Wear Analysis of Crankshaft Thrust Washer Bearing Material

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Abstract—This research experimentally quantifies and maps the behaviour of thrust washer under various conditions. The bearings are tested at controlled loads and speeds for a governed period of time or until failure. In present work copper based thrust washer bearing materials are tested under dry condition at different loads and Velocities. The present work is to find out the wear and coefficient of friction of bearing materials under dry as well as lubrication conditions. For finding the wear and friction, we used pin on disc machine. The testing is done by maintaining the similar condition of testing as in case of actual engine. Therefore we have to use disc material as material of shaft i.e. EN 31. The disc is hardened and tempered (60 RC). Pin on disk machine records frictional force, temperature and height loss from which the wear rate and coefficient of friction can be calculated.

Keywords— Thrust washers, wear, wear analysis, Pin on Disk, Bearings, Dry friction.

I. INTRODUCTION

Thrust washers are designed to prevent movement along the axis of a shaft. These rugged washer 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 specific provision for axial or thrust loads. In their simplest form, thrust washers are long-wearing flat bearings in the shape of a washer that transmit and resolve axial forces in rotating mechanisms to keep components aligned along a shaft. 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 a shaft. They are designed to prevent movement along the axis of a shaft. These crankshaft thrust washers are very thin of size 3 to 4 mm. Hence there are high chances of them to get distorted during punching operation. In present paper crankshaft thrust washers are tested at varying load and velocities and wear trend for them is studied. This is done with the help of pin on disk apparatus for finding the wear rate, coefficient of friction and the frictional force. The effect of load and sliding velocity on these parameters is observed for getting fruitful conclusions.

II. EXPERIMENTAL DETAILS

A. Wear Testing On Pin on Disk Machine

The machine Wear and friction Monitor TR 20 Ducom machine as a pin on disk is used for testing the wear of bearing materials. During testing the pin specimen is kept stationary while the circular disc rotates. The wear test is carried out under dry conditions at room temperature using a pin on disc sliding wear testing machine. The apparatus consists of an EN 31 disc (RC 60) of diameter 165 mm used as counter face. A fresh surface of specimen is used each time and before each test both disc and pin needs to be cleaned with acetone to remove any possible traces of grease and other surface contaminants. Every time new track radius is used so that pin is exposed to fresh surface of counter face. The reading of frictional force is measured by force transducer and it display directly on the controller of load cell. The height loss of the pin is measured by LVDT (linear variable differential transformer), which is mounted on the lever as and that reading displays on controller in microns.

B. Bearing Materials

The copper based bearing material is used for testing wear and friction under lubrication condition. Following is the composition of the bearing material used.

	SAE 793					
Cu %	Remainder					
Pb %	8					
Sn %	4					
Fe %	0.7					
Ni %	0.5					
P %	0.1					
Sb %	0.5					
Zn %	4					
Si %	0					
S %	0					
Al %	0					

Table.1: Elements in copper based material.

The materials contain copper, tin and lead alloys. The lead metals get distributed uniformly along the grain boundaries of sintered copper tin i.e. bronze matrix on to the steel backing. The forms of bearings in this family are half bearing, wrapped bush, thrust washer and flanges. These alloys having superior hard phase properties like load carrying capacity and cavitations resistance, which are necessary for higher-powered engines.

C. Experimentation

1) Pin Manufacturing: The bearing materials are considered as the pin. But the bearing materials are in the form of sheets; therefore we are going to use the blank of 10 mm and join it to the pin of mild steel and the lining portion of the materials will be turned to a diameter to maintain the required pressure



Fig.1: Pin

2) Disc Manufacturing: The shaft material i.e. EN 31 is considered as disk material. The hardness of the disk will be maintained as per the hardness of the shaft i.e. 60 RC. The

0.93

0.2741

17.48

4.3

0.2457

15.67

-0.22

0.2625

16.74

wear(µ)

CF

FF(N)

wear(µ)

CF

FF(N)

wear(µ)

CF

FF(N)

6.28

8

10

6.5

-0.1

0.3202

20.42

6.09

0.315

20.09

1.72

0.2778

17.72

20.53

0.2048

13.06

6.33

0.3897

24.85

41.19

0.2256

14.39

75.95

0.2043

13.03

9.85

0.3958

25.24

80.05

0.2943

18.77

158.2

0.2021

12.89

11.02

0.3936

25.1

91.31

0.3296

21.02

252.37

0.19

12.12

13.08

0.3679

23.46

97.55

0.3216

20.51

339.35

0.207

13.22

20.84

0.3862

24.63

103.79

0.2694

17.18

417.87

0.206

13.14

21.47

0.3776

24.08

106.69

0.344

21.94

477.38

0.195

12.44

25.62

0.3563

22.72

110.72

0.349

22.26

482.56

0.2683

17.11

26.29

0.398

25.38

113.76

0.3795

24.2

size of the disk is 165 mm in diameter and 8 mm thickness. The disk is as shown in fig.2



