# THE TRIBOLOGICAL PROPERTIES OF PTFE COMPOSITES FILLED WITH GLASS FIBER, $MOS_2$, BRONZE REINFORCEMENT

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**Abstract -** PTFE that is Polytetrafluroethylene has wide increasing demand because of its unique properties like low coefficient of friction, high chemical resistivity, and high temperature stability. However, PTFE exhibits poor wear resistance, especially abrasion. The wear resistance of PTFE can be significantly improved by addition of suitable reinforcement (filler) materials. Among the most common filler materials are glass fibers, MoS2 and bronze. In this paper, it is presented a review of tribological properties of composite materials with PTFE matrix and above mentioned filler materials.

***Key Words*: PTFE, composites, glass fibers, $MoS_2$, bronze, friction, wear**

## 1.INTRODUCTION

### 1.1 Overview

Nowadays, there is very intensive growth in the large scale production of the fiber reinforced polymer composites since they possess certain advantages over the metals. The advantages include lower density, less need for maintenance and lower cost. Polymers and polymers reinforced with fibers are used for producing of various mechanical components, such as gears, cams, wheels, brakes, clutches, bush bearing and seals. Considerable efforts are being made to extend the range of applications. Such use would provide the economical and functional benefits to both manufacturers and consumers. Many researchers have studied the tribological behavior of Polytetrafluroethylene (PTFE). Studies have been conducted with various shapes, sizes, types and compositions of fibers. In general these composites exhibit lower wear and friction when compared to pure PTFE.

The most commonly used reinforcements (fillers) for tribological applications are MoS2, b and glass fiber. Generally the fillers improve the wear resistance from 10 to 500 times, depending on the filler type and shape and subject of this paper are composites with PTFE matrix. Filler materials investigated in this paper are glass fiber, $MoS_2$ and bronze. The paper analyzes tribological characteristics like coefficient of friction and wear at dry sliding conditions. Most probably cases, friction and wear tests were carried out on pin-on-disc Tribometer at ambient conditions (temperature and humidity). Counterpart material used in the experiments was always harder than composite. In most cases, counterpart material was steel. All tests were carried out at dry sliding conditions. Overall results from all analyzed papers are summarized and presented in Table.

### 1.2 Problem Statement:-

From the discussion with deputy chief engineer to know the problems faced in the past & the problems arises during the season for the mill bearings of milling section of this sugar factory, it comes to know that

1) Sometimes the lubricating oil may get mixed with sugar cane juice due to leakage and may change the juice properties slightly.

2) The life of a bottom roller bearing is one to five seasons longer than that of top roller bearings.

3)High and non-uniform wear of journal bearing surface (1 to 5 mm) over its length along with the corrosion, pitting scoring and „v" grooving.

### 1.3 Objectives:-

1) To suggest the best suitable self-lubricating PTFE composite material for the journal bearing applications from the tested PTFE composite materials for the existing hydrostatically lubricated gun metal or brass journal bearing used for sugar Mills.

2) To find out the behavior of bronze filled PTFE composite material from wear &friction point of view and the effect of various sliding speeds and loads on it.

3) To develop relationship of total wear with the applied normal load, sliding velocity and percentage of bronze by using regression analysis

## 2 LITERATURE REVIEW

### 2.1 Review of Book, Journal & International Paper

From study of literature it is observed that pure PTFE has poor sliding and wear properties and to enhance the friction and wear behavior of PTFE composites tremendous work had been carried out regarding filler material and its %, size of the particles, surface treatment to fillers, shape and orientation of the fillers, sliding time (distance), counter face material and its roughness, external lubrication, normal load between two surfaces, sliding speed between two surfaces and mechanism of wear and concluded that the strength and adherence of a transfer films produced during friction is responsible for the friction and wear behavior of polymer composites. Also it is determined that the bronze filled PTFE composites were produce very thick, uniform and adherent transfer films of both PTFE and bronze as compared to carbon, copper and glass fiber, which itself is a source of high friction and heat generation, reinforced PTFE composites. Also, from the study of literature it is found that no work had been carried out on effect of distilled water+ % variation of MoS2 as a lubricant on friction and sliding wear behavior of PTFE composites for low speed and high load applications. Many of the researcher works to improve the performance of journal bearing with different bearing material & lubricants. It is observed that very less work had been done as a polymer bearing for sugar mill. Here the more practical option for improving existing bearing material & lubrication system, polymer is the best alternative. So the study of effect of varying percentage of MoS2 in distilled water as a lubricant on friction and sliding wear behavior of bronze filled PTFE composites for low speed and high load application of sugar mill bearing is carried out as a project work.

