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Mechanical Behavior Of Al 6063/ Mos_2/ Al_2o_3 Hybrid Metal Matrix Composites

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Abstract: In the present investigation research work is based on development of Al 6063 base hybrid metal matrix composite reinforced with 10 weight percentage of Aluminium Oxide (Al2O3), and varying weight percentage of Molybdenum disulphide (i.e. 3%, 5%, 7% & 9%). The composite was prepared by using stir casting technique. The density of Al 6063/ MoS2/ Al2O3 were increasing when reinforcement of MoS2 increases from 3% to 9%. The Ultimate Tensile Strength decreasing due to the additions of 3% to 9% of MoS2 and also reinforced with alumina (Al2O3) into the base matrix. It was seen that while the Al 6063 alloys shows the pre- dominantly ductile fracture (base matrix). The composite specimens (with a MoS2 addition) show an increase in the mixed mode (ductile and brittle regions). Investigation also predicts that hardness increases due to varying addition of MoS2. Micrographs of the composite specimen are taken for the study of particular or overall behaviour of the material.

1. INTRODUCTION

Aluminium silicon alloys and composites are being used in automotive applications like pistons, brake rotors and engine block cylinder liners.Tribological behaviour is an important aspect in the use of aluminium metal matrix composites in automotive applications. The wear behaviour of Al-Si alloys can be further enhanced by adding ceramic particles. Abrasive particles like silicon carbide, alumina, and diamond are added to improve the tribological behaviour by increasing the hardness of a composite. Nevertheless, lubricating particles like graphite and MoS_2 have also been added to improve the tribological behaviour of different materials by providing a solid lubricating layer. The additions of these particles considerably affect the mechanical behaviour of the composites.

There are various methods of producing composites like blending and consolidation, vapor deposition and consolidation, stir casting, infiltration process, spray deposition and consolidation, as well as in-situ reacting process. Of all these processes, stir casting is the simplest and the most economical method. Self-lubricating Al-MoS_2 composites have been prepared by using the powder-metallurgy route. In this investigation, four self-lubricating composites of molybdenum disulphide, namely, Al 6063 / 3% MoS_2 / 10% Al_2O_3, Al 6063 / 5% MoS_2 / 10% Al_2O_3, Al 6063 / 7% MoS_2 / 10% Al_2O_3 and Al 6063 / 9% MoS_2 / 10% Al_2O_3 have been produced with the stir-casting route. The changes in the mechanical and tribological properties caused by the addition of MoS_2 are studied.

2. DETAILS OF EXPERIMENT

2.1 Materials

Al 6063 was used as the matrix, alumina as hard reinforcement and molybdenum disulfide as soft reinforcement. This matrix alloy was used for intricate, thin-walled castings that demand high strength, such as castings for the automotive industry and general engineering.

Table 1 Chemical Properties of Al 6063

Component	Mn	Fe	Mg	Si	Zn	Ti	Cr	Cu	Others
Weight %	0.0 - 0.10	0.0 - 0.35	0.45 - 0.90	0.20 - 0.60	0.0 - 0.10	0.0 - 0.10	0.0 - 0.10	0.0 - 0.10	0.0 - 0.15

It has very good castability and is suitable for sand, gravity die-casting, and high-pressure die casting. To produce composites, the stir casting technique was used. Particle size of 400 micron alumina and 400 micron particle sizes of molybdenum disulfide reinforcements were used in this composite. Molybdenum disulfide in varying amounts ranging between 3%, 5%, 7%, and 9 wt. % was mixed with Al 6063 and 10 wt. % alumina composite. The densities of the composites were measured using Archimedes principle. The weight of the composite samples was measured with the help of an electronic balance.

2.2 Preparation of the composite

First of all sand mould is prepared. The four main components for making a sand casting mold is base sand, a binder, additives, and a parting compound. In this casting process a pattern is made in the shape of the desired part i.e. cylinder. This pattern is made of metal. Stir- casting technique is used for the preparation of material. This approach involves mechanical mixing of the reinforcement particulate into a molten metal bath and transferred the mixture directly to a shaped mould prior to complete solidification. After the melting of material pouring is accomplished with gravity. Cast ingot surface is clean by machining process.

