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PROCESSING – MECHANICAL AND WEAR PROPERTIES OF ALUMINIUM BASED METAL MATRIX COMPOSITE SYNTHESIZED USING VORTEX METHOD.

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ABSTRACT

In this study, Metal Matrix Composite (MMC) was produced using aluminium as base metal matrix reinforced with silicon carbide particulates using conventional casting technique. Macro structural studies conducted on the samples revealed a more uniform distribution of silicon carbide particulates. Sliding wear studies were carried out to study the wear behavior of composites. The co-efficient of friction has reduced and resistance to wear increased with the increase in percentage of SiC particulates. The hardness of MMCs increased considerably,. but density of MMCs decreased with the increase in percentage of SiC particulates.

Keywords: Al-based MMC, SiC particulates, Macrostructure, Abrasive Wear, Hardness

1. INTRODUCTION:

The emergence of modern processing techniques coupled with the need for lighter materials with high strength and stiffness has catalysed considerable scientific and technological interest in the development of numerous high performance composite materials as serious competitors to the traditional engineering alloys. The majority of such materials are metallic matrix reinforced with high strength, high modulus and often brittle second phase in the form of fiber, particulate, whiskers embedded in a ductile metal matrix. The reinforced metal matrix offer potential for sufficient improvement in efficiency, reliability and mechanical performance over traditional monolithic alloys.

In this work wear characteristics, hardness and density were studied for MMCs having three percentages of SiC particulates and Aluminium as metal matrix. MMCs were prepared in the laboratory using vortex method. Macrostructure was also studied.

2. MATERIALS & EXPERIMENTAL PROCEDURE:

2.1 Materials:

Aluminium alloy (LM6) was used in this experimental investigation whose chemical composition is given in Table I. The Aluminium metal matrix is reinforced with SiC particulates with an average grain size of 20µm and the percentage addition made was 5%, 10% and 12% by weight.

Table – I: Chemical Composition (weight %) of matrix alloy (LM6)

Si	Fe	Cu	Mn	Mg	Zn	Al
12.2	0.322	0.002	0.621	0.065	0.0215	Bal

2.2 Processing:

The synthesis of the metal matrix composite used in the present study was carried out according to the following procedure. The metal ingots prior to melting were cleaned for surface impurities. The cleaned metal ingots were melted in electrical resistance furnace (fig.1) to the desired super heating temperature of 800°C under a cover of flux in order to minimize the oxidation of molten metal and were degassed at a temperature of 780°C. SiC particulates, preheated to around 300°C were then added to the molten metal and stirred continuously by using mechanical stirrer at 720°C. The stirring time was maintained between 5 – 10 minutes at an impeller speed of 500 rpm. During stirring, Magnesium was added in small quantities to increase the wettability of SiC particles. The dispersion of the preheated SiC particulates was achieved in accordance with the vortex method. The melt with the reinforced particulates were poured into the cylindrical cast iron metallic moulds of size 80mm diameter and 150mm height (fig.2). The pouring temperature was 680°C. The melt was allowed to solidify in the moulds for 60 minutes. For the purpose of comparison, the base alloy was cast under similar processing conditions as described.

Fig.1. Electrical Resistance Furnace used for melting Aluminium

Fig. 2.Al based MMC sample.

2.3 Density Measurements:

Density measurements were carried out on the base metal and reinforced samples. Density measurements were carried out using Archimedes's principle [1].

2.4 Hardness Measurements:

Bulk hardness measurements were carried out on the base metal and composite samples. Brinell hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. Load-500kgs,time-30sec,ball dia-10mm were used for hardness measurement.

2.5 Macrostructure:

Macrostructural characterization was conducted on the machined composite specimens in order to study the distribution of SiC particulates, size of SiC particulates retained in the MMC.

2.5 Abrasive Wear:

Wear can be generally described as the removal of material from a surface in relative motion by mechanical and/or chemical process. Abrasive wear has been defined as the displacement of material caused by hard particles or hard pertuberances where these hard particles are forced against and moving along a solid surface [2,3].

