

Mechanical Behaviour of Aluminium Based Metal Matrix Composite Reinforced with Silicon Carbide and Graphite

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DOI:- <http://doi.org/10.5281/zenodo.3466882>

Abstract

The present work investigates the mechanical nature of AA6082 aluminums alloy reinforced with Silicon Carbide and Graphite. With the stir casting composite is made. Tensile strength and hardness test were conducted to find out the properties of the meatal matrix composite. Tensile strength and hardness test results for casted synthesis were plotted in Microsoft excel and compared with alloy AA6082. The results show that there is increasing in the mechanical properties of the casted composite with increasing the particles percentage up to the certain limit.

Keywords: - MMC and Mechanical stir casting, AA6082\SiC\Gr.

INTRODUCTION

With developing world and present demands, metal matrix composites (MMCs) have more advantages in comparison to conventional alloys in strength, hardness etc. It is necessary to invent an alternate to monolithic materials with improved properties. Composite materials are designed to combined desirable properties of metals and ceramics

to improve mechanical properties of a metal alloy. The hard particles of ceramics are mixed into the metal matrix phase. Aluminium is a soft metal to increase its hardness silicon carbide particles are mixed with it. Aluminium is the most abundant metal on the earth. It can be reformed by melting and can be reused having least losses. Due to lower specific weight it is mainly used in

transport industry to decrease the gross weight of the vehicles. It poses no health hazards. Pure aluminium have 99 to 99.8% of aluminum. This is also usable for building's interior and exterior applications in the form of aluminium composite panel. It allows more design liberty.

SELECTION OF THE MATERIAL

Matrix material

Aluminium alloy AA6082 is nominated as a matrix material. Since AA6082 is an intermediate strength alloy but having outstanding corrosion resistance. In 6000 series alloys it has the uppermost strength and replaces 6061 in numerous applications. AA 6082 is known as a structural alloy. Percentage of manganese controls the grain structure.

Silicon Carbide

Silicon carbide is an excellent abrasive; produce a very hard and strong material having good mechanical properties. It is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C. In air, Sic forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal conductivity coupled with

low thermal expansion and high strength gives this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600°C with no strength loss.

Graphite

The material is generally greyish-black, opaque and has a lustrous black sheen. It is unique in that it has properties of both a metal and a non-metal. It is flexible but not elastic, has a high thermal and electrical conductivity, and is highly refractory and chemically inert. Graphite has a low adsorption of X-rays and neutrons making it a particularly useful material in nuclear applications. The carbon atoms are arranged hexagonally in a planar condensed ring system. The layers are stacked parallel to each other. The atoms within the rings are bonded covalently, whilst the layers are loosely bonded together by Vander-walls forces.

EXPERIMENTAL PROCEDURE

The metal matrix composite sample is prepared by using stir casting process. Composite were prepared by varying the percentage of aluminium alloy, silicon carbide and graphite in a high frequency induction furnace.

First Aluminium alloy was melted in a crucible by heating it in a muffle furnace at 800oC for three to four hours. The silicon carbide particles and graphite particles were preheated at 1000oC and 1200oC respectively for one to three hours to make their surfaces oxidized. The furnace temperature was first raised above the liquids temperature of aluminium near about 750oC to melt the aluminium alloy completely and then cool down just below the liquids to keep the slurry in semi-solid state. Automatic stirring were carried out with the help of radial drilling machine for about 10 minutes at stirring rate of 300 RPM. At this stage, the preheated silicon carbide and graphite particles were added manually to the vortex. In the final mixing processes the furnace temperature is

controlled within 700-7100C. After stirring process the mixture poured into the other mold to get desired shape of specimen. The presence of reinforcement throughout the specimen is inspected by cutting the casting at different locations and under microscopic examination. Same process was used for specimens for different compositions of silicon carbide and graphite. The below table shows the different samples having different compositions.

RESULTS AND DISCUSSIONS

Tensile Strength Test

The specimens of different compositions were fabricated by mechanical stir casting process and tested on Universal Testing Machine under different load conditions.

Table:-1 Sample Composition

S. No.	Composition
1	Plane AA6082 Alloy
2	AA6082 Alloy (93% vol.) + SiC(5% vol.) + Gr (2% vol.)
3	AA6082 Alloy (86% vol.) + SiC(10% vol.) + Gr (4% vol.)
4	AA6082 Alloy (79% vol.) + SiC(15% vol.) + Gr (6% vol.)
5	AA6082 Alloy (72% vol.) + SiC(20% vol.) + Gr (8% vol.)
6	AA6082 Alloy (65% vol.) + SiC(25% vol.) + Gr (10% vol.)