2.3 Testing of materials

The density of metal matrix composites was determined by Archimedes principle. The microstructure of the composite specimens was identified using an optical microscope. First of all rough grinding of specimen was done using emery papers of different grades. After the rough grinding fine polishing of the specimen was done. This polishing was done to remove fine scratches of specimen. For this purpose two different grades of polishing powder were used of size 0.017µm and 0.014 µm. Etching of the specimen was done to remove any surface contamination and to reveal the grain boundaries. The tensile strength testing was carried out using universal testing machine. The ultimate tensile strength of the specimen was calculated from the load at which a fracture occurred. The hardness testing was carried out using vickers hardness machine. The hardness of the specimen is defined as the load divided by the surface area of the indentation.

Table 2 Mechanical property of Metal Matrix Composites

Metal Matrix Composites	UTS (N/mm^2)	Density (kg/mm^3)	Hardness (HB)	Decrease in UTS, %	Increase in Density, %	Increase in Hardness, %
Al 6063 / 3% MoS_2/ 10% Al_2O_3	72.41	2860	36.2	-	-	-
Al 6063 / 5% MoS_2/ 10% Al_2O_3	67.45	2890	36.3	6.85	1.05	0.27
Al 6063 / 7% MoS_2/ 10% Al_2O_3	56.48	2930	36.6	16.26	1.38	0.83
Al 6063 / 9% MoS_2/ 10% Al_2O_3	25.60	2970	37.1	56.64	1.36	1.37

3. RESULTS AND DISCUSSIONS

3.1 Microstructures

Optical microstructure of the composite material is shown in the figure. Figure 1 explains that microstructures are not fully refined due to the lack of poor mixing. But the same part also shows that composites of Molybdenum disulphide (MoS_2) are good. Figure 2 explain that grain size is crystal clear and refine the microstructure from previous one. It also shows some voids or pores in the Metal Matrix Composite (MMCs). Figure 3 & 4 gives the clear information regarding the voids or holes in the Metal Matrix Composite due to increase in reinforcement upto 7 & 9 weight percentage Molybdenum disulphide (MoS_2).

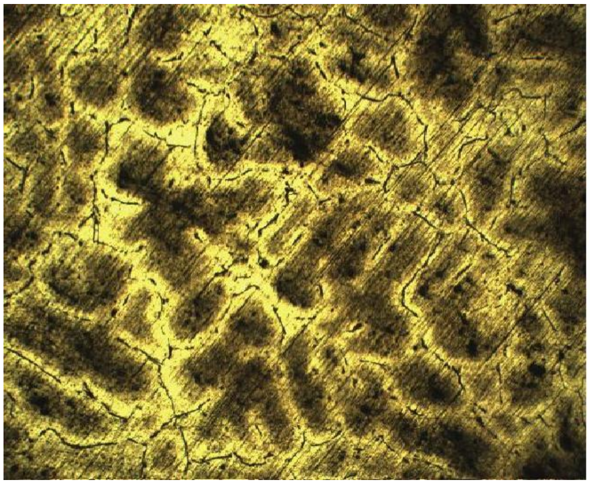
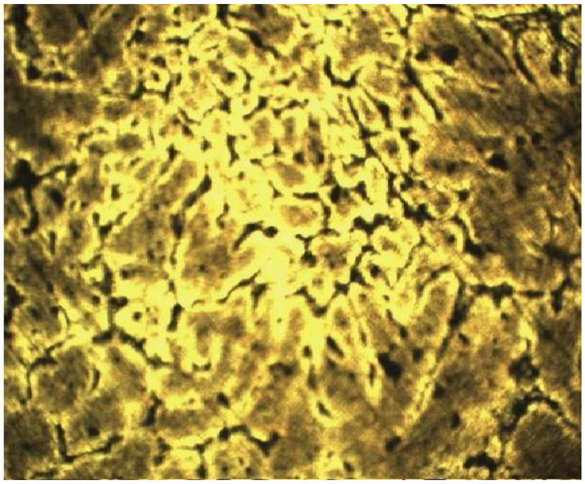

