WEAR ANALYSIS OF ALUMINIUM 7075/ SIC METAL MATRIX COMPOSITES

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Abstract-Aluminium metal matrix composites (AMMCs) with improved tribological property has been one of the major requirement in the field of material science and technology. Aluminium alloy 7075 with silicon carbide (SiC) as reinforcement is replacing the existing components due to higher wear resistance application. In this present research work, is to evaluate the wear properties and micro structure of SiC as reinforced aluminium matrix composites. The aluminium metal matrix composites are produced as aluminium alloy 7075 matrix metal and SiC reinforced by varying 0 and 10 wt.% respectively. Scanning electron microscope (SEM) is employed to investigate the structural morphology and distribution of SiC in the metal matrix composites. The mechanical properties of metal matrix composites we characterized in term of hardness, tensile, wear tests as per the ASTM standards. At addition of 10 wt.% of SiC the wear rate reduced by 40%, when compared with neat metal matrix composites.

Key words: Aluminium metal matrix composites, silicon carbide, wear resistance, Scanning electron microscope, structural morphology.

I. INTRODUCTION

Composite material are the material made from two or more constituent materials with significantly physical or chemical properties, that when combined to produce a material with different characteristics from the individual components. The components remain separate and distinct within the finished structure. The new material may be preferred reasons common examples include materials which are stronger, lighter less expensive when compared to traditional materials. Composite materials are generally used for buildings, bridges and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite and marble sinks and counter tops. The most advanced examples perform routinely spacecraft in demanding environments. Typical engineered composite materials include:

- Composite building materials such as cements, concrete.
- Reinforced plastics such as fiber-reinforced polymer
- Metal composites
- Ceramic composites (composite ceramic and metal matrices) [1]

Metal matrix composites (MMCs) have many advantages when compared with polymer metal matrix (PMCs), with high wear resistance, heat resistance, high hardness, high tensile and shear modules, high resistance to environmental attack, low coefficient of thermal expansion. MMCs which gives high mechanical properties and low expensive when compared with convectional material. [2]

In most metal matrix composites, reinforcement is added to the matrix of the material to increase strength, wear and friction of the matrix. The most common composites system is an aluminium alloy reinforced with silicon carbide. So for most of alloy has been chosen as matrices among all aluminium alloy series. Although few studies have been reported on 7075 alloy reinforced with silicon carbide particulates. Aluminum alloy 7075 series shows that has highest strength of commercially available and widely used for structural application. The main role of reinforcement material to produce the composites with high mechanical properties. The properties of a composites material depends upon the nature of the reinforcement.

II. EXPERIMENTATION

Aluminium 7075 alloy is an aluminum alloy, with zinc as the primary alloying element and magnesium as the secondary alloying element. It has good hardness and good fatigue strength when compare any other aluminium alloy element. Aluminium 7075 alloys composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals.

TABLE1 : COMPOSITION OF AL7075 MATRIX

COMPONENT	Aluminum (Al)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Magnesium (Mg)	Manganese (Mn)	Silicon (Si)	Titanium (Ti)	Zinc (Zn)
WT.%	87.1-91.4	0.18-0.28	1.2-2	Max 0.5	2.1	Max 0.3	Max 0.4	Max 0.2	5.1-6.1

silicon carbide used as the reinforcing material. It is one of the most ceramic used for the reinforcing material, which gives high strength. The structure of the silicon carbide is hexagonal 4H crystal structure and sometimes hexagonal 6H with 15R rhombohedra.

III. FABRICATION OF COMPOSITES BY STIR CASTING PROCESS

Non-homogeneous particle distribution is one of the supreme problems in casting of metal matrix composites (MMC); because of ceramic materials have different density, melting point and boiling point. Other light-weight materials like Aluminium, Copper and Magnesium etc., have less density, high melting point and boiling point, thus ceramic particle mixing is exceptionally difficult to light materials.

Liquid state manufacture of Metal Matrix Composites involves integration of dispersed phase into a molten matrix metal, preceded by its solidification. In order to endow with high level of mechanical properties of the composite, good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be obtained. Wetting enhancement possibly will be achieved by coating the dispersed phase particles (fibers). Proper coating reduces interfacial energy, in addition prevents chemical interaction between the dispersed phase and the matrix. The simplest and the most cost effective method of liquid state fabrication is stir casting.

Metal matrix composites of the aluminium 7075 alloy and silicon carbide reinforced by stir casting. In this casting process is carried out in stir casting with particle treatment for 10% of SiC. In this particle treatment casting process, the reinforcement is heated at high temperature to remove the impurities. Before placing the aluminium 7075 alloy in the furnace some amount of coverall is added to remove the impurities from aluminium 7075 alloy. Then it is heated at upto 850℃ for 30 min to get a molten stage. Then pre-heated silicon carbide is added in molten aluminium alloy 7075 and then stirring is done. The stir casting process carried out at a constant stirring speed of about 250 rpm during the entire stirring process. Then the mixture is heated to temperature at which the mixture remains in the liquid state, the temperature is maintained at around 850℃ Now the mixture kept at constant temperature for about 30 minutes. Then the molten slurry is poured into the steel die.

