FABRICTAION AND CHARACTERISATION OF SIC AND AL_2O_3 PARTICLES REINFORCED AL6061 METAL MATRIX COMPOSITIES

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Abstract: The necessity of aluminium based composites in the fields of Automobile, Aerospace, Electrical was started due to high Strength, Hardness and Stiffness at low weight. The commonly used reinforcements for aluminium are SiC, Al_2O_3, graphite etc. By the addition of ceramic particles to aluminium increases strength, hardness remarkably. In this study SiC and Al_2O_3particles were taken as reinforcement and mixed with Al 6061 by using stir casting technique. Experimental tests such as tension, hardness were conducted on composite samples, base metal and those values are compared. In the microstructure of composite samples, uniform distribution of reinforced particles was observed by conducting scanning electron microscope (SEM).

Index Terms– Composites, Ceramic particles, Reinforcements, Stir casting, SEM etc.

1. INTRODUCTION

The term composite material has many meanings based on various literatures; one of them is the combination of different multifunctional material systems that provide excellent properties which are not possible in individual systems. Initial investigations were made with process development using fiber reinforcement. Anisotropy, expensive fabrication cost and restricted secondary processing has led to the use of short fiber / particulate / whisker reinforced composites. The combination of good transverse properties, low cost high workability and significant increase in performance over unreinforced alloys are the commercially attractive features of these discontinuous reinforced composites. Compared to dispersion strengthened systems, particulate reinforced composites contain coarse size reinforcement (1-100 µm) in relatively high weight fractions (1-30%). In particulate composites, both matrix and reinforcement bear substantial load. In addition, matrix strength as affected by precipitation and dislocation strengthening plays an important role in the load bearing capacity of these composites. Metal matrix composites reinforced with ceramic particles are widely used due to their high specific modulus, strength and wear resistance.

2. LITERATURE SURVEY

The need for light weight materials was created the demand of metal matrix composite materials in the field of aerospace and automobile. Metal Matrix Composite materials are the materials which have superior properties than the monolithic materials. Among these composites Aluminum metal matrix attracts much attention because of its low weight, high strength, moderate casting temperature and other properties. Many kind of ceramic materials such as e.g, Al_2O_3, SiC, TiC, WC, TiB_2, MgO, TiO_2, B_4C, BN, CNT and graphite are most commonly used **[1,2]**.Alumina (Al2O3) and Silicon Carbide (SiC) have attracted scientific and technological interest because of their significant advantages in comparison with most existing materials. Many researchers have shown that Silicon Carbides possess remarkable mechanical properties, such as exceptionally high elastic modulus and high tensile strength **[2]**.

Kumar et al. [3] opted the stir casting route to fabricate the Al6061 composites with fly ash. Different particle size 75-100, 45-50 and 4-25µm of fly ash were taken to introduce in molten phase. Each of the set covers three different types of samples reinforced with weight fractions of 10, 15 and 20%. Investigations reveal that the size of particles of fly ash affects compressive strength, hardness and tensile strength of the Al6061. It was also observed that the increasing weight fraction of the fly ash particles decreases the ductility in the composite. However, increase in ultimate tensile strength, compressive strength and hardness values. There was novoids have been seen through SEM study.

Rajan et al. [4] Investigated three stir casting techniques on Al-Si -Mg alloy composite reinforced with fly ash particles was investigated. In these investigations the liquid metal stir casting, compo-casting, and modified compo casting followed by squeeze casting routes were evaluated. Modified compo casting results in a composite free from any type of porosity and proper distribution of particles.

Jayaseelan et al. [5] Compared the extrusion characteristics of Al-SiC produced by two methods namely powder metallurgy & stir casting. Stir cast specimens exhibited finer microstructure & high hardness as compared to specimens produced by powder metallurgy. They also possess higher strength.

Keshavamurthy et al. [6] Fabricated Al7075-TiB2 in-situ composite through stir casting technique. Investigations revealed that micro hardness, yield strength and ultimate tensile strength of Al7075-TiB2 composite, were considerably higher when compared with unreinforced alloy.

Prabu et al.[7] Studied the influence of stirring process during 64 Suman Kant and Ajay Singh Verma Fabrication of Al/105 SiC composite. Observations reveals that the microstructure of composite under varying stirring speed and stirring time shows the change in structure along with hardness of fabricated composite. Findings also reveal that particle agglomerate was more when operated at low stirring speed with less stirring time. However, increase in stirring time and speed shows better particles distribution.

