International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Tribological Investigation and Development of Brass composite Bearing Material

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Accepted 05 March 2015, Available online 10 March 2015, **Vol.5, No.2 (April 2015)**

Abstract

Tribology is the science and technology of interacting surfaces in relative motion of related subjects and practices. Sliding and rolling surfaces represent the key to much of our technological society. Understanding of tribological principles is essentials for successful design of machine elements. When two normally flat surfaces are placed in a contact, surface roughness causes contact to occur at a discrete contact spots and an interfacial adhesion occurs. Materials coatings and surface treatments are used to control friction and wear. One of the most effective means of controlling friction and wear is by proper lubrication, which provides smooth running and satisfactory life of machine elements. Lubricants can be liquid, solid, gas. Present scenario works on solid lubricant as per demands from the industries. Some applications has too complicate design and some application has to be installed in complicate placeless where periodically oiling requires for its better performance. In such cases lubrication is also serious problem because of machine location and complicate design. Solid lubrication is the solution for such application. So now a day the more emphasize has been taken on investigation of solid lubricants. Meanwhile the number of works has been done on metal matrix composites. The aim of this work is to find and develop the better combination of metal matrix solid lubricant for different application. Graphite flakes, and sub- micropartical ofMoS2 and Brass (20%Zinc), were investigated in dry sliding conditions. Friction and wear experiments were conducted on pin-on-disc apparatus, using composite pins against polished EN8 steel counterparts, performed within the room temperature. With the addition of sub-micropartical, the frictional coefficient and wear rate of the composites were further reduced especially at high loading condition. In this investigation, with insertion of Mos2 in Brass,improves friction and wear properties but also enhance the mechanical characteristic of Brass.

Keywords: *Brass, Bass composites, Solid lubrication, wear, coefficient of friction; friction, fictional force.*

1. Introduction

In the petroleum, food processing, chemical industry and coalmines where high temperatures often evolved, special materials have to be used. The high wear rate at high temperature and high load is a serious problem in a large number of industrial applications such as elevated temperature compressor piston rings and bearings. Meanwhile to meet the combination of light weight and high strength demands, alloy as well as metal matrix composites materials are increasingly used in many industries. However, wet lubrication is not beneficial or not much more significant effects, due to contamination of oil. Some application such as compressors and juice extracting machine, where oil contamination with a various food products is a serious problem. However someone is complicate design and some application is installed in complicate places where periodically oiling is difficult as it necessary for its better performance. In such cases lubrication is also serious problem because of machine location eg. Fan and blower etc. and complicate design. Solid lubrication is the solution for such application. So now a day the more emphasize has been taken on investigation of solid lubricants (Wenyi Yan *et al*, 2002).

Meanwhile the number of works has been done on metal matrix composites (Hani Aziz Ameen, *et al*, 2011). This metal matrix composites has proven good tribological characteristics under the heavy load conditions. (Hani Aziz Ameen, *et al*,2011). The wear rate in this plane strain region can be determined from a two dimensional idealization of the contact problem, reducing the need for computationally expensive three dimensional contact analyses. A study had been made on the wear rate for different materials (Steel, Aluminum and brass) under the effect of sliding speed, time and different loads, where the apparatus pin on disc was used to study the specification of the adhesion wear. The results will show that the rate of adhesion wear will be direct proportional with (time, sliding speed and load), and the low carbon steel has less wear

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rate than the other materials. Brass and Gunmetal as well as New non metallic material Cast Nylon (J. D. Bressana *et al*, 2008). Friction and Wear are the most important parameters to decide the performance of bearing.

2. Experimental

2.1 Preparation of material sample

Commercially available Brass fine powder contains 20% Zinc with the average diameter of 100μm is supplied by Micro metal Pvt. Ltd. Nasik. Molybdenum disulfide powder of diameter 90μm also supplied by Vishal Pharmacies Mumbai.Phinollic resin used as metallic binder also brought from micro metal Pvt. Ltd. Nasik. The composite were prepared by sintering process. First Brass powder and MOS2 were mixed with different proportion for various batches with batch size150gm.From various literature survey the percentage of Mos2 has been decided and taken 5% to 10%. For accurate weighing digital weighing balance is used with accuracy 0.0001gm. and for uniform mixing have done by compounding of raw materials. The samples were prepared with following proportion.