Figure 1 Al 6063 +3% MoS_2 + 10% Al_2O_3 **Figure 2** Al 6063 +5% MoS_2 + 10% Al_2O_3

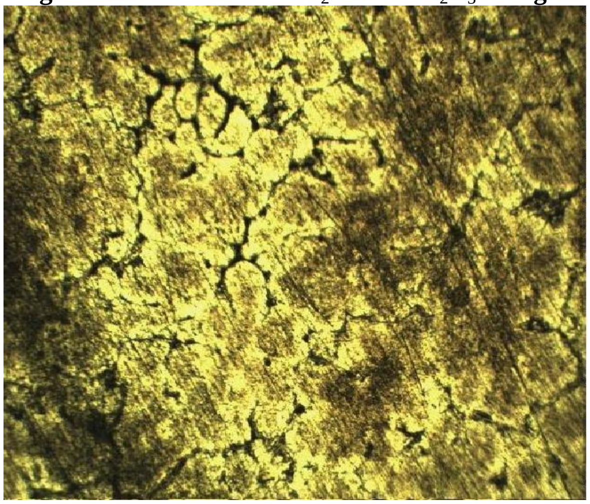
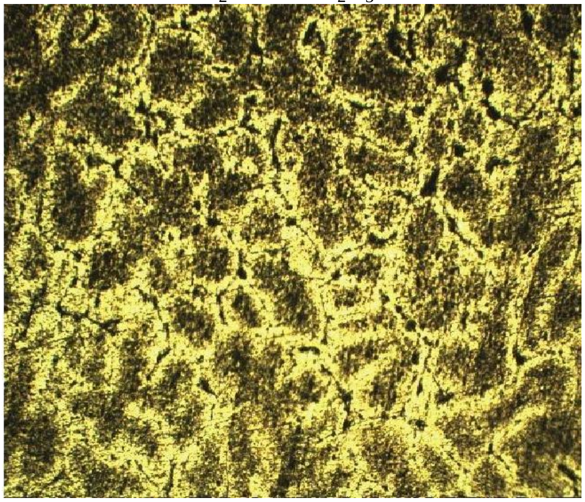

Figure 3 Al 6063 +7% MoS_2 + 10% Al_2O_3 **Figure 4** Al 6063 +9% MoS_2 + 10% Al_2O_3

3.2 Mechanical Properties

The mechanical properties of the composites (density, hardness and tensile strength), given in Table 2. Shows the average properties of various test specimens at different composition.

The density of Molybdenum disulfide (MoS_2) is higher than that of the aluminium alloy and hence an increase in the Molybdenum disulfide (MoS_2) content will raise the density of the composite. The densities of increase in Molybdenum disulfide from 3% to 9% were marginally higher than the density of the aluminium alloy by 1 % and 2 % respectively.

The tensile strength decreases considerably due to the additions Molybdenum disulfide (MoS_2) from 3% to 9% by mass. The observed decrease in UTS may be due to various mechanisms like the particle pull-out and crack propagation, which are initiated by the presence of MoS_2.

The hardness increases considerably due to the additions Molybdenum disulfide (MoS_2) from 3% to 9% by mass. This is due to an increase in the proportion of the hard particulates in the composites, which increases the composites resistance to indentation in comparison to the monolithic alloy.

4. CONCLUSIONS

In this research work, Al 6063/ MoS_2/ Al_2O_3 composites are fabricated using the stir-casting technique and the mechanical behaviour of the metal matrix composites were studied. The following important observations can be noted:

1. Vickers hardness of Al 6063 with molybdenum disulphide (MoS_2), Alumina (Al_2O_3) and Magnesium Metal Matrix Composites (MMCs) are increases when increasing the weight percentage of Molybdenum disulphide.

2. Density of Al 6063 with molybdenum disulphide (MoS_2), Alumina (Al_2O_3) and Magnesium Metal Matrix Composites (MMCs) are increases when increasing the weight percentage of Molybdenum disulphide.

3. Ultimate tensile strength of Al 6063 with molybdenum disulphide (MoS_2), Alumina (Al_2O_3) and Magnesium Metal Matrix Composites (MMCs) are decreases when increasing the weight percentage of Molybdenum disulphide.

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