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Microstructure and Wear Characterization of A356-$ZrSio_4$ Particulate Metal Matrix Composite

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Abstract: ***In the present industrial scenario aluminum alloys are playing a very important role as a substitutional material for conventional ferrous metals owing to their excellent properties like high strength and light weight. Metal matrix composite (MMC's) are very much popular in the field like automobile and aerospace industries, because of ease of fabrications process and excellent mechanical properties. In this paper it is aimed to present the research findings of A356-$ZrSio_4$ (Zirconium Silicate) metal matrix Composites prepared by Stir Casting technique. The amount of reinforcement is varied from 0 to 7.5%.The prepared composites are subjected to wear testing as per ASTM standards using pin on disc machine. The Brinell's hardness of the composites was found to increase with increase in reinforcement in the composite. The structural analysis studied with help of optical microscope. The results indicated that as reinforcement content in the composites increase the wear resistance improved appreciably.***

Keywords: Microstructure, Aluminum, Zirconium Silicate, MMC

1. Introduction

Particle reinforced aluminum metal matrix composites (MMCs) have been developed in the last few years, in order to reduce the weight of components in structural applications and to improve their mechanical properties and physical properties [1].

It was reported in the investigation of the wear behavior of Al6061–SiC particulate reinforced composites prepared by liquid metallurgical technique, that dispersed SiC in Al6061 alloy and Al_2O_3 in Al7075 alloy with the increased % age of these reinforcements in respective alloy material concluded that increase in hardness, tensile strength and improvement in density of composites [2].

In the investigation on the wear behavior on Al6061 reinforced with Al_2O_3 particle [5]. When a sufficiently high load is applied on the contact, the matrix phase is plastically deformed, and the strain is partially transferred to the particulates, which are brittle with small failure strains. It was clearly demonstrated that the effects of applied load and temperature on the dry sliding wear behavior of Al6061 alloy matrix composites reinforced with SiC whiskers or SiC particulates and concluded that, the wear rate decreased as the applied load is increased [2].

It reveals from the literature that very little information is available regarding the Wear Characterization of the composites with metal matrix composites of A356 alloy reinforced with $ZrSio_4$ particulates. Hence the present paper describes the wear behavior of $ZrSio_4$ filled with A356 alloy metal matrix composites.

2. Experimental Details

2.1 Materials used

The matrix material for the present study is A356 alloy. Table.1 gives the chemical composition of A356alloy. The reinforcing material selected was $ZrSio_4$ of particle size of 44 µm.

Table 1: shows chemical composition of A356alloy

Element	Si	Fe	Cu	Mn	Mg	Ni	Zn	Ti	Pb	Al356
Wt%	7.5	0.2	0.25	0.35	0.45	0.1	0.35	0.2	0.1	Remaining

2.2 Preparation of Composites

The liquid metallurgy route (stir casting technique) has been adopted to prepare the cast composites as described below. Preheated $ZrSio_4$ powder of laboratory grade purity of particle size 44 µm was introduced into the vortex of the molten alloy after effective degassing. Mechanical stirring of the molten alloy for duration of 10 min was achieved by using ceramic-coated steel impeller. A speed of 400 rpm was maintained. A pouring temperature of 730^{0}C was adopted and the molten composite was poured into cast iron moulds. The extent of incorporation of $ZrSio_4$in the matrix alloy was varied from 0 to 7.5 wt% .Thus composites containing reinforcement particles 0 to 7.5wt% were obtained .

2.3 Testing of composites

The cast composites were machined and the specimens for the measurement of hardness as well as for wear behavior were prepared as per ASTM standards

2. 4 Pin on Disc tester

A pin on disc tester was used to measure wear, frictional force, and temperature. Tests were carried in accordance with ASTM standard has been shown in table 2.

Table 2: Wear Test Parameter

Track Radius	40 mm
Sliding distance	0.5-2.0 Km
Load	20-50N
Speed	800RPM

2.5 Hardness test

Hardness test was conducted by using Brinell hardness tester.

