Experimental Analysis of Crankshaft Washer

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Abstract: Axial movement of the crankshaft is controlled by two half thrust washer position both side of Centre main bearing. In this work tribological behavior of aluminum base and copper base material of crankshaft thrust washer studied. The aim of the research presented in this paper is focused on finding out the wear and coefficient of friction of bearing materials under lubricated conditions and suggest the suitability of the thrust washer bearing material fitted to the crankshaft. The Aluminum and Copper base bearing material is to be tested two loads and three critical speeds for a governed period of time. The results obtained from the experiment are analyzed and the effect of load and speed on both the bearing materials along with wear trends obtained with respect to time is studied and suitable thrust washer bearing material is chosen.

Key Words - crankshaft thrust washer; pin on disc machine; engine condition; coefficient of friction; wear.

1. INTRODUCTION

Crankshaft located axially in the crankcase by plain thrust bearing which restrain it against endwise movement from loading imposed mainly by transition system. This loading may be forward direction during release friction clutch and in reward direction when fluid coupling is in operation. The axial movement of the crankshaft is controlled by two half thrust washer position both sides of centre main bearing. Thrust washers are washers designed to prevent motion along the axis of a shaft. These rugged washers shaped flat bearings are used to prevent wheels from moving sideways on axles whenever the bearing that handles the radial load such as a bushing or roller bearing has no coherent provision for axial or thrust loads. Typical sideways or axial loads are encountered every time turning a corner and the vehicle is thrust sideways towards the outside of the curve Crankshaft thrust washer is two semicircular metal pieces that fit over the crankshaft on either side of the upper half of the rear main crankshaft bearing. They held up into a groove in the bearing cap and cannot be seen with the rear bearing cap in place unless of course they are at the bottom of the oil pan. Friction bearings a thrust surface on the shaft rubs against a similar surface on the crankcase. A precision insert main bearing may have a thrust flange for the crank to rub against it thrust washer use. Half thrust washers are often used which is inserted both sides of radial bearing in a recess in housing in the bearing cap in the present trend in smaller engine size is mainly toward the lower cost solution loose thrust washer which has always been standard in large engine foe reason of manufacturing.

2. REVIEW OF LITERATURE

R L Jackson and I Green et al. [1] Linked thrust washer bearing’s point of distress to thermo-elastic instability (TEI) and is marked by a sudden increase in the coefficient of friction (COF) and the bearing temperature.
R L Jackson and I Green et al. [2] PTFE coating flat thrust washer bearing located between helical gear and carried it tested on lading various loads and speed. It investigates the coating are reducing the wear and friction. Also improve bearing life and operation behavior to give additional resistance to bearing distress and scuffing.
Dooroo Kim et al. [3] An experiment analyzed for the effects of grooves on thrust washer bearings is investigated. Eight equally sized grooves are machined about 100 μm deep into one side of a flat-faced steel washer.
Prasad B.K. [4] The sliding wear behavior of leaded-tin alloys over a wide range of applied pressure and speeds was studied by using a pin on disc test machine. The sliding speeds used in his study were 0.42 and 4.60 m/s. The wear mechanism changed to wear induced plastic deformation of the subsurface regions followed by the effective formation of heavily deformed transfer layers and a lubricating film of lead at higher speed.
Bekir S. [5] Investigated the tribological and mechanical properties of copper, tin-lead based alloys for journal bearing applications using a radial journal bearing wear test apparatus with non-conformal contact. These test materials were slid against a steel shaft under lubricated test conditions at 20 N load and 0.78 m/s sliding velocity. The highest friction coefficient and bearing temperature occurred in Cu-Sn and Cu-Zn bearings, whereas the lowest friction coefficient and bearing weight loss occurred in Zn-Al, AlCuMg and SnPbCuSb bearings. The highest bearing wear rate occurred in CuSn10 and CuZn30 bearings, and the lowest bearing wear rate occurred in ZnAl bearing. The mechanical properties of CuSn10, CuZn30 and AlCuMg2 bearing materials were better than those of ZnAl, and SnPbCuSb bearing materials. The low coefficient of friction and wear loss was recorded for lead containing bearing material with lead content less than 3%.
Ugur ozsarac et al. [6] Studied the tribological characteristics of tin bronzes and tin based lead bronzes using a specifically designed sliding wear tester with nonconformal contacts in dry test conditions. The coefficient of friction and wear rates were calculated at different contact loads. They observed increased coefficients of friction and wear rate with an increase in load. They also identified that tin-based lead bronzes had a slightly higher coefficient of friction (0.73) than tin bronzes (0.69) and the reduction in the embedded ability occurred with a decrease in the amount of lead in bronze. This suggested that the high-lead content bronze has the necessary strength and load carrying capacity for the particular application
Ahsan Q., Haseeb et al. [7] studied the tribological characteristics of two different types of leaded tin bronzes. , the higher lead content of the good bearing compared with lower lead of the failed bearing helped to establish a protective transfer layer on the worn surface. The steady state friction coefficients were found to be 0.24 and 0.19 for the failed and good bearings, respectively. The wear rate of the failed sample was several times higher than that of the good sample. The higher lead content of the good

