Tribological Investigation of Bronze Filled PTFE Composite Material for Journal Bearing Application

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ABSTRACT

Polytetrafluroethylene (PTFE) is a vital engineering material. When rubbed or slide against a hard surface. PTFE exhibits a low coefficient of friction however a high rate of damage. So to enhance the wear and tear rate of PTFE, different fillers like bronze, glass fibers, Mos2, carbon etc. are added. In this work attention is given to suggest self-lubricating PTFE composite bearings in place of the existing hydrostatically lubricated gun metal or brass bearing used for sugar mills. Bronze filled PTFE composites produces very thick, uniform and adherent transfer films of both PTFE and bronze. Therefore the investigation of friction and wear behavior of PTFE composites filled with bronze particles considering the parameters like varying loads of sugar mill was carried out as a work. Experimental work is carried out by varying loads of 100.91N, 109.049N, 113.07N, 117.189N at sliding velocity 0.12 m/s, keeping rest of the parameters constant. Rubbing the test pins of PTFE composites against AISI SS 304 stainless steel disc surface (Ra = 0.14 µm) in wet condition using distilled water + Mos2 as a Lubricant by pin-on-disc Tribometer (TR-20LE) at NTP. Composites of PTFE + 40 % bronze particles filled are taken as bearing materials to investigate its friction and wear behavior.

Keyword : - *PTFE, Fillers, Friction, Wear, Mos2 etc.*

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1. INTRODUCTION

Tribology is the science of rubbing surfaces in relative motion. It is the study of the friction, wear and lubrication of engineering surfaces with a view of understanding surface interactions in detail and then prescribing improvements in given applications. One of the important objectives in tribology is the regulation of the magnitude of frictional force according to whether we require a minimum or a maximum. This objective can be realized only after a fundamental understanding of the frictional process for all conditions like load, sliding velocity, lubrication, surface finish, temperature and material properties [1].

In recent times, there has been a remarkable growth in the large-scale production of polymers and polymer matrix composites. Polymer composites are being more and more used as structural components that are very often Subjected to friction and wear loadings under use. In certain situations, the coefficient of friction is of the highest Importance, but largely it is the mechanical load-carrying capacity and the wear life of components that determine their acceptability in industrial applications under different operating conditions. Variables in friction and wear testing are load, velocity, contact area, surface finish, sliding distance, environment ,material of counter face, type of lubricant used, hardness of counter face and temperature. Usually wear is undesirable, because it makes necessary frequent inspection and replacements of parts and also it will lead to deterioration of accuracy of machine parts. It can induce vibrations, fatigue and consequently failure of the parts. For the particular practical application the kind of wear loading can be different, and therefore the structure of the composite material used for these applications can also be different in order to fulfill the particular requirements. For over sixty years, our world and the quality of its inhabitant's lives have been improved by a resin known as polytetrafluoroethylene or PTFE. It is discovered in 1938 by a DuPont chemist, Mr. Roy J. Plunkett. Upon examination, DuPont learned that PTFE gives a combination of friction, temperature, chemical, mechanical and electrical resisting properties. PTFE is reported in The Guinness Book of World Records for the lowest coefficient of static and dynamic friction as 0.02 - equivalent to wet ice on wet ice [2]. PTFE is a kind of self-lubricating material having super low coefficient of friction, outstanding corrosion resistance, chemical inertness and wide service temperature range [3]. PTFE is a frequently used as a solid lubricant both as a filler and matrix [4]. PTFE is currently finding increasing usefulness in high performance mechanical seals due to its unique properties like high chemical resistivity, low coefficient of friction and high temperature stability [5,6]. However, its application has been greatly limited due to its poor mechanical properties, high linear expansion coefficient, bad thermal conductivity and poor wear and abrasion resistance [3, 4, 7].

Adding glass fibers, bronze, carbon, Mos2 fillers to PTFE were found effective in reducing the wear rate of PTFE composite. In addition for the range of loads and speeds used in this investigation, wear rate showed very little sensitivity to test speed and more sensitivity to the applied load, particularly at high load value. [5]

PTFE is extensively used for large variety of structural applications as in aerospace, automotive, earth moving, electrical, electronics, chemical and computer industries. On account of its good combination of properties, they are used for producing a number of mechanical components such as gears, cams, wheels, brakes, clutches, bearings, gaskets, seals as well as wires, cables, electronic components, medical implants, surgical instruments etc. [2].