Rajesh Kumar et.al [8] Studied the effect of process parameters in stir casting for the fabrication of Al2O3/SiC reinforced Aluminum composites.

Madeva Nagaral et.al[9] Studied the mechanical behavior of Al6061, reinforced with 6 wt% of Al_2O_3 and graphite is added from 2, 4 and 6 wt % into the base matrix. Mechanical properties like hardness and tensile strength of MMC were found to increase with the addition of Al_2O_3 particles but Micro-Vickers hardness of the Al6061-6wt% Al_2O_3 were found to be decreasing with the increase of graphite content and the influence of graphite content on tensile strength is very less.

Jayashree P .K et.al[10] Observed the effect of SiC reinforced Aluminum composite on mechanical and wear properties through stir casting

3. MATERIALS AND METHOD

3.1. MATERIAL

Aluminium 6061(Al6061) alloy is a precipitation-hardened aluminum alloy, containing magnesium and silicon as its major alloying elements.

Table 3.1.1: Chemical Composition of Al6061

Components	Amount (% wt.)
Silicon	0.4-0.8
Magnesium	0.8-1.2
Copper	0.015-0.40
Manganese	0-0.15
Iron	0-0.7
Chromium	0.04-0.35
Zinc	0-0.25
Titanium	0-0.15
Others	0.15 not more than 0.05& each*
Aluminium	95.85-98.56

Table 3.1.2: Physical and Mechanical Properties of Al6061

Physical Properties	
Density (ρ)	2.70 g/cm^3
Mechanical Properties	
Young's modulus (E)	68.9 GPa
Tensile strength (σ_t)	124–290 MPa
Elongation (ε) at break	12–25%
Poisson's ratio (ν)	0.33

3.2. METHOD

Stir casting method is a liquid state method for making the Metal Matrix Composites. Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional metal forming technologies.

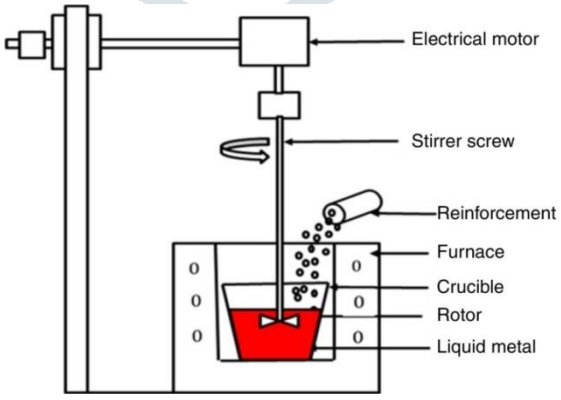


Fig.3.2: Stir Casting Apparatus

The matrix material used for the present study is 6061Al-alloy. The chemical composition of matrix material is as shown in Table 3.1.1. SiC and Al2O3 particles with size of 100-150μm and with varying amounts of 5,10wt% are being used as reinforcing material in the preparation of composites. Stir casting technique has been used for the preparation of composites. Initially calculated amount of Al6061alloy was charged into SiC crucible and superheated to a temperature of 800^{0}C in an electrical resistance furnace. Vortex is generated with the help of a zirconia coated steel impeller. At every stage before and after introduction of reinforcement, mechanical stirring is carried out for a period of 10 min. The stirrer was preheated before immersing into the melt, and is located approximately to a depth of 2/3 height of the molten metal from the bottom and run at a speed of 200 rpm. Composite mixture was poured into permanent cast iron moulds having diameter 12.5mm and length of 125mm at a pouring

temperature of 750^0 C. The prepared composites were characterized by microscopic studies. Specimens of 12mm diameter and thickness of 10mm were cut from the central portion of the casting for microstructural studies.SEM photographs were obtained using Scanning Electron Microscope (make-Joel, Japan). To investigate the mechanical behaviour of the composites the hardness and tensile tests were carried Conducted. The Micro-Vickers hardness values of the composites before and after addition of SiC and Al2O3 particles were measured with a load of 20N using MVH-II digital micro hardness tester. The hardness value reported is the average value of 10 readings taken at various locations on the polished specimen. Similarly tensile tests were carried out before and after addition of SiC and Al2O3 particles.

4. RESULTS AND DISCUSSIONS

4.1. MICROSTRUCTURE

