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INVESTIGATION OF THE TRIBOLOGICAL PROPERTIES OF JOURNAL BEARING UNDER WEAR TEST

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ABSTRACT

Occurrence of the friction and wear at machine parts of rotating system which run together, affects the efficiency of machine negatively. Because of its simplicity, low of cost and efficiency journal bearings are used widely in industry. It is difficult to accurately predict the component life due to wear and friction. This attempt is to study the influencing parameters like load, speed and temperature, friction coefficient during wear test. The main objective to the paper is to study wear rate of Babbitt journal bearing. The Babbitt metal is tested in lubricated condition using 20W40 oil under Pin-on-Disc Tribometer. Results found that, metals prone to wear at considered operating conditions due to change in frictional coefficient at contact surface.

KEYWORDS: Babbitt metal, Journal Bearing, Pin-on-Disc, Power loss, Wear test.

1. Introduction

A fluid film bearing may be defined as a bearing in which the mating surfaces are completely separated by a film of lubricant. Plain journal bearing used widely in rotary machineries such as compressors, turbines, pumps, electric motors and electric generators. Journal Bearings consists outer cylinder (bearing) stationary and the inner ring (shaft) rotating with an angular velocity, both rotates relative to each other. The main purpose of the journal bearing is to support the load for rotating machinery and to minimize the friction due to rotation. The high-pressure fluid film in the clearance between the journal and bearing provides the hydrodynamic film lubrication during running (Ramamohana and Mohanram, 1994).

Sliding lubricated surfaces shows lubrication regimes corresponding to the Stribeck Curve as shown in Figure 1. The curve represents the minimum value of friction between full fluid separation and direct contact of two surfaces. The friction coefficient is plotted as a function of a lubrication ηN/P, where η is the dynamic viscosity, N is the speed of shaft and P is the external load. It shows, the highest friction condition occurs in the boundary lubrication region, which represents significant or complete asperity contact between the two mating surfaces (Priest and Taylor, 2000).

Hydrodynamic lubrication region represents a full load supported by the lubricating fluid film with no asperity contact. Finally, the mixed lubrication region represents partial load support from the lubricating fluid with partial asperity contact. Significant wear of journal bearings can occur during boundary and mixed lubrication conditions when there is insufficient pressure generated in the lubricant to bear the load. These conditions occur during startup, shutdown and low speeds of journal rotation (Mokhtar et al., 2008), (Feng & Kenio, 2007).

Excessive wear of journal bearings will lower the performance over time and results in bearing failure which gives significant production losses and maintenance costs to companies that rely on them within their machinery. Researchers indicate that among other factors, bearing wear rate is dependent upon frequency of starts and stops, surface velocity, load, and material hardness (Knauder et al., 2013), (Allmaier, 2013).

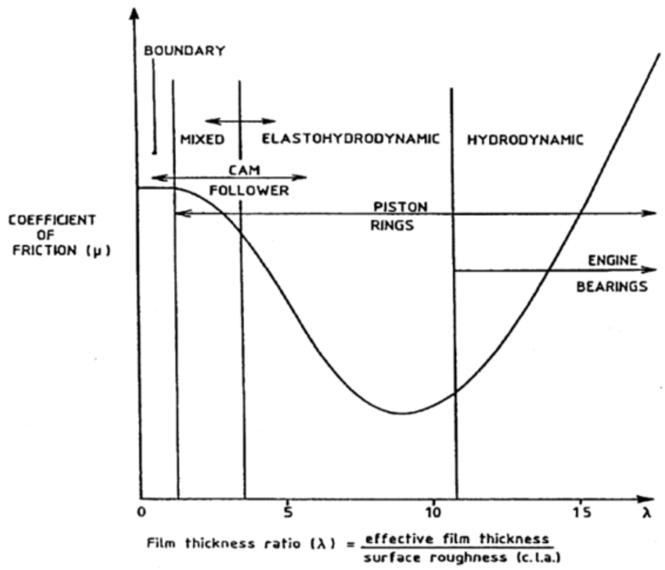

Figure 1: Modified Stribeck curve (Priest and Taylor, 2000).

2. Material manufacturing

Babbitt alloy used as bearing metal for axles and crankshafts, based on the tin alloy invented in 1839 by Isaac Babbitt for use of steam engine. Modern Babbitt provides low friction lining for bearing shells made of stronger metals such as cast iron, steel or bronze. Babbitt alloy classified mainly by composition Tin-based and Lead-based.

Different Babbitt alloys are available according to purpose and graded differently by societies such as ASTM, SAE etc. Genuine Babbitt tin-based alloy composed of Sn-89%, Sb-7.5%, and Cu-3.5%. Babbitt metal is available in ingot form of 6-40lbs and in wire for flame spraying application. Babbitt Ingot cast in square bar of 13.5x13.5x500 cm dimension. Ingot is melted to its pouring temperature of 230°c and poured in mould through sprout having a hole. Casted rod of dimension 13mm diameter and 100 cm long is then turned over Lathe to formed into small cylindrical pin of 10mm diameter and 30 mm height as shown in figure. 2.

