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Analysis of Composite Journal Bearing

G. R. Jadhav, PG Student, Late G. N. Sapkal, COE, Nashik,
D. B. Zoman, Assistant Professor, Late G. N. Sapkal, COE, Nashik,
D. R. Mahajan, Assistant Professor, Late G. N. Sapkal, COE, Nashik

***Abstract*— In this work tribological behavior of composites having base material polyether-ether-ketone (PEEK) with filler materials like Polytetrafluroethylene (PTFE), MoS2, bronze and the conventionally used brass is studied. In this the wear rate analysis is carried out using pin on disk apparatus. The journal bearing in connecting rod of an IC engine was taken as an application for the study. The main objective behind this is to find the wear rate of different materials and to suggest the best material which minimizes the wear also to give the best values of parameters at which minimum wear occurs. PEEK having mechanical properties like high wear resistance, strength and low thermal conductivity also it is an injection moldable polymer with a high operating temperature and chemical resistance [1]. PTFE having excellent tribological properties. By addition of PEEK and PTFE with fillers modifies the tribological properties. During the experiment variable load and speed was selected according to the application.**

***Index Terms*—journal bearing, wear rate, PEEK, PTFE, MoS2, bronze.**

I. INTRODUCTION

When there are two surfaces moving relative to each other then there is friction between the surfaces. The important consequence of this friction can be wear, which may leads to the degradation or many times damage to components. This leads to deficiency of machines. To cater for the problems of wear arising from the conventional materials it is needed to develop novel composites [2] by using polymeric materials like polyetheretherketone (PEEK) and polytetrafluoroethylene (PTFE) by addition of one or more non-conventional filler materials which are having required properties to improve wear resistance. PEEK is a polymeric matrix material with excellent mechanical properties like high wear resistance, strength and low thermal conductivity. Also it is an injection moldable polymer with a high operating temperature and chemical resistance [1]. Because of its robustness, PEEK is used to fabricate items used in applications like bearings, piston parts, pumps, compressor plate valves. On the other hand PTFE is finding increasing utility due to its advantageous tribological properties such as high temperature stability, high chemical inertness, lower friction coefficient. Because of these properties PTFE is widely used as filler material in various applications [1]. However PTFE has poor abrasion and wear resistance, but it can be significantly improved by addition of suitable filler materials [2].

Great work has been done to study the tribological behavior of different composite materials. J R Vail et al [1] has studied the effect of PTFE fiber reinforced PEEK composites and proven that by addition of PTFE in PEEK significantly reduces both the coefficient of friction and the wear rate of the conventional materials. J Khedkar et al [2] studied wear behavior of PTFE composites, the tribological behavior of PTFE and PTFE composites with filler materials such as carbon, graphite, glass fibers, MoS2 and poly-p-phenyleneterephthalamide (PPDT) fibers. He proved that The highest wear resistance was found for composites containing (i) 18% carbon + 7% graphite, (ii) 20% glass fibers + 5% MoS2 and (iii) 10% PPDT fibers for which Scanning electron microscopy (SEM) was utilized to examine composite microstructures and study modes of failure. Wear testing and SEM analysis showed that three-body abrasion was probably the dominant mode of failure for PTFE + 18% carbon + 7% graphite composite, while fiber pull out and fragmentation caused failure of PTFE + 20% glass fiber + 5% MoS2 composite. The composite with 10% PPDT fibers caused wear reduction due to the ability of the fibers to remain embedded in the matrix and preferentially support the load. The results indicated that composites with higher heat absorption capacity exhibited improved wear resistance. K M Bhuptani [3] et al, investigated wear behavior of journal bearing used in connecting rod of an IC engine, with an objective of to check and compares conventional bearing materials with respect to new bearing material name Cast Nylon. It was found that because of co-efficient of friction, the power loss due to friction was five times in Brass and 2.5 Times in Gun Metal compare to Cast Nylon, comparing at the same speed, load and lubricant. Even density of the Brass and Gun Metal is approximately seven times heavier than the Cast Nylon. Therefore, we can replace conventional bearing made either from the Brass or Gunmetal by the new material name Cast Nylon and improve the performance of the engine bearing by way of reducing power loss and less induced temperature due to lower value of co-efficient of friction. S Baskar [4]et al, investigated the friction and wear behavior of journal bearing material has been investigated using pin on disc wear tester with three different lubricating oils i.e. synthetic lubricating oil (SAE20W40), chemically modified rapeseed oil (CMRO), chemically modified rapeseed oil with Nano CuO. Wear tests were carried out at maximum load of 200 N and sliding speeds of 2 to 10 m/s. The results showed that the friction and wear behavior of the journal bearing material have changed according to the sliding conditions and lubricating oils. The journal bearing material has a lower friction coefficient for CMRO with Nano CuO than other two oils. Higher wear of journal bearing material was observed in SAE 20W40 and CMRO. Worn surfaces of the journal bearing material with three lubricating oils were examined using scanning electron microscope (SEM) and wear mechanisms were discussed.