2.6 Microstructure

The microstructure of A356-$ZrSio_4$ particulate metal matrix Composites samples were examined under NIKON optical microscope.

3. Results and Discussion

3.1 Hardness testing

The change in the hardness of composites with increased content of reinforcement shown in Fig.1 represents the variation in hardness.It is observed that the hardness of A356-$ZrSio_4$ composites increase with increased content of the $ZrSio_4$ reinforcement. Improved hardness results in decrease in wear rate. Finer the grain size better is the hardness of composites and leading to lowering of wear rates [4]. This increase in hardness of the composites may be due to the reason the reinforcement material is much harder than the matrix material and good interfacial bonding between particle and alloy matrix.

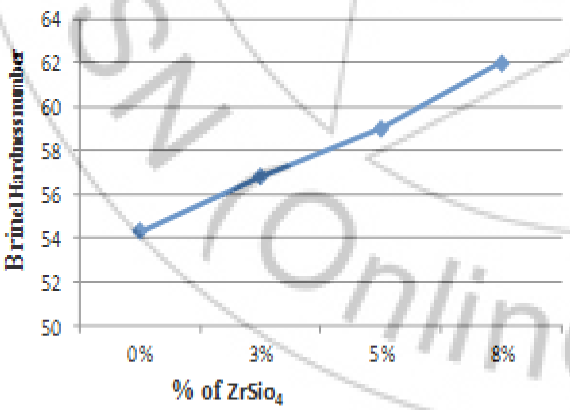


Figure 1: Graph representing Effect of reinforcement on hardness

3. 2 Wear testing

3.2.1 Effect of Sliding Distance on Coefficient of Friction
It reveals from figures 2 & 3 with the addition of $ZrSio_4$ particles, that coefficient of friction of the composite increases as the sliding distances increases.

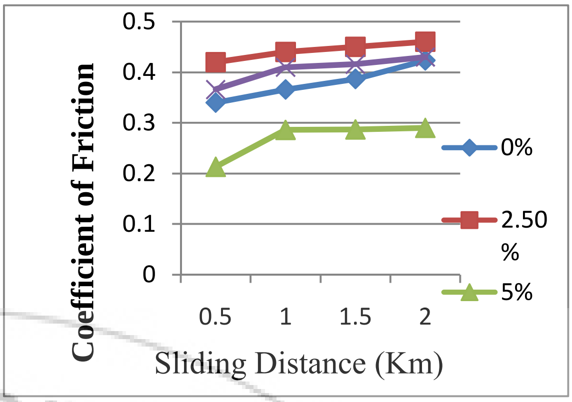


Figure 2: Graph representing coefficient of friction v/s sliding distance for 20N at 800 rpm

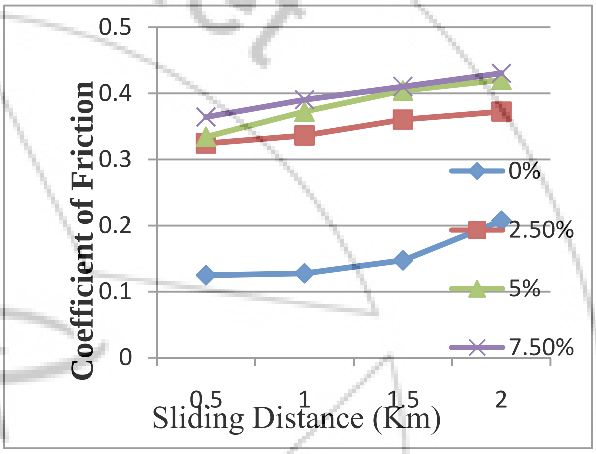


Figure 3: Graph representing coefficient of friction v/s sliding distance for 50N at 800 rpm.