## 3 EXPERIMENTAL METHODOLOGY

### 3.1 Preparation of Specimen

For the testing PTFE composite materials are purchased from Mahavir sales Ahmednagar, MIDC, This material is in the form of powder from and using metal compaction method with help of ball make testing specimen with dimension's 30mm diameter and 50 mm length. The test specimens (pins) of 8mm diameter and 30 mm length are cut from Sai Engg works Ahmednagar using lathe machine. The disc of material AISI SS 304 stainless steel plate is finished by PDVVP COE Ahmednagar

Table No 3.1 sample pin composition

| Sr.no | Composite pin |
|---|---|
| 1. | Ptfe+30% glass fiber+5% mos2+5%Bz |
| 2. | Ptfe+25%glass fiber+5%mos2+5%Bz |
| 3. | Ptfe+20%glass fiber +5%mos2+5%Bz |
| 4. | Ptfe+15%glass fiber+5% mos2+5%Bz |

### 3.2 Experimental Setup

Experimental set up which is available in PDVVP College of Engineering, Ahmednagar isas shown in following fig. 3.2. Using a pin on disc Tribometer (TR20LE) reading of wearand frictional force are taken

Fig. 3.2 Photograph of experimental set up (Tribometer TR20LE-PHM-400).

Table 3.2 Specifications of PIN and Disc Tribometer (TR20LE)

| Specifications of pin on disc Tribometer (TR-20) | MAKe: Ducom Ltd, Bangalore. |
|---|---|
| Pin Size | 3 to 12 mm diagonal |
| Disc Size | 165 mm dia. X 8 mm thick |
| Wear Track Diameter (Mean) | 10 mm to 160 mm |
| Sliding Speed Range | 0.26 m/sec. to 10 m/sec. |
| Disc Rotation Speed | 100-2000 RPM |
| Normal Load | 200 N Maximum |
| Friction Force | 0-200 N, digital readout, recorder output |
| Wear Measurement Range | 4 mm, digital readout, and recorder output |
| Power | 230V,15A,1 Phase,50 Hz |

## 4 RESULT AND DISCUSSION

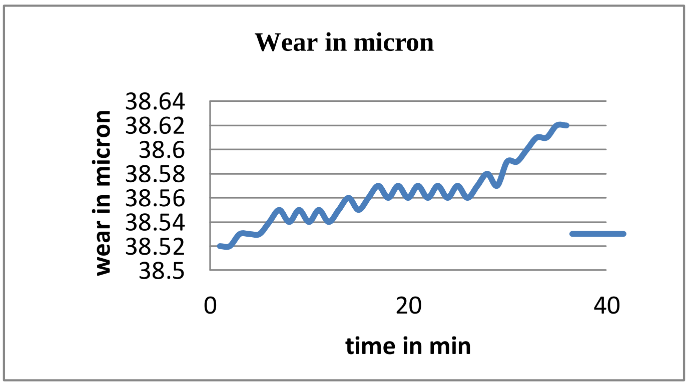
Pin1:-Effect of Time on Ptfe+30% glass fiber+5% mos2+5%Bz

To evaluate the wear performance of PTFE the wear test has been carried out for 3hr duration. The wear has been noticed for every 10 minute interval of time, their relation have been studied after the completion of test. The readings obtained after the test have been shown in Table