Table 2 Tensile Strength Test Results

S. No.	Composite (vol. %)	Load (Kg)	Tensile strength (Mpa)	Elongation (%)
1	AA6082	460	130	5
2	AA6082 (93%) +SiC(5%) +Gr (2%)	520	145.35	3.8
3	AA6082 (86%) +SiC(10%) +Gr (4%)	580	162.05	3.2
4	AA6082 (79%) +SiC(15%) +Gr (6%)	640	173.15	2.5
5	AA6082 (72%) +SiC(20%) +Gr (8%)	700	169.52	2.8
6	AA6082 (65%) +SiC(25%) +Gr (10%)	760	165.31	3.4

There are some Histogram showing values for different AA-SiC-Gr composite with Ultimate tensile strength, Yield strength and %Elongation.

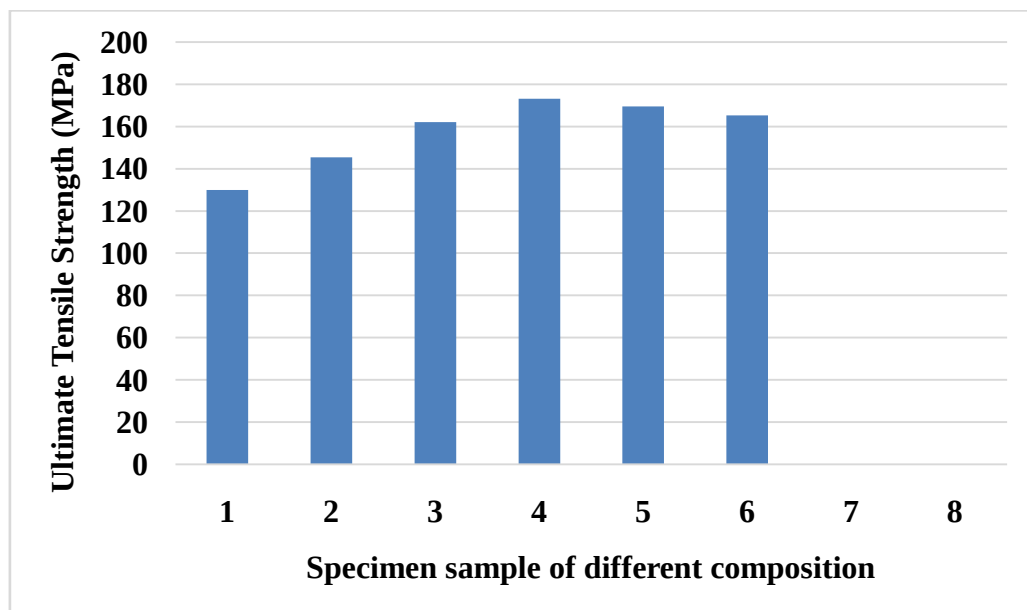


Fig. 1 Histogram showing values of UTS of different AA-SiC-Gr composite

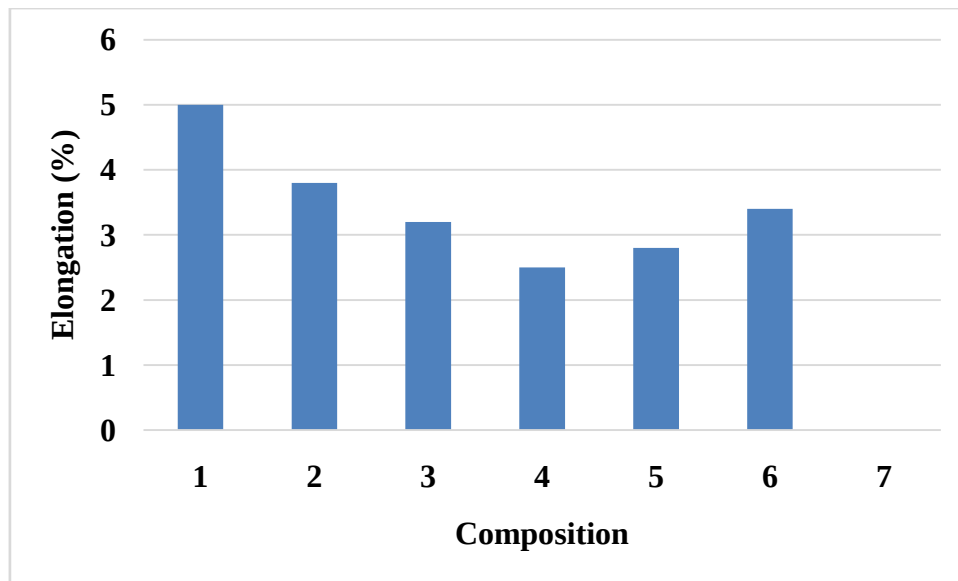


Fig. 2 Histogram showing values of % elongation for different AA-SiC-Gr composite

