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Development and Fabrication of an Experimental Set Up to Determine Friction Coefficient and Wear Rate of Aluminium and its Alloy Sliding Against Mild Steel

KEYWORDS: Friction Coefficient, Normal Load, Pin, Scanning Electron Microscope, Sliding velocity, Wear

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ABSTRACT *In the present paper experimentally investigate the effects of normal load and sliding speed on the friction coefficient and wear properties of an aluminium disc sliding against mild steel pin. To do so, a pin-on-disc apparatus was designed and fabricated.*

LM6 aluminium is most successful materials used for recent works in the industry. Metal LM6 aluminium significantly improved properties including hardness and wear resistance compared to alloys or any other metal. Friction and wear test is done by pin-on-disc method and the microscopic examination done by scanning electron microscope (SEM).The investigation results show that LM6 aluminium good tribological properties and used in automobile components for reliable, long life and high performance.

1. Introduction

In the past few years, numerous investigations have been carried out and several researchers observed that friction and wear depend on several parameters such as normal load, surface roughness, sliding velocity, relative humidity, lubrication etc. There have been also many investigations to explore the influence of type of material, temperature, stick-slip, contact geometry and vibration [1-5]. Normal load and sliding velocity are the two important parameters that dictate the tribological performance of metals and alloys. Copper and copper based alloys are widely used in many engineering applications because of high thermal and electrical conductivity, very good corrosion and wear resistance and self-lubrication property [6, 7]. Copper based alloys are used as bearing materials to achieve a high wear resistance

[8]. aluminium and aluminium based alloy are gaining huge industrial significance because of their outstanding combination of mechanical, physical and tribological properties over the base alloys [9]. These properties include high specific strength, high wear and seizure resistance, high stiffness, better high temperature strength, controlled thermal expansion coefficient and improved damping capacity. These properties obtained through addition of alloy elements, cold working and heat treatment [10]. Alloying elements are selected based on their effects and suitability. The alloying elements may be classified as major and minor elements, microstructure modifiers or impurities however the impurity elements in some alloys could be major elements in others [11]. Now days the aluminium silicon alloys found many industrial application. All of these properties significantly affect the fatigue and wear life [12]. In the high load regime, friction coefficient decreases with load for many metallic pairs. It is believed that due to a large amount of wear debris and increased surface roughening, friction force decreases [13, 14]. At loads from micro to nanonewton range, friction coefficient may be very low when the contacting surfaces are very smooth [15, 16]. For different material combinations, friction may increase or decrease when the sliding velocity is increased. During friction process, because of increased adhesion of counterface pin material on disc, friction increases with the increase in sliding velocity [17].

In the previous investigations, metals and alloys sliding against different pin materials showed different frictional properties under a range of operating conditions [18-20]. Despite these investigations, friction and wear of copper and aluminum sliding against mild steel are yet to be investigated. Therefore, in this study, the comparison of friction coefficient as a function of normal load, the comparison of friction coefficient as a function of sliding velocity and the comparison of wear rate as a function of normal load behaviour of aluminium sliding against mild steel are investigated.

2. Experimental Detail

Experiments are carried out using a pin-on-disc set-up which is shown in Figure 1. A

Cylindrical pin (both ends flat) can slide on a horizontal surface (disc) which rotates using the

power from a motor. A circular test disc is fixed on a horizontal plate which can rotate and this rotation (rpm) can be varied by an electronic speed control unit. A vertical shaft connects the horizontal plate with a stainless steel base plate. The alignment of this vertical shaft is maintained properly through two close-fit bush-bearings in such a way that the shaft can move axially.

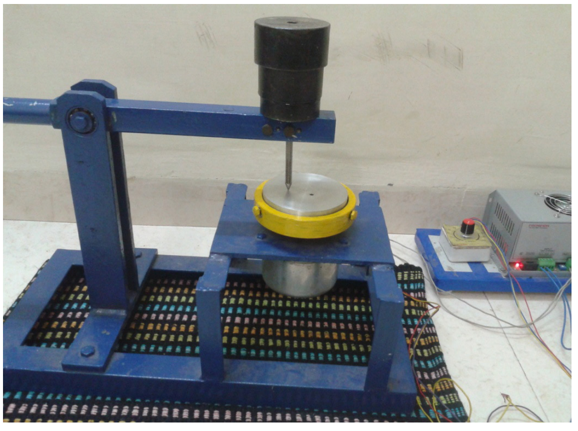

Figure 1: pin-on-disc

Figure 2: Aluminium Alloy-disc

S. No.	PARAMETER TESTED	RESULT	REQUIR-MENTS
1	% Silicon, Si	11.21	10.0-13.0
2	%Magnesium, Mg	0.08	0.10
3	%Manganese,Mn	0.34	0.5
4	%Copper,Cu	0.032	0.1
5	%Zinc,Zn	0.061	0.1
6	%of Aluminium	Reminder	Reminder

Test Result: The given test sample Complies to Specified requirement as per LM-6 grade

To provide the alignment and rigidity to the main structure of this set-up, four vertical cylindrical bars are rigidly fixed around the periphery to connect horizontal plate with the stainless steel base plate. The whole set-up is placed on a main base plate which is made of mild steel (10 mm thick). For power transmission from the motor to the mild steel base plate, A cylindrical pin (6 mm diameter) of mild steel is fitted in a holder and this holder is subsequently fixed by an arm. The contacting foot of the pin is flat so that it can easily slides on the rotating test disc. The arm is pivoted so that it can rotate horizontally and vertically with negligible friction. There are two ways to change the sliding speed, namely, (i) by changing the rotational speed of shaft or, (ii) by changing the frictional radius.To obtain the friction coefficient, the measured frictional force was divided by the applied normal load. To obtain the wear of the test disc, an electronic balance was used to measure the weight before and after the test. To measure the roughness, a precision roughness checker was used. Each experiment was carried out for 30 minutes and after each experiment, new pin and new test sample were used. Each experiment was repeated five times to ensure the reliability of test results and the average value was taken into consideration. Table 1 shows the detail of the experimental conditions.