II. Experimental Work

A. Specimen Preparation:

In this work, the investigation was done to find the best suitable composite material than the conventionally used brass material for journal bearing in connecting rod of an IC engine which will give minimum wear rate. The brass material for pin was purchased from the market to prepare pin sample [3] of dimensions 4 mm diameter and 20 mm length. PEEK with 450G powder with an average diameter 100µm is an commercially available material which was supplied by Victrex, PTFE powder with diameter 60µm was supplied by PCEE textile Kanpur, bronze powder with 10% tin was supplied by Pometon India ltd., molybdenum disulfide powder of diameter 100µm supplied by Vishal Pharmachem, Navi Mumbai. The pins of composites were prepared by compression as well as injection molding. All the materials were mixed with different proportions. Digital weighing machine was used to take proper proportion of different materials. Uniform mixing was done by compounding of raw materials. Twin screw extruder was used during compounding of material. This compounding was done by compression molding. The product of this process was long thread like pallets and then it would be again cut into small granules. Following proportions were used to prepare specimens.

Table I. Composition of materials

Sr. No.	Notations for specimens	Proportions of Raw Materials (% by weight)
1	P1	Brass 100 %
2	P2	PEEK(65)+PTFE(20)+BRONZE(15)
3	P3	PEEK (65) + PTFE (20) + Bronze(15)

Then the pins are prepared according to the dimensions as 4 mm diameter and 25 mm length.

Fig. 1 Image of pins

The counterpart was prepared as per the considerations of application. Normally the journal bearing material for connecting rod made up by stainless steel or grey cast iron, so that the counterparts also selected as made up of same material. So the disc material was selected steel with grade EN 8 and grey cast iron.

B. Wear Test:

The Pin on disc apparatus was used to study the tribological behavior of prepared composite material pins. This apparatus is supplied by DUCOM instruments from Bangalore. This test was conducted at Padmashri Dr. Vithhalrao Vikhe Patil, College of Engineering, Ahmednagar. As shown in the figure 1, the arrangement was done to carry out the test. The readings were recorded at regular interval of 5 minutes for 1 hour duration test.

Fig. 2 Experimental set up

Following parameters were selected for carrying out the test at room temperature:

Table II. Operating parameters

Sr. No.	Parameters	Description
1	Loads	10, 20, 30 N
2	Speed	100, 150, 200 rpm
3	Sliding velocity	1.8m/s to 3.4m/s
4	Temperature	Atmospheric temperature (23ºC)
5	Duration	60 minutes

During the experiment the sample of pin was run against the prepared steel disc having the surface roughness of 0.4 µ. The sliding velocity was selected in the range of 1.8 to 3.4 m/s. prepared pin samples was press fitted in pin holder and this pin holder was mounted in collet of pin on disc apparatus. The readings were recorded by following the procedure as per instructions in the manual of WINDUCOM instruments. The test was carried out in three steps for each material. In the first step for brass material reading were recorded by taking the load of 10 N and 100 rpm, 20 N and 150 rpm, 30 N and 200 rpm. In the second and third steps same procedure was carried out for remaining two composite materials.

III. Results and Discussion:

The readings were recorded in a tubular form as shown in table 3.

Table III. Wear Rate (micrometer) of Pins

	Wear (micrometer)		
	10 N, 100 rpm	20 N 150 rpm	30 N, 200 rpm
P1	294.12	472.54	574.26
P2	58.47	85.24	106.26
P3	14.69	23.33	66.28

For the comparative study between different materials, tribological study was carried out under different operating parameters. Results obtained from this study were correlated with each other. Wear behavior of given materials was studied with respect to time.

