# MECHANICAL PROPERTIES OF STIR CASTED AL6063-SiC METAL MATRIX COMPOSITE

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***Abstract:*** **Several technical challenges exist with the casting technology in achieving a uniform distribution of reinforcement within the matrix, which affects directly on the properties and quality of composite material .In the present study a modest attempt would be made to develop Aluminum based silicon carbide particulate MMCs with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. To achieve these objectives two step-mixing method of stir casting technique has been proposed and subsequent property analysis has been made. Aluminum 6063 T6 and SiC particle has been chosen as matrix and reinforcement material respectively. Experiments are planned for conducting varying weight fraction of SiC (in the steps of 5%) while keeping all other parameters constant. The results would be evaluated by Tests-Hardness, Impact (including micro-structure) for this 'development method'. The trend of hardness and impact strength with increase in weight percentage of SiC would be observed and recommendation made for the potential applications accordingly.**

**KEYWORDS***: MMC (Metal Matrix Composites), SiC (Silicon Carbide), Stir Casting Method*

## I.INTRODUCTION

Metal Matrix Composite (MMC) is engineered combination of metal (Matrix) and hard particles (Reinforcement) to tailored properties. Metal Matrix Composites (MMC's) have very light weight, high strength, and stiffness and exhibit greater resistance to corrosion, oxidation and wear. Fatigue resistance is an especially important property of Al-MMC, which is essential for automotive application. These properties are not achievable with light weight monolithic titanium, magnesium, and aluminum alloys. Particulate metal matrix composites have nearly isotropic properties when compared to long fiber reinforced composite. But the mechanical behavior of the composite depends on the matrix material composition, size, and weight fraction of the reinforcement and method utilized to manufacture the composite. The distribution of the reinforcement particles in the matrix alloy is influenced by several factors such as rheological behavior of the matrix melt, the particle incorporation method, interaction of particles and the matrix before, during, and after mixing. Non homogeneous particle distribution is one of the greatest problems in casting of metal matrix composites. Nai and Gupta [1] reported that the average coefficient of thermal expansion of the high SiC end was reduced as compared to that of the low SiC end. Hashim et al. [2] reported that the distribution of the reinforcement material in the matrix must be uniform and the wettability or bonding between these substances should be optimized. However, aluminum alloy with discontinuous ceramic reinforced MMC is rapidly replacing conventional materials in various automotive, aerospace, and automobile industries. Amongst various processing routes stir casting is one of the promising liquid metallurgy technique utilized to fabricate the composites. The process is simple, flexible, and applicable for large quantity production. The liquid metallurgy technique is the most economical of all the available technique in producing of MMC.

In this study stir casting is accepted as a particularly promising route, currently can be practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production, and allows very large sized components to be fabricated. The cost of preparing composites material using a casting method is about one-third to half that of competitive methods, and for high volume production, it is projected that the cost will fall to one-tenth.In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt. To obtain a suitable dispersion the stir casting method is used. The solidification of the melt containing suspended SiC particles is done under selected conditions to obtain the desired distribution.

From the past review, it is found that the number of research work on wear behaviour of MMCs have been published, but only few work related to the influence of weight fraction on mechanical properties like hardness, impact strength, percentage of elongation etc., have been reported. In this study, different weight fractions of Silicon Carbide particulates are added with aluminium matrix to fabricate the Al/SiC metal matrix composites. Different samples have been fabricated by melt-stirring casting and their microstructure, hardness and impact strength are studied.

## II.MATERIALS AND FABRICATED METHOD

### 2.1. Materials

The base material for the investigation is aluminium alloy (6063), as-received in the form of round bar as shown in Fig.1 with a chemical composition (determined by the use of a spectrometric analyzer) as presented in Table I. Silicon carbide (SiC) is used as reinforcement. 1% by weight of pure magnesium powder is used as wetting agent.Fig.2 shows the Silicon carbide powder.

