Mechanical Properties of Aluminium 6063 Alloy Based Graphite Particles Reinforced Metal Matrix Composite Material

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Abstract— The present work deals with the investigation of the mechanical behavior of Aluminium6063 alloy composites reinforced alloy by silicon carbide (SiC) and Graphite particles with a total metal matrix reinforcement and in this hybrid reinforcement the variations of SiC and Graphite (2+2)%, (4+2)%, (6+2)%, were taken in to account for investigating the properties such as hardness, tensile strength, thermal conductivity and microstructure of the composites produced by Stir casting technique. The mechanical properties of composite combinations evaluated from the experimental studies of the Rockwell hardness testing, universal testing machine, thermocouple and scanning electron microscope (SEM).

Key words: Metal Matrix Composite reinforcement, Stir casting, Mechanical properties

I. INTRODUCTION

The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. [1] Aluminium is the most abundant metal in the Earth's crust, and the third most abundant element, after oxygen and silicon. It makes up about 8% by weight of the Earth's solid surface. Due to easy availability, High strength to weight ratio, easy machinability, durable, ductile and malleability Aluminium is the most widely used non-ferrous metal in 2005 was 31.9 million tonnes. [2]

II. MATERIALS

A. Silicon Carbide as Reinforcement:

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties [3]. It is used in abrasives, refractoriness, ceramics, and numerous high-performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Silicon carbide is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. This produces a very hard and strong material. [3]

Properties of Silicon Carbide

- Low density
- High strength
- Low thermal expansion
- High thermal conductivity
- High hardness
- High elastic modulus
- Excellent thermal shock resistance
- Superior chemical inertness

Properties	Value	Properties
Melting Point (°C)	2200-2700	Linear coefficient of expansion (10^{-6} K)
Limit of application (°C)	1400-1700	Fracture toughness (MPa-$m^{1/2}$)
Moh's Hardness	9	Crystal structure
Density (g/cm^3)	3.2	Linear coefficient of expansion (10^{-6} K)

Table 1: Detailed properties of SiC are shown in

B. Al6063:

Aluminium alloys are alloys in which Al is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, and zinc where the silicon and magnesium plays major role[4].

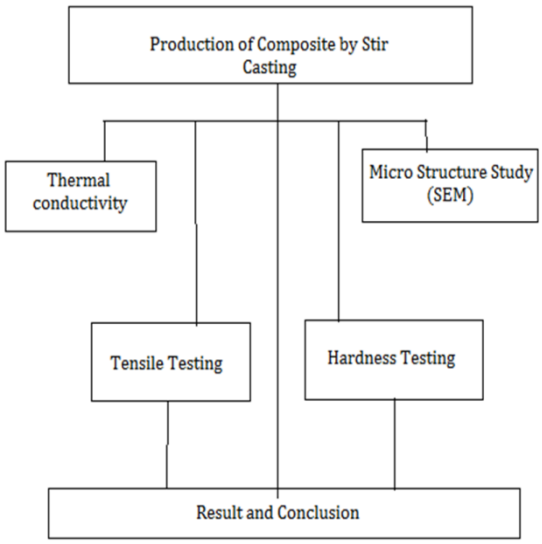
Si	Fe	Co	Mn	Mg	Cr
.431%	0.102 %	0.0073%	0.029%	0.50%	0.0026 %
Ni	Co	Cd	Zn	Li	Al
.0036 %	<0.001 %	<0.0001 %	0.0049 %	<0.0002 %	98.8%

Table 2: Chemical Composition of Al 6063 Alloy

Composites	Al 6063	SiC	Graphite
A1	900%	0%	0%
A2	96%	2%	2%
A3	94%	4%	2%
A4	92%	6%	2%

Table 3: Composition of matrix and reinforcement in wt%

C. Experimental Processor:



D. Stir Casting Setup:

Aluminium Alloy was melted in a crucible by heating it in a muffle furnace at 800°C for three to four hours. The silicon carbide particles and Graphite particles were preheated at 1000oC and 900oC respectively for one to three hours to make their surfaces oxidized. The furnace temperature was first raised above the liquidus temperature of Aluminium near about 750oC to melt the Al alloy completely and was then cooled down just below the liquidus to keep the slurry in Semi solid state. Automatic stirring was carried out with the help of radial drilling machine for about 10 minutes at stirring rate of 290 RPM. At this stage, the preheated SiC particles and Graphite particles were added manually to the vortex. In the final mixing processes the furnace temperature was controlled within 700 ± 10oC. After stirring process the mixture was pour in the other mould to get desired shape of specimen as shown in Figure. The presence of reinforcement throughout the specimen was inspected by cutting the casting at different locations and under microscopic examination. Same process was used for specimens with different compositions of SiC and Graphite. Compositions of samples are shown in Table 3. [6]