The wear is the loss of material due to relative contact between two components, which is relatively small in most of the machinery and engineering tool (Archard, 1953). For measuring wear, we are using some apparatus and instruments, which give results about the wear rate in tools and machinery.

Figure 2: Babbitt pin manufactured

3. Experimental Setup

The Pin-on-Disc (POD) is common test rig used to evaluate the tribological properties of materials. It consists of an arm to which the pin is attach, a fixture that accommodates disks of EN-31 steel. Material is formed into pin that is under investigation in order to find the consequences of friction and wear under different operating conditions, such as dry, lubricant and lubricant with different additives for varying loading and sliding speed. Cylindrical pin specimens for testing are at range from 2 to 10 mm diameter and that of 20 to 30mm height. Specimens are possible to test across the load weighing range from 0.5 to 20Kgf with speed ranges from 100 rpm to 2000 rpm (ASTM G99-95a, 2000).

A pre-determined Hertzian pressure is automatically applied to the pin using a system of weights, which gives sliding wear, friction coefficient as well as a friction force. Users need to simply specify the speed, the load, and any other desired test variables such as work duration and temperature limit. It is designed for unattended use; a user need only place the test material into turntable fixture and simply specify the test variables. Software included with this test rig provides for quick calculation of the Hertzian pressure between the pin and disc. A sink provided which dually used for liquid lubricants during a wear test (optionally). Electronic Sensor (PID) used for measuring the friction force, coefficient of friction, wear and temperature. WIDCOM's computer software displays the parameters, printing and storing data for analysis.

DUCOM's Pin-on-Disc (POD) Tribometer is used to evaluate the tribological properties of Babbitt material (ASTM B23 Grade-2) with 20W40 lubricant oil. Material tested at variable operating conditions. Babbitt Pin of 10 mm circular cross-section with length 30mm placed normal to a fixture that accommodates disks of EN-31 steel of 165 mm in diameter & 8 mm thick. Different operational condition is tabulated in table -1.

Figure 4: Actual Test Rig

Ertugrul Durak (Durak, 2008) studied the behavior of journal bearing from start-up to shut-down. He proposed that bearing prone to wear during start-up and shut-down i.e. for lower speed. During start-up journal climbs with insufficient lubrication causes direct contact with bearing surface which gives the wear at start. Similarly for the shutdown, journal slips down during rest which gives corresponding wear for bearing.

Table 1: Experimental operating conditions

Sr. No	Sample ID	Load Kg	Speed RPM	Sliding Speed	Sliding Distance
1.	1-1	8	300	1.571 m/s	100 mm
2.	1-2	10			
3.	1-3	14			
4.	1-4	16			
5.	1-5	20			
6.	2-1	8	600	3.141 m/s	
7.	2-2	10			
8.	2-3	14			
9.	2-4	16			
10.	2-5	20			
11.	3-1	8	900	4.712 m/s	
12.	3-2	10			
13.	3-3	14			
14.	3-4	16			
15.	3-5	20			

4. Result & Discussion

Babbitt pin as a specimen is tested for different operating conditions tabulated on table-1. And corresponding test results wear tabulated in table-2.

Figure 6(a) shows the graph plotted as wear Vs Time for 8, 10, 14, 16 and 20 Kg load operated at 300 rpm it shows hat, load dominates to wear. Increase of load gives successive rise of wear. Peak values for load are marked as 13.88, 14.07, 16.44, 17.25, 46.75 µm.

Figure 6(b) shows wear for same load varying at 600 rpm; it gives high shear thinning due to low viscosity and friction coefficient of 0.021 at direct asperity contact.

Figure 6(c) shows wear profile at 900 rpm speed. This shows at higher speed, wear is comparatively lower with high frictional force that also shown in figure 5.