India is the largest sugar producing country in the world & sugar industry in India is the second largest manufacturing industry. Presently Indian sugar industries are operating at different cane crushing capacity ranging from 1000 to 10,000 tons per day.[10] In sugar industry juice from sugar cane is extracted in milling section. The sugar mills use number of running components fabricated with ferrous and non-ferrous alloys which requires frequent or continuous lubrication. These mills often suffer from corrosion related problems which in turn results in the need for large maintenance, thereby increasing the production cost.[12] Now there is a scope to reduce the cost of sugar production and increase the efficiency of the sugar mills by replacing some of the conventional material components with those of newly developed light weight composites. In this work attention is given to suggest the replacement of the existing hydrostatically lubricated gun metal or brass bearing used for sugar mills by self-lubricating PTFE composite bearings. because of this, In this paper tribological behaviors of PTFE+40% bronze composites against MoS_2 filled distilled water were comparatively investigated by considering the parameters like loads and sliding velocity of existing bearing of sugar mills. Wear tests are carried out by rubbing the test pin of PTFE composites against stainless steel disc surface in wet condition using a pin-on-disc Tribometer.

The influence of Normal load, % of Mos_2 in distilled water as a lubricant and 40% bronze filled PTFE is discussed in results and discussion.

2. METHODOLOGY

2.1 Preparation of Specification

PTFE composite material consist of 40% bronze is easily available in market in the form of cylindrical rod with the dimensions 20 mm. diameter and 155 mm in length the sample specimen of diameter 8mm and length 30 mm has been prepared by performing necessary facing and turning operations on respective rod. The disc of material AISI SS 304 stainless steel plate is finished at Prathmesh industries MIDC, Moshi, Pune.

Table I. Counter face Part I (Pin)

Specimen	Chemical Composition In Wt.%
I	40% Bronze Filled PTFE

Table II. Counter face Part II (Disc)

Content	C	Si	Mn	P	S	Cr	Ni	C
%	0.08	0.75	2.00	0.045	0.03	18	10	0.08

2.2 Experimental Setup-

Using a pin-on-disc Tribometer (TR-20LE) reading of wear and frictional force are taken.

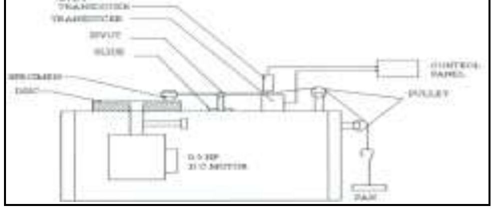

Fig.1 Experimental set up (Tribometer TR-20LE)

2.3 Variables in Wear Testing-

The variables in Wear Testing are as follows.

a) Normal Load

In sugar cane mill bearing hydrostatic lubrication is used. Hydrostatic oil pressure varies from 775 psi to 900 psi depending on the load on mills. This hydraulic pressure directly acts on the piston of diameter 300 mm of the cylindrical chamber of Hydrostatic oil pressure bearing.

1 psi = 0.07031 kg/cm2

∴ Pressure on piston = 54.4903 kg/cm^2 to 63.279 kg/cm2

∴ Minimum Load on the piston = $\pi/4 \times 302 \times 54.4903 = 38516.9234$ kg.

∴ Maximum Load on the piston = $\pi/4 \times 302 \times 63.279 = 44729.2893$ kg.

This load directly acts on the bearing of projected area Ø380 × 495 mm^2.

∴ Minimum pressure on the bearing = 38516.9234 / (380 × 495) = 0.2048 kg/mm2.

∴ Maximum pressure on the bearing = 44729.2893 / (380 × 495) = 0.2378 kg/mm2.

So these pressures can be considered as directly acting on the test pins of Ø8 mm.

∴ Minimum Load on the test pin, $P_{min} = \pi/4 \times 8^2 \times 0.2048 = 10.29$ kg.

∴ Maximum Load on the test pin $P_{max} = \pi/4 \times 8^2 \times 0.2378 = 11.95$ kg.

Therefore, considering the masses available with the testing unit TR-20LE, loads to be applied on the test pins through the lever and the pulley arrangement are selected as 10.29 kg, 11.12 kg, 11.53 kg and 11.95 kg. I.e. the normal loads of 100.91 N, 109.049 N, 113.07 N and 117.189N. are to be taken for the experimentation.

b) Sliding Velocity

The unit is equipped with a 1.5 HP, variable speed motor with a ± 0.5% accuracy (full scale) configured for 220 V, single phase, 50 Hz. The motor drives the upper vertical shaft on which the base disc is placed. The speed is controlled using control potentiometer with speed ranges from 20 to 2000R.P.M.

Sugar cane milling roller rotates slowly from 4.5 rpm to 6 rpm depending load on it. Therefore sliding velocity of journal of Ø380 mm in hydrostatic bearing is:

$V_{min} = \pi dN/60 = 0.09$ m/s.