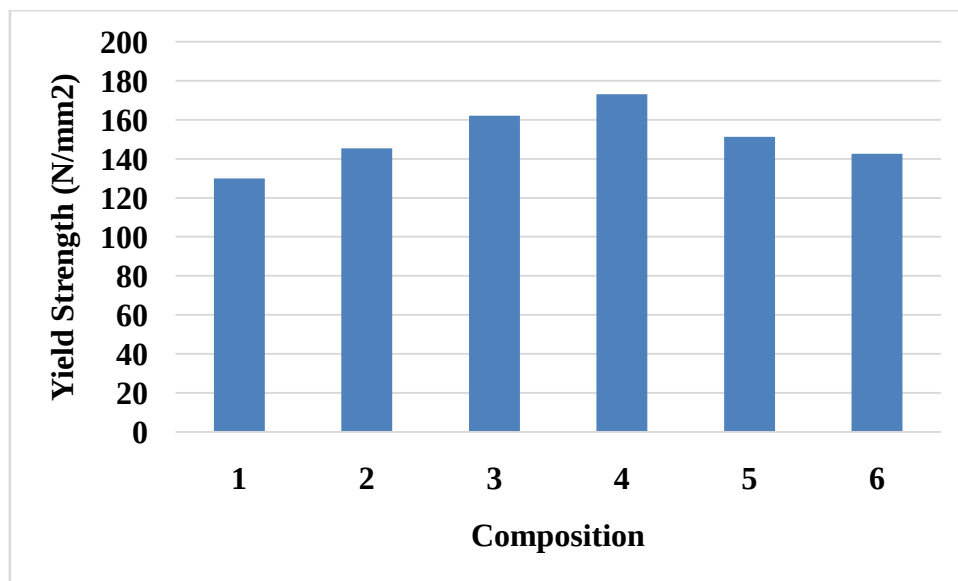


Fig. 3 Histogram showing values of Yield strength for different AA-SiC-Gr composite

(a) Discussion

From the above figures it is observed that the Ultimate tensile strength and Yield strength increases with the increase of percentage of silicon carbide and graphite particles upto 15% and 6% respectively. Further increasing the percentage of

silicon carbide and graphite particles the Ultimate tensile strength and Yield strength decreases. Since beyond this limit silicon carbide and graphite particles interact with each other leading to clustering of particles and lowering the tensile strength and yield strength. The

yield strength of the alloys are calculated by 0.2% offset method, according to ASTM standard.

Hardness Test

A Brinell hardness tester machine used for the hardness measurement. The surface

being tested generally requires a metallographic finish and this is done with the help of 100, 220, 400, 600 and 1000 grit size emery paper. The table 4.2 shows the hardness test result.

Table 3 Hardness Test Results

Specimen Number	Composition	Load (Kg)	Ball Dia.(mm)	Indentation dia.(mm)	BHN	Avg. BHN
1	AA6082	600	10	4.39	35.4	35.5
				4.38	35.5	
				4.37	35.7	
2	AA6082 (93%) + SiC(5%) + Gr (2%)			4.11	40.4	40.2
				4.10	40.2	
				4.09	40.0	
3	AA6082 (86%) + SiC(10%) + Gr (4%)			3.99	43.3	43.1
				4.00	43.1	
				4.01	42.9	
4	AA6082 (79%) + SiC(15%) + Gr (6%)			3.78	47.6	47.4
				3.77	47.2	
				3.76	47.3	
5	AA6082 (72%) + SiC(20%) + Gr (8%)			3.39	55.4	55.2
				3.38	55.2	
				3.37	54.9	
6	AA6082 (65%) + SiC(25%) + Gr (10%)			3.80	50.2	51.8
				3.84	53.4	
				3.82	51.8	