Pin on disc wear testing machine (fig.3) was used for the purpose of wear studies. A sophisticated, fully computer controlled pin on disk wear testing machine was used. The pin size (sample size) was 5mm dia. and 20mm long. The disc was made of stainless steel material of dia. 100mm. and hardness 64 HRC. Track velocity was maintained at 95mt/sec with a normal load of 14.7N. Coefficient of friction and wear were recorded against time.

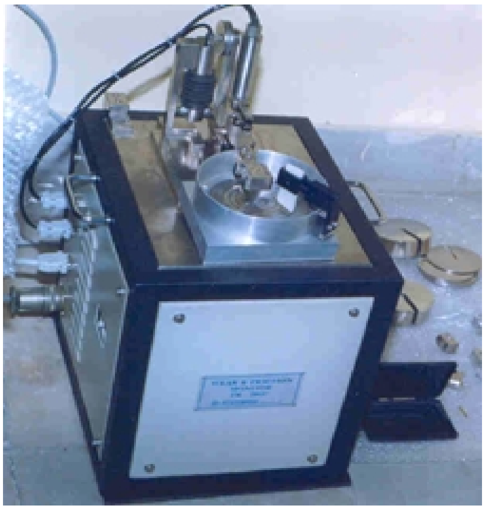

Fig.3. Computerised Wear testing machine

3. RESULTS:

3.1 Hardness Measurement:

The results of bulk hardness measurements conducted on the base metal and reinforced materials are as shown in fig 4. The results reveal that on increase in the SiC particulates in MMC, increases the material hardness.

3.2 Density Measurement:

The results of density measurement on the base metal and reinforced materials are shown in fig 5. The results reveal that on increase in the SiC particulates in MMC decreases the material density.

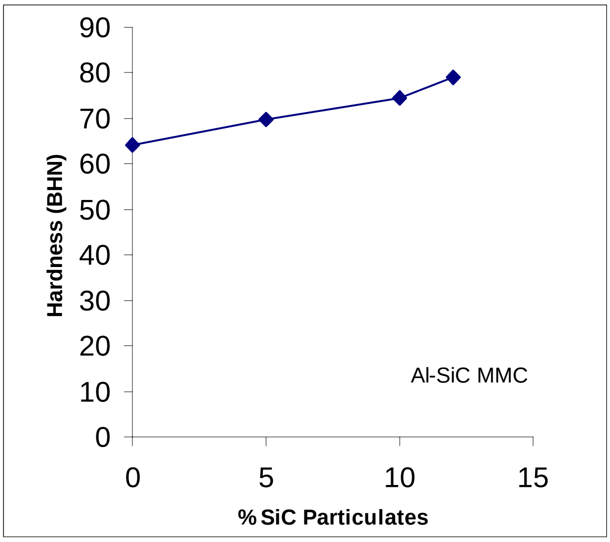

Fig. 4. Graphical representation of variation of Hardness in MMC with % SiC particulates.

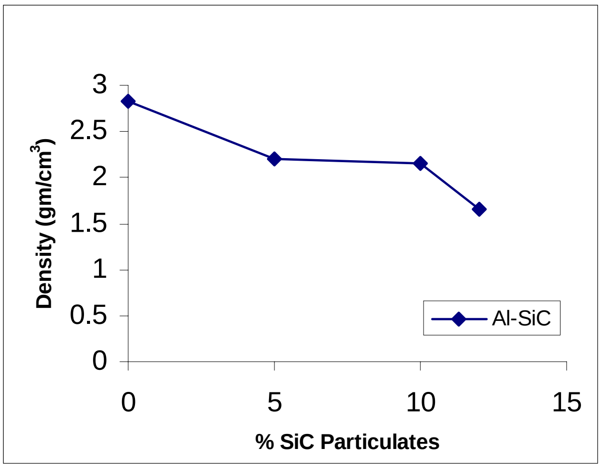

Fig. 5 Graphical representation of variation of Density in MMC with % SiC particulates.

3.3 Macrostructure studies:

A photograph of machined MMC sample for macro structural studies is shown in fig 6.

