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Wear Analysis of Aluminium Silicon Alloy and Aluminium Graphite Composite

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ABSTRACT: Aluminium alloys have extensive application in industries. The range of physical properties that can be imparted to them is remarkable .Addition of Silicon to Aluminium helps to increase their strength and wear resistance. Al-Si alloys are extensively used in industrial applications due to better tribological properties. In the present work, an attempt has been made to study the tribological properties of Aluminium as-cast alloy ie. Al- 10wt%Si and. Al-Graphite metal matrix composite ie.Al6%wt graphite. Wear tests were conducted using a pin-on-disc type wear testing machine (DUCOM wear and friction monitor).The operational parameters that were varied normal load, sliding velocity, sliding distance.

Keywords: Aluminium-Al, Silicon-Si.

I. INTRODUCTION

Aluminium (Al) is the second-most plentiful element on earth and it became an economic competitor in the engineering applications as early as the end of the 19th century. The emergence of three important industrial revolutions would, by demanding material characteristics consistent with the unique qualities of Aluminium and its alloys, greatly benefit growth in the production and use of the metal. Among the most striking characteristics is its versatility. The range of physical properties that can be developed-from refined high-purity Al to the most complex alloys-is remarkable. Aluminium and its alloys are extensively used as the materials in transportation (aerospace and automobiles), engine components and structural applications [1].Thus it becomes all the more vital to study the tribological characteristics of Aluminium and its alloys.

II. LITERATURE REVIEW

An alloy is a material that has metallic properties and is formed by combination of two or more chemical elements of which at least one is a metal. The metallic atoms must dominate in its chemical composition and the metallic bond in its crystal structure. Commonly, alloys have different properties from those of the component elements.

Aluminium alloys are alloys in which aluminium(Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al-Si, where the high levels of silicon (4.0% to 13%) contribute to give good casting characteristics.

Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required. Aluminium alloys are mainly used in aerospace industry, marine industry, making cycling frames and other components, automotive industry etc. The prime reason for their wide application is their high strength to weight ratio as aluminium is a light metal. So designing auto parts with such alloys leads to less fuel consumption, stiffer and lighter designs can be achieved with aluminium alloys than is feasible with steels.

Alloys with Silicon as a major alloying element are by far the most important commercial casting alloys, primarily because of their superior casting characteristics in comparison to other alloys. A wide range of physical and mechanical properties is afforded by these alloys. Binary aluminium silicon alloys combine the advantages of high corrosion resistance, good weldability, and low specific gravity. Although castings of these alloys are somewhat more difficult to machine than the aluminium-copper or aluminium magnesium alloys, all types of machining operations are routinely accomplished, usually using Tungsten carbide tools and appropriate coolants and lubricants.

Abrasive wear occurs when a hard rough surface slides across a softer surface. ASTM (American Society for Testing and Materials) defines it as the loss of material due to hard particles or hard protuberances that are forced against and move along a solid surface. Wear, in turn, is defined as damage to a solid surface that generally involves progressive loss of material and is due to relative motion between that surface and a contacting substance or substances. The rate at which the surfaces abrade depends on the characteristics of each surface, the presence of abrasives between the first and second surfaces, the speed of contact, and other environmental conditions. In short, loss rates are not inherent to a material.

III. EXPERIMENTAL DETAILS

A. Sample Preparation

Materials used for testing are:

1. Al-Graphite metal matrix composite(6% Graphite reinforcement)
2. Al-Si alloys(10% Si)

Total number of samples prepared: Total 2 (1 sample from Al-Graphite composite and 1 sample from Al-Si alloy).

Al-Graphite metal matrix composite is produced by stir casting route. Molten aluminium metal is poured into a crucible and graphite powder is incorporated into the mould. Stirring is done by mechanical means and they are allowed to solidify. Cylindrical samples of 6 mm diameter and 50mm height are machined from the as-cast Al-graphite ingot in the lathe machine for sliding wear test.