Table 2.1 Designation of Composites

Specimen	Compositions
S1	BRASS (100%wt)
S2	BRASS(95%WT)+mos2(5%)wt
S3	BRASS (90%wt) + mos2(10%)wt

2.1.1 Sample preparation for wear test

Sample preparation are done in following steps

i) Manual mixing.ii) Compacting by compressive testing machine.iii) Sintering. The specimen for wear test has been produced by sintering process. The Brass powder and Mos2 powder with proportion 95:5 % has taken in crucible and phinollic resin is used as binder with negligible weight which is not consider in the specimen weight as it evaporate during the heating process. First brass and Mos2 powder were mixed manually in crucible up to 15minute. The dried powder is put in small plastic bottle and shack it for five minute for uniform mixing. Add the phinollic resin to the mixture and stirred it properly. It appears solid wet mud. The wet mixture than put in cylindrical die with dimensions of 100 mm long and 20 mm in diameter. The die and plunger assembly with raw metal is kept to compression testing machine and applied the load 150 KN for 30 minute. Similarly different sample is produced by compacting. After the compacting of sample it is kept in the hot furnace for heating process. The sintering temperature were set from 800 ^{0}C to 850 ^{0}C for 1 hr duration and sample were cooled inside the furnace up to2 hr and then removed from the furnace. The sintered sample was ready for its processing; it is to be machined on lath for obtaining required dimension of 10mm × 30mm .In this way specimen were ready for wear test of different combinations.

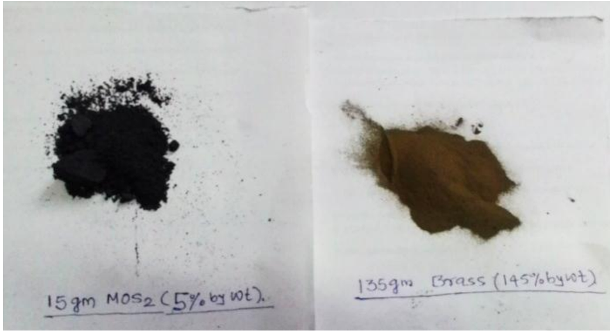

Fig.2.1 powder of Mos2 and Brass

Fig. 2.2 Mixing of Raw material

Fig. 2.3 compressive strength testing machine

Fig. 2.4 Sintering of raw sample after compacting

Fig.2.5 Raw sample after sintering

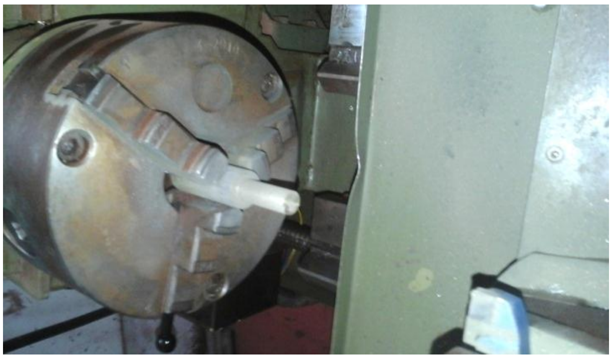

Fig. 2.6 Turning of Raw sample after sintering

Fig. 2.7 Final finished specimen of size 10mm× 30mm

2.1.2. Selection of Counterpart

The counterpart is selected with consideration of application like centrifugal pump .The generally the outer race of journal bearing is made up by stainless steel or cast iron materials, with this reference 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. The main aim of selection of counter surface of EN8 is, generally the rotating part inside the pump and small rotating machine are used steel and steel alloys and EN8 is the one of the grade of steel. Initially the raw material for were purchases from Nasik MIDC area PAUL STEEL TRADERS in the form of cylindrical billet. The disc material initially cuts in dimension Ø180mmx 15 mm thickness from the billet. These raw materials were processed in Vishal Engineering Pvt. Ltd. All finishing such as turning and grinding has been done at Visual Engineering and finally disc with dimension Ø165mmx8mm thickness made ready for test. After that disc hardness was checked by Brinell hardness Tester and surface roughness 0.4μm was checked at Vishal Engineering.

