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An Experimental Based Case Study on Effect of SiC Particulates on Mechanical Properties of AA6063

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ABSTRACT

About 12.5% of total available materials for engineering use in the markets are composites. This sharing directly reflects the importance of the composites. Composites are playing a significant role in the present industrial field. These materials are attracting the attentions of researchers and scholars from past few decades. In this research paper there is a study of the Al 6063 (Aluminium Alloy) and Silicon Carbide (SiC) based composites material (AMCs) made by stir/compo casting method. And also to study that what will be happened to the mechanical properties mainly the tensile strength, hardness and microstructure of Al 6063 after mixing the preheated SiC powder of 220 mesh in it with different weight percentages (1, 3, 5, 7, 9). AMCs (aluminum matrix composites) are now highly preferred in the applications where there good strength, hardness, wear resistance, light weight (as compared to the size), corrosion resistance and other mechanical properties are required in an increasing manner. The application of AMCs is increasing day by day in the medical sector, the automotive industry, aeronautical field, underwater applications, structures, door accessories, etc. In present work, stir casting technique is employed in making AMCs. Further, various testing likely tensile testing, microstructure analysis and hardness testing are employed on the different specimens made accordingly to ASTM standards.

Keywords: Al6063, SiC, AMCs, compo/stir casting, muffle furnace, tensile strength, hardness, microstructure.

I. INTRODUCTION

As we already discussed that composites have good strength, hardness, resistance to abrasion, light weight (as compared to the size), resistance to corrosion and other mechanical properties which are utilized to manufacture various components and parts of automobiles (i.e. Engine blocks, piston, fins, axle, casing for transmission box, braking system, wheels, etc.), medical and surgical equipments, aeronautical parts, marine parts, structure and many other elements and components of the above said characteristics. The MMCs made by AMC base is from one of the most explored MMCs. Aluminium alloy constituent is called matrix phase, whereas the other part is an integral part that encloses closely and act as reinforcement. This reinforcing element usually from ceramics or from non-metals e.g. graphite, red mud, silicon carbide, alumina etc. In this paper there is emphasis on the homogeneous preparation of Al 6063 and SiC composites by adopting the stir/compo casting technique. The total weight of the both the materials was 1 Kg net during making all the castings. However, the weight percentage (per 1000) of SiC powder during making all the castings was changed respectively to1, 3, 5, 7 and 9 percent. Al 6063 was melted and SiC was preheated in separate crucibles (coated with graphite) placed in a muffle furnace. Total 20 samples of different compositions were made for different type testings i.e. tensile testing, hardness testing, microstructure testing. After testing results and graphs are taken and then a comparative study of these results and graphs is accomplished. And after all, in the last, there is a conclusion phase in which summary of the work is listed.

II. EXPERIMENTAL WORK

Following section shows the procedure adopted for MMCs preparation and testing.

Procedure adopted for MMCs preparation

In this sub-section materials used and the method adopted for the preparation of MMCs in this study are discussed. This is earlier discussed that what is MMCs (metal matrix composites). First, materials used in MMCs making and then a methodology of making MMCs will be discussed here.

Al 6063

Al 6063 is a matrix phase of this experimental study. Al 6063 is an alloy of aluminium of alloy designation 6XXX which are Mg (magnesium) and Si (silicon) containing alloy. It is one of the most used aluminium alloy for extrusion purpose .Generally, this alloy has good mechanical properties and this can also be heat treated and welded. The chemical composition of this alloy by weight percentage is shown in the following table A and the picture of raw material is shown in the fig. 1.

Table A: Various compositions of Al 6063.

Al	Mg	Fe	Cu	Si	Mn	Ti	Cr	Zn
97.8	0.8	0.3	0.1	0.6	0.1	0.1	0.1	0.1

SiC

Silicon carbide is (somewhere also called as Carborundum) known as a compound of carbon and silicon. Due to the presence of carbon it is hard and usually it is used as abrasive. It has a higher melting temperature above 2700°C. In AMMCs (Aluminium Metal Material Composites) silicon carbide acts as a reinforcing material. It strengthened the composite in many aspects. Some useful properties of silicon carbide are shown in the following table B and pictorial view of powder is in fig. 2.

