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Effect of Orientation and Applied Load on Abrasive Wear Property of Brass 60:40

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ABSTRACT

Wear is a continuous process in which material is degraded with every cycle. Scientists are busy in improving the wear resistance. Approximately 75% failure in components or machine parts is due to wear. The present paper investigates experimentally the effect of orientation and normal load on alloy of copper and zinc, *i.e*. Brass, and calculates weight loss due to wear. To do so, a multi-orientational pin-on-disc apparatus was designed and fabricated. Experiments were carried out under normal load 05-20 N, speed 2000 rpm. Results show that the with-increasing load weight loss increases at all angular positions. The loss in weight is maximum at zero degree (horizontal position) and minimum at ninety degree (vertical position) for a particular load. Maximum wear occurs when the test specimen is held at 0˚ angle and minimum wear occurs when the specimen is held at 90˚ angle for given applied load. The circumferential distance travel is constant for all positions and for all loads but still mass loss varies.

KEYWORDS

Abrasive Wear; Brass; Grinding Disc; Mass Loss; Orientation

1. Introduction

Wear is a continuous process in which material is degraded at every cycle. Kloss *et al*. emphasized the various tools such as wear measuring equipments, mathematical modeling, tribo meters and simulations are used for measuring wear resistance and wear rate over many decades. It was observed by several authors [1-11] that the variation of friction and wear rate depends on interfacial conditions such as normal load, geometry, relative surface motion, sliding speed, surface roughness of the rubbing surfaces, type of material, system rigidity, temperature, stick slip, relative humidity, lubrication and vibration. Among these factors, sliding speed and normal load are the two major factors that play a significant role for the variation of friction and wear rate. As reviewed by Becker, *et al*. [12], the three important wear mechanisms mentioned over the years are: corrosion, abrasion, and adhesion. Researchers also suggest some parameters like hardness, fatigue or tensile strength producing effect in wear rate. Hardness does give any indication of the wear resistance of a material; however studies have demonstrated that the addition of certain alloying elements increases the wear resistance but not the hardness. Brass 60:40 is widely used in numerous engineering applications where friction requirement is meager such as locks, gears, bearings etc., including transport and construction where superior mechanical properties such as tensile strength and hardness are essentially required. Typical mechanical properties for Brass 60:40 are presented in **Tables 1** and **2**.

This paper is in series with "Effect of Orientation and Applied Load on Abrasive Wear Property of Alumunium Alloy-Al6061" [13]. The objective of this work is to design a new type of pin on disc setup which can check wear rate or loss of weight of the selected specimen at different orientation and at different loads.

2. Materials and Methods

In order to carry out the experimental work the following procedure is adopted:

(1) Design of Setup; (2) Materials Selection; (3) Wear Behavior.

2.1. Design of Setup

In view of the objective a set-up was needed to be designed which can calculate wear rate at different angular positions (0˚, 30˚, 45˚, 60˚, 90˚) of work piece. The designed setup is shown in the Figure 1.

The set up has following different parts (1) Controller (2) D.C. Motor (3) Flange Coupling (4) Bearing (5) Main Frame (6) Frame(Angular) (7) **Acrylic Sheet** (8) Grinding Wheel (9) Specimen (10) Screw Jack (11) Load Cell.

2.2. Selection of Material

For the present investigation Brass 60:40 type Brass alloy has been selected. Tables 1 and 2 show the Chemical Composition of the Brass 60:40 alloy.

2.3. Specimen Preparation

The specimen for wear studies was cut from the Brass alloy plate. The specimen cross section used was 1 cm × 1cm with a thickness of 4.5 cm. The top and bottom specimen surfaces were made planer by polishing against emery papers of appropriate grits. For the preparation of the surface to be used for wear studies, the final grit size of the emery paper was the same as the one to be used for the wear studies.

Table 1. Properties of brass 60:40.

Elements	Cu	Zn	Fe	Tensile Strength	Shear Modulus
Wt %	60%	39.65%	0.35%	370 MPa	37 GPa

Table 2. Properties of brass 60:40.

Melting Point	Density	Modulus of Elasticity (E)	Poison's Ratio
885˚C - 900˚C	8.49 gm/cm^3	97 GPa	0.31

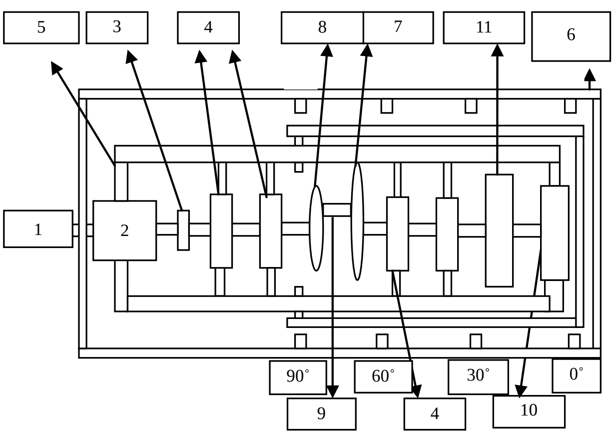

Figure 1. Design of setup.