2.2. Wear Test

The prepared samples were used for tribological test at room temperature on Wear and friction measuring test rig TR-20 at P. Dr. V.V Patil College of Engineering Ahmednagar. Maharashtra. The Wear was performed on a pin-on disc apparatus according to ASTM D2538 and ASTM D2396.The test rig was supplied by DUCOM Instrument Bangalore,is shown in fig .2.8

2.8 Selection of Operating Parameters

Initially the calculations were done before test,especially the wear tests were conducted for non-lubricating rotating centrifugal pump having capacity 1 Hp. The basic aim was that to minimize wear rate and fine better material for non-lubricating rotating compressor, machine or centrifugal pumps. The Specimen pin 10 mm diameter and 30 mm long was run against the polished steel disc of grade EN-8 with an initial surface roughness of 0.4 μ. With contact pressure ranges from 0.6 to 1.2MPa.The value of contact pressure is selected an application of centrifugal pumps, usually works on working pressure in range of 6 to 12 bar (1.2MPa) and sliding velocity were selected in the range from to 1.1 to 3m/s. This value of velocity is selected from motor specification as rated electric motor speed used for centrifugal pump varies from 1440 rpm to 1800 rpm. So in this work lowest or optimum speed at loading condition has to be selected. From reference data available for balancing 10 meter of water column of discharge of 1 cm, discharge pressure approximately is to be found 1 Kg/cm^2 i.e. 1 bar or 0.1Mpa. The test load values were selected from ranges 25N to 75N. If considering the bearing application for centrifugal pump of 1 Hp and as per reference data and conversion analysis it has been found that 1 Hp pumps consume 0.746 Kw of electrical energy and. Create discharge water pressure force up to 0.6 to 1.2 Mpa. It means that it during the test, the

Table 2.2.1 Kirloskar Centrifugal Pumps specification; MODEL: BD-NL

Working pressure	6.25 bar or 0.626Mpa
Pump speed	1440 rpm
Operating parameter selected:	
Loads	25 to 75 N
Sliding velocity	1 m/s to 3m/s
Temperature	Ambient (23^{0}C)
Duration of experiment	30 minutes

Table 2.2.2 Tribology properties of Brass and Brass composites

S. No.	Specimen	Load (N)	Specific Wear rate $Ws = \frac{\Delta m}{Fn \times L}$ mm^3/Nm	Frictional Force Fn = μR_n (N)	Coefficient of friction (μ)
1	Brass	25	3.48 × 10^{-4}	3.65	0.146
2	Brass+5%Mos2	25	1.60× 10^{-4}	4.24	0.069
3	Brass + 10%mos2	25	3.34× 10^{-4}	4.23	0.203
4	Brass	50	4.36× 10^{-4}	6.13	0.122
5	Brass+5%Mos2	50	3.95× 10^{-4}	2.10	0.042

frictional coefficient is recorded and calculated by a ratio between the tangential force and normal load. This is also monitored by placing load cell transducers. The reduction in height of the specimen was measured by a displacement transducer, could be used to characterize the wear process. However the reliability of this measurement is affected by the possible thermal expansion of the sliding counterparts. Therefore after the test the mass loss of the specimen was measured to calculate the specific were rate by the equations. The calculated specific wear rate used to validate the reliability of the recorded height loss of specimens. The table 2.2.2 summarized the wear results performed at the room temperature (RT).Each result is the average value of last three experimental data,is the mean values during the steady state of the sliding process. The details of composition of the blends are shown in Table 3. The blends were characterized for their mechanical properties in the laboratory and results are shown. The operating parameters were selected with reference of Kirloskar centrifugal pump. It was also taken with reference papers for general purpose.