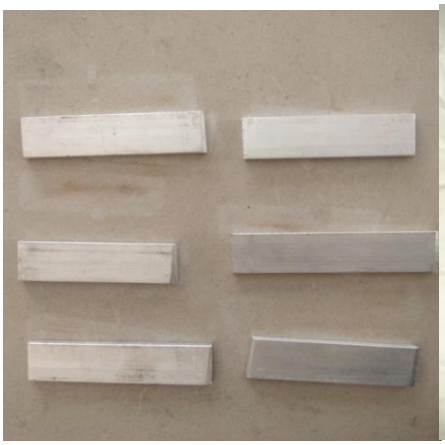


Fig. 1. Al 6063 strips.

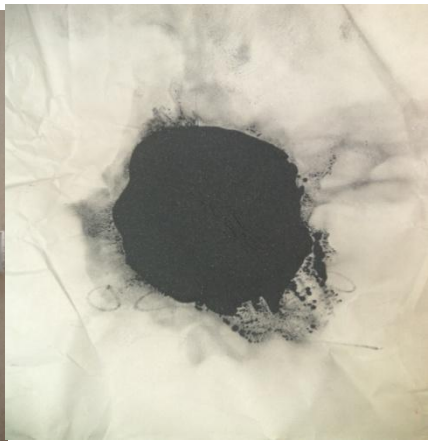


Fig. 2. SiC powder.

Table B: Various properties of SiC.

Compressive Strength (in MPa)	Density (in gms/cc)	Elastic Modulus (in GPa)	Hardness (in kgf/mm²)
3900	3.1	410	2800

Stir Casting / Compo Casting

Stir casting is also called as compo casting. It is from one of the most common techniques adopted for making MMCs. As the name is showing that there is some function of stirrer in this casting. And the function of the stirrer is to mix the reinforcing material (i.e. SiC in this study) into the matrix phase (i.e. Al 6063 in this study) homogeneously. In this process, reinforcing phases (ceramic particles, short fibers) introduce by mean of mechanical stirring into molten metal. In this method of casting, first of all we melt the matrix phase material and preheat the reinforcing material. When the melted material turned into its mushy state (semi- solid) at 675°C, then the preheated reinforcing material is mixed by stirrer

usually mechanical stirrer. About 5 minutes later the stirrer is escape out and again the mixture is treated with a temperature rise upto 765°C. Just after it the mixture is poured out in the mould of the casting for solidification. In the following table C there are some pictures of the equipments used in this process. In the pic. 3 these are the crucibles one is big for the melting of aluminium 6063 and small one is used for preheating of SiC powder, in pic. 4 this a casting mould in which mixture Al 6063 and SiC is poured outfor casting just after the stirring process to blend the SiC particulates into the molten Al 6063, in pic. 5 this is a tong which is used to hold the crucible having the molten mixture, in pic. 6this is a stirrer fitted with a motor used to blend the composite, in pic. 7 this is a muffle furnace in which higher controlled temperature occurred which resulting in the melting of the material placed in the crucible and in the pic. 8 there is a stir casting setup mounted on the muffle furnace.

Table C: Various equipments used in stir casting.

		
3) Crucibles	4) Casting mould	5) Tong
		
6) Stirrer	7) Muffle furnace	8) Stirrer arrangement

III. METHODOLOGY AND TESTINGS

As this is clear that in this study MMCs of Al 6063 and SiC are to be made through stir casting process. Al 6063 strips are cut into suitable size that fit in the crucible. Further, according to the percentage ratio of the matrix phase and reinforcing material is weighted on the electronic scale and the matrix phase is taken into the big crucible while the reinforcing material is taken into the small crucible.Then both the crucibles are placed in the muffle furnace to turn the Al 6063 into a semi-solid (mushy state) state and to preheat the SiC powder. After that the preheated reinforcing material is mixed homogeneously into the semi-solid Al 6063 by using stirring arrangement. After this, again the temperature of the furnace is increased upto about 765°C, resulting in melting of the mixture and after that the mixture is poured out in the casting mould with the help of tong. After the completesolidification ; the MMC is taken out and then various types of test specimens are prepared according to some standards. After it various testings are carried out and the final results are taken. Various results taken from various tests e.g. tensile test, hardness test and microstructure test; and a comparative study is made on the basis of the results.