Fig.2: Disk

Load (kg)	Velocity (m/s)	Time	20	40	60	80	100	120	140	160	180	200	Average friction
	1	(sec)											coefficient
		wear(µ)	3.72	7.04	8.46	14.11	14.52	16.18	17.44	18.82	19.38	20.24	2
4.5	4.2	CF	0.1664	0.1823	0.2047	0.3141	0.3164	0.2775	0.3284	0.3495	0.4036	0.4168	0.2959
	65	FF(N)	7.35	8.05	9.04	13.87	13.97	12.25	14.5	15.43	17.82	18.4	2
		wear(µ)	7.64	12.56	14.72	13.5	11.85	13.54	17.11	24.77	31.87	36.61	
	6.28	CF	0.193	0.1936	0.2369	0.2752	0.3137	0.383	0.4036	0.4068	0.4419	0.4308	0.3279
		FF(N)	8.52	8.55	10.46	12.15	13.85	<u>16.91</u>	17.82	17.96	19.51	19.02	1.1
		wear(μ)	1.84	1.16	2.59	2.97	2.05	4.97	9.61	14.13	18.59	22.18	
	8	CF	0.2799	0.3599	0.3617	0.4134	0.4007	0.3921	0.4159	0.4181	0.3996	0.34	0.3781
100		FF(N)	12.36	15.89	15.97	18.25	17.69	17.31	18.36	18.46	17.64	15.01	
		wear(µ)	0.13	4.77	9.49	16.29	20.79	23.86	24.81	25.73	25.83	29.64	
	10	CF	0.2559	0.3024	0.3366	0.3284	0.3081	0.2933	0.3107	0.2951	0.3701	0.4161	0.3216
10	1000	FF(N)	11.3	13.35	14.86	14.5	13.6	12.95	13.72	13.03	16.34	18.37	
]	Table 1: WEAR TRANSITION DATA SHEET FOR SAE 793 (in Dry condition) Time of sliding =200 seconds (CF-												
coefficient of Friction, FF-Frictional force)													
1								1					A
Load	Velocity	Time	20	40	60	80	100	120	140	160	180	200	friction
(kg)	(m/s)	(sec)					100	-					coefficient
	-	wear(µ)	4.11	14.1	22.08	25.03	34.49	104.19	192.12	291.57	380.78	459.64	1
	4.2	CF	0.2266	0.2537	0.31	0.3285	0.2565	0.2057	0.1947	0.1935	0.2253	0.1814	0.45
	1	FF(N)	14.45	16.18	19.77	20.95	16.36	13.12	12.42	12.34	14.37	11.57	1

III. RESULT AND ANALYSIS

 Table 2: WEAR TRANSITION DATA SHEET FOR SAE 793 (in Dry condition) Time of sliding =200 seconds (CF-coefficient of Friction, FF-Frictional force)

Table 2 & 3 show the wear transition data for SAE 793 in dry condition at load of 4.5 kg and 6.5 kg respectively.

0.92

0.023

0.26



Fig.3: Graph of Wear Vs Time for Different Speeds for load 4.5 kg

From the above graph we can observe that the wear rate is highest for sliding velocity of 6.28 m/s. we can also observe that sliding velocities 6.28 & 8 m/s show increasing trend while velocities 4.2 & 10 m/s tend to stabilize after some time. Thus for three velocities 4.2, 6.28 &10 m/s the wear rate increases with increase in sliding velocity.



Fig.3: Graph of Wear Vs Time for Different Speeds for load 6.5 kg

From the graph we can observe that as the load is increased the material wears out quickly. For the low speed the wear rate is higher but as the sliding velocity is increased the wear rate is decreased. Thus at high sliding velocities we get lower wear rate. When the load is increased we can observe that the wear rate is still higher in case of sliding velocity 6.28 m/s and hence, bearing should not be operated at this velocity.



Fig.4: Graph of Coefficient of Friction Vs Pressure for different Sliding Velocities

From the graph of coefficient of friction Vs pressure it can be observed that as the pressure increases the coefficient of friction decreases for all range of sliding velocities. Thus at high sliding velocity we get minimum coefficient of friction which indicates that the bearing can be operated at high sliding velocity. In above case it can be also observed that as the sliding velocity increases the coefficient of friction also increases.



Fig.5: Microstructure after wear test

From the wear test it is observed that there are no changes in the microstructure before and after wear tests are performed at different loads and sliding velocities.

IV. CONCLUSION

From the wear analysis results following conclusions can be drawn:

- The wear of copper based material is directly proportional to Pressure and inversely proportional to velocity.
- As the load increases the coefficient of friction of SAE 793 decreases slightly.
- The microstructure of all materials is normal and acceptable before as well as after testing.
- Thus rate of wear goes on increasing with increasing load.

- It can be also be concluded that at some higher range of sliding velocity a good trend of wear rate can be observed.
- Addition of lead in copper reduces the wear resistance and improves the friction behavior.

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