2.4. Wear Characterization

The following method was adopted for wear characterization.

2.4.1. Selection of Applied Load and the Position of the Specimen

The following loads were selected for present objective

(1) 5 N (2) 10 N (3) 15 N (4) 20 N

For each load the position of the specimen was kept at 0˚, 30˚, 45˚, 60˚ and 90˚ respectively.

2.4.2. Selection of Grinding Wheel

The type of grinding wheel used for certain application, greatly influence the quality of the surface produced. Therefore, for different types of materials, different types of abrasive wheels can be used. Thus for Brass the grade of grinding disc taken is C46-K6V.

2.4.3. Speed of Grinding Wheel

The speed of grinding disc is kept at constant value of 2000 rpm.

2.4.4. Test Procedure

Before the test the weight of the test specimen was taken accurately using an electronic balance with an accuracy of 0.001 g. The maximum weighing capacity of the electronic balance was 320 g. After a travel time of 05 minutes against the grinding disc, the sample was taken out carefully so that the debris's were removed from the valleys of the specimen and exact wear materials can be measured. Once again weight was taken carefully using the above balance and the difference in weight was noted. This was continued for five times with same specimen and at same position. After that next specimen was taken for next test condition *i.e.* 30˚ angle and 5 N applied load and so on. The tests were conducted for five different orientations namely 0˚, 30˚, 45˚, 60˚ and 90˚. Thus a total of 25 reading is taken for one particular load. This is continued for load of 10 N, 15 N, 20 N respectively. The cumulative effect of weight loss was taken for calculating the wear mass.

3. Results

The effect of load on the specimen is shown in Figures 2-6 at various angular positions namely 0˚, 30˚, 45˚, 60˚ and 90˚ respectively. The mass loss of the materials is presented for loads 5 N, 10 N, 15 N, 20 N. The effect of orientation on the specimen is shown in Figures 7-10.

Grade of grinding disc taken is C46-K6V for Brass material.

3.1. Effect of Load at Different Orientations

- From Figure 2 it is observed that the wear mass increases from 0.916 gm to 1.262 gm as the applied load on the specimen increases from 5 N to 20 N when orientation of the specimen is 0˚.
- From Figure 3 it is observed that the curve follows the same pattern as in graph 3.1. The wear mass increases from 0.908 gm to 1.247 gm as the applied load on the specimen increases from 5 N to 20 N when orientation of the specimen is 30˚.
- From Figure 4 it is observed that the wear mass increases from 0.750 gm to 1.031 gm as the applied load on the specimen increases from 5 N to 20 N when orientation of the specimen is 45˚.
- From Figure 5 it is observed that the wear mass increases from 0.589 gm to 0.865 gm as the applied load on the specimen increases from 5 N to 20 N when orientation of the specimen is 60˚.
- From Figure 6 it is observed that the wear mass increases from 0.303 gm to 0.638 gm as the applied load on the specimen increases from 5 N to 20 N when orientation of the specimen is 90˚ [11].

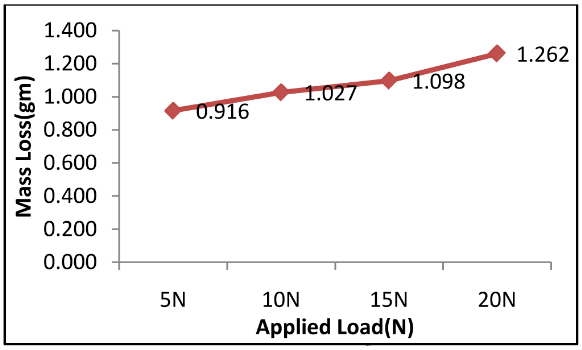

Figure 2. Effect of load at 0˚ orientation.

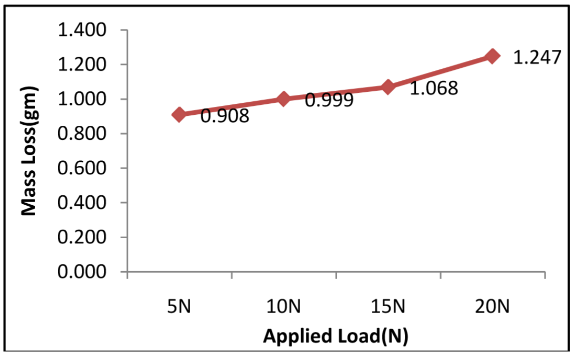

Figure 3. Effect of load at 30˚ orientation.