Tensile testing

For the tensile test or tension test rectangular dumble shaped test specimens are made according to ASTM standards. Tensile tests were performed on the universal testing machine namely UNITEK 94100 with a maximum capacity manufactured by FIE (Fuel Instruments & Engineers) Pvt. Ltd, Yadrav, Maharashtra(India).The tensile test specimens areshown in the following fig. 3.

Fig. 3. Tensile specimens. **Fig. 4. Hardness & microstructure specimens.**

Micro-structure testing

For micro-structure testing, samples are finished in such a fine way that there should be mirror like finishing of the upper surface. This surface finish of samples was achieved by rubbing emery papers (100 to 2000 micron)and velvet clothfitted on a rotating type polishing machine until it gives mirror like finish and then this surface is washed by Killer's etching reagent (25% Methanol, 25% HCl, 25% water, 25% HNO3, and one drop of HF). In this testing the micro structures of the AMCs samples are captured and seen that the proper and homogeneous mixing of the reinforcing material is done or not. This testing was carried on the MICRO-STRUCTURE TESTER manufactured by DEWINTER TECHNOLOGIES, ITALY. Micro-structure test specimens are shown in the fig. 4.

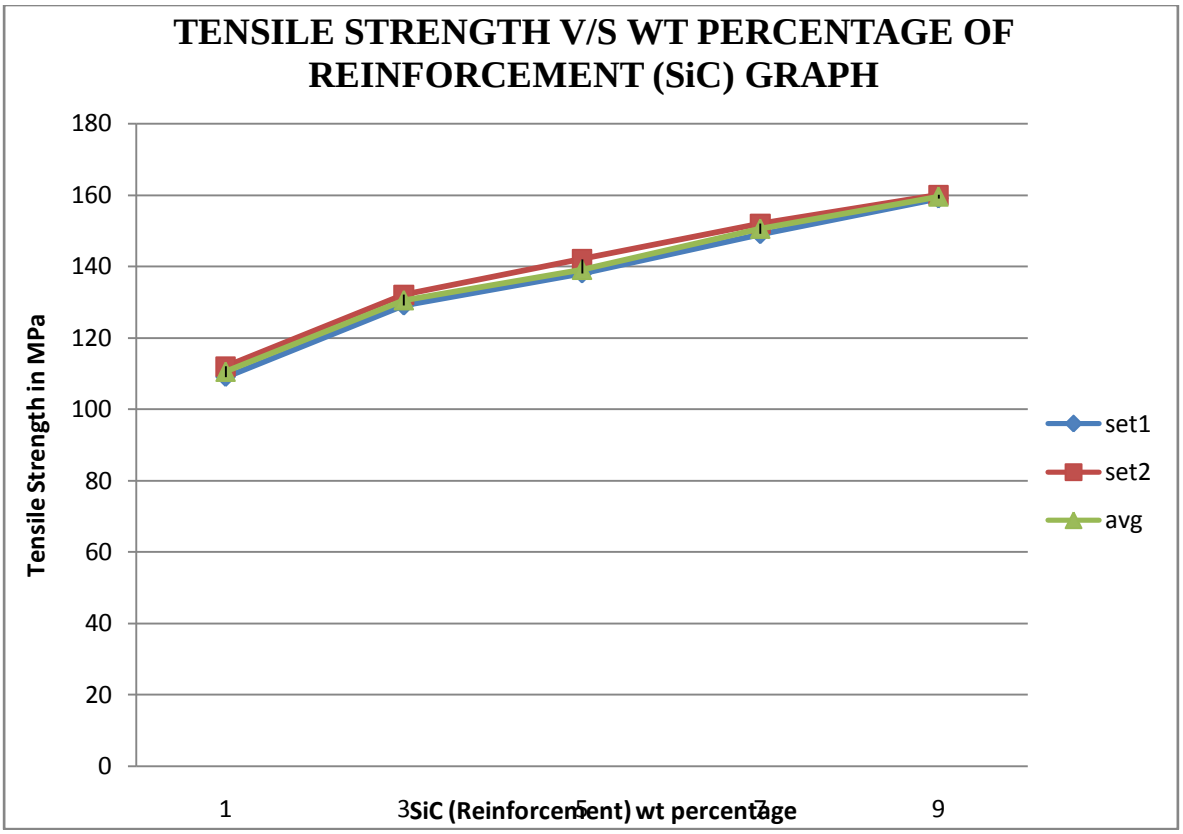
Hardness testing

For hardness testing, testing specimens are same as of microstructure testing which are shown in the fig. 4 above. Hardness testing was performed on the MICROVICKERS HARDNESS TESTER, model name- MV1-PC with the maximium capcity of 1000 gf and is manufactured by FIE(Fuel Instruments & Engineers Pvt. Ltd. Yadrav, Maharashtra (India). In this testing the hardness of AMCs is measured and after that an analysis is made that what is the effect of reinforcing material in the AMCs. All the three testing machines are shown in the fig.5(a, b, c).

Fig. 5: a) U.T.M Unitek 94100 b) Microstructure Tester c) Microvickers Hardness Tester

IV. RESULTS AND DISCUSSION

Results of various testing done on MMCs having Al 6063 and SiC by weight percentage(%) are discussed below.



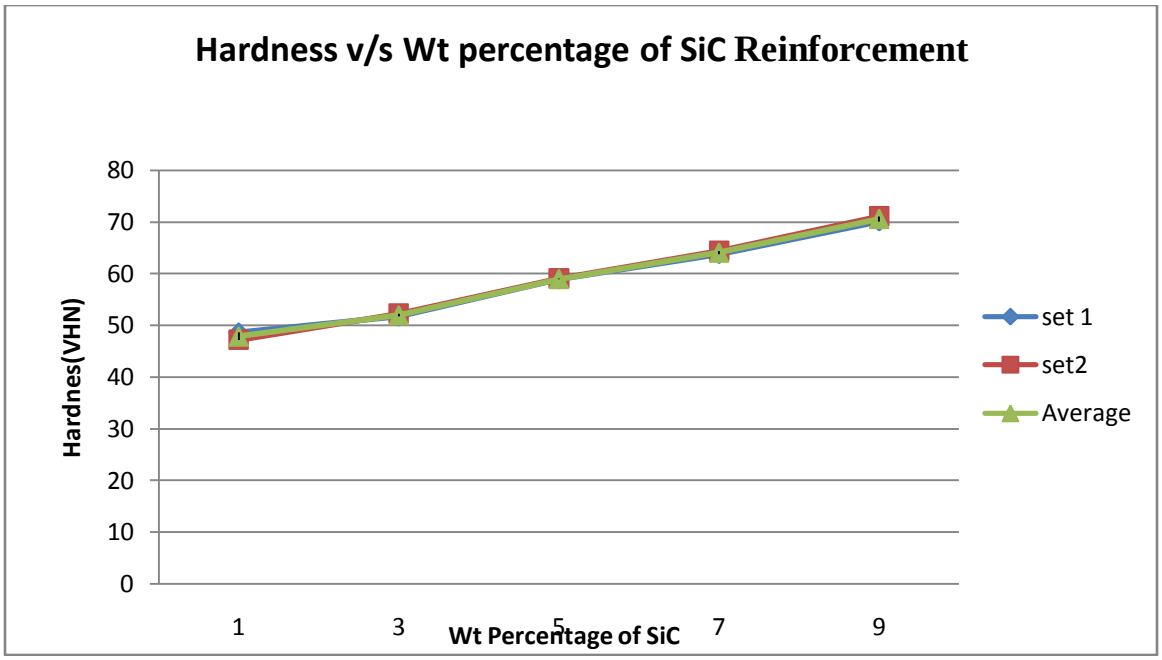
Graph: For Tensile Strength of AMCs samples.

Table D: Tensile strength of composites for AMCs.

