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Tribological Studies on Aluminium Silicon Alloy and Aluminium Silicon Carbide Composite

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ABSTRACT: Among the materials of tribological importance, Aluminium-silicon composites have received extensive attention for practical as well as fundamental reasons. This investigation describes about the wear characteristics of Al-Si alloys and Al- SiC composite using pin-on-disc wear test at room temperature. Here different weight percentages of Si and SiC are taken with Aluminium by stir casting method. It is found that addition of silicon/ silicon carbide improves the wear resistance, machinability, and corrosion resistance. It has been found that the wear rate is strongly dependent on applied load, sliding speed, alloy composition. It is observed, Al-SiC particulate composite bears higher hardness than that of Al-Si alloys.

Keywords: Al-Si alloys, Al-SiC composite, tribology, wear, metal matrix composites.

I. INTRODUCTION

In recent decade, Aluminium-Silicon composites have potentially grown up in engineering structural applications ranging from automobile & aerospace industries to marine industries. Due to high strength to weight ratio, makes Al-Si composite a favorable material. Aluminum-Silicon alloys also constitute an important category among aluminum foundry alloys. Aluminum alloys with silicon, offers better corrosion resistance, excellent castability, good machinability property and easy weldability.

In this investigation an effort has been made to understanding of the formation of the aluminum silicon composite and applying our understanding to alleviate the problems of wear in structural applications. Al-SiC composites have been prepared by addition of SiC powder in molten aluminium by stir-casting. The Wear study has been done by abrasive wear test on Pin on Disc machine. In abrasive wear testing, the wear rate was calculated in terms ofwear depth by taking data from the DUUCOMP Tribometer.

II. LITERATURE REVIEW

The word Tribology is derived from the greek word tribos, which means rubbing. In a nutshell the meaning of Tribology is “science of rubbing” and it is the science and technology of interacting surfaces in relative motion and of related subjects and practices.

The interactions taking place at the interface control its friction, wear and lubrication behavior. During these interactions, forces are transmitted, mechanical energy is converted, physical and chemical nature including surface topography of the interacting materials is altered.

Composite material can be defined as a material consisting of two or more physically and chemically distinct parts, suitably arranged, having different properties respect to those of each constituent parts [1]. Metal matrix is material where matrix is metal or its alloys. Metal matrix composites (MMCs) are types of material where varying the volume percentage of the reinforcement unique property combinations can be achieved. AlSiC metal matrix composite is produced by stir casting, which has has very low coefficient of thermal expansion, very low density and very good Wear resistance properties.

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. 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. Binary aluminium-silicon alloys combine the advantages of high corrosion resistance, good

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weldability, and low specific gravity. Alloy 443 (5.3% Si) may be used for all casting processes for parts in which good ductility, good corrosion resistance, and pressure tightness are more important than strength. For die casting, A 413 (12% Si) also have good corrosion resistance but are superior to alloy 443 in terms of castability and pressure tightness. Aluminum silicon alloys with greater than 12% Silicon are called hypereutectic aluminum-silicon alloys. These have outstanding wear resistance, a lower thermal expansion coefficient, and very good casting characteristics [3].

III. METHODOLOGY

A. Sample Preparation

Materials used for testing are:

1) Al-Si alloys (10% Si)
2) Al-Si alloys (18% Si)
3) AlSiC metal matrix composite (5% SiC reinforcement)

AlSiC metal matrix composite is produced by stir casting route. Weighed aluminium metal is melted in the machine furnace at a temperature of 700^{o}C, and preheated SiC powder at 1000^{o}C incorporated into the furnace and stirred continuously by mechanical means. After proper stirring for about 10 minutes, the mixture is poured in to the die and are allowed to solidify. Cylindrical samples of 6 mm diameter and 50mm height are machined from the as-cast Al-SiC ingot in the lathe machine for sliding wear test.

Al-Si alloys are prepared by die casting and cylindrical sample of 6 mm diameter is machined from the cast alloy for sliding wear test. Surfaces are polished prior to testing.