Fig.1: Aluminum 6063-T6 material

Fig.2: Silicon carbide (SiC)

Table I
Chemical composition of AL-6063 T6

| Chemical Element | % Present |
|---|---|
| Manganese(Mn) | 0.0-0.10 |
| Iron(Fe) | 0.0-0.35 |
| Magnesium(Mg) | 0.45-0.90 |
| Silicon(Si) | 0.20-0.60 |
| Zinc(Zn) | 0.0-0.10 |
| Titanium(Ti) | 0.0-0.10 |
| Chromium(Cr) | 0.0-0.10 |
| Copper(Cu) | 0.0-0.10 |
| Other(Each) | 0.0-0.05 |
| Others(Total) | 0.0-0.15 |
| Aluminium(Al) | Balance |

### 2.2. Method

#### 2.2.1. Stir casting

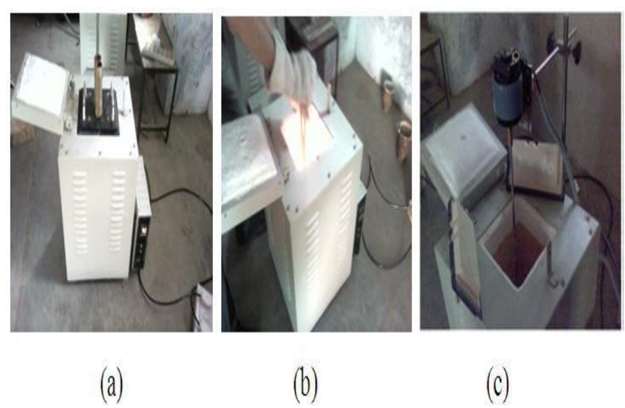



**Fig 3:**(a), (b) Induction resistance furnaces with temperature regulator cum indicator and (c) Melt-stirring setup utilized for casting of composites

Stir casting process starts with placing empty crucible in the muffle. At first heater temperature is set to 500°C and then it is gradually increased up to 900°C. High temperature of the muffle helps to melt aluminium alloy quickly, reduces oxidation level, enhance the wettability of the reinforcement particles in the matrix metal. Aluminium alloy Al6063 is used as Matrix material. Required quantity of aluminium alloy is cut from the raw material which is in the form of round bar. Aluminium alloy is cleaned to remove dust particles, weighed in the crucible for melting as shown in Fig 3.During melting nitrogen gas is used as inert gas to create the inert atmosphere around the molten matrix. Aluminium 6063, silicon carbide (SiC) and graphite are used as reinforcement. 1% by weight of pure magnesium powder is used as wetting agent. At a time total 700 gram of molten composite was processed in the crucible. Required quantities of reinforcement powder and magnesium powder are weighed on the weighing machine. Then it is thoroughly mixed with each other with the help of blending machine for 24 hour. This mixture is kept ready 1 day before the test has to carry out. Prior to conducting the test this mixture is kept for heating in another heater.

Reinforcements are heated for half hour and at temperature of 500°C. When matrix was in the fully molten condition, Stirring is started after 2 minutes. Stirrer rpm is gradually increased from 0 to 300 RPM with the help of speed controller. Temperature of the heater is set to 630°C which is below the melting temperature of the matrix. A uniform semisolid stage of the molten matrix was achieved by stirring it at 630°C.Pouring of preheated reinforcements at the semisolid stage of the matrix enhance the wetability of the reinforcement, reduces the particle settling at the bottom of the crucible. Reinforcements are poured manually with the help of conical hopper. The flow rate of reinforcements measured was 0.5 gram per second. Dispersion time was taken as 5 minutes. After stirring 5 minutes at semisolid stage slurry was reheated and hold at a temperature 900°C to make sure slurry was fully liquid. Stirrer RPM was then gradually lowered to the zero. The stir casting apparatus is manually kept side and then molten composite slurry is poured in the metallic mould as shown in Fig 4. Mould is preheated at temperature 500°C before pouring of the molten slurry in the mould. This makes sure that slurry is in molten condition throughout the pouring.

