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Tribological Behaviour Analysis of Tin Based Babbitt Alloys and Brass Materials

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Abstract: *In this study, the tribological behavior of Tin-based Babbitt and Brass material has been analyzed with the dry and wet sliding conditions. The Experiment is carried out on wear testing machine based on the design of experiment (DOE). At various normal loads and sliding speed, a variation of wear and coefficient of friction (COF) with duration of rubbing is studied. The experiment is performed under both Dry and wet (SAE 50) conditions. Application of such materials is found in bearings, gears, cams and follower, piston rings etc. After conducting test it is observed that for same operating condition, Brass has low COF compared to Tin based Babbitt. However the brass has higher wear rate compared to tin based Babbitt which helps to reduced power lost due Wear and Friction, increase overall performance of a system. Wear rate raise with the rise in normal load and sliding speed.*

Keywords - *Brass, Design of experiment, Friction, Wear, Tin based Babbitt, Tribology*

I. Introduction

Nowadays Tin-Based Babbitt and Brass materials are most commonly used where wear and friction are key parameters for example rollers, bearing, and gears, seals, breaks and synthetic joints. Due to less wear rate, these materials are frequently used in place of other materials. Moreover, these materials have a small value of friction coefficient. It is required to select the suitable material composition which has excellent tribological properties and to select the right kind of material. In maximum applications, properties of the material are altered by changing composition to suit a high strength or high modulus requirements. In maximum applications, properties of alloys are improved by varying chemical composition to increase the strength requirements. Different alloys offer a different combination or grouping of properties and strength that are either analogous to or improved than many traditional metallic materials. The wear depends on factors like sliding velocity, perpendicular load, geometry, materials types, rubbing surfaces roughness, material rigidity, lubrication, temperature, relative humidity, stick-slip, surface cleanliness and vibration. Out of these variables, perpendicular loads (L) and sliding rate (v) are the main factors to play important role in changing wear and friction. If material surface contains surface film which produces either by reaction with environment or deliberately applied, change the COF which is function of load and sliding rate. In various metals, friction coefficient reduces with normal load. According to Newton's law of friction, friction is not depending upon sliding speed but it not valid mostly. For diverse grouping of material friction value may rise or reduce on varying of sliding speed. Now a day demand of alloys is increased. On the other hand the data of their tribological behavior is limited and lack of predictability. Hence it is important to select the known composition structures and system parameters for tribological properties which are often a difficult task. It is essential to know the wear properties (wear behaviors) of different type of composition and material at different working conditions. It is required to select the proper material which have excellent tribological properties and which is used to get the right kind of material. Function of Lubrication is generally to reduce wear or friction. Different types of lubricant are used depending upon application. In lubrication (base oil) alumina (Al_2O_3), silica (SiO_2), titania (TiO_2), graphite (Gr), silicon carbide etc. are extensively used as conventional additive. The most frequently use of additive in lubrication is to, reduce the coefficient of friction, improve wear resistance and also improves thermal properties. Brass and babbitt metal are used as bearing material because of ant frictional property.

The objective of present work is to discover the out optimum parameter and to get tribological characteristics of the selected materials. The objective of present work is as follows:

1. To analyze the wear mechanism of the Tin Based Babbitt and Brass materials under the diverse working conditions that is perpendicular load, sliding rate, sliding time, dry and lubrication.
2. To study the co-relationship between friction coefficients, frictional force, speed and load.
3. To analyze the effect of lubricant (SAE 50) on wear and COF.
4. To recommend the best appropriate material and parameter for the diverse applications from the tested materials.

