 35% carbon filled PTFE bearings is experimentally studied. In this study the effects of sliding distance, bearing pressure and sliding velocity is studied. The various results are shown graphically, it shows that friction coefficient increases as the velocity increase & friction coefficient decreases as bearing pressure increase. Friction Coefficient of 35% carbon filled bearing is 1.2 to 1.6 times that of pure PTFE.

W. Gregory Sawyer, Kevin Freudenberg, Praveen Bhimraj, Linda S.schadler, et. al. [4] carried out study on "A study on the friction & wear behavior of PTFE filled with alumina nanoparticles", Wear 254 (2003) 573-580. In this paper a friction & wear test is carried out with filler as Nano particles of alumina. The various results are given in tables & analyzed with graphs. Here the mixture of powder is blended with PTFE by jet milling apparatus. A composite with filler (20wt %) has greater wear resistance than pure PTFE and it increasing filler concentration. In this test the composites were tested against stainless steel counter face on a reciprocating tribometer.

David L. Burris, W.Gregory Sawyer et. al. [5] studied "A low friction & ultra-low wear rate PEEK/PTFE composite", science Direct, Wear 261(2006) 414-418. In this paper PEEK is used as filler to PTFE. The friction coefficient & wear rate of this composite material are evaluated with the help of linear reciprocating tribometer with different samples with different percentage of PEEK. In this paper there are several graphs as coefficient of friction vs. sliding distance, volume loss vs. sliding distance etc. The results of this test shows that the composite material has low coefficient of friction & low wear rate than pure PTFE.

M.V.S. Babu, A. Rama Krishna, and K.N.S. et. Al. [6] had carried out study on "Suman have reviewed on Journal Bearing Materials and Current Trends". American Journal of Materials Science and Technology (2015) Vol. 4 No. 2 pp. 72-83. In this paper, a critical review has given on Journal bearing materials; right from the old-age Babbitt to advanced materials in use till date is presented. Metallurgical aspects and mechanical behaviour of successful widely used bearing materials along with their micro and Nano composite alternatives are discussed. Tin Babbitt is an ideal material for journal bearing applications. So, it is taken as reference for comparing the quality of other bearing materials.

A. Zeren, E. Feyzullahoglu, M. Zerenet.et. Al. [7] carried out study on "A study on tribological behaviour of tin based bearing material in dry sliding", Materials and Design 28 (2007) 318–323, Has studied tribological behaviour of tin based bearing material in dry sliding. They investigated the tribological behaviour of two different tin-based bearing materials in dry sliding conditions. One of these alloys with low Sb content (7%) is known as SAE 12 and is widely used in the automotive industry and the other with high Sb content (20%) is a Sn–Sb–Cu alloy. Wear and friction characteristics were det ermined with respect to sliding distance, sliding speed and bearing load, using an Equipment HFN type 5 journal bearing test equipment. Hardness measurements were carried out to determine the effect of the increase in Sb content and its impact on tribological properties. Light microscopy is used to understand the tribological events in these two different bearing materials. The purpose of this study is to investigate the tribological properties of tin-based bearing alloys with different compositions, used especially in heavy industrial service conditions.

Adalet Zeren et.al. [8] has studied the "Embeddability behaviour of tin-based bearing material in dry sliding"", Materials and Design 28 (2007) 2344–2350. In which studied that tin-based bearing material has been investigated in dry sliding conditions. The low Sb content (7%) is known as SAE 12 and is Sn–Sb– Cu alloy and is widely used in the automotive industry. Wear and friction characteristics were determined with respect to sliding distance, sliding speed and bearing load, using an Equipment HFN type 5 journal bearing test equipment. Scanning electron microscopy (SEM) and energy-disperse X-ray spectrography (EDX) is used to understand the tribological events, especially embeddability. The purpose of this study is to investigate the tribological properties of tin-based bearing alloy used especially in heavy industrial service conditions.

2. EXPERIMENTAL

2.1 Preparation of Specimens

In this study, PTFE, Tin bronze and White metals specimens were used as journal bearing and EN31 hardened steel of hardness 60 HRC was used as shaft.

Table -2.1.1: Material used for Pin Specification

Sr. No.	Specification of Pin	Material
1	P 1	PTFE
2	P 2	Tin bronze
3	P 3	White metal

Table -2.1.2: Chemical composition in % of Weight of the journal materials

Material	C	Mg	Si	P	Mn	Cr
EN31	1.5	0.05	0.22	0.05	0.52	1.3

Table -2.1.3: Chemical composition of the journal bearing materials (Wt. %)

Material	Sn	Pb	Cu	Sb	other
PTFE	-	-	-	-	$(C_2F_2)_n$
Tin Bronze	10	-	90	-	-
White metal	80	3	6	11	-

2.2 Specimen Preparation

The PTFE Tin bronze and White metals material for the pin was used to prepare pin sample of dimensions ϕ10 mm and 25mm in length. PTFE, Tin bronze and White metals powder was supplied by Ideal Steel Pvt. Ltd, MIDC, Ahmednagar, Maharashtra, India. The pins were manufactured by Powder Metallurgy from raw materials as mentioned in table -2.1.1 According to the dimensions required for test at Ideal Steel Pvt. Ltd, MIDC, Ahmednagar, Maharashtra, India.