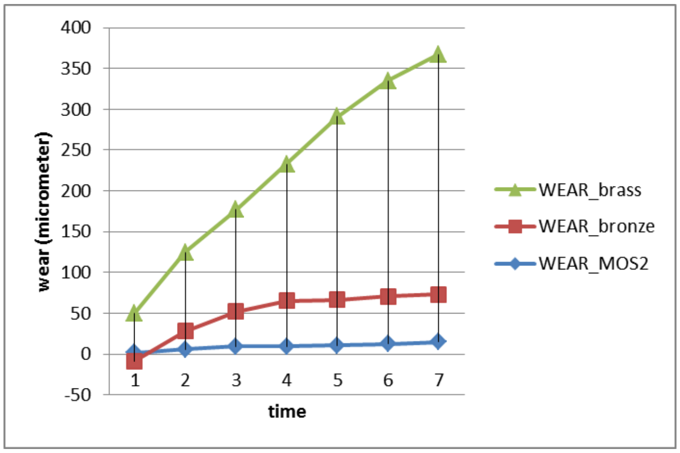

Figure. 3 comparative study of wear for 10 N, 100 rpm

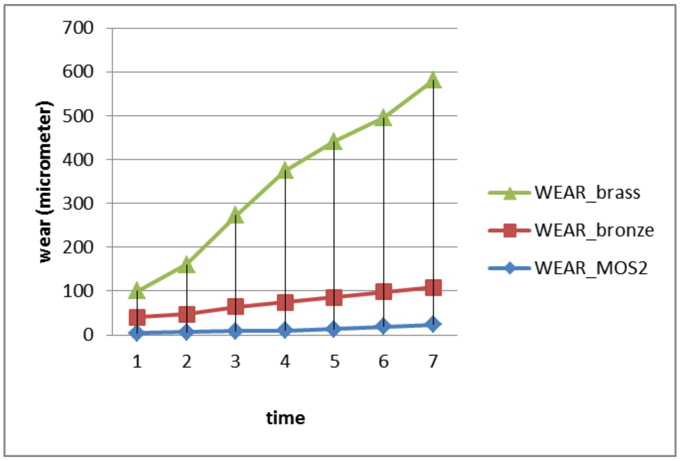

Fig. 4 comparative study of wear for 20 N, 150 rpm

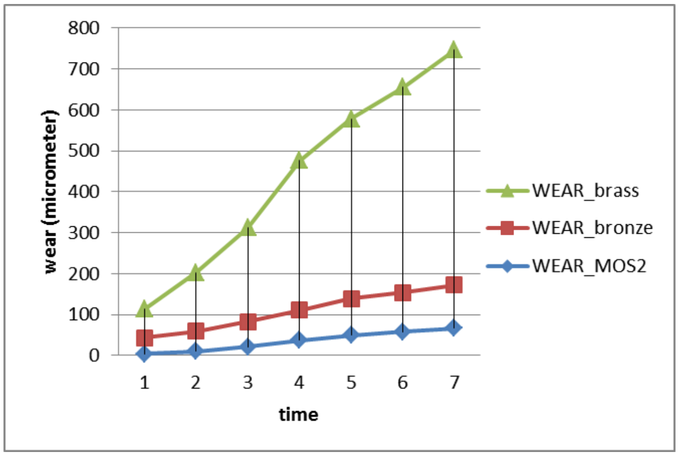

Figure. 5 comparative study of wear for 30 N, 200 rpm

From the above comparative study between the different materials at different loading and speed conditions, it was observed that MoS_2 was having the lowest wear among all the three materials.

Also the coefficient of friction was calculated from the frictional force obtained during the experiment and normal load applied. It was observed that, the coefficient of friction for the brass material was greater than other composite materials. Coefficient of friction for sample 2 and 3 was 0.29 and 0.16 respectively. For the brass material coefficient of friction was 0.36.

IV. Taguchi Analysis:

A. Experimental run

Taguchi analysis was done for the MoS_2 material because wear for this material was less than other materials. The objective of Taguchi analysis was to obtain the best value from the parameters which will give the best optimum value at which minimum wear of pin samples occurs.