Fig.1 Stir casting setup

Fig.2 Pictures of composite plates manufactured by stir casting process

III. TESTING, RESULTS AND DISCUSSION

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Some material (e.g. Metal) are harder than other (e.g. plastics). Macroscopic hardness is generally characterized by strong intermolecular bonds. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity. Hardness were carried out to observe the effect of wt% addition of silicon carbide on aluminium 7075 alloy matrix since hardness is an indicator of material resistance to plastic deformation . Since we are checking for the micro hardness, Vicker's mode of hardness testing is employed.

A. Vickers hardness test

The Vickers hardness test method consists of indenting the test material with a diamond indenter. Applying load 0.5kg at four different places on the specimen for 20 seconds time period respectively. Vickers micro hardness test procedure as per ASTM E-384-16 is carried out, indentation are made on the sample with a range of load using diamond indenter which is then measured and converted to a hardness value.

Table 2: vicker's hardness test at various places

Sample	Place 1	Place 2	Place 3	Place 4	Average
	HV @ 0.5kg Load				
Al 7075	173.4	174.6	176.7	175.4	175.02
Al7075 +10% SiC	189.4	190.1	188.9	189.7	189.5

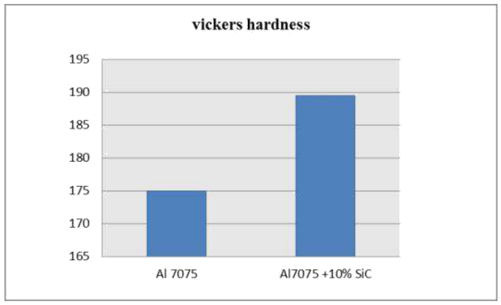


Fig 3 : vicker's hardness graph

From the above graph, we infer that composite materials prove to be superior in quality and property than the base materials. The hardness value increased from 175.02 to 189.5.

B. Tensile test

The tensile test is commonly used to test the material property with respect to strength and ductility of the materials. Tensile test is performed on 50T capacity UTM machine as per ASTM E8 standard testing procedure.

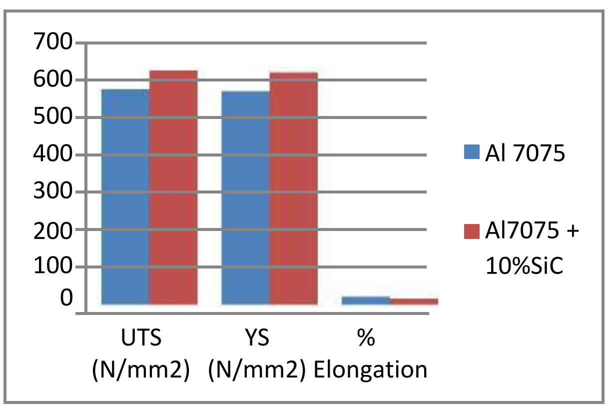


Fig 4: graph of ultimate tensile strength, yield strength and % of elongation

Table 3: testing of ultimate tensile strength

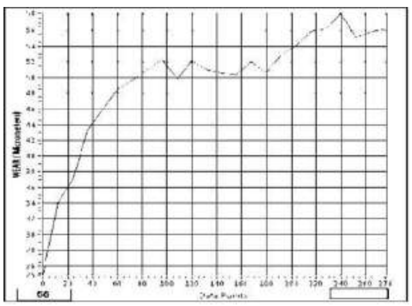
Sample	UTS (N/mm^2)	Yield strength (N/mm^2)	% elongation
Al 7075	572	568	20
Al7075 + 10%SiC	620	615	16

C. Pin on disk

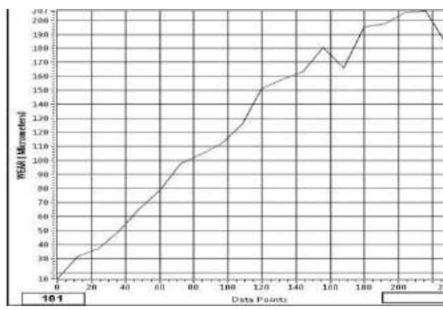
Pin on disk testing is a method of characterizing the coefficient of friction and rate of wear between two materials. Pin on disk test procedure as per ASTM G133 is the standard test method for pin on disk which is then the measured and converted to a coefficient of friction and rate of wear values. Material loss due to wear and friction is found by applying different load at different rpm like 40N at 300 rpm, 60N at 600 rpm and 80N at 900 rpm respectively.