2.3 Test Setup

The TR-20LE-PHM-400, Wear and friction monitor testing machine represents a substantial advance in terms of simplicity and convenience of operation, ease of specimen clamping and accuracy of measurements, both of wear and frictional force. The equipment is designed to apply load up to 200N & speeds starting from 200 to 2000 rpm, provision is made only to conduct tests under dry and heated conditions. This apparatus facilitates study of friction and wear characteristics in sliding contacts under different test conditions, sliding occurs between the stationary pin and a rotating disc. The Pin on disc apparatus was used to study the tribological behaviour of pins. The prepared samples of pins were used for the tribological test at P. Dr. V. Vikhe Patil College of Engineering, Ahmednagar, Maharashtra. The Wear was performed on a pin-on disc apparatus according to ASTM D2538 and ASTM D2396. The test rig was supplied by DUCOM Instrument Bangalore, India

2.4 Operating Parameters

Following operating parameters were selected for the test at room temperature condition.

Table -2.4.1: Operating Parameter

Parameters	Dimensions
Pin Size	10 mm diameter, 25 mm long
Disc Size	165 mm × 8 mm
Loads	5 Kg
Speed	500 rpm
Temperature	Atmospheric temperature
Duration	30 minutes

2.5. Wear Test

The journal bearing wear test apparatus are designed to examine the wearing of bearing materials. In this study, a special bearing wear test apparatus has been designed to examine the wearing behavior of bearing material and the shaft together. Therefore, it is possible to investigate different bearing and shaft materials and the effects of heat treatments on these materials. Such a mechanism provides wear of bearings rather than using standard methods as this is more appropriate direct. The Specimen pin ϕ10mm and 25 mm in length were run against the polished EN31 disc. The sample of the pin was kept in pin holder or collect which was kept inside the collet holder. During the test, load values were selected as 5 Kg. The speed of the disc was selected as 500 rpm. The readings were recorded for 30 minutes duration. The readings were recorded for a sample of Pl, P2, and P3 pin. Speed and time were set for the readings.

3. RESULTS AND DISCUSSION

3.1 Wear test

For the study between different materials, the wear test was carried out under different operating parameters. Wear behaviour of given materials was studied with respect to time.

A. Wear (Microns) of pin P1, P2, P3 at 5 Kg, 500rpm

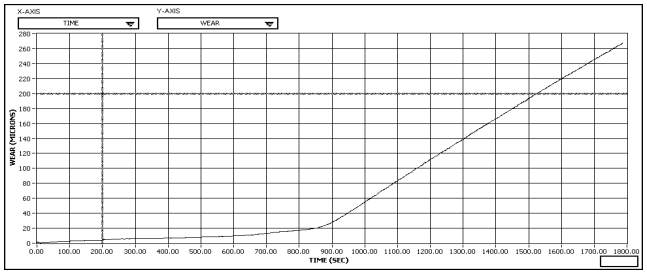

Fig -3.1.1: Wear (Microns) Vs. Time (sec) of pin P1

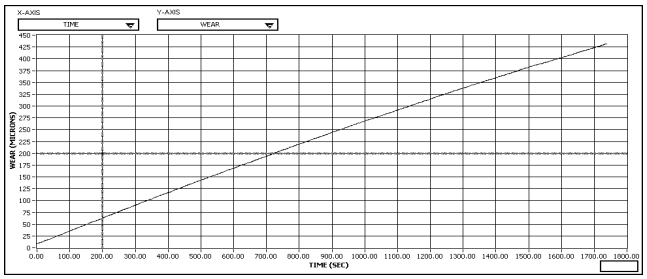

Fig -3.1.2: Wear (Microns) Vs. Time (sec) of pin P2

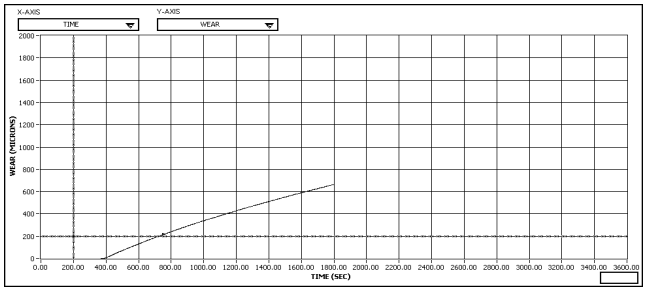

Fig -3.1.3: Wear (Microns) Vs. Time (sec) of pin P3

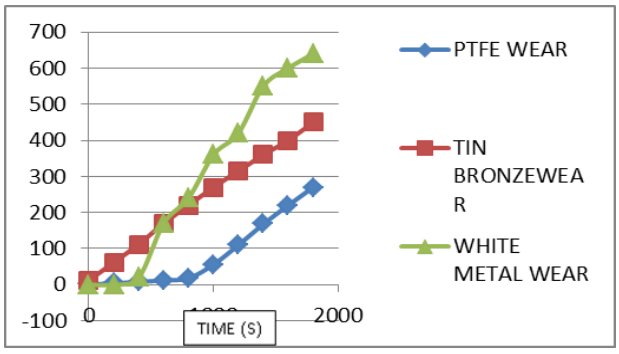

Fig -3.1.4: Wear (Microns) vs. Time (sec) of P1, P2 & P3

From the comparative study between the different material samples at the given loading and speed conditions, it was observed that PTFE having the lowest wear among all the three materials.