B. Sliding wear test apparatus

The machine used to measure the abrasive wear is a DUCOM pin on disk tribometer, which consists of a pin on disc, loading panel and controller. The sample machined as a pin is attached to the pin holder mechanism of the machine. The wear disk is a EN31 Steel disk, Hardened to 60HRC. Forrotation of the disc to take place, time period of revolution is set up initially in the control panel. The wear of the pin sample is displayed in real time in the monitor graphically in micrometer scale. The machine is automatically stopped whenthe given time period is reached.

Fig. 1. DUCOM Pin on Disk Tribometer

The software also has functionalities to study and compare various other parameters like coefficient of friction, operating temperature, frictional force etc.

Table 1. Specifications of the ducom pin on disk tribometer

Parameter	Unit	Minimum	Maximum
Disc speed	RPM	200	2000
Pin diameter	mm	4	12
Pin length	mm	10	50
Wear track dia	mm	50	100
Normal load N	N	0	200
Frictional force	N	0	200
Temperature	^{o}C	0	300

IV. RESULTS AND DISCUSSIONS

In the present investigation, Al 10% Si and Al 18% Si commercial alloys are procured directly from the market and Al-5% SiC composite fabricated by stir casting route has been used. Various physico-mechanical properties are been studiedin 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 samples are measured using Vicker's Hardness tester, each data point is the average of three readings.

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Table 2. Vicker's hardness values for the materials

Material	Hardness(HV)
Al-10% Si alloy	57.2
Al-18% Si alloy	72.4
Al-SiC composite	90.7

B. Tribological Studies

Al-Si alloys and Al-SiC composites are been used in automobile parts since years, commonly in engine cylinders and break assembly etc, which undergoes lot of friction and wear. Hence it is required to study the tribological behaviour and improvement for such materials. Aiming at these aspects sliding wear behaviour has been investigated [5].

1) Effect of sliding speed on wear volume

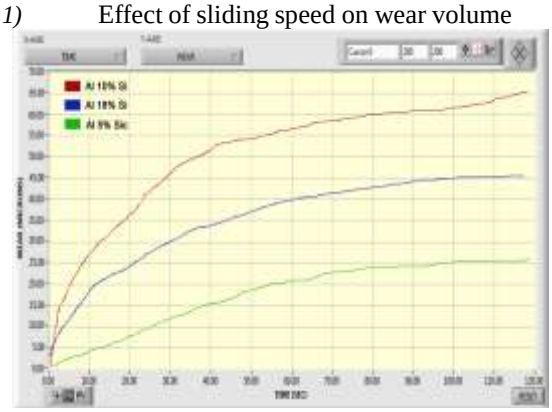

Fig.2. Wear volume at sliding speed 350 rpm, normal load 2.5 Kg and track diameter 50 mm

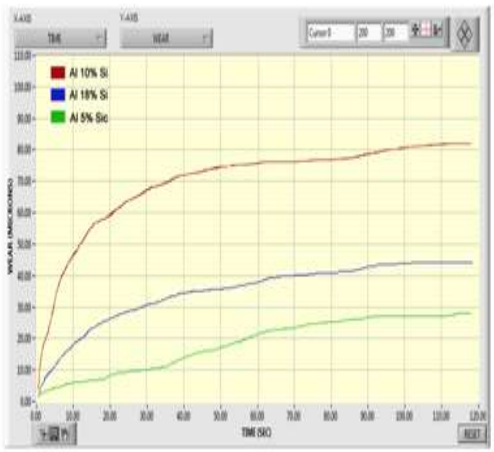

Fig.3. Wear volume at sliding speed 500 rpm, Normal load 2.5 Kg and track diameter 50mm

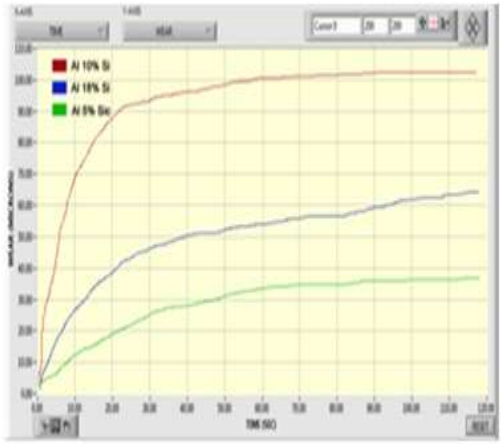

Fig 4. Wear volume at sliding speed 650 rpm, normal load 2.5 kg and track diameter 50 mm