III. RESULTS AND DISCUSSION

A. Rockwell Hardness Test:

Test material is prepared with a 2cm X 2 cm X 1 cm rectangular test piece. It indented with 5 mm diameter hardened diamond cone subjected to a load of 150N applied for 10 seconds. The indentation diameter of the test material is measured with a low powered microscope. Rockwell harness number is calculated by dividing the load applied by the surface area of the indentation. The diameter of the impression is taken more than one time readings at right angles.

A Rockwell hardness tester machine used for the hardness measurement. The surface being 400, 600 and 1000 grit size emery paper. Load used on Rockwell's hardness tester was 150 kgf at dwell time 20 seconds for each sample. The result of Rockwell's hardness test for simple alloy without reinforcement (Sample No.1) and the wt.% variation of different reinforcements such as SiC + graphite and Al alloy (6063) (Sample No. 2-4) are shown in Table.

Sample no	Sample name	Hardness (HRC)					Mean hardness
		Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	
1	A1	36	38	37	36	35	36.4
2	A2	36.1	37.5	37.9	43	40	38.9
3	A3	47	46	39.1	40	45.01	43.42
4	A4	60	54.2	54	74	77	63.84

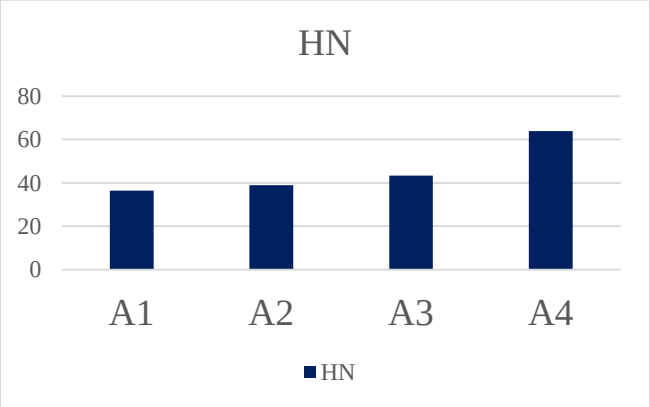


Fig. 1: Mean hardness bar chart

IV. TENSILE STRENGTH TEST

Tensile tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined to tensile specimens with a diameter of 16mm and gauge length of 10 cm. Ultimate tensile strength (UTS), often shortened to tensile strength (TS) or ultimate strength, is the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross-section starts to significantly contract.