B. Coefficient of friction of pin P1, P2, P3 at 5 Kg, 500rpm

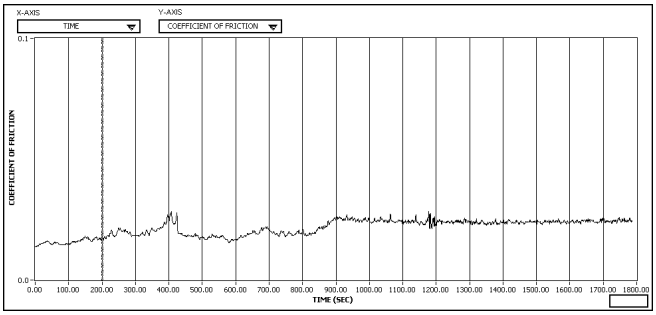

Fig-3.1.5: Coefficient of friction Vs. Time (sec) of pin P1

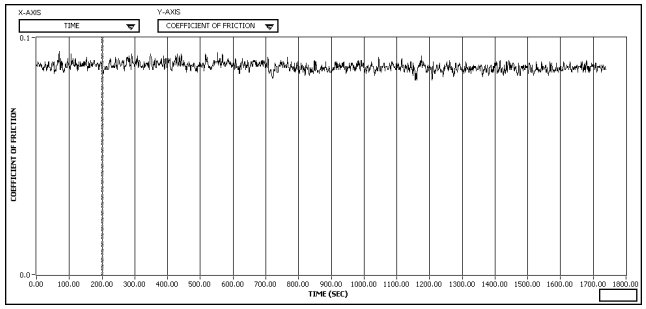

Fig -3.1.6: Coefficient of friction Vs. Time (sec) of pin P2

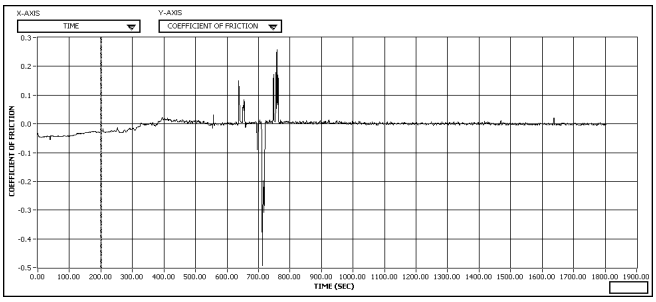

Fig -3.1.7: Coefficient of friction Vs. Time (sec) of pin P3

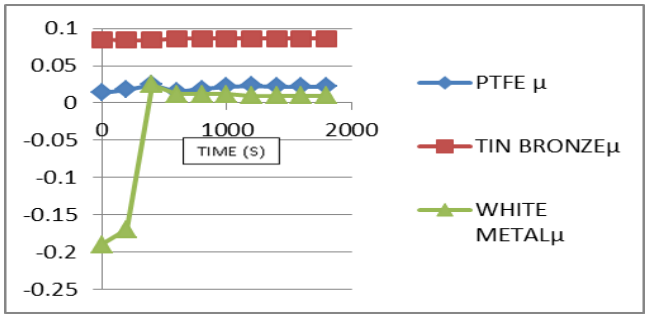

Fig. 3.1.8: Coefficient of friction Vs. Time (sec) of pin P1, P2 & P3

From the comparative study between the different material samples at different loading and speed conditions, it

was observed that White metal having the lowest Coefficient of friction among all the three materials. PTFE has the moderate Coefficient of friction among all the three materials.

4. CONCLUSIONS

In this study, tribological properties of journal bearings manufactured by PTFE, Tin bronze and White metal were investigated by Pin on disc tribometer at various operating parameter. The following conclusions were drawn:

1. The wear and coefficient of friction of PTFE are 270 microns and 0.022, tin bronze are 450 microns and 0.086, and white metal are 640 and 0.01 respectively.
2. The lowest wear occurred in PTFE, moderate Wear occurred in tin bronze (CuSn10) and the highest wear occurred in White metal (CuSnPbSb).
3. The lowest coefficient of friction occurred in White metal (CuSnPbSb), PTFE shows the moderate coefficient of friction and tin bronze (CuSn10) shows highest coefficient of friction among all the three materials.
4. PTFE is seemed to be a very good polymer material which can be effectively used for many applications and hence PTFE acts as good solid lubricants for journal bearing application.

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