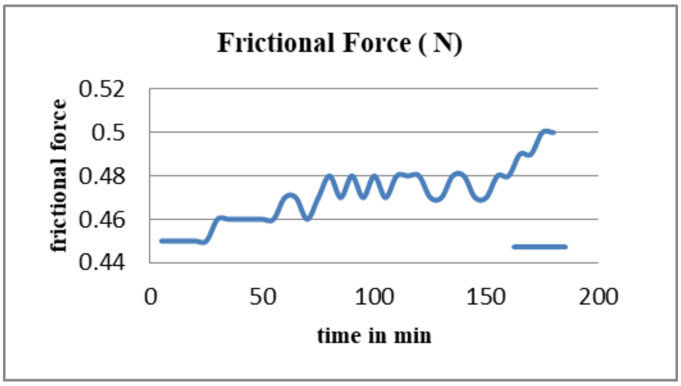
Table 4.1.1: Observations Table for PIN-P1

| Time (min) | Wear in micron | Frictional Force ( N) |
|---|---|---|
| 5 | 38.52 | 0.43 |
| 10 | 38.51 | 0.42 |

| | | |
|---|---|---|
| 15 | 38.53 | 0.43 |
| 20 | 38.53 | 0.45 |
| 25 | 38.53 | 0.45 |
| 30 | 38.54 | 0.46 |
| 35 | 38.55 | 0.46 |
| 40 | 38.52 | 0.42 |
| 45 | 38.55 | 0.46 |
| 50 | 38.54 | 0.43 |
| 55 | 38.53 | 0.46 |
| 60 | 38.54 | 0.46 |
| 65 | 38.55 | 0.47 |
| 70 | 38.56 | 0.46 |
| 75 | 38.55 | 0.47 |
| 80 | 38.56 | 0.49 |
| 85 | 38.56 | 0.47 |
| 90 | 38.52 | 0.48 |
| 95 | 38.57 | 0.47 |
| 100 | 38.56 | 0.48 |
| 105 | 38.58 | 0.47 |
| 110 | 38.56 | 0.48 |
| 115 | 38.57 | 0.48 |
| 120 | 38.56 | 0.48 |




4.1.1.a :Effect of time on wear of PIN-1



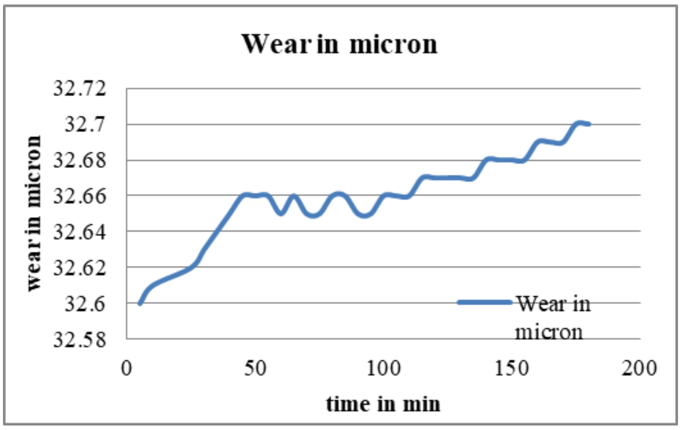

4.1.1.b :Effect of time on frictional force of PIN-1

Pin 2:- Effect of Time on Ptfe+25%glass fiber+5%mos2+5%Bz

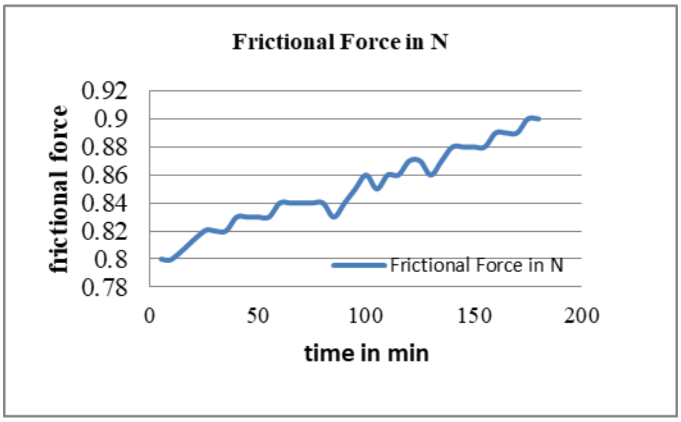
The fig 7.1.2: A effect of time on wear rate of PTFE composite at standard operating conditions. It has been observed that specific wear for PIN-2 was initially somewhat high because of sudden normal and tangential force acted on the pin during the starting of test rig