In the present work, the literature survey has been done to discover the impact of perpendicular load and sliding rate on the tribological characteristics of the tin-based babbitt and brass material with dry and wet condition. The impact of perpendicular load and sliding rate on wear mechanism has been considered seriously in the previous decades. Feyzullahoglu et al. [1] study the tribological mechanism of brass and babbitt materials with lubrication conditions. From experiment it found that, performance of brass with wet conditions is superior to tin-based alloys as a result of its hardness. Amount of wear in tin-based alloys is higher than brass under analogous loading situation. Therefore, overall life of brass is estimated to be more than tin-based babbitt. Hairong et al. [2] examined tribological mechanism of babbitt material sliding against the aluminum and bronze under marine water environment. The results show that the COF reduced with rise in load up to 35N and then stayed constant level (steady) at large loads, however coefficient of friction (COF) reduced with rise in sliding velocity. Rise in load the wear rate also rises, but reduced with sliding velocity. Zeren et al. [3] investigate the tribological mechanism of two diverse type babbitt materials under dry sliding conditions. Chowdhury et al. [4] examined the effect of speed on COF of Brass material Sliding on or against various Steel Counter faces. The results show that COF drops with the rise in speed and COF initially rise then it become stable or steady for rest of experimental duration. Zhang et al. [5] analyzed tribological mechanism of babbitt material composite with PU coating with dry and wet conditions. The result shows that babbitt with PU composite coating give batter wear resistance and friction reduction than counterparts of simple babbitt.

II. Experimental Details

2.1 Specimen preparation

The specimen material used in this project was tin-based babbitt metal and brass. The Pin material was prepared by using extrusion process in form of the cylindrical road (6mm in diameter and 2 m long). The first step is to melt babbitt in crucible electric furnace under the atmospheric condition. The melting point of Tin based babbitt is 350C. After melting Tin metal different percentage of material like antimony and copper are added to improve properties of Babbitt material. Then babbitt is poured into die to get required shape. Then specimen is machined on center lathe to obtain the exact dimension (6mm in diameter and 28 mm long) that are required for the experiment. A similar method is used for the preparation of brass pin. The chemical composition of both materials shown below

Table 2.1 Chemical Composition

Element	Cu %	Sn %	Pb%	Fe%	Al%	Zn%	Sb%
Tin based Babbitt	55.77	0.33	2.42	0.027	0.061	41.392	0.0
Brass	5.05	81.74	0.22	0.0	0.0	0.0	12.13

2.2 Apparatus

Wear test is conducted on Pin on Disc (POD) apparatus using Friction and Wear monitor, manufacture, and installation by DUCOM. POD apparatus is used to find out the Wear, COF and Frictional force in a laboratory. With the assistance of this experiment, the effect of numerous working parameters link perpendicular load, Sliding rate, Contact area at a constant sliding distance is determined.

Fig.2.1 Pin-on-Disc Wear Test Apparatus

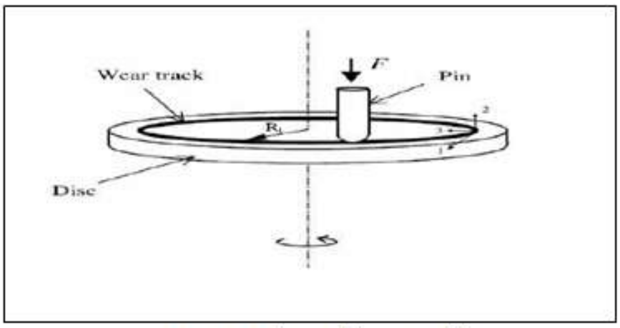

Fig. 2.2 Pin on disc assembly

III. Experimental Results

Measurement Methods of Wear
1. Optical technique
2. Mechanical gauging method
3. Weighting technique
4. Radio tracer method

In the present research, weighting method is used. In this method weight of the sample before testing and after conducting testing is measured it gives weight lost (wear). From volume loss and sliding distance, calculate wear rate. Initially Pre-Testing is conducted under the dry condition to known the tribological behavior of tin-based babbitt and brass material. From experiment, it's found that amount of wear in both materials are very high at high speed and high load. Due to the increase of temperature deformation of tin-based Babbitt take place. The range of experimental parameters is decided based on literature survey and pre-testing. Experimental result of tin-based Babbitt metal and brass material under dry and lubrication (SAE 50) are as shown in table 2