bearing was believed to lead to the formation of a more or less continuous tribo layer on the bronze surface. This soft layer acted as a protective layer and helped to reduce friction coefficient as well as wear damage.

Pandey and Prasad [8] studied the desire effect of applied pressure and sliding velocity on zinc-based and copper-based alloys. The highest wear rate of the copper-based alloy was attributed to its micro cracking tendency. The cracks were mostly present at the low sliding speed and didn't make at higher velocity due to the higher frictional heating.

Pathak and Mohan et al. [9] examined the tribologic properties of aluminum bearing alloys under lubrication. They prepared Al–Pb and Al–Sn alloys by impeller mixing and bottom discharge chill casting technique. They studied the sliding wear characteristics of these alloys under lubrication in detail. They also implemented a debris and worn surface analysis. It was found in this study that the wear rate of Al–Pb alloys is lower than Al–Sn alloys. They showed that the Al – Pb bearing alloys exhibited a superior wear resistance with slightly lower mechanical properties than that of Al–Sn alloy.

Kim et al. [10] Produced Al-Pb and Al-Pb-Cu-Mg alloys after melting in induction furnace and by cooling it quickly by means of the gas atmosphere as it is in liquid form and without segregation. It was seen the Al-16Pb alloy is the material with the best wear resistance among others.

Leitner, et al. [11] studied the characterization of mechanical Properties of sliding bearing material based on aluminum and Reported that the static strength as well as the fatigue strength showed a strong dependence on temperature.

Marrocco, et al. [12] The wear resistance of the Al-Sn-Cu-Si alloy is considerably higher than that of an Al-Sn-Cu or Al-Sn-Cu-Ni alloy due to the existence of hard Si particles.

M.A. Chowdhury et al. [13] Pin on disc test are used to find the tribological performance of several metal components Sliding contacting each other in laboratory scale.The test often employing for accessing friction and wear characteristics which use in investigations.

H. So et al. [14] investigate characteristics pin on disc apparatus wear result in moderate to high speed. Characteristics base on temperature of disc, effect of moving specimen, effect of sliding speed and normal load, oxidation effect on wear rate.

3. PROBLEM DEFINATION

Crankshaft thrust washers form an important part of the main journal bearing that transmit and resolve axial forces in rotating mechanisms to keep components aligned along the shaft. They are designed to prevent movement along the axis of a shaft. These crankshaft thrust washers are very thin, nearly in size of 2 to 4 mm in thickness. Hence there are high chances of them getting distorted during punching operation. Presently two types of thrust washers are used. One is Aluminum based and other is a copper based material. Both are manufactured by different manufacturing processes. Aluminum based material is manufactured by casting and rolling method while the copper based material is manufactured by sintering and rolling. Aluminum based material (SAE 783) is softer and therefore it gets deformed during punching of thrust washers and hence its rejection rate is high thus uneconomical. While the copper based material is much harder, but corrosive hence coated with tin (Sn) layer. Thus, two different families of bearing materials are used here. Hence the comparative study base on wear rate and coefficient of friction of two thrust washers bearing materials under different speed, load, sliding velocity provide the best opportunity to select the best material for journal bearing fitted to the crankshaft.