Molten Al-Si alloy is poured in to a crucible and allowed to solidify. A cylindrical sample of 6 mm diameter is machined from the as-cast alloy for sliding wear test. Surfaces are polished prior to testing.

B. Wear Testing Apparatus

The machine consists of a pin on disc, loading panel and controller. The sample is put in that hole and screwed with a pin. For rotation of the disc to take place, time period of revolution is set up initially in the control panel. The wear is shown in the monitor in micrometer. The frictional force is shown in KN. The machine is automatically stopped when the given time period is reached. The abrasive we used for studying wear is a steel surface without any emery paper or SiC paper on it.

Fig.1: Pin on Disk Tribometer

C. Specifications of the DUCOM wear and Friction Monitor

Table 1: Specifications

Parameter	unit	Minimum	Maximum
Disc speed	RPM	200	2000
Pin diameter	mm	4	12
Pin length	mm	20	60
Wear track dia	mm	50	100
Normal load N	N	5	200
Frictional force	N	0	200

D. Operating Parameters

The variables involved in wear test are: Normal load, sliding velocity, sliding distance.

E. Wear Measurement

Wear is directly measured from directly taking the data from the monitor. The monitor shows wear in micrometer and frictional force in KN in both numerical and in graphical form. To study the effect of one parameter on the wear, all other parameters are fixed and the respective parameter is varied. Thus wear is studied.

IV. RESULTS AND DISCUSSIONS

In the present investigation, Al 10% Si commercial alloy available in the market and Al-6% graphite composite fabricated by stir casting route are been used. The Physico-mechanical properties are been studied in this piece of work.

A. Hardness Measurement

Hardness is the basic requirement of a material for use in specified machine parts. The

Hardness of the sample are measured using Vicker's Hardness tester, each data point is the average of five readings.

Vicker's hardness values for the materials are

Hardness (HV)	
Al-10% Si alloy	57.2
Al-graphite composite	81.6

B. Tribological Studies

Al-Si alloys and Al-graphite composites are been used in automobile parts since years. Hence it is required to study the tribological behavior and improvement for such materials. Aiming at these aspects sliding wear behavior has been investigated.

1) Effect of Track Diameter on Sliding wear Of Al-10%Si sample.

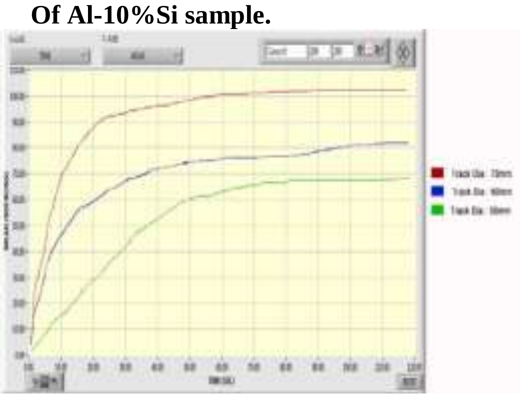

Fig.2: Effect of Strand Length on Dry Sliding Wear of Al-Si Sample

The above figure shows that with decrease in track diameter, time required for the wear to be static increases. This is because as the track diameter decreases, the distance covered in one revolution also decreases. A static wear is achieved after the material has covered a certain distance. With smaller strand length, the sample will take more time to attain this distance. In this test for track diameter 70mm, static wear is achieved in a minimum time where for track diameter 50mm it is maximum. The test was done varying the track diameter and keeping load (2.5Kg) and sliding speed (500 RPM) as constant.

2) Effect of Sliding speed on wear of Al-Si sample

Wear is also dependent on sliding speed. Here the sliding peed is measured in RPM. The more is the sliding speed, the more distance will be covered by the sample. So static wear will be achieved faster .Wear will be higher for higher sliding speed. The above figure shows that with increase in sliding speed wear increases. From our figure it can be shown that at a particular time, wear is maximum for sliding speed 650 RPM where it is minimum for sliding speed 350 RPM.