Table IV. Experimental Run for Taguchi Analysis

Run no.	Load	Speed	Time	wear	FF
1	10	100	0	2.1	0.1
2	10	150	15	10.00	0.9
3	10	200	30	27.7	0.9
4	20	100	15	41.0	2.6
5	20	150	30	77.9	3.7
6	20	200	0	6.5	0.5
7	30	100	30	72.5	4.5
8	30	150	0	9.8	0.6
9	30	200	15	85.5	7.2

Again the test was carried out for the above experimental runs and the readings were recorded for wear and frictional force as shown in above table.

By applying Taguchi analysis the optimum values were obtained. These values are as shown in figure below.

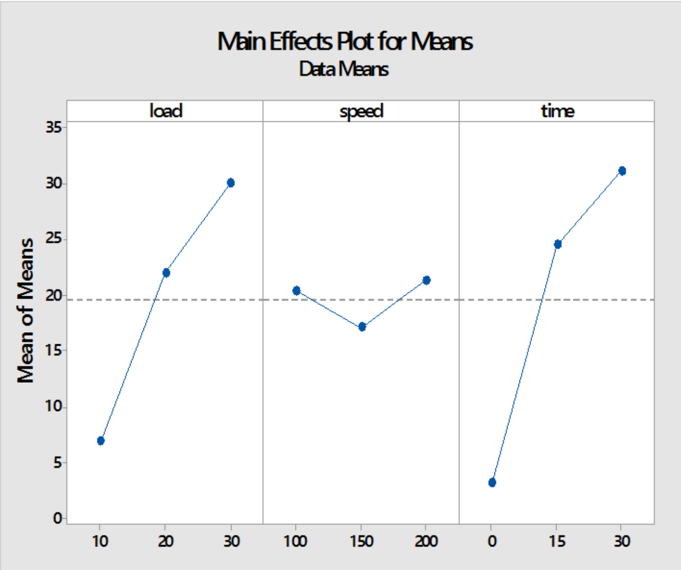

Fig. 6 Main Effects Plot For Wear

Table V. Response Table of Means for wear

level	load	speed	time
1	6.950	20.467	3.267
2	22.033	17.150	24.533
30	30.017	21.383	31.200
Delta	23.067	4.233	27.933
Rank	2	3	1

Taguchi analysis was implemented successfully to obtain the set of values for the parameters and by using these values we can obtain minimum amount of wear. The confirmation test can be carried out to validate the results. The estimated value for wear of sample of pins can be calculated using the following prediction equation,

ηopt = ηm + (optimum level for factor A - ηm) + (optimum level for factor B - ηm) + (optimum level for factor C - ηm),

Where, ηopt = predicted optimum average,

ηm = overall average of all the experimental data for response.

From the above predicted optimum average formula and putting values in it, the predicted value was 1.544

B. Confirmation Test:

Confirmation test was carried out to validate results obtained from Taguchi analysis. The optimum parameters were selected for the confirmation from the main effects plot. These are as follows.

Table VI. Optimum Parameters

Factors	Optimum Values
Load (N)	10
Speed (rpm)	150
Time (min)	0

Table VII. Confirmation Test Results

Experiment No.	Wear (micrometer)
1	1.7
2	1.5

From the confirmation test it was observed that the percentage deviation from predicted and confirmation result was found to be 0.93.This indicated that the optimum values from main effects plot gives best parameters.

V. Conclusion :

The conclusion was drawn from experimental work as follows:

- From the comparative study at different speed and loading conditions between the conventionally used brass and compsite materials, it was found that as the load and speed is increased wear rate is also increased. Composite material with MoS2 gives very less wear rate compared to Brass and Bronze composite.
- The coefficient of friction value was obtained from frictional force from the experimental result and normal load applied. Brass was having highest coefficient of friction value i.e. 0.36 while for MoS2 it was least i. e. 0.16
- Taguchi analysis was carried out for the MoS2 composite because it gave least wear rate than other materials. The objective was to find best values of parameters at which minimum wear occurs. From main effects plot the best values of parameters was 10 N, 150 rpm, 0 min. Optimum predicted value obtained is 1.544.
- Confirmation test was carried out to validate the results from optimum prediction value. From the confirmation test it was observed that the percentage deviation from predicted and confirmation result is very less.

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