Table 3.1 Testing Parameters

Sl. No	Parameters	Operating condition
1	Normal Load	10,20,40N and 50 N
2	Sliding Velocity	200,300,400 and 500 rpm
3	Duration of Rubbing	20 min
4	Surface Condition	1.Dry 2.Lubrication (SAE 40)
5	Disc Material	Stainless steel (E8 Steel)
6	Pin Material	1.Tin based Babbitt alloys 2.Brass

Table 3.2 Experimental Result of Tin-based Babbitt material

Sr. no	Load N	Speed rpm	Surface Condition	Wear (micro)	COF
1	10	200	Dry	34	0.33
2	10	300	Wet	0	0.005
3	20	200	Wet	98	0.003
4	20	400	Dry	238	0.448
5	30	300	Dry	215	0.452
6	30	400	Wet	6	0.007
7	50	300	Dry	161	0.21
8	100	600	Dry	1600	0.07

Table 3.3 Experimental Result of Brass Material

Sr. no	Load N	Speed rpm	Surface Condition	Wear (micro)	COF
1	10	200	Dry	43	0.166
2	10	300	Wet	0	0.003
3	20	200	Wet	19	0.002
4	20	400	Dry	643	0.226
5	30	300	Dry	895	0.228
6	30	400	Wet	51	0.006
7	50	300	Dry	1280	0.151
8	100	600	Dry	1508	0.32

Wear rate is calculated from the following equation

$$wear = \frac{\Delta w}{2\pi rnt} \quad \ldots\ldots 3.1$$

Where $2\pi rnt$ is sliding distance (cm), t is sliding time (sec), $\Delta w = w_1 - w_2$ change in wear rate and n sliding speed (rpm)

IV. Results And Discussion

4.1 Wear test

4.1.1 Dry Condition

From result table 3.2, it is observed that wear depends on the perpendicular load and sliding velocity. As perpendicular load and sliding velocity rise, the wear also rises. Reason for increasing wear is the increase in surface temperature and hardness of the material. Material softening takes place as surface temperature increases which effects in a material distortion causing material wear.

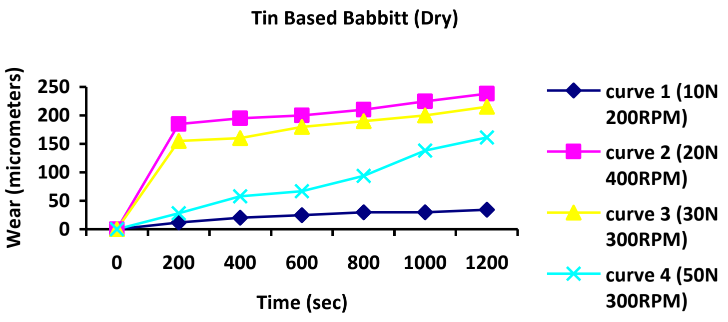

Fig. 4.1 Relationship between wear and sliding time at different normal load and sliding speed for Tin based Babbitt Material

The Figure 4.1 clearly shows the correlation between the wear and duration of rubbing. The variation of wear against rubbing duration was intended at different condition. Initially wear increase rapidly and after that attend the steady state (increase with constant rate). With further increase in normal load, wear rate also increases at the fast rate. Minimum wear in tin-based Babbitt occur when a normal load is 10N and sliding speed is 200 rpm and maximum occur when the normal load is 20N and sliding 400rpm. Due to dry condition initially wear rate is more. As load and speed increase wear rate also increase. Under similar condition wear is more in case of brass under dry conditions due to more hardness of wear compared to tin based Babbitt.