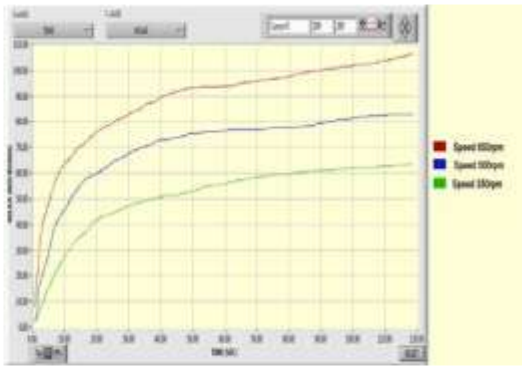

Fig.3: Effect of Sliding Speed on Wear

3) Effect of Normal Load on wear of Al-Si sample

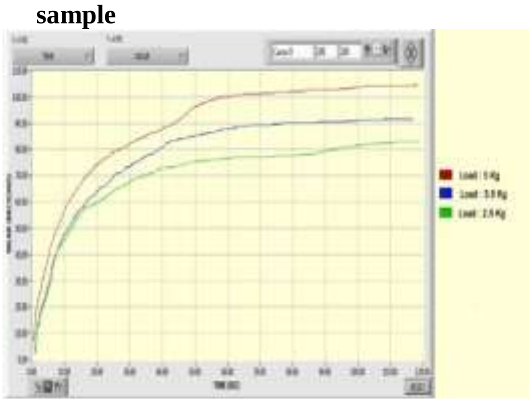

Fig.4: Effect of Normal load on wear

The more is the normal load, the more will be the wear. The tests were done varying the normal load and, keeping the track diameter and sliding speed fixed. In atomic level the surface of a material cannot be fully flat. When two surfaces are in contact, they touch each other at some points and when load is applied, plastic deformation occurs locally in those points which lead to removal of material. More the load more will be the plastic deformation. Hence wear will be more.

4) Effect of Track diameter on Wear of Al-graphite

Composite

The effect of strand length on wear of al-graphite reinforced metal matrix composite is similar to its effect on wear of al-si alloy. The trend lines are similar in both case, increase the strand length, smaller will be the track diameter. Hence to slide the same distance, sample tested under larger

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strand length condition will take more time before attaining the static wear than smaller strand length.

Fig.5: Effect of Strand Length on wear of Al-Graphite

Composite

5) Effect of Sliding speed on wear of Al-graphite sample

Wear is also dependent on sliding speed. Here the sliding speed is measured in RPM. The more is the sliding speed, the more distance will be covered by the sample. So static wear will be achieved faster .Wear will be higher for higher sliding speed. The above figure shows that with increase in sliding speed wear increases. From our figure it can be shown that at a particular time, wear is maximum for sliding speed 650 RPM where it is minimum for sliding speed 350 RPM.

Fig.6: Effect of Sliding Speed on Wear

6) Effect of Normal load on wear of Al-graphite composite

Fig.7: Wear w.r.t time at Different Normal Load

The above figure shows that at a particular time wear is higher for a higher load. No engineering surface is perfectly planar; some protuberance is always present on the surface. There may be dirt or some other particle on the surface. When load is applied, those particles penetrate into the solid surface causing local plastic deformation. Material removes from those areas. Higher the load, higher will be the penetration and more will be the wear.

V. CONCLUSION

The present work will lead to the following conclusions.

1) The sliding wear behavior of Al-graphite material possesses superior sliding wear sustainability than that of Al- 10% Si alloy.
2) The sliding wear rate is magnified more than two times in the Al-10% Si alloy, than graphite is used for making aluminium metal matrix composite.
3) Hence it can be concluded that the hardness of the material, sliding distance, speed of rotation and applied pressure are responsible for sliding wear behavior.
4) It was revealed that the hardness of composite samples decrease with increasing the weight percentage of particles.
5) The Al-graphite composite can use in various applications like automobile and aircraft Industries.

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