Table 1: Experimental Conditions.

Sl. No.	Parameters	Operating Conditions
1	Normal Load	5, 10, 15 N
2	Sliding Velocity	1, 1.5, 2 m/s
3	Duration of Rubbing	30 minutes
4	Surface Condition	Dry
5	Disc material	Aluminum
6	Average Roughness of Aluminum, R_a	0.40-0.50
7	Pin material	Mild steel
8	Average Roughness of mild steel, R_a	3.5-4.0

3. Results and Discussion

The effect of normal load on the friction coefficient is shown in Figure 1 and these results

Show a comparison of friction coefficient of aluminium. Results show that as the normal load increases from 10 to 20 N, coefficient of friction decreases from 0.4 to 0.37 for aluminium. These results are supported by the findings of Chowdhury *et al*. [21] i.e. as the load increases, friction coefficient decreases within the observed range.

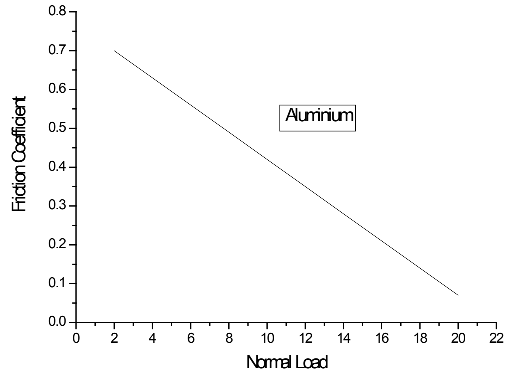

Figure 3: Comparison of friction coefficient as a function of normal load

The influence of sliding velocity on the friction coefficient is presented in Figure 3 and these results show a comparison of friction coefficient of aluminum. In the experiments it was found that as the

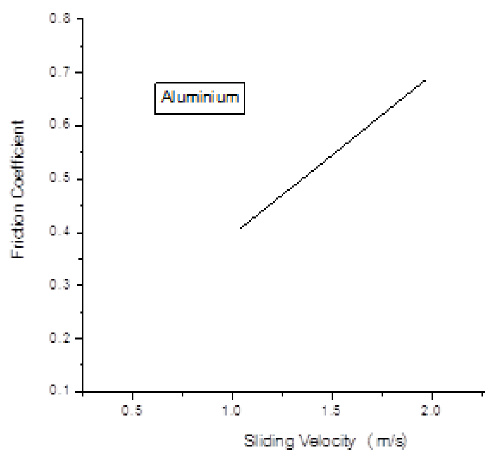

Figure 4: Comparison of friction coefficient as a function of Sliding velocity

friction coefficient of aluminum increases from 0.4 to 0.7 as the sliding velocity increases from .75to 2 m/s. Due to the interaction of the asperities of two contact surfaces, frictional heat generation occurs and hence temperature increases at the contact surfaces. Due to more adhesion of pin material on the disc with the increase in sliding velocity, friction increases. These findings are supported by the previous findings of Nuruzzaman and Chowdhury [22] i.e. friction increases with the increase in sliding velocity.

The effect of normal load on the wear rate of aluminum is shown in Figure 4. It is observed that for the increase in

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normal load from 10 to 20 N, wear rate of aluminium shows the increased wear rate from 1.8 to 5 mg/min as the load increases from 10 to 20 N. Because of the increase in normal load, frictional thrust is increased and real surface area is also increased, hence causes higher wear. These results are supported by the findings of Chowdhury and Helali [23].

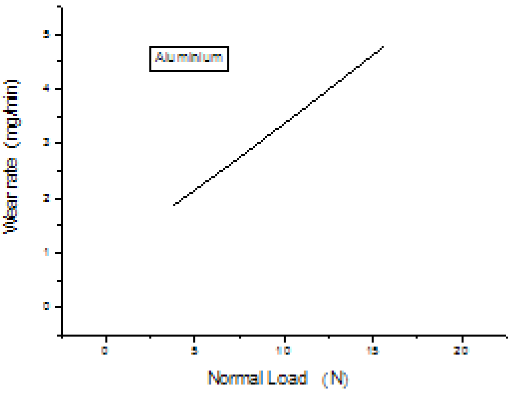

Figure 5: Comparison of Wear rate as a function of normal load

4. Conclusion

Alloying elements are selected based on their effect and Suitability. The different alloying elements added to Al-Si alloy will improve its tribological properties. Some composites of Al-Si alloys are also improve its wear rates and friction properties. In the experiments pin-on- disc, mild steel pin slides on aluminum disc at different normal load conditions 10, 15, and 20 N. Experiments are also carried out at different sliding velocities 1, 1.5 and 2 m/s. It is found that during friction process, aluminum disc takes less time to stabilize as the normal load or sliding velocity increases. Time to reach steady friction varies depending on applied normal load or sliding velocity for aluminum. Within the observed range, friction coefficient decreases when applied load is increased while it increases when sliding velocity is increased for aluminium and wear rate increases with the increase in normal load.

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