Table 4: Wear test using Pin on Disc setup

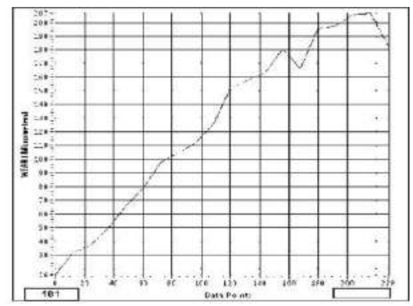
Sl. No.	Wear rate of AL7075, µm	Wear rate of AL7075/SiC, µm	Load,N	Speed,rpm
1	55	30	40	300
2	181	68	60	600
3	1065	113	80	900



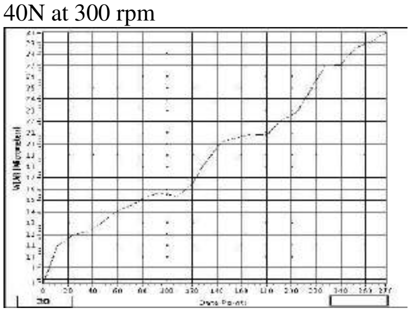
(a) Wear graph of AL7075 with respect to 40N at 300 rpm



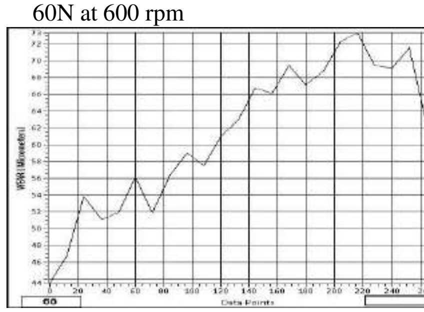
(b)Wear graph of AL7075 with respect to 60N at 600 rpm



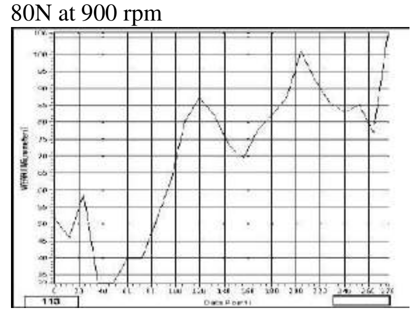
(c) Wear graph of AL7075 with respect to 80N at 900 rpm



(d) Wear graph of AL7075/SiC with respect to 40N at 300 rpm



(e) Wear graph of AL7075/SiC with respect to 60N at 600 rpm



(f) Wear graph of AL7075/SiC with respect to 80N at 900 rpm

Fig 5: graph a,b,c,d,e and f represent the wear resistance of AL7075 and AL7075/SiC

The above graph clearly explains that the wear of matrix metal is higher when compared to AL7075/SiC composites. This results have been proved to be successful in both the samples for all three loads and corresponding speeds. The increase in hardness with respect to increase in wt.% the reinforcement. This improved property has enhanced the wear property of the composite when compared to the base metal.

D. Scanning electron microscope

The specimens were polished by rubbing with uniform force on the rotating wheel of the polishing machine, covered with canvass cloth and the paste prepared with abrasive powder of magnesium oxide and water, as per ASTM standards. The prepared sample when exposed to SEM reveals the bonding nature and strength of the base metal and aluminium composite.

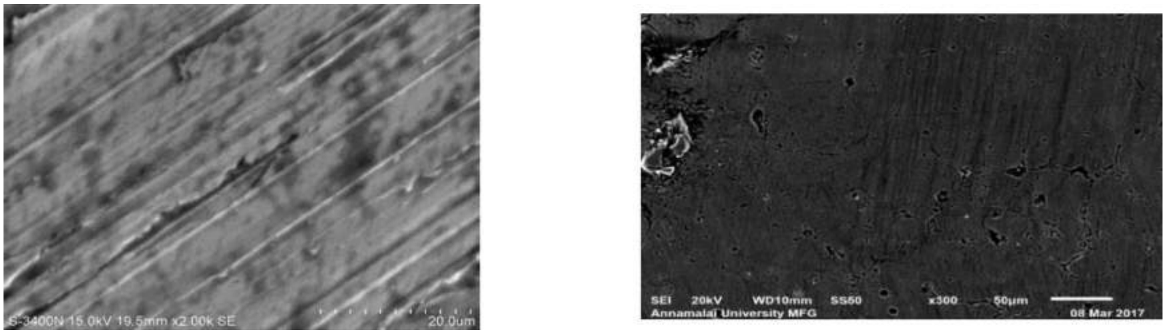


Fig (a) SEM image of AL7075 (b) SEM image of Al7075/SiC composite Fig 6: SEM images of AL7075 and Al7075/SiC composites

The above SEM image 6 (a) shows the Aluminium 7075 internal structure, 6 (b) shows distribution of SiC in Aluminium 7075.

IV. CONCLUSION

In this study, Al 7075 (Al – Mg –Zn –Si), alloy reinforced with 10% SiC was fabricated by stir casting process. The mechanical properties and microstructure of cast metal matrix composites

Were investigated through SEM. From the present work, the following conclusions were arrived at:

1. The results confirmed that stir casted Al alloy 7075 with SiC reinforced composites was superior in properties than base alloy Al7075.

2. The tensile strength increased and percentage elongation deceased with addition of SiC.

3. The wear resistance increased with addition of 10% SiC with Al7075 .

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