3. Result and discussion

This chapter discussed the variation in frictional force, frictional coefficient and specific wear against the time as well as load under the same operating conditions for Brass and Brass composites. The behavior of brass has to be change observed from the resulting data mentioned in Table no 2.2.2 It has been cleared that the wear resistance greatly enhanced by the addition of fillers. Without reinforcements the base material Brass is easily removed by hard asperities of the metallic counterpart, resulting high wear loss. When the brass was modified with 5% to 10% Mos2, a metallic Lubricating film can be transferred to the EN8 metal disc counterpart, resulting resistance to adhesive wear mechanism. The effects of various parameters were studied after the test has formulated into graphs and discussed briefly as bellow.

3.1 Comparative study of Brass and Brass composites

The characteristic of pure Brass and Brass composites have been studied under the comparative study. The comparison between the various characteristic of Brass and brass composites at various operating conditions, discussed below.

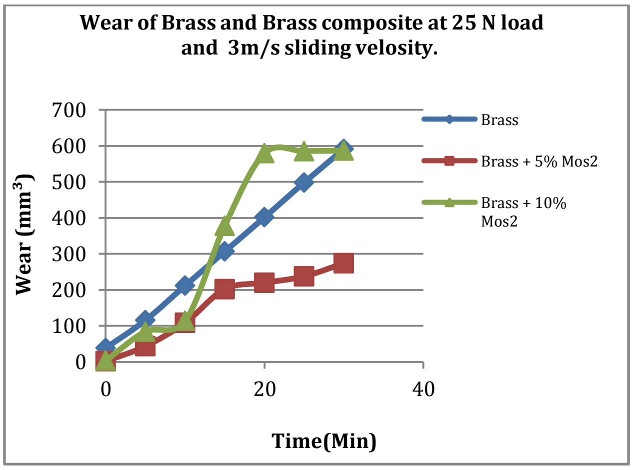

Fig.3.1.1 Time vs. wear of Brass and brass composites

Initially the value of specific wear was low for pure Brass, the value of wear goes on increasing with increasing time. This is because of thermal expansion of Brass which enables to release the material particle. The particles of Brass loose it physical as well as mechanical properties with respect to the time interval. The specimen S2 is composition of brass plus 5%Mos2, on testing with same operating parameters it has been observed that the wear rate for specimen S2 lowered as compared to pure brass. The wear resistance characteristics for Pin 2 have been increase gradually as compared to pin S1. The wear value for specimen $S_2$is stabilized at 274.5 micron which is half that of pure brass. This indicates that for same operating condition and same parameter the wear resistances of Brass composite with 5% Mos2 doubled. This is because of addition of Mos2 act as solid lubricant; it tends to form lubricating film against the counterpart. Due to formation of lubricating film on counters face of rotating disc this enable to prevent the metal to metal contact during rotation and less material in contact implies the less wear. Similarly the specimen or pin S3 also tested with same operating condition but specimen S3 has found to be less significant as compare to S2 but has good wear resistance characteristics that S1 or pure brass.

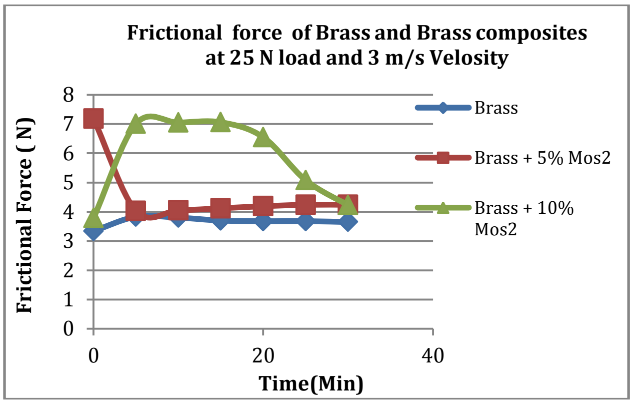

Fig.3.1.2time vs. Frictional force of Brass and brass composites

Fig.3.1.2 shows the relationship about frictional force Vs time with same operating parameter for all three type of pin S1, S2, and S3.The value of frictional force of pin S1 (pure brass) was less as compared to the Pin S2 and S3 The value of frictional force found to be lass in second trial at high loading condition as compare to low load due to which wear characteristics also enhanced. The pin S3 isa composition of Brass plus 10% Mos2 show the higher value of frictional force as compared to the Pin S1 and S2.