4. EXPERIMENTAL METHOD

A pin-on-disc Multipurpose Friction and Wear tested Apparatus was used in the analysis of friction and wear behaviors of test samples. The wear tester was produced in pursuance of TR 20 LE-PHM-400DUCOM. The strain gauge transducer in the wear tester measures the friction forces at a contact point. The load cell can measure forces up to200 N. The disc has a diameter of 165 mm and was produced with 60 RC hardness SAE 1040 steel. In the experiments, samples were tested at various loads and speeds under lubrication. It was conducted at 1.47, 2.22, 3.675 m/s (455, 687, 1133 rpm) sliding speeds. Samples were scaled during 30 minutes of work in order to determine the volume loss. As a consequence of this process The tests were carried 50 N and 70 N normal load while 15 W/40 engine lubricant was used for the lubrication.. During the study, friction force was recorded with a load cell; and temperature of the sample was measured with an infrared thermometer. The tests were conducted at 25^0C and at 50% RH humidity.

4.1 TESTED MATERIALS

1. Al–Sn bearing alloys

Al–Sn alloys, which have high resistance and excellent surface finish properties, Higher contents of tin gives higher scuff resistance, but lower elastic limit, ductility and rupture strength have been used as the bearing materials for a long time. The compatibility of Al–Sn alloy is close to the tin-based white metals; and the fatigue strength of white metals is higher.

2. Copper base material

These alloys have exceptionally high fatigue strength and use heavily loaded bearing. Being harder and less able to embed abrasive particles. The material has poor corrosion resistance the leads dissolve by acidic oil and destroy the boundary and wear resisting properties. Copper alloy is giving a combination of properties such as strong, high thermal conductivity, machinability and ductility.

Fig. No. 1

Each experiment was carried out for 15 minutes and after each experiment, new pin and new test sample were used. Table 1. shows the detail of the experimental conditions.

Table No. 1 Chemical Composition

Material	Pb	Sn	Si	Ni	Cu	Al
Al alloy		21.92	0.48	0.0745	0.82	70.30
Cu Alloy	8.23	5.11		1.12	82.11	

Table No. 2 Operating Parameter

Sr. No.	Parameters	Description
1	Loads	50,70 N
2	Speed	455, 683, 1133 rpm
3	Sliding velocity	1.47, 2.22, 3.675 m/s
4	Temperature	(35ºC)
5	Duration	15 minutes

According to the Taguchi technique the three important factors Load, Speed & Sliding velocity were considered as experimental constant variables. The variation of parameters is shown in the table. 3.

Table No. 3 Operating variable factors and their level

Parameter	Min.	Avg.	Max.
Load (N)	50	70	90
Sliding velocity (m/s)	1.47	2.22	3.675
Speed (rpm)	455	687	1133

The values of these parameters vary from a minimum, average to maximum limits as shown in the above table. By considering different combinations of these parameters and limits (3*3) = 9 experiments were conducted. The experiments were conducted to determine the wear rate at different working environment.