Table 4.1.2: Observations Table for PIN-2

| Time in min | Time in min | Frictional Force in N |
|---|---|---|
| 5 | 32.60 | 0.80 |
| 10 | 32.61 | 0.80 |
| 25 | 32.62 | 0.82 |
| 30 | 32.63 | 0.82 |
| 35 | 32.64 | 0.82 |
| 40 | 32.65 | 0.83 |
| 45 | 32.66 | 0.83 |
| 50 | 32.66 | 0.83 |
| 55 | 32.64 | 0.83 |
| 60 | 32.65 | 0.84 |
| 65 | 32.66 | 0.84 |
| 70 | 32.65 | 0.84 |
| 75 | 32.65 | 0.84 |
| 80 | 32.66 | 0.85 |
| 85 | 32.66 | 0.83 |
| 90 | 32.65 | 0.84 |
| 95 | 32.65 | 0.86 |
| 100 | 32.66 | 0.86 |
| 105 | 32.66 | 0.85 |
| 110 | 32.66 | 0.86 |
| 115 | 32.67 | 0.86 |
| 120 | 32.67 | 0.87 |




4.1.2.a: Effect of time on wear of PIN-2

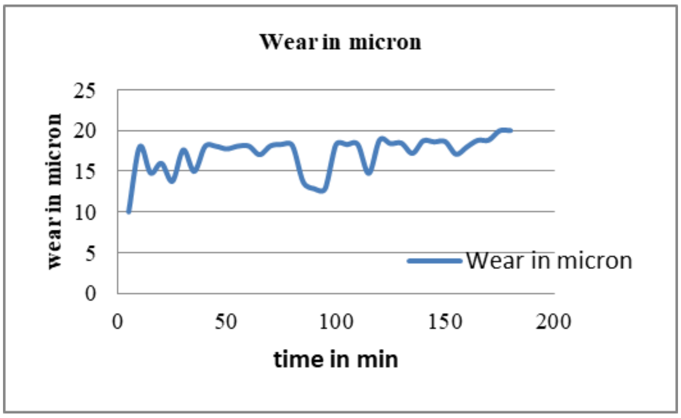



4.1.2.b :Effect of time on frictional force of PIN-2

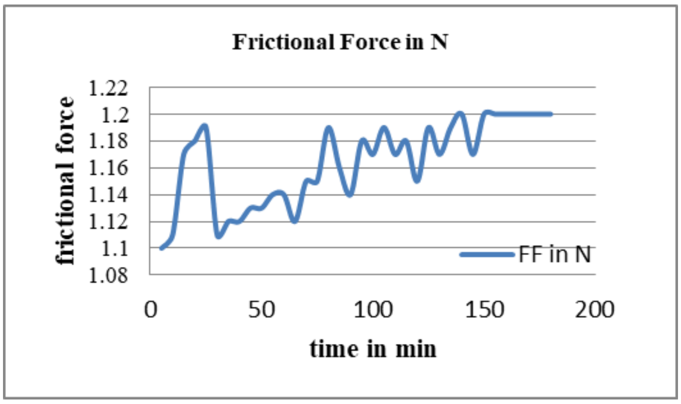
Pin 3:- Effect of Time Ptfe+20%glass fiber +5%mos2+5%Bz The fig 4.1.3.a shows the effect of time on specific wear rate of PTFE at standard operating conditions. Initially the wear rate was negative this is because of sudden thermal expansion between disc and pin. The expansion detoriates mechanical properties due to which base material initially lose some pin material in a vicinity of counter parts and adhere on the surface of pin. This transfer film creates resistance against wear properties. The addition of MOS2 with glass fiber act as self-lubricating agent help to form a thin black gray color transfer film on disk along with thermal expansion of pin material. Addition of 5%MoS2 in glass fiber reduces the abrasion