The diagrams are formed on the basis of wear and material loss of the sample pin under different values of sliding speed, the experiment is conducted in three sliding speed values 350rpm, 500 rpm and 650 rpm keeping all the other test parameters constant, such as normal load at 2.5 Kg, and track diameter 50mm. The experiment was conducted at room temperature.

It is obvious that the wear volume of the composites A l- 5%SiC is several times less than the wear volume of the alloys. With increase of sliding speed, wear volume of the composite and the alloys also increases. When we consider the alloys itself, we can see that the increase in Si% in the alloy, reduces the wear volume considerably but not much as the composite. Other studies on the subject also limit the use of high percentage of Si in aluminum alloys because the presence of the extremely hard primary Silicon phase reduces tool life during machining [5].

2) Effect of normal load on wear volume

The diagrams below are formed on the basis of wear and material loss of the sample pin under different values of normal load, 2.5Kg, 3.5 Kg and 5Kg keeping sliding speed at 500rpm, and track diameter 50mm.

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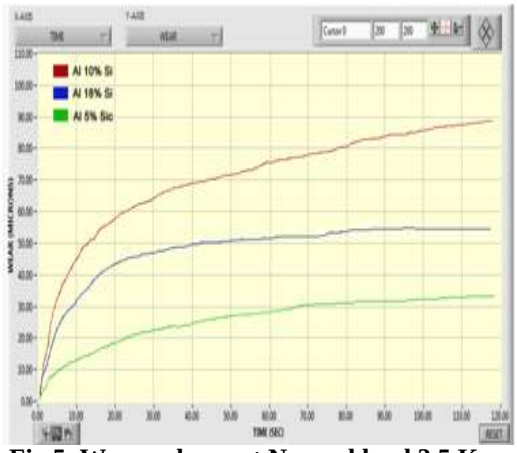

Fig.5. Wear volume at Normal load 3.5 Kg, sliding speed 500rpm, and track diameter 50mm

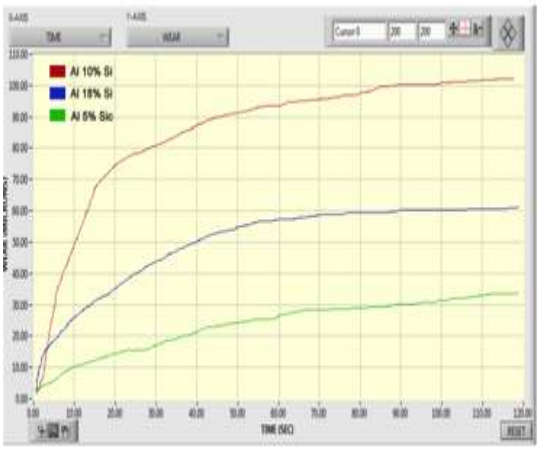

Fig.6. Wear volume at Normal load 5 Kg, sliding speed 500rpm, and track diameter 50mm

The wear volume of the composites A l-5%SiC is found several times less than the wear volume of the alloys. With increase of Normal load, wear volume of the composite and the alloys also increases.

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 [6]. More the load will be the plastic deformation. Hence wear will be more.

V. CONCLUSION

The present work on Tribological studies on aluminium silicon alloys and aluminium silicon carbide composite led to following conclusions

- Aluminium Silicon carbide particulate composite bears higher hardness than that of Aluminium Silicon alloy.
- The sliding wear behaviour of Al-18%Si alloy possesses superior sliding wear sustainability than that of Al-10% Si alloy.
- Hardness of the material, sliding speed and applied normal load influences the sliding wear behaviour.
- These high wear resistive composites can found applications in automotive industries, aircraft industriesand space industries etc.

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