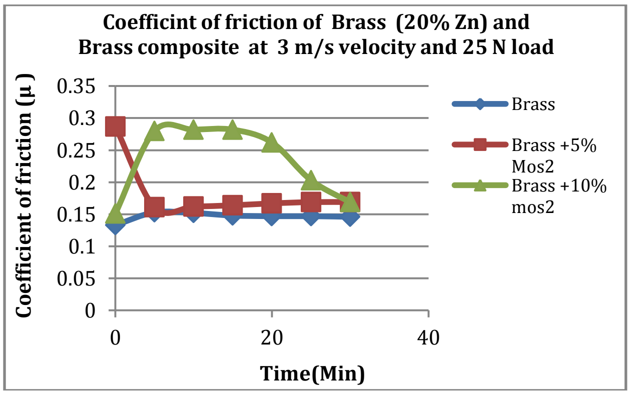

Fig.3.1.3 Time vs. Coefficient of Friction for Brass and Brass composites

Fig.3.1.3 shows the effects Time interval Vs coefficient of friction of Pin S1, S2 and S3 the graph plotted from the given data about the coefficient of friction between the rubbing parts of pin and disc. It was found that the Pin S1 of pure brass martial has less value of coefficient of friction as compared to the pin S2 and S3, but the S2 has better coefficient of friction value then the S3 Pin at same operating conditions. This value was found satisfactory as per some of the references regarding the bearing material selection. The standard value of coefficient of friction for copper based bearing with sintered operation µ= 0.03 l at contact pressure 0.6mpa to 1.2 Map. In experimental analysis of brass composites this value obtained near aboutµ= 0.04.

3.2 Effect of load on pure Brass and Brass composites

The Pin S1, S2 and S3 initially were tested at 25 N load for same operating parameter and results were tabulated in to observation table. From that data the best Pin S2 of composition of 5% mos2 was selected and again it was tested at 50 N loads under the same operating conditions.

3.2.1 Effect of load Vs wears characteristics for Brass and Brass composites

Fig 3.2.1 fig.3.2.2 and 3.2.3.represented the relation between load and wear properties. At 25 N loads the Pure Brass material shows the less wear properties at the same operating parameters. It has been observed that the wear resistance of brass decreased with increased load. But with addition of Mos2 in brass, wear resistance properties enhanced at high load i.e. 50 N at same operating conditions.

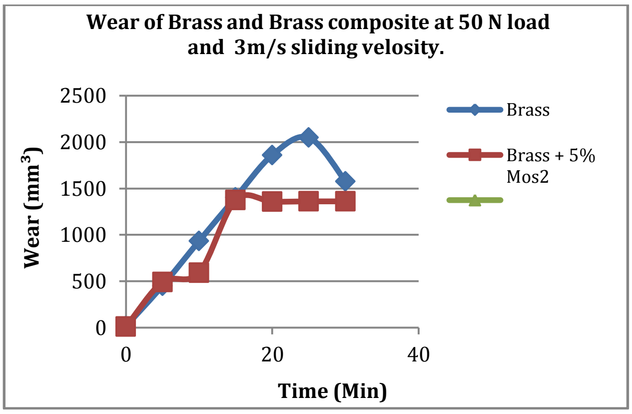

Fig.3.2.1 Time vs. wear of Brass and brass composites

Fig.3.2.1 shows the relation between load and wear characteristics for pure brass and brass composite. From above the graph, it has been observed that the wear characteristic for pure increased with increased of load with addition of filler material 5% mos2 increased the wear resistance. As discussed earlier the wear characteristics enhanced due to addition of Mos2, this mos2 act as the solid lubricant.