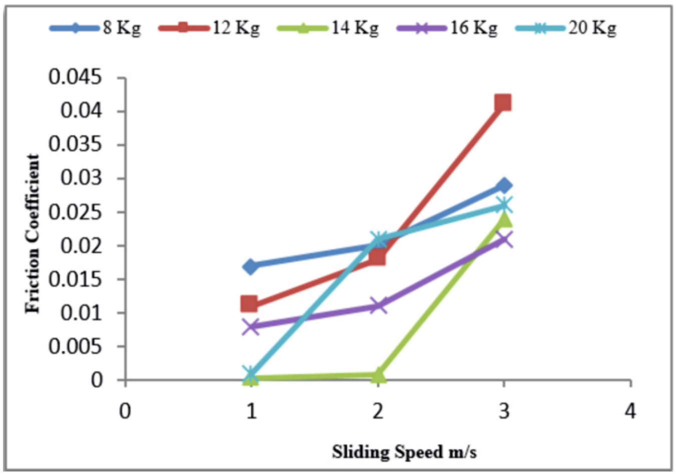

Figure 5: Relationship between Friction coefficient and sliding speed

Table 2: Experimental Results

Sr. No.	Load	Speed RPM	Friction Coefficient (Mean)	Frictional Force N-m	Wear µm
1.	8	300	0.017	0.0221	+13.88
2.	10		0.011	-1.3178	+14.07
3.	14		0.0003	0.0843	+16.44
4.	16		0.008	4.7146	+17.25
5.	20		0.001	-0.2002	+46.75
6.	8	600	0.02	1.2966	+0.38
7.	10		0.018	1.4287	+0.86
8.	14		0.0009	-0.1520	+2.64
9.	16		0.011	1.4229	+2.09
10.	20		0.021	3.8025	-0.81
11.	8	900	0.029	1.4334	+0.26
12.	10		0.041	3.8612	-0.61
13.	14		0.024	3.0791	+0.38
4.	16		0.021	3.5631	-0.04
15.	20		0.026	4.5289	0.12

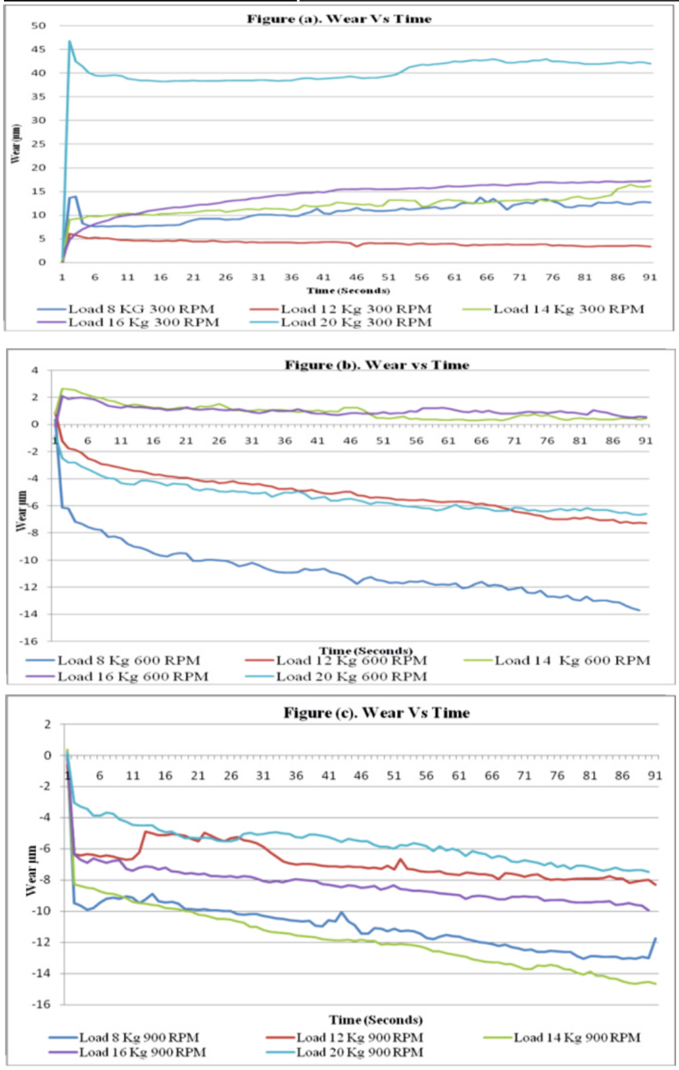

Figure 6: Wear Vs Time graph plotted for 8kg, 12Kg, 14Kg, 16Kg, 20Kg for (a) 300 (b) 600 and (c) 900RPM for 900 seconds of time duration

5.Conclusion

In this paper, the tribological properties of journal bearing were studied. Genuine Babbitt of grade tested different working conditions and conclusions are summarized as below:

1) Tribological properties of bearing metal such as coefficient of friction, wear and frictional force were studied at different load and operating speed. Test results indicate that, bearing load and rotational speed dominates to changes its tribological properties during considered time period.

2) Babbitt material have high wear rate at low speed and varying higher loads. This shows, at low speed the effect shear thinning in oil is more due to high viscosity and vice versa.

3) With increase of speed wear found to be decreasing successively for corresponding same load. For 16 Kg load, wear found to be as 17.25, 2.09 and -0.04µm with friction coefficient plotted as 0.028, 0.010 and 0.023 for 300, 600 and 900 rpm respectively.

4) At 900 rpm running speed, mean friction coefficient marked as 0.025, 0.041, 0.024, 0.023, and 0.023 for 8, 12, 14, 16 and 20 Kg load respectively, which is found be higher as compared to 300 and 600 rpm speed due to shear thinning.

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