Alloy (LM6)	UTS N/mm2	Elongation (%)
A1	180	8
A2	226	7.6
A3	233	6
A4	252	4.1

A. Ultimate Tensile Strength:

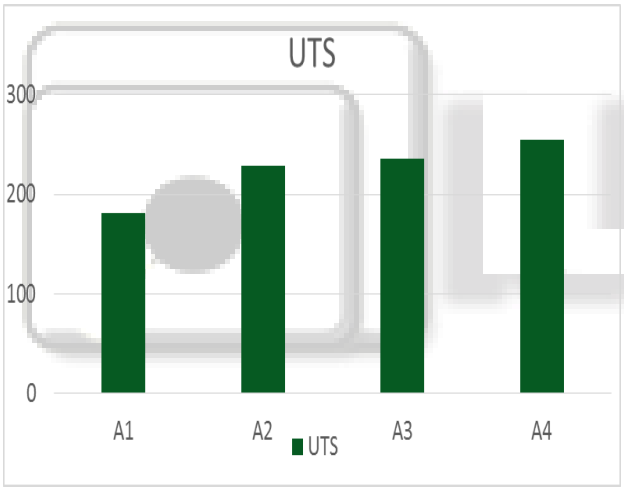


Fig. 2: Ultimate Tensile Strength

B. Elongation:

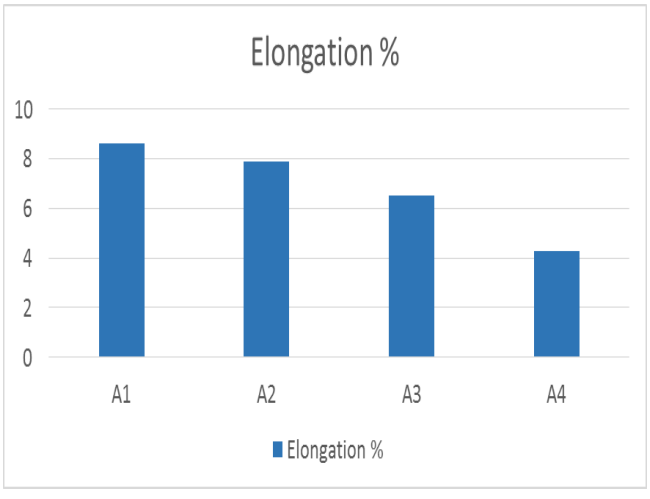


Fig. 3: Bar chart for elongation of composites

C. Distribution:

The SEM images show the uniform distribution of the metal matrix composite reinforcement also the inter metallic formation in the reinforced composites, the pore formation of the aluminium6063, SiC and Graphite reinforced composite in a different composition.

1) Below Figures Shows The Distributions Of Reinforcements In The Respective Matrix Are Fairly Uniform:

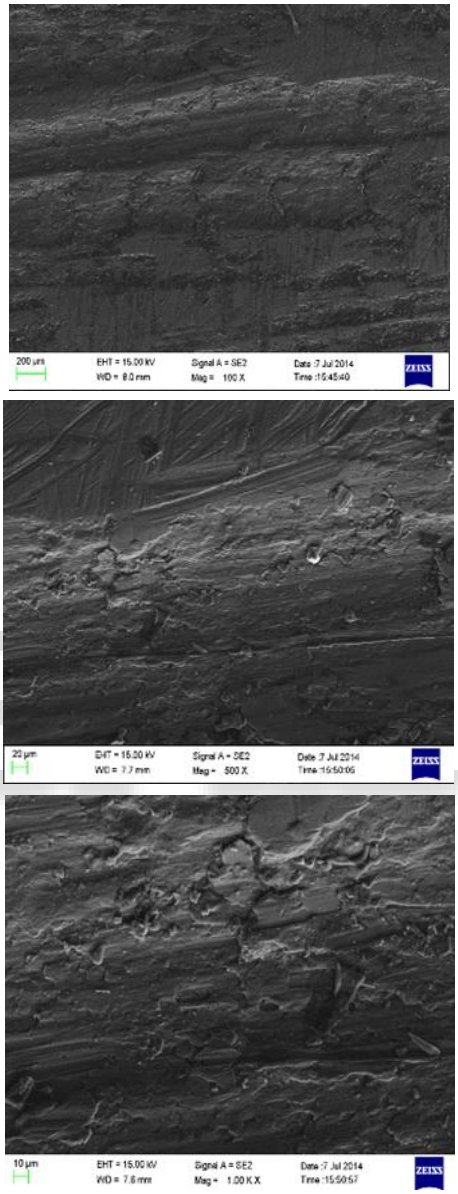
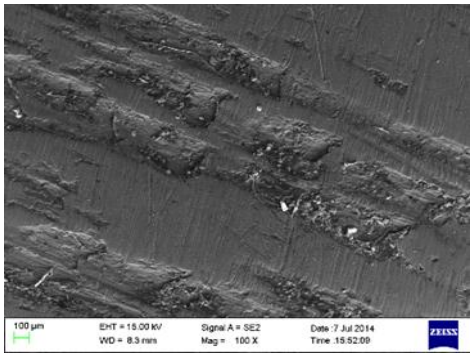


Fig. 4: Microscopic View of 6063 Aluminium 100 X, 500 X, 1000 X



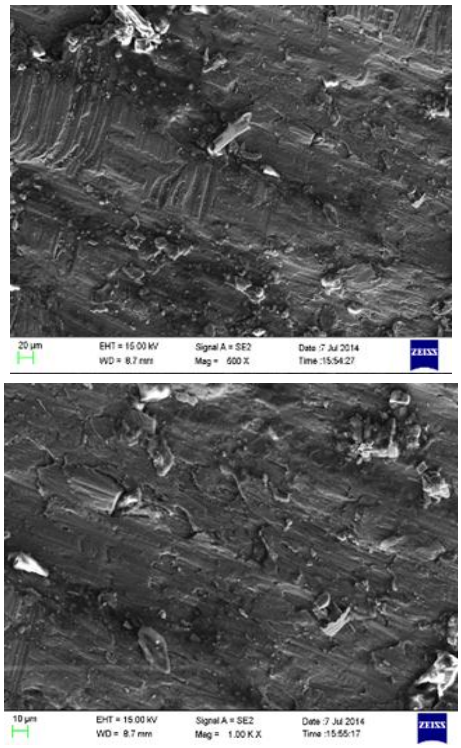


Fig. 5: Microscopic View of 2 % SiC Reinforced in 6063 Aluminium 100 X, 500 X, 1000 X