3. 2.2 Effect of Sliding Distance on Wear Rate
It has been observed from figures 4 & 5 with the addition of $ZrSio_4$ particles the wear rate decreases as the sliding distance increase.

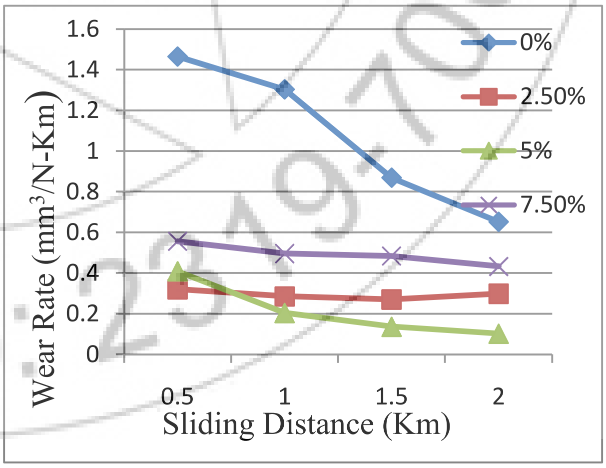


Figure 4: Graph representing wear rate v/s Sliding distance for 20N at 800 rpm

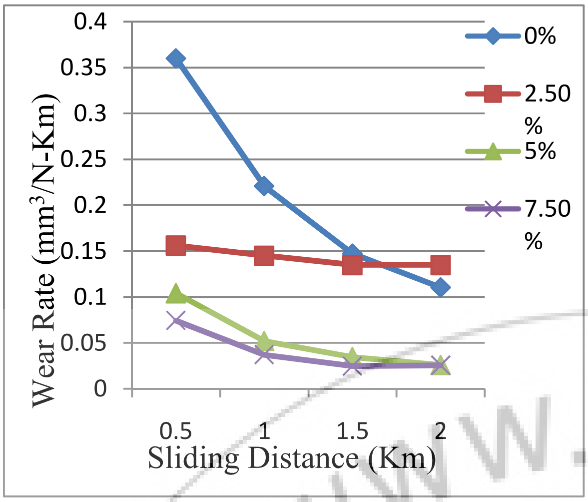
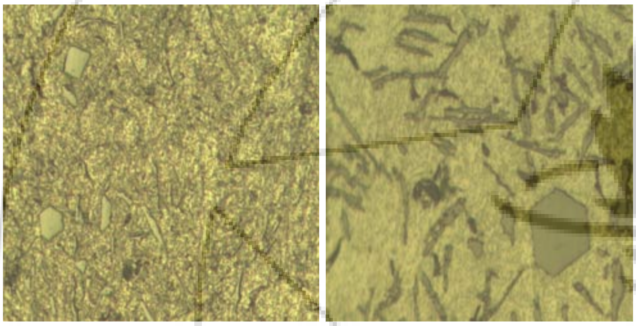


Figure 5: Graph representing wear rate v/s. Sliding distance for 50N at 800

3.3 Microstructure



200x 0.5% HF 500x 0.5%HF

Figure 6: photomicrograph of A356+7.5$ZrSio_4$Composite

Photomicrographs ofA356+7.5%$ZrSio_4$composites are shown in Fig6. The observation of photomicrographs indicate that the reinforcement particles distributed homogeneously in the matrix alloy.Thus summarizing the homogeneous distribution of particle contributed for the improved wear rate and hardness of metal matrix composite material.

4. Conclusion

The composite material with Aluminum as base alloy (A356) and $ZrSio_4$ particulates as reinforcement material were successfully fabricated through liquid metallurgy route for 2.5%, 5% and 7.5% reinforcement. Wear increases as the % of Zirconium silicate increases. Wear rate decreases as sliding distance and load increases. The hardness of the composite found to be higher than the base matrix this is mainly due to the influence of $ZrSio_4$. The microstructure of the cast composite shows uniform particle distribution with less priority.

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