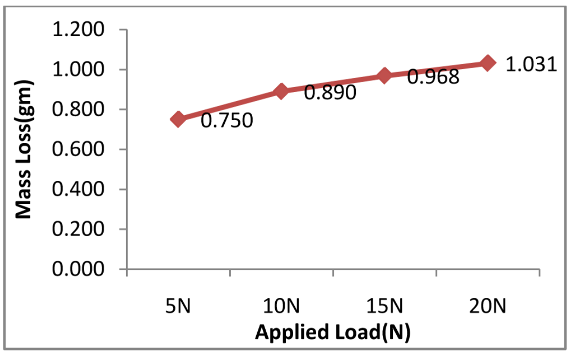

Figure 4. Effect of load at 45˚ orientation.

3.2. Effect of Orientation at Different Load

The following observations were made:

- From Figure 7 it is observed that as the orientation of the specimen changes from 0˚ to 90˚, the wear mass decreases from 0.916 gm to 0.303 gm when applied load is 5N.
- From Figure 8 it is observed that the wear mass follows the same pattern as in graph 3.6. The wear mass decreases from 0.1.0274 gm to 0.4048 gm as the orientation changes from 0˚ to 90˚ when applied load is 10 N.
- Similarly from Figures 9 and 10 it is observed that the wear mass decreases from 1.098 gm to 0.512 gm and from 1.261 gm to 0.638 gm respectively as the orientation of the specimen changes from 0˚ to 90˚ when applied loads are 15 N and 20 N respectively.

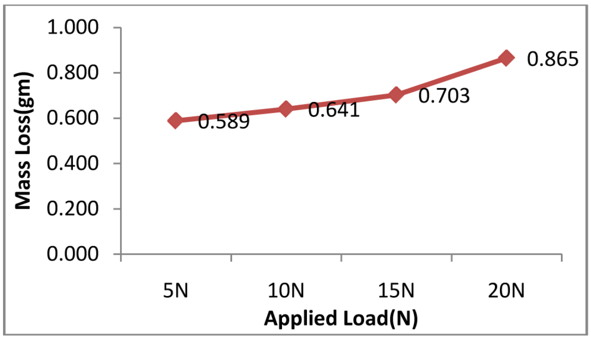

Figure 5. Effect of load at 60˚ orientation.

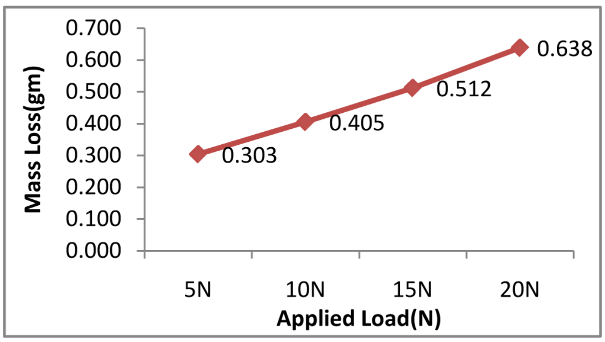

Figure 6. Effect of load at 90˚ orientation.