Table 4.1.3: Observations Table for PIN-P3

| Time in min | Wear in micron | FF in N |
|---|---|---|
| 5 | 10 | 1.1 |
| 10 | 17.99 | 1.11 |
| 15 | 14.78 | 1.17 |
| 20 | 15.98 | 1.18 |
| 25 | 13.77 | 1.19 |
| 30 | 17.62 | 1.11 |
| 35 | 14.98 | 1.12 |
| 40 | 18.05 | 1.12 |
| 45 | 18.06 | 1.13 |
| 50 | 17.75 | 1.13 |
| 55 | 18.08 | 1.14 |
| 60 | 18.09 | 1.14 |
| 65 | 17.04 | 1.12 |
| 70 | 18.11 | 1.15 |
| 75 | 18.3 | 1.15 |
| 80 | 18.15 | 1.19 |
| 85 | 13.65 | 1.16 |
| 90 | 12.85 | 1.14 |
| 95 | 12.84 | 1.18 |
| 100 | 18.27 | 1.17 |
| 105 | 18.28 | 1.19 |
| 110 | 18.29 | 1.17 |
| 115 | 14.74 | 1.18 |
| 120 | 18.85 | 1.15 |




4.1.3. a :Effect of time on wear of PIN-3



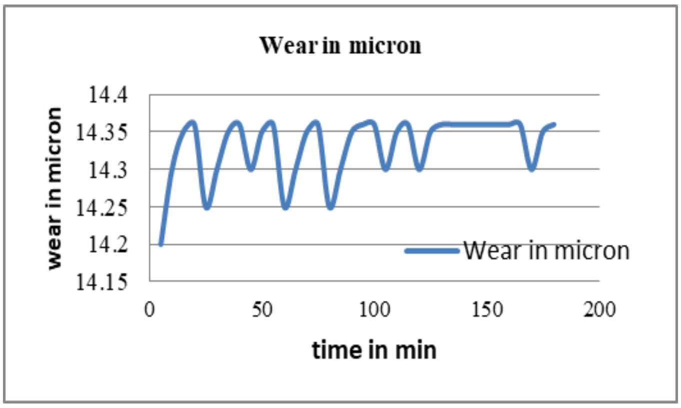

4.1.3. b :Effect of time on frictional force of PIN-3

Pin 4 :-Ptfe+15%glass fiber+5% mos2+5%The fig 7.4.1 shows the effect of time on wear rate or specific wear rate of PTFE at standard operating conditions. The fig shows initially less wear, and increase continuously with respective time. During the test the thin brown color transfers film form on disc. The specific wear rate has been found 3.79x 10-6 mm3/Nm after completion of test. The fig 7.1.4.

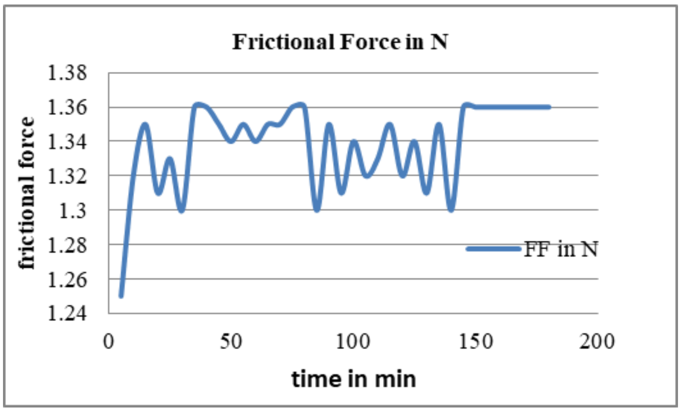
Table 7.1.4.: Observations Table for PIN-P4 Time in min Wear in micron FF in N