Macro structural observation on the machined samples revealed uniform distribution of SiC particulates with the presence of small macro pores and macro segregation of SiC particulates.

Fig. 6. Photo macrograph of Al-SiC Metal matrix Composite for macrostructure studies.

3.4 Abrasive Wear studies:

The results of wear studies on SiC particulate reinforced Al-based MMC is shown in fig. 7 & 8. The results revealed that the wear and coefficient of friction would decrease as the percentage of SiC increases. The weight fraction of SiC used are 5%, 10%, 12%.

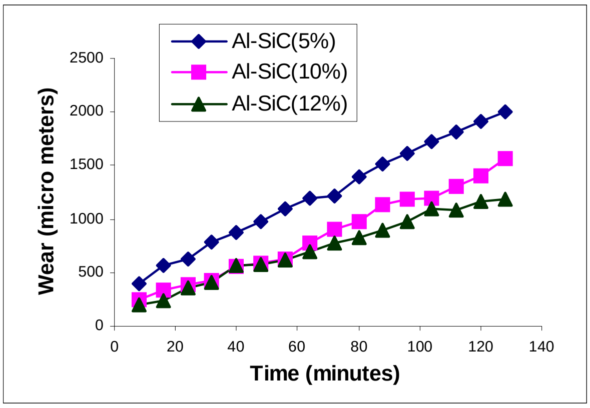

Fig.7. Graphical representation of wears studies on SiC reinforced Al-based MMC

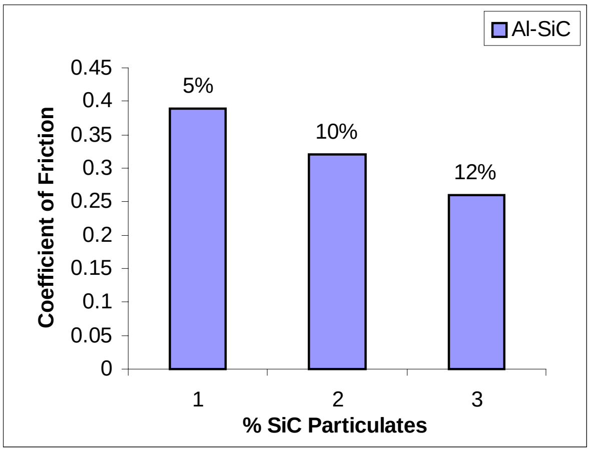

Fig.8. Graphical representation of coefficient of Friction for different weight fraction of SiC.

4. DISCUSSION:

4.1 Synthesis of Metal Matrix Composite:

The synthesis of Al-SiC composites containing upto 12% weight percentage of SiC particulates was successfully carried out in the present study. This can primarily be attributed to good processing technique used and improved wetability between SiC particulates and molten aluminium alloy for the following reasons.

a. Pre-heating of SiC particulates
b. Use of small amounts of alloying element - Mg
c. Degassing techniques.

4.2 Hardness:

The increase in the bulk hardness of the composite samples with an increase in the weight percentage of SiC particulates may be attributed to the presence of harder SiC particulates in the matrix, microstructural changes such as increase in the dislocation density in the matrix and presence of residual stresses brought about by the incorporation of SiC particulates in the metal matrix.

4.3 Abrasive Wear:

The increase in the wear properties such as resistance to wear and decrease in coefficient of friction with increase in weight percentage of SiC particulates may be attributed to the abrasive properties of SiC particulates compared to Al. metal. It would appear that the presence of SiC particulates enables the Al. matrix to slide more freely.

5. CONCLUSION:

a) Aluminium alloy matrix containing 5,10 and 12 wt % particulates of SiC were produced successfully.
b) Macrostructural observation revealed near uniform distribution of SiC particulates.
c) Coefficient of friction decreases with increase in SiC particulates.
d) Wear resistance increases with the addition of SiC particulates.
e) Hardness increases with the addition of SiC particulates.
f) Density of MMC has reduced with the addition of SiC particulates.

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