5. RESULT AND DISCUSSION

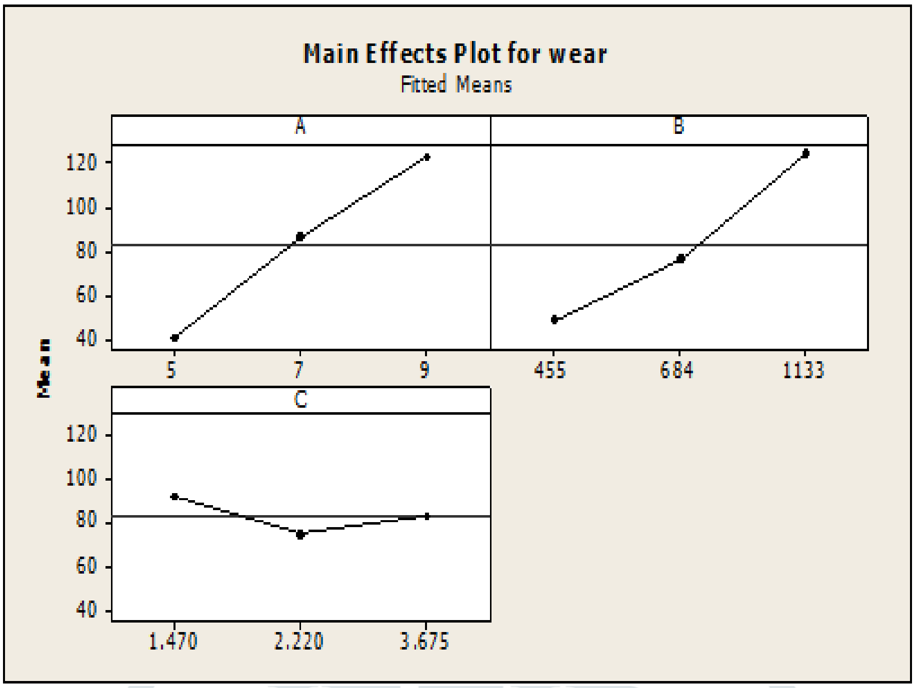

Fig.2 Main Effects Plot for wear

Table No. 3 Response table for means

Level	Load	Speed	Sliding velocity
1	41.48	49.41	91.51
2	86.37	76.76	74.73
3	122.54	124.22	83.15
Delta	82.05	75.82	16.78
Rank	1	2	3

After conducting Taguchi analysis for optimization of parameters for aluminium samples it was found that the parameter load and speed have more contribution as compared to other factor for significant change in wear but less for a change in COF.

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 giving materials was studied with respective time.