$V_{max} = \pi dN/60 = 0.12$ m/s.

So the rotary speed 6 rpm i.e. sliding velocity 0.12 m/s, is to be taken constant for experimentation.

TABLE III. NUMBER OF EXPERIMENTS

Pin No.	Condition	Load	Distilled Water+ %Mos2	Sliding Velocity (m/s)
1.	WET	100.91	D+3	0.12
2.	WET	109.09	D+3	0.12
3.	WET	113.07	D+3	0.12
4.	WET	117.19	D+3	0.12
5.	WET	100.91	D+5	0.12
6.	WET	109.09	D+5	0.12
7.	WET	113.00	D+5	0.12
8.	WET	117.19	D+5	0.12

3. RESULTS & DISCUSSIONS

Fig.2 & 3 shows that variation of wear with the time for distilled water filled with 3%, & 5% Mos_2.During the experiment, sliding velocity is 0.12 m/s constant. Curves 1, 2, 3 & 4 of these figures are drawn for normal load 100.91N, 109.91N, 113.07N and 117.18N respectively. From the figures of wear in micrometer vs. time plotted above for the 40% bronze filled PTFE composite test pins it is observed that for all the values of normal loads, and constant sliding velocity initially material wear increases with time and after certain time wear curve becomes almost stable. Meanwhile slight decrements in wear are observed and it may be due to thick formation of transfer film between the sliding surfaces. Stability of wear curve depends on how strongly the transfer film adhered and continued till its breakage.

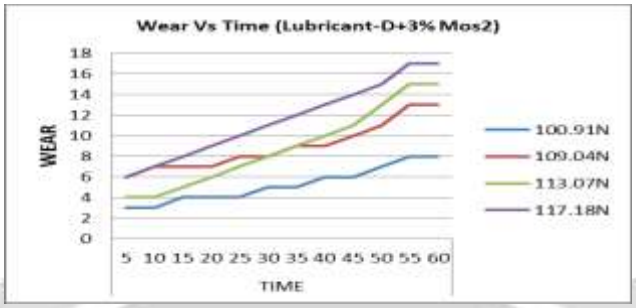

Fig.2 Variation of wear vs. time for D+3% Mos_2

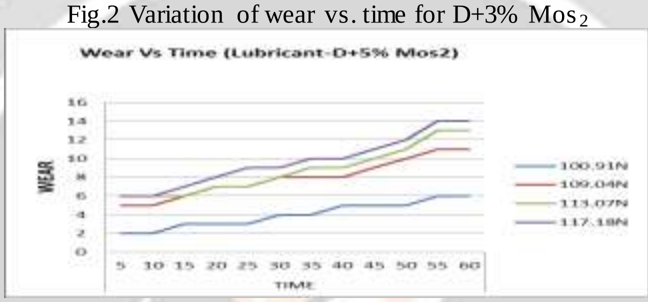

Fig.3 Variation of wear vs. time for D+5% Mos_2

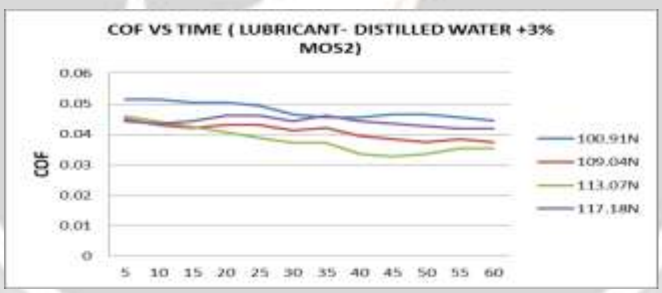

Fig.4 Variation of Cof vs. time for D+3% Mos_2

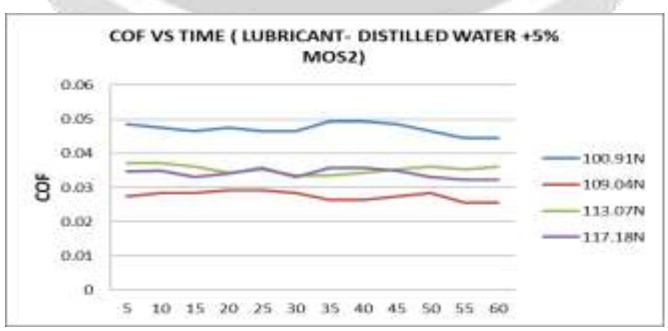

Fig.5 Variation of Cof vs. time for D+5% Mos_2

Fig.4 &5 shows that variation of wear with the time for distilled water filled with 3% & 5%, Mos_2. Also from the figures of coefficient of friction vs. time it is observed that, initially coefficient of friction slightly increases with time, but after certain time it remains almost constant or decreases with time. Generally the decrement in coefficient of friction or frictional force is observed for increments in wear or vice versa.