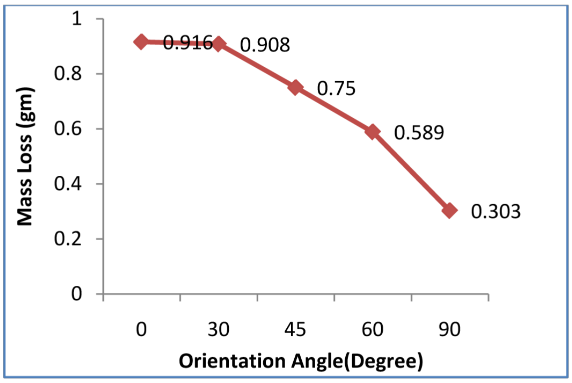

Figure 7. **Effect of orientation angle at 5 N**

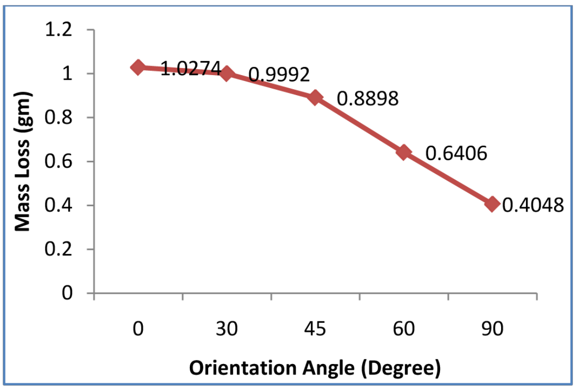

Figure 8. **Effect of orientation angle at 10 N.**

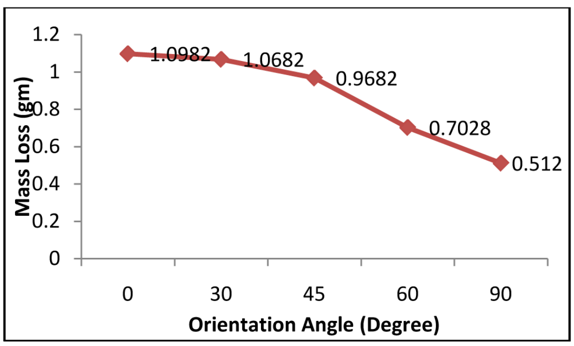

Figure 9. **Effect of Orientation angle at 15 N.**

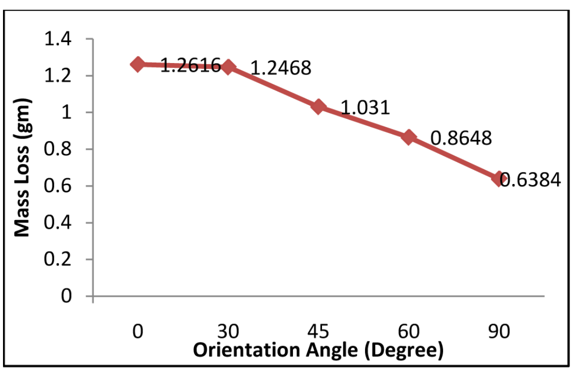

Figure 10. **Effect of orientation angle at 20 N.**

4. Discussion

As the position changes from 0 degree to 90 degree, the forces applicable on the debri-particle changes, this changes the motion of debri-particle. Therefore a complete analysis of forces applicable done. The variation of wear mass shown in the above graph shows that as position changes from zero degree to 90 degree wear mass decreases due to the changes in orientation of forces. The Figure 11 shows orientation at 0 degree whereas Figure 12 shows orientation at 90 degree. It can be concluded that:

4.1. At 0 Degree

- It can be seen from the FBD in Figure 11 that weight of debri-particle (mg) and centrifugal force (mrw^2) add to each other. The debri do not trap in between specimen and abrasive disc. Due to addition of wt. of debri-particle and centrifugal force, the debri-particle of specimen falls.
- It becomes two body abrasions against general perception.
- The Brass alloy (Brass 60:40) gets fresh abrasive surface, due to this wear resistance decreases.

4.2. At 90 Degree

- It can be seen from the FBD in Figure 12 that the set-up rotates to 90 degree. The load on the specimen adds to weight of debri-particle and centrifugal force (mrw^2) and weight (mg) are perpendicular to each other.

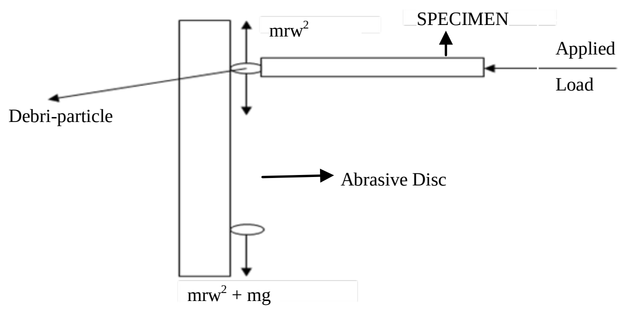

Figure 11. **Specimen at 0˚ (horizontal).**

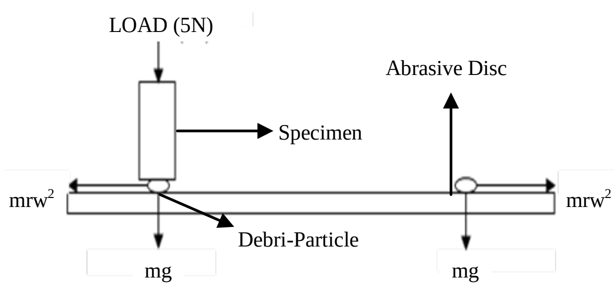

Figure 12. **Specimen at 90˚ (vertical).**

- Since debri traps in between specimen and abrasive disc hence it becomes three body abrasions due to this Brass 60:40 do not get fresh abrasive surface.
- This Change in nature of forces increases the wear resistance.

5. Conclusions

On the basis of experimental work, the following conclusions can be drawn:

1) With increasing load, wear (mass loss) increases at all angular positions, and this is in agreement with M. A. Chowdhury, M. K. Khalil, D. M. Nuruzzaman and M. L. Rahaman [11];

2) The loss in mass is maximum at zero degree (horizontal position) for a particular load;

3) The loss in mass is minimum at ninety degree (vertical position) for a particular load;

4) Maximum wear occurs when the test specimen is held at 0˚ angle;

5) Minimum wear occurs when the specimen is held at 90˚ angle for given applied load;

6) The circumferential distance travel is constant for all positions and for all loads, but weight loss still varies [14].

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