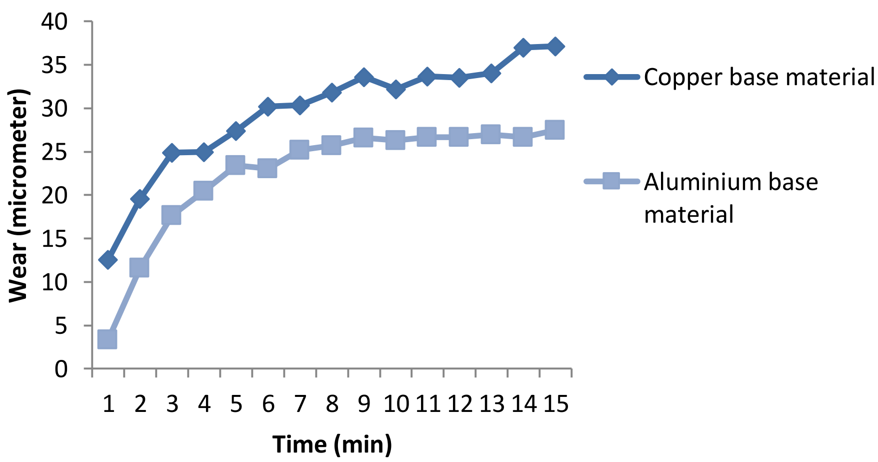

Fig.3 Comparative study of wear for 50N, 455 rpm

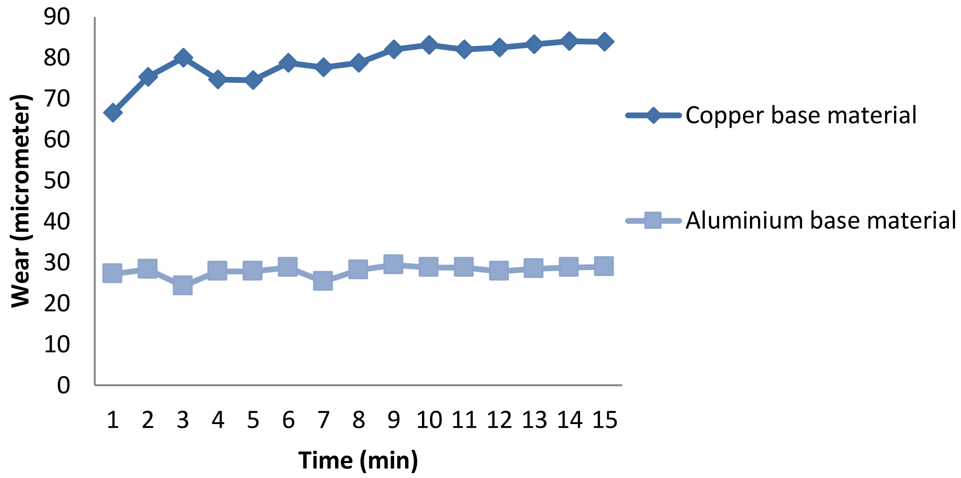

Fig.4 comparative study of wear for 50N, 683 rpm

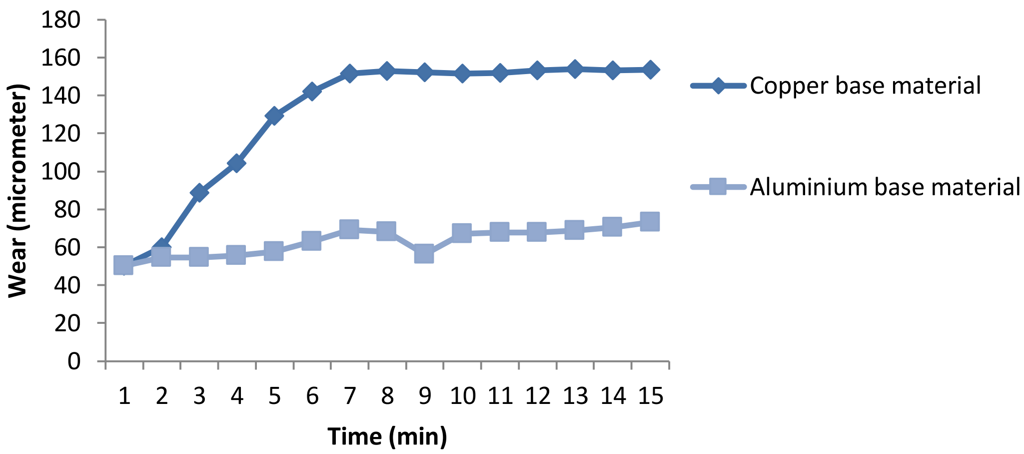

Fig.5 comparative study of wear for 50N, 1133 rpm

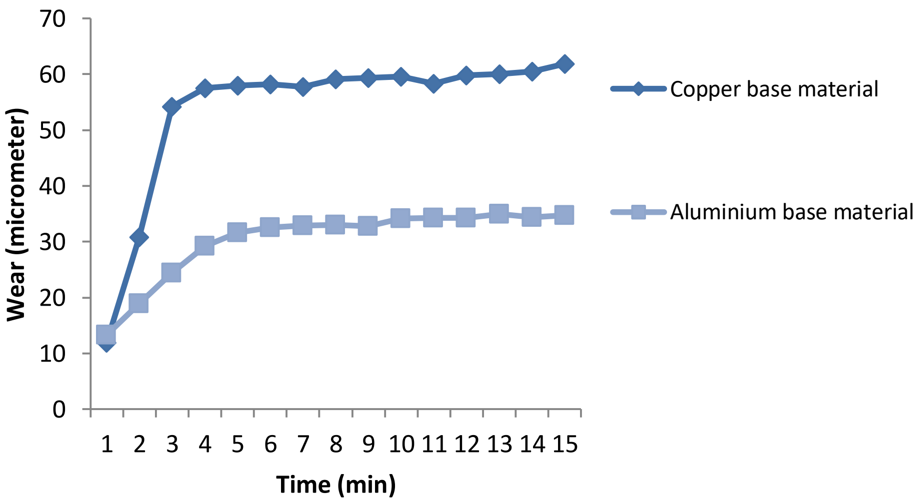

Fig.6 Comparative study of wear for 70N, 455 rpm

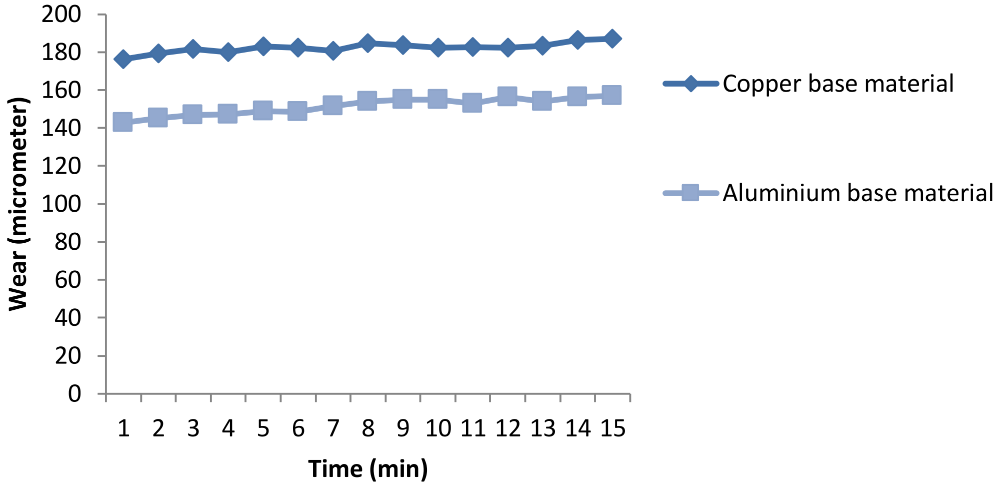

Fig.7 Comparative study of wear for 70N, 1133 rpm

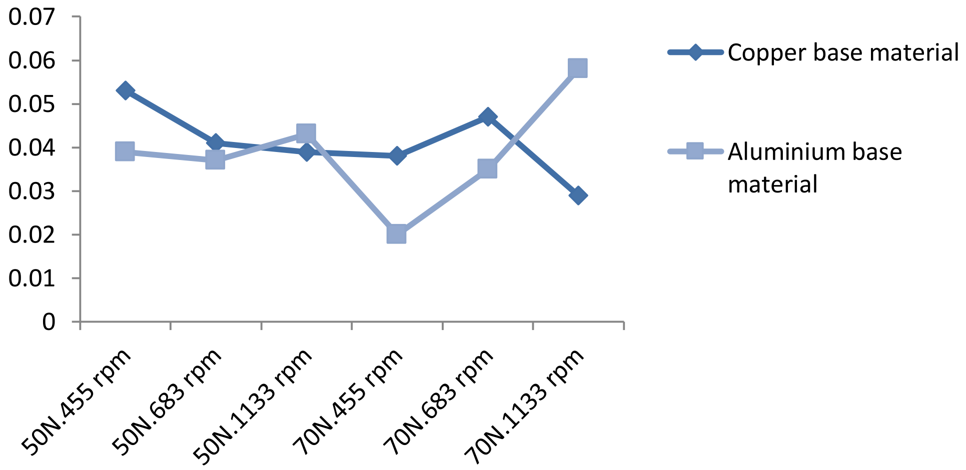

Fig.8 Comparative study of COF for lubricating condition

From above comparative study between aluminium base material and copper base material at different loading and speed condition it was observed that aluminium base material was lowest wear among the copper base material. As for the load and speed–friction coefficient relation, it was observed that the friction coefficients increased rapidly in the beginning of the process. This was due to the transient metallic contact occurred in the beginning of this sliding movement. It was observed that friction coefficient then decreased; and a more stable stance was obtained after the lubrication. Thus, a decrease would be observed in the friction coefficients of copper and aluminium base bearing material in the maximum pressure as sliding speed rises. Especially under high pressures, the main reason of this decrease in the friction coefficient can be explained as the dispersion of the lubricant between the surfaces due to speed completely. The temperature increases of copper base material higher than the temperature increases of aluminium base material. The copper base material had the highest hardness and the highest surface roughness values were the most worn material. These features also affected the increase in temperature.

6. CONCLUSIONS

The conclusion was drawn from experimental work as follows:

1. From the comparative study of different speed and loading conditions between the conventionally used Aluminium and Copper base bearing materials, it was found that as the load and speed is increased wear rate is also increased for bearing material. Aluminium base bearing material of thrust washer gives wear rate increase with increase speed and load. In lubricated condition under given parameters observed better wear characteristics and Friction characteristics of Aluminium bearing material as compared copper base bearing material of the crankshaft thrust washer.
2. The coefficient of friction value was obtained from frictional force from the experimental result and normal load applied. Coefficient of friction value increases speed. The COF of Aluminium bearing material, i.e. 0.020 it was least than copper base material i.e. 0.038.
3. Under given the condition it is observed that the Aluminium bearing material is better material for crankshaft thrust washer.

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