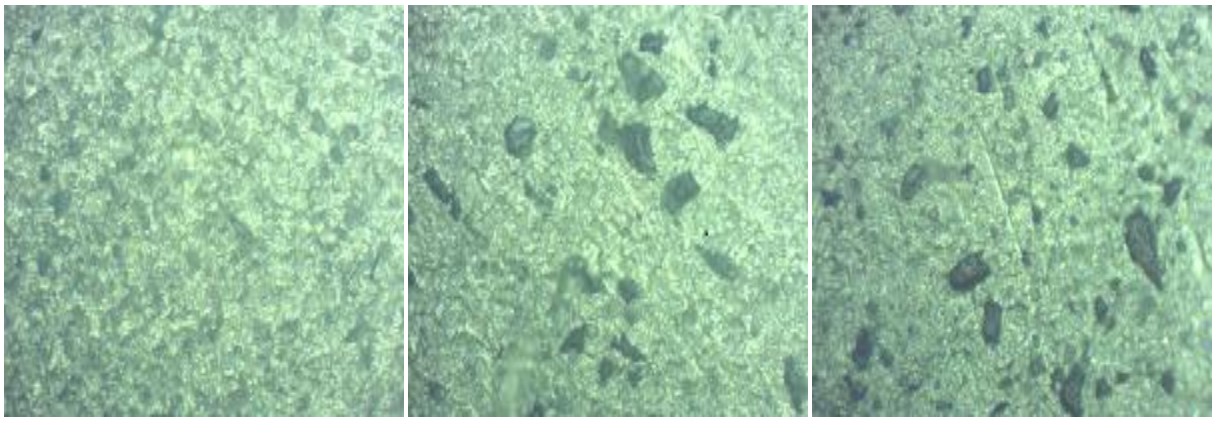
S.NO.	Wt percentage	Tensile strength in MPa (Set1)	Tensile Strength in MPa (Set2)	Tensile strength in MPa (average)
1	1	109	112	110.5
2	3	129	132	130.5
3	5	138	141	139.5
4	7	149	152	150.5
5	9	159	160	159.5

Table E: Hardness v/s Weight percentage of reinforcement (SiC).

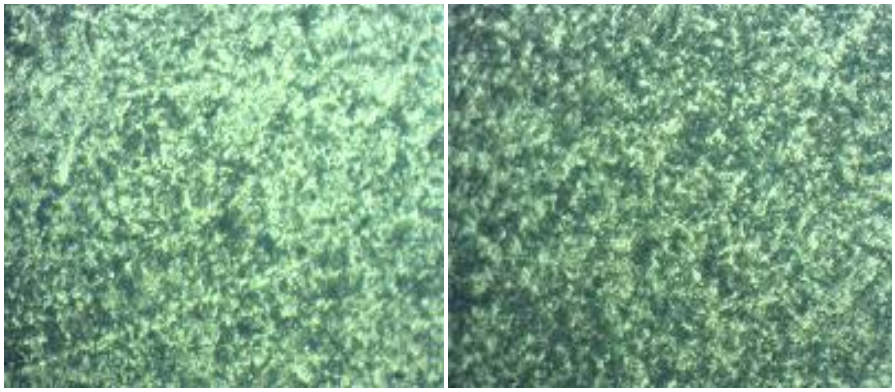
S.No.	**Weight (%)**	**Hardness (VHN) Set 1**	**Hardness (VHN) Set 2**	**Hardness (VHN) Average**
1.	1	48.6	47.2	47.9
2.	3	51.7	52.3	52
3.	5	58.9	59.1	59
4.	7	63.8	64.4	64.1
5.	9	70.1	71.1	70.6



Graph: Hardness v/s Weight (%) of Reinforcement (SiC).



(1 %) **(3%)** **(5%)**



(7%) **(9%)**

Various graphs, figures and images proves that after adding reinforcement (SiC) the various properties of the composite made by stir casting process are improved and have many new applications rather than old.

CONCLUSIONS

The prominent conclusions of the present research paper are as follows:

- There is a major emphasis was given on the homogeneous mixing of the reinforcing material (SiC) into the matrix material (Al 6063).
- Process adopted for making AMCs was moderate stir casting process.
- A major time was given to moderate the procedure in this research work.
- The percentage of reinforcing material (SiC) directly affects the tensile strength of the AMCs; as the increase in SiC, resulting in increased tensile strength of the AMCs.
- By increasing reinforcement in the AMCs, the hardness of the AMCs is also increased; however the grain size matters, because finer the grain size better the hardness.
- However, elongation(%) of the AMCs made by increasing reinforcement percentage, resulting in decreasing level.

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