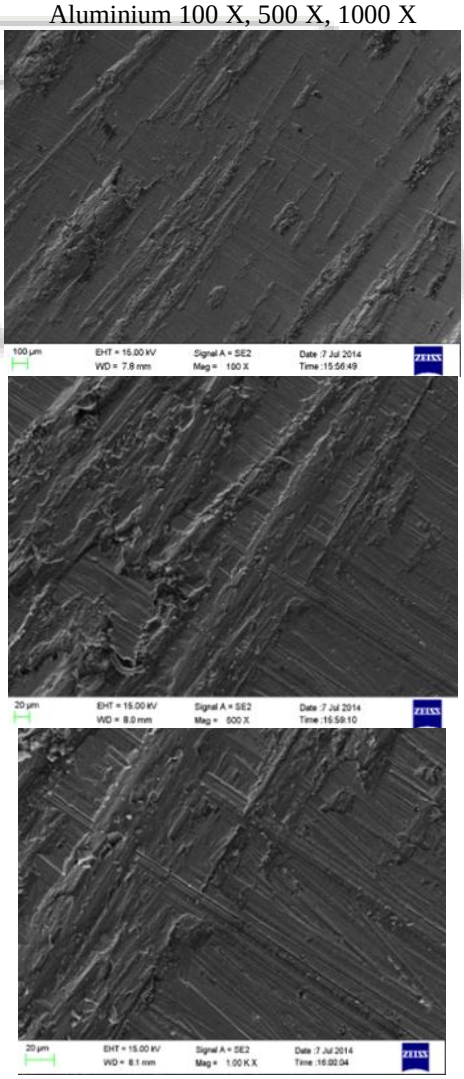


Fig. 6: Microscopic View of 4 % SiC Reinforced in 6063 Aluminium 100 X, 500 X, 1000 X

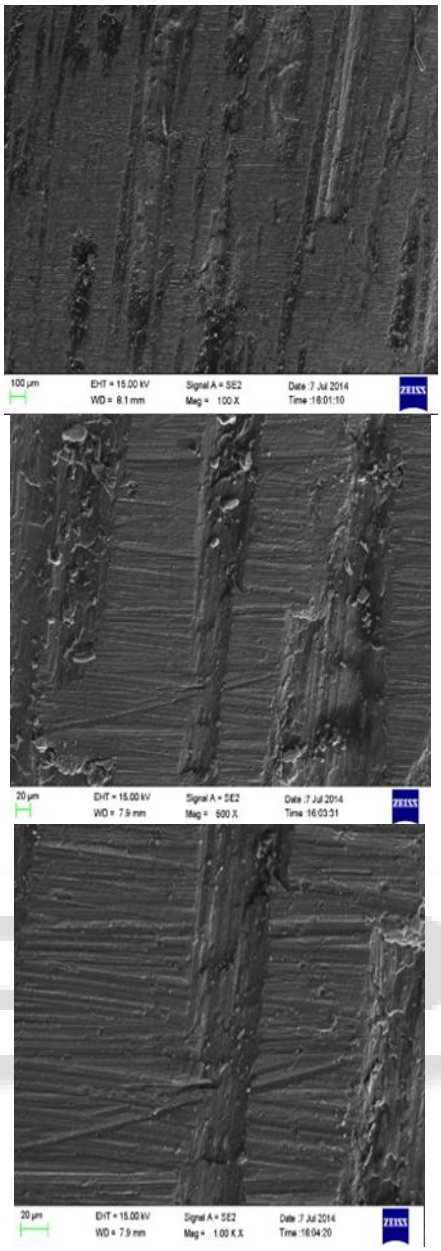


Fig. 7: Microscopic View of 6 % SiC Reinforced in 6063 Aluminium 100 X, 500 X, 1000 X

V. CONCLUSION

Al 6063 alloy metal matrix composites reinforced with SiC and Graphite particles has been successfully synthesized by the stirring casting method. The results reveals the matrix reinforced composites have the property improvement better than Al 6063.

The hardness and the tensile strength of the composite having the higher value at the metal matrix composite sample having the reinforcement combination of Al 6063 + SiC 2 %, 4 %, 6 % + Graphite 2 % in its wt.

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