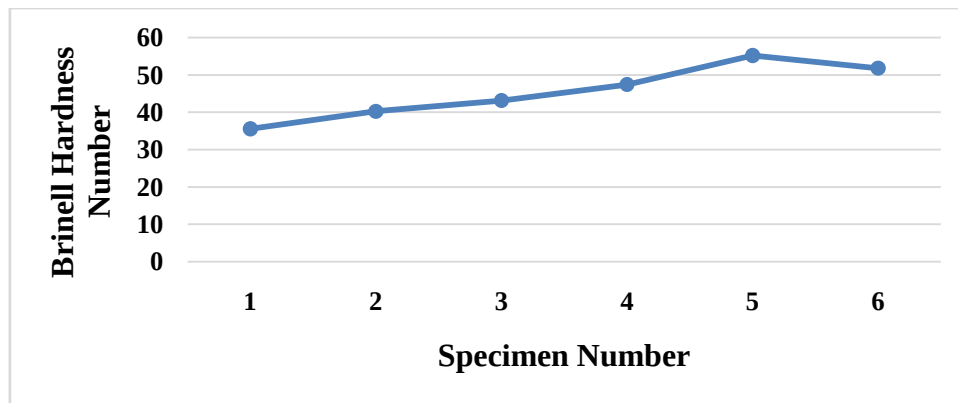


Fig. 4 Graph showing values of Brinell hardness number for Specimen of different composition

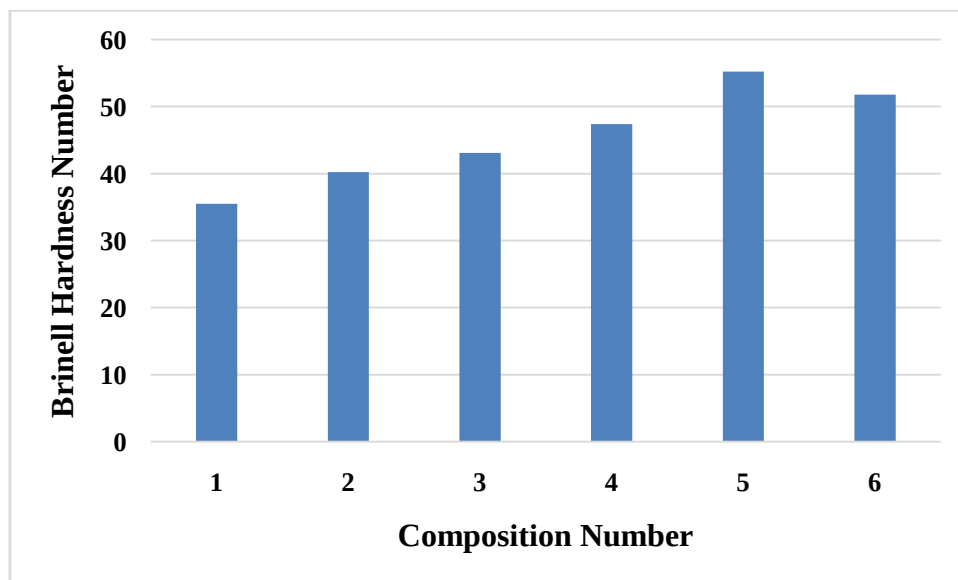


Fig. 5 Histogram showing values of BHN for different compositions

Discussion

Hardness of the composition is increasing continuously by increasing the weight percentage of silicon carbide upto 20% and graphite upto 8%. Further increasing the weight % of silicon carbide and graphite the hardness started decreasing. Since beyond this limit silicon carbide and graphite particles interact with each other

leading to clustering of particles and lowering the hardness.

CONCLUSION

The present work has successfully demonstrated the production of aluminium 6082 based metal matrix composites with % of Silicon Carbide particles and Graphite particles by volume as reinforcement through Stir casting process.

The conclusions drawn from the present work are as follows:-

1. The results confirmed that stir formed AA6082 with silicon carbide particles and graphite particles reinforced composites is clearly superior to base Al alloy AA6082 in the comparison of Tensile strength, as well as Hardness
2. Hardness of the sintered sample is studied and found to be increasing with increasing % of Silicon carbide particle and graphite particles by volume upto 20% and 8% respectively. Further increasing the percentage of silicon carbide and graphite hardness start decreasing.
3. It is found that elongation tends to decrease with increasing particles wt. percentage of silicon carbide and graphite particles upto 15% and 6%, which confirms that silicon carbide and graphite addition increases brittleness. Further addition of weight percentage of silicon carbide and graphite elongation increases.
4. Yield strength and Ultimate tensile strength increases with increases of weight percentage of silicon carbide and graphite particles upto 15% and 6%. Further addition of weight

percentage of silicon carbide and graphite particles Yield strength and Ultimate tensile strength decreases.

5. From the present study it is revealed that a proper control of process parameters can results in improved design of the Al-based MMC'S.

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Cite this Article As

Surendra Kumar (2019). “**Mechanical Behaviour of Aluminium Based Metal Matrix Composite Reinforced with Silicon Carbide and Graphite**” Journal of Research in Mechanical Engineering and Applied Mechanics, 4(3), 1- 10

<http://doi.org/10.5281/zenodo.3466882>