3.2.2. Effect of load Vs Frictional force characteristics for Brass and Brass composites

Fig 3.2.2 represented the relation between load and frictional force properties. At 25 N loads the Pure Brass material shows the less frictional force as compare to brass composite but with increased of load this value increased and became stable. At 50 N load initially the frictional force value of brass composite was found to high because of increased of hardness by sintering process but as the time advanced the mos2 asperities settled down on the rotating disc and formed the thin lubricating film that start to prevent the metal to metal contact so the friction between the two sliding part minimized. This help to reduce the frictional force shown in fig .3.2.2

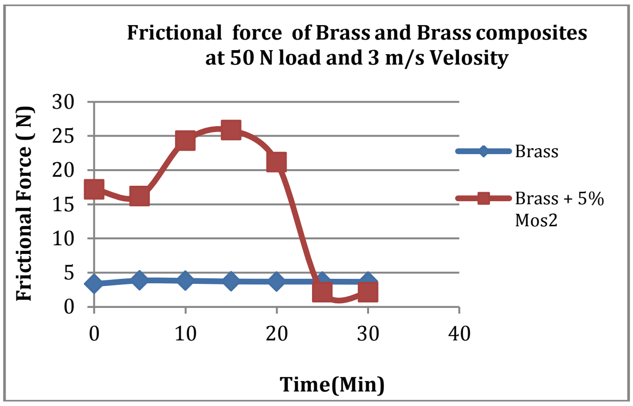

Fig.3.2.2 Time Vs. Frictional force of Brass and brass composites at 50 N load

3.2.2. Effect of load Vs Frictional force characteristics for Brass and Brass composites

Fig 3.2.3 show the relation between load and coefficient of friction properties.

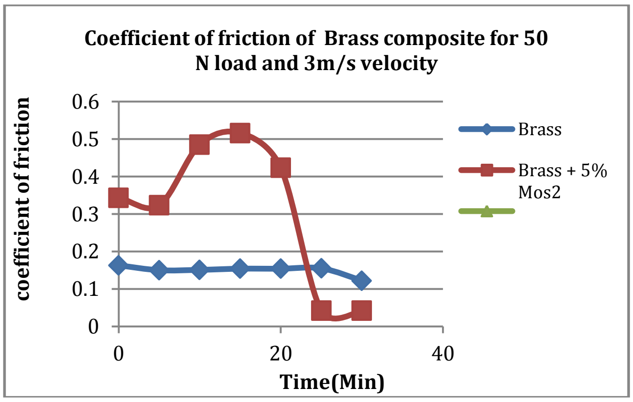

Fig.3.2.3 Time vs. Coefficient of Friction for Brass and Brass composites at 50 N loads

At 25 N loads the Pure Brass material shows the less coefficient of friction as compare to brass composite but with increased of load this value increased and became stable. At 50 N load initially the frictional force value of brass composite was found to high because of increased of hardness by sintering process but as the time advanced the mos2 asperities settled down on the rotating disc and formed the thin lubricating film that start to prevent the metal to metal contact so the friction between the two sliding part minimized. This help to reduce the coefficient of friction and the leas value of coefficient of friction was found to be μ=0.041

Conclusions

The tribological properties of Brass and Brass composites filled with mos2 were systematically studied under different operating condition at ambient temperature. From the result the following conclusions are drawn.

It has been observed that at same operating conditions pure brass has higher wear value as compare to brass composites. This also clear that mos2 filled Brass shows good lubricity quality than pure Brass.

With addition of 10% Mos2 in Brass, has not shown too much significant result against the wear resistance, with addition of 5% mos2 clear that, composites with 5% mos2 showed more effective in wear resistance.

it is also cleared that Brass composite can be act as good solid lubricants at low as well as at high loading condition as compare to pure brass .

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