While pouring the slurry in the mould the flow of the slurry is kept uniform to avoid trapping of gas. Then it is quick quenched with the help of air to reduce the settling time of the particles in the matrix as shown in Fig 5.

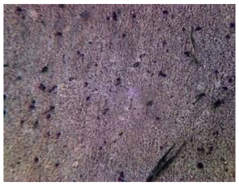
Fig 4: Pattern making for test specimen

Fig 5:Pouring of molten metal into mould

## III.RESULTS AND DISCUSSION

### 3.1 Microstructure

Metallographic samples were sectioned from the cylindrical cast bars. A 0.5 % HF solution was used to etch the samples wherever required. To see the difference in distribution of SiC particles in the aluminum matrix, microstructure of samples were developed on Inverted type Metallurgical Microscope (Make: Nikon, Range-X50 to X1500). Fig4 show Micrograph of Al/Sic-MMC's samples for different weight fraction (5%, 10%, 15%) of SiC particles. Optical micrographs showed reasonably uniform distribution of SiC particles. In this Al matrix SiC particles are clearly labeled.



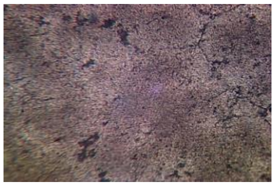


Fig 6(a): Al6063-SiC 5% Fig 6(b):Al6063-SiC 10%

Fig 6(c):Al6063-SiC15%

Micrograph of Al/Sic-MMC's samples for different weight fraction (5%, 10%, 15%) of SiC particles

**3.2 Hardness**

Hardness is another measure of the ability of a material to be deformed. There are many different tests of hardness measurement.

**3.2.1 BHN**

The brinell test consists of indenting the surface of the metal by a hardened steel ball under a load. The load is applied by lever system and the specimen is placed on stage with its ground face upwards. The height of the specimen can be raised by hand wheel so that the specimen is brought into contact with the indenter which is forced into the specimen by the specified load.

Formula for Brinell hardness

$$\text{B.H.N} = \frac{2P}{\pi D(D-\sqrt{D^2-d^2})} \text{--(1)}$$ **where**

P= load applied (kgf)

D= diameter of indenter (mm)

d = diameter of indentation (mm)

**3.2.2 Rockwell**

In the Rockwell hardness test, the hardness is determined by the depth of penetration of a indenter, rather than by surface area of the indentation. The specimen placed on stage is brought into contact with the penetrator , the penetrator is then slowly forced into the specimens surface by weights acting through a system of levers.

Model RAB from SEU Pvt. Ltd type equipment was used tomeasure the two types of hardness at load=150kgf, ball=2.5mm. Yield & ultimate strength values were shown in tabular form in TableIIand test specimens of different Sic compositions are also shown in Fig8 (a,b,c) and graphically in Fig 9.

Fig 7: Hardness testing machine

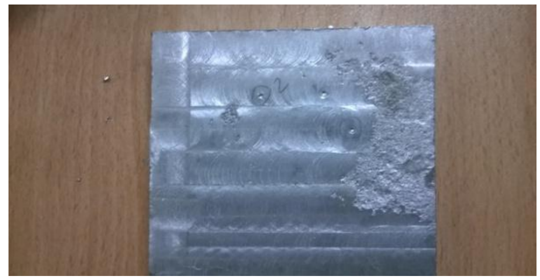


Fig 8(a): Al - 5% of SiC hardness test

Fig8(b): Al - 10% of SiChardness test specimen

Fig 8(c): Al - 15% of SiChardness test specimen

TableII

Brinell& Rockwell hardness results in BHN & RCN

| % of sicp | 5% | 10% | 15% |
|---|---|---|---|
| BRINELL | 86 | 96 | 97.5 |
| ROCKWELL | 16 | 26 | 27.5 |