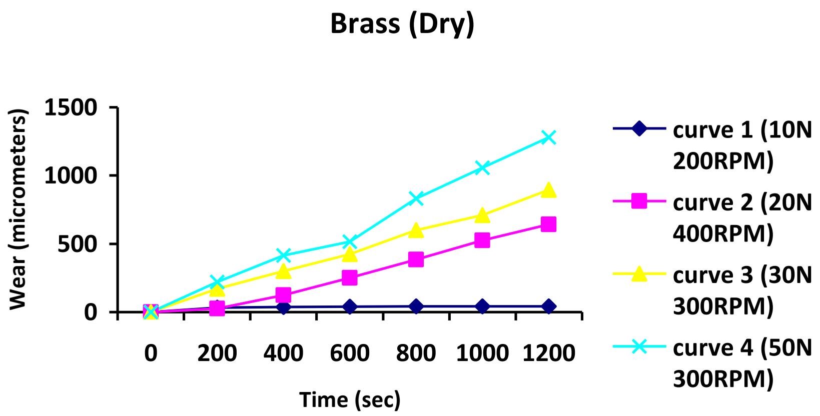

Fig. 4.2 Relationship between wear and sliding time at various normal loads and sliding speed for Brass material

4.1.2 Lubrication

Figure 4.3 show the changes of wear with the sliding time at various sliding velocity and perpendicular load. Curve 1 is drawn for sliding speed 200 rpm and normal load 20N. This curve shows that the amount of wear rise exactly linear up to 75 micrometers and after that, it remains steady for remaining experiment. Curve 2 (10N and 300rpm) and curve 3 (30N and 400 rpm) show that value of wear is very low due to lubrication.

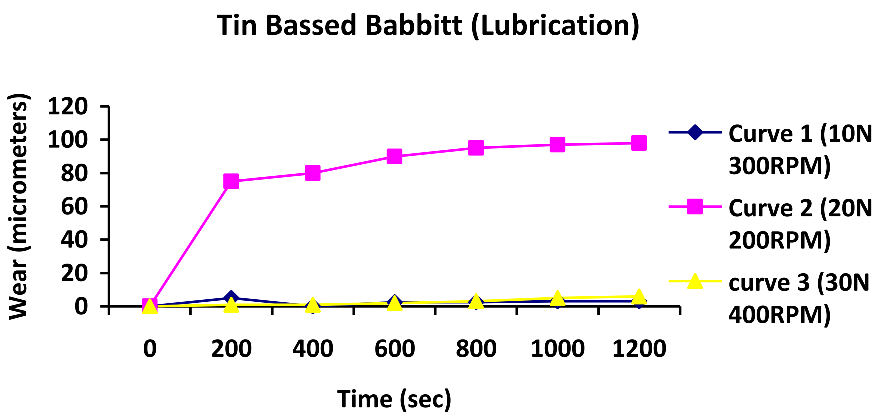

Fig. 4.3 Relationship between wear and sliding time at different normal load and sliding speed for Tin based babbitt with lubrication

In case of a brass with lubrication (SAE 50 Oil) amount of wear is more compared to tin based Babbitt material. Figure 4.3 shows that the amount of wear increases with increase in sliding velocity and normal load but the amount of wear is low when compared to the dry surface condition. Curve 1 of figure 4.3 is drawn for sliding speed 400 rpm and normal load 30N. This curve shows that the amount of wear increases almost linearly up to 20 micrometers then increase at a steady rate for rest of experiment. Curve 2 (20N and 200rpm) and curve 3 (10N and 300 rpm) show that amount of wear is low compared to curve 1.

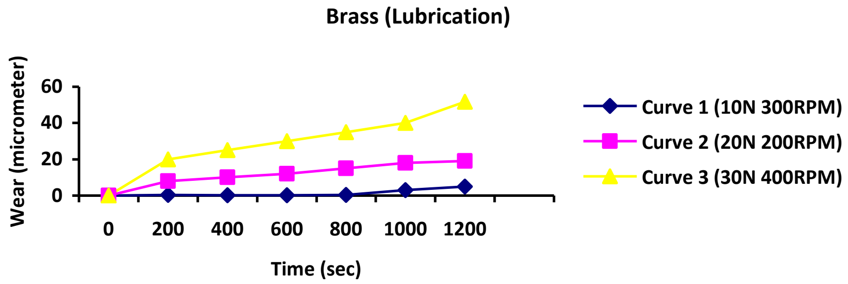

Fig. 4.4 Relationship between wear and sliding time at various normal loads and sliding speed for Brass material with lubrication

4.2 Coefficient of friction (COF)

Different values of COF (friction coefficient) measurement are observed and plotted in Fig. 4.5 and 4.6 for Tin based Babbitt metal and brass metal samples at a constant time of 20 minute.

