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 Aluminium alloy and calculating 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 occur when the test specimen is held at 0° angle minimum wear occur when the specimen is held at 90° angle for given applied load The circumferential distance travel is constant for all positions and for all load but still mass loss varies.

Keywords: Abrasive Wear, Aluminium, 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, tribometers 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 whose play 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 are also suggested some parameters 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. Al 6061 is widely used in numerous engineering applications including transport and construction where, superior mechanical properties such as tensile strength and hardness are essentially required. Typical mechanical properties for Al 6061 are presented in Table 4.1.

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.

(i) Design of setup (ii) Materials Selection (iii) 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 fig.2.1

![Fig.2.1. Design of setup](image)

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 Al-alloy 6061 type Aluminium alloy has been selected. Table 2.1 shows the Chemical Composition of the Al6061 alloy
Table 2.1- Properties of Al6061

<table>
<thead>
<tr>
<th>Elements</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Si</th>
<th>Fe</th>
<th>Cr</th>
<th>Ti</th>
<th>Zn</th>
<th>Density</th>
<th>MOE</th>
<th>PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt %</td>
<td>0.15-0.40</td>
<td>0.15</td>
<td>0.8-1.2</td>
<td>0.4-0.8</td>
<td>0.7</td>
<td>0.04-0.35</td>
<td>0.15</td>
<td>0.25</td>
<td>2.7 g/cm³</td>
<td>70-80 GPa</td>
<td>0.33</td>
</tr>
</tbody>
</table>

2.2.1 Specimen Preparation
The specimen for wear studies was cut from the Al alloy plate. The specimen cross section used was 1 cm x 1 cm 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.

2.3 Wear characterization
The following method was adopted for wear characterization

2.3.1 Selection of Applied Load and the Position of the Specimen
The following loads were selected for present objective
(i) 5 N  (ii) 10 N  (iii) 15 N  (iv) 20 N
For each load the position of the specimen was kept at 0°, 30°, 45°, 60° and 90° respectively.

2.3.2 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 Aluminium the grade of grinding disc taken is C46-K6V.

2.3.3 Speed of Grinding Wheel
The speed of grinding disc is kept at constant value of 2000 rpm

2.3.4 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 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 10N, 15N, 20N 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 fig. 3.1 to 3.5 at various angular positions namely 0°, 30°, 45°, 60° and 90° respectively. The mass loss of the materials is presented for loads 5N, 10N, 15N, 20N. The effect of orientation on the specimen is shown in fig. 3.6 to 3.9. Grade of grinding disc taken is C46-K6V for Aluminium material.
3.1 Effect of Load at Different Orientations

- From graph 3.1 it is observed that the wear mass increases from 0.801 gm to 1.012 gm as the applied load on the specimen increases from 5N to 20N when orientation of the specimen is 0°.
- From graph 3.2 it is observed that the curve follows the same pattern as in graph 3.1. The wear mass increases from 0.753 gm to 0.926 gm as the applied load on the specimen increases from 5N to 20N when orientation of the specimen is 30°.
- From graph 3.3 it is observed that the wear mass increases from 0.710 gm to 0.905 gm as the applied load on the specimen increases from 5N to 20N when orientation of the specimen is 45°.
- From graph 3.4 it is observed that the wear mass increases from 0.629 gm to 0.882 gm as the applied load on the specimen increases from 5N to 20N when orientation of the specimen is 60°.
- From graph 3.5 it is observed that the wear mass increases from 0.376 gm to 0.630 gm as the applied load on the specimen increases from 5N to 20N when orientation of the specimen is 90°.[13]
3.2 Effect of Orientation at Different Load

The following observations were made:

- From graph 3.6 it is observed that as the orientation of the specimen changes from 0° to 90° the wear mass decreases from 0.801 gm to 0.376 gm when applied load is 5N.
- From graph 3.7 it is observed that the wear mass follows the same pattern as in graph 3.6. The wear mass decreases from 0.917 gm to 0.439 gm as the orientation changes from 0° to 90° when applied load is 10N.
- Similarly from graph 3.8 and 3.9 it is observed that the wear mass decreases from 0.940 gm to 0.605 gm and from 1.012 gm to 0.630 gm respectively as the orientation of the specimen changes from 0° to 90° when applied loads are 15N and 20N respectively.
4.0 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 fig. 4.1 shows orientation at o degree. It can be concluded that:

At 0 Degree
- It can seen from the FBD 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 Alumunium alloy (Al6061) gets fresh abrasive surface, due to this wear resistance decreases.

![Fig 3.8 - Effect of Orientation angle at 15N](image1.jpg)

![Fig 3.9 - Effect of orientation angle at 20N](image2.jpg)

Fig 3.8 - Effect of Orientation angle at 15N  Fig 3.9 - Effect of orientation angle at 20N

![Fig 4.1 – Specimen at 0° (Horizontal)](image3.jpg)
At 90 Degree

- In this case 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.
- Since debri traps in between specimen and abrasive disc hence it becomes three body abrasions due to this Al6061 do not get fresh abrasive surface.
- This Change in nature of forces increases the wear resistance.

**Fig 4.2** – Specimen at 90° (Vertical)

5.0 CONCLUSION

On the basis of experimental work the following conclusion can be drawn:

(i) With increasing load wear (mass loss) increases at all angular positions this is in agreement with M. A. Chowdhury, M. K. Khalil, D. M. Nuruzzaman, M. L. Rahaman [14]
(ii) The loss in mass is maximum at zero degree (horizontal position) for a particular load
(iii) The loss in mass is minimum at ninety degree (vertical position) for a particular load.
(iv) Maximum wear occur when the test specimen is held at 0° angle
(v) Minimum wear occur when the specimen is held at 90° angle for given applied load
(vi) The circumferential distance travel is constant for all positions and for all load but still weight loss varies.

REFERENCES