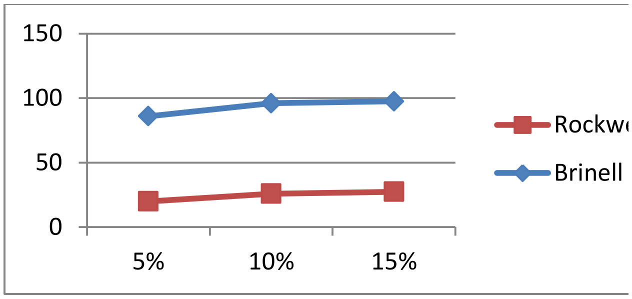



Fig 9: Brinell& Rockwell Vs Wt % OfSiC

From the above results, we can observe that the hardness of composite material increasing by varying the amount % of sic.

### 3.3 Impact strength

This is also known as the Charpy V-notch test is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. The Charpy testing machine is available in variety of sizes. A usual size is one having a capacity of about 30 KJ for testing metals. A notched specimen is mounted as simple supported beam and heavy pendulum is allowed to strike the specimen from a fixed height

Fig 10: Impact testing machine

The charpy testing machine with following specifications Maximum capacity: 30J,Minimum capacity: 2J,Distance between supports: 40mm±0.2mm is used for impact test. Impact test specimens at different Sic compositions are as shown in Fig11.

Fig 11:Impact test specimens

Impactis a high force or shock applied over a short time period when two or more bodies collide. Such a force or acceleration usually has a greater effect than a lower force applied over a proportionally longer time period of time. The effect depends critically on the relative velocity of the bodies to one another. The test results are shown in tabular form in TableIII and graphically inFig 12.

Table III

Impact test results in J

| % of SiC | 5% | 10% | 15% |
|---|---|---|---|
| Charpy | 7.4 | 11 | 18 |

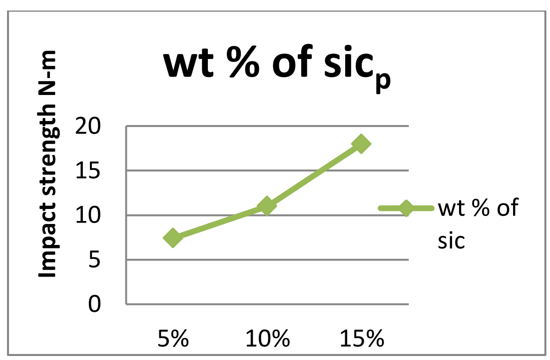



Fig 12: Impact strength Vs Wt % of SiC

From the above results, we can observe that the composition of 15% sichas the highimpact strength comparing to the compositions of about 5%SiC, 10%SiC

## IV.CONCLUSION

The composition of aluminum with the increased weight fraction of silicon carbide increases the mechanical properties. The mechanical properties like impact and hardness attained maximum at 15% of SiC. At the composition of Al 6063-SiC from 5%

to 10% there is a drastic change in mechanical properties and at 10% to 15% there is small vary in mechanical properties. Homogenous dispersion of SiC particles in the Al 6063-SiC particle Composite shows an increasing trend in the samples prepared by applying stirring process, with manual stirring and with 2-Step method of stir casting technique respectively.Due to the extensive applications of aluminum 6063/SiC metal matrix composites it is used in manufacturing industries, structural designs, automotive parts (hydro dynamic tube chassis)

## REFERENCES

[1] Nai, S.M.L. and Gupta, M. ,"Synthesis and Characterization of Free Standing, Bulk Al/Sicp Functionally Gradient Materials: Effects of Different Stirrer Geometries," *Material Research Bulletin*, 38: 1573-1589. 2003.

[2] Hashim, J., Looney, L. and Hashmi, M.S.J., "Particle Distribution in Metal Matrix Composites," Part-I, *Journal of Materials Processing Technology*, 123: 251-257. 2002.