Graphs of variation of wear and variation of coefficient of friction with time are plotted as shown in fig.From these figures for all test samples it is observed, for all the combination of values of sliding velocities and normal loads that initially material wear increases with time due to the formation of poor transfer film between the surfaces. After certain time the transfer film is relocated and is uniform and strong enough to retain itself, stabilizing the wear rate. In between the slight decrement in wear is observed and it may be due to formation of additional layer on transfer film between the sliding surfaces. Stability in wear depends on how strongly the transfer film adhered and maintained till its breakage.

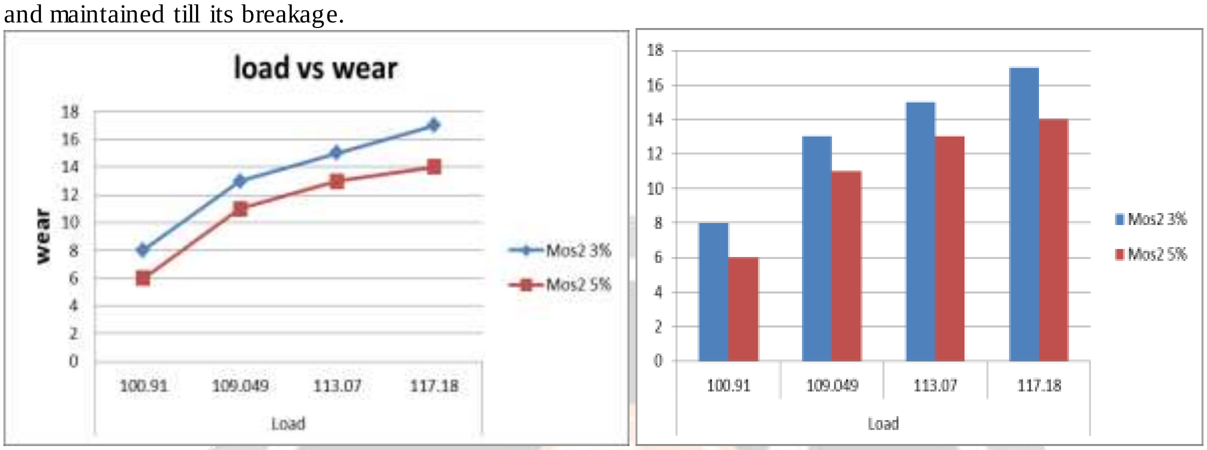

Fig.6 Effect of load on wear for different combination of lubricants

Fig.6 Shows variation of wear with load for different % of Mos_2 filled in distilled water (Lubricant) from fig. it is observed that less wear is observed in 5% Mos_2 filled in distilled water as compared to distilled water + 3% Mos_2. This is because it is observed during experimentation in case of Mos_2 5% in distilled water strong and stabilized transfer film of lubrication is formed in between pin and steel counter face because of that less wear is observed in this combination. and in other combination like Distilled water+3% Mos_2 and Distilled water +3% Mos_2 more wear is observed because poor and inadequate film is formed between pin and steel counter face so more wear is observed in distilled water + 3% Mos_2 than distilled water + 5% Mos_2.from this we can easily conclude that as % mos2 in distilled water increases less wear is observed during the experimentation.

CONCLUSIONS-

Based on present study the following conclusions can be drawn:

1. For the PTFE + 40% bronze composites, initially wear is more & after certain sliding time wear curve shows very small wear with time or it gets stabilized .This may be due to formation of more & more uniform transfer film on the counter face.
2. Frictional coefficient initially increases with sliding time & later it remains almost constant due to more compact and uniform transfer film.
3 .Wear increases with increase in applied load.
4. Depending upon load, velocity of sliding, lubrication used in this study can be ranked as Distilled Water+5 % Mos_2> Distilled Water+ 3 % Mos_2 for their wear resistance Performance.
5. From above experimentation we can conclude that we will get more wear resistance in sugar mill journal bearing if we use 5 % Mos2 in distilled water as a lubricant.

ACKNOWLEDGMENT

The author would like to thanks Prof. R.R.Kharde HOD, Prof. S.R.Nimbalkar of Mechanical Engineering Department, Pravara Rural Engineering College, Loni. For their valuable Guidance and Prof.M.S.Mhaske, for skillful assistance with the work.

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