| Time in min | Wear in micron | FF in N |
|---|---|---|
| 5 | 12.96 | 1.25 |
| 10 | 13 | 1.32 |
| 15 | 13.1 | 1.35 |
| 20 | 13.15 | 1.31 |
| 25 | 13.2 | 1.33 |
| 30 | 13.25 | 1.3 |
| 35 | 13.3 | 1.36 |

| | | |
|---|---|---|
| 40 | 13.35 | 1.36 |
| 45 | 13.4 | 1.35 |
| 50 | 13.45 | 1.34 |
| 55 | 13.5 | 1.35 |
| 60 | 13.55 | 1.34 |
| 65 | 13.6 | 1.35 |
| 70 | 13.65 | 1.35 |
| 75 | 13.55 | 1.36 |
| 80 | 13.5 | 1.36 |
| 85 | 13.5 | 1.3 |
| 90 | 13.45 | 1.35 |
| 95 | 13.5 | 1.31 |
| 100 | 13.55 | 1.34 |
| 105 | 13.6 | 1.32 |
| 110 | 13.65 | 1.33 |
| 115 | 13.7 | 1.35 |
| 120 | 13.75 | 1.32 |




4.1.4. a :Effect of time on wear of PTFE+PTFE+GF+MOS2+Bronze




4.1.4. b :Effect of time on frictional force PIN-4

## 5 RESULT AND DISCUSSION

### 5.1. Comparative study of wear, frictional force and coefficient of friction of pure PTFE with PTFE composites:

Table 5.1:

| Specimen | Specific wear rate mm3/Nm(x10^-6) | Coefficient of friction (µ) |
|---|---|---|
| At ambient temperature :(23°C) | | |
| PIN-4 | 1.365x10^-5 | 0.138 |
| PIN-3 | 1.7145x10^-5 | 0.133 |
| PIN-2 | 3.0846 x10^-5 | 0.15 |
| PIN-1 | 3.752 x10^-5 | 0.182 |

Table 5.2: Comparative study of frictional force and coefficient of friction

| Specimen | Frictional Force (N) | Coefficient of friction (µ) |
|---|---|---|
| At ambient temperature :(23°C) | | |
| PIN-4 | 1.338 | 0.138 |
| PIN-3 | 1.164 | 0.133 |
| PIN-2 | 0.805 | 0.15 |
| PIN-1 | 0.470 | 0.182 |

## 6 CONCLUSION

The PTFE based composite shows two phases, i) transfer phase and ii) stabilized wear phase. From the experimental study the following conclusions are drawn.

1. Pure PTFE shows high wear rate, K0= 2.65 x 10-6mm3/Nm.

2. The addition of glass fibers to PTFE/PTFE improves its wear resistance properties.

3. It was also found that the 15% glass fiber reinforced with PTFE/PTFE improving the friction and wear behavior of polymer composite. Also fiber fillers improve the creep resistance and composite strength of the PTFE composite and result enhance wear résistance, it is Ko= 2.1345x 10-6 mm3/Nm

4. It was also found that the Composite Pin-3 composition 5% MoS2 with 15% glass fibers in PTFE/PTFE exhibited low coefficient of friction and high wear resistance. It shows very less wear rate than that of PTFE/PTFE reinforced with glass fibers. It is 7.963x 10-8 mm3/Nm. This is because of proportion of solid lubricant.

5. MoS2 and Bronze is used as solid lubricant material. These materials easily enter the roughness valley and stably stay on disk. It provides necessary lubrication during sliding. This is helpful to reduce the wear and increase wear life of component.

6. Also conclude that while increasing the percentage of bronze that is 20% in PTFE composite shows high wear resistance than pin 4.it improves from 3.79x10-6 mm3/Nm to 7.80257x 10-7 mm3/Nm.

7. By adding various filler materials in polymer composite improve the tribological properties. Pin -3 shown greater Wear resistances at variable load condition than pure PTFE.

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