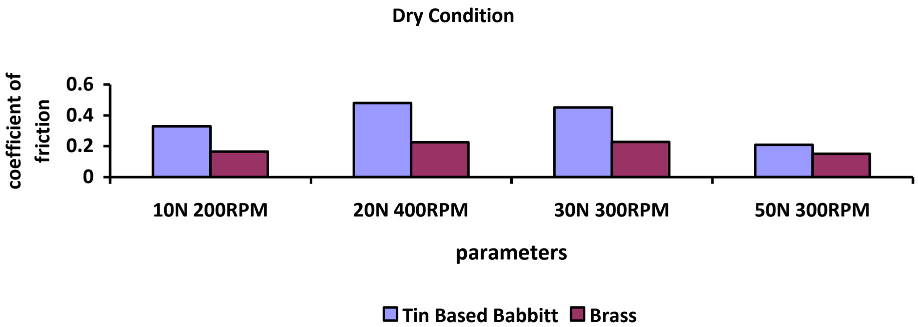

Fig. 4.5 Effect of various normal loads and sliding speed on coefficient of friction of Tin based Babbitt and Brass material with Dry condition

The value of the COF for a brass material is low when compared to the Tin based Babbitt material. Coefficient of friction is minimum at normal load 50N and sliding speed of 300 rpm for brass and Tin based Babbitt material. From column chart it is shown that value of the coefficient of friction first increases then decrease with increase in normal load and speed.

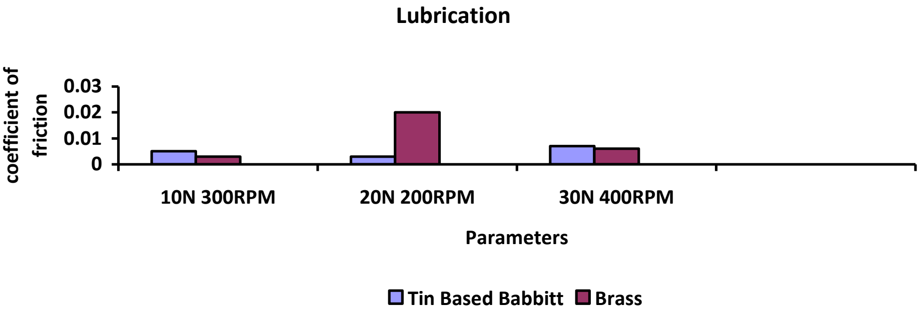

Fig. 4.6 Effect of various normal loads and sliding speed on coefficient of friction of Tin based Babbitt and Brass material with lubrication (SAE 50) condition

If we use brass and babbitt with lubrication are used then value of the coefficient of friction decreases. which reduce power lost due wear and friction and help to raise overall performance of system.

V. Conclusion

Based on the research carried out it is concluded as follows

1. The sliding velocity and normal load plays a dominant role in tribological behaviour of tin based babbitt and brass materials.
2. Tin based babbitt is better suited for maximum contact pressures up to 0.5 Mpa and sliding speed 200 rpm.
3. Amount of wear in brass material is more compared to tin based babbitt material with dry conditions. If this material is used with SAE 50 Oil (lubrication) then amount of wear reduces by large amount.
4. With tin based babbitt and brass material at low speed and load amount of wear is low compared to the high speed and load.
5. Value of coefficient of friction of brass material is smaller than tin based Babbitt material.
6. Coefficient of friction (COF) decreases with increase in sliding velocity. Magnitude of Coefficient of friction (COF) is different for different materials, therefore consider appropriate array of perpendicular load and sliding speed. Select optimum value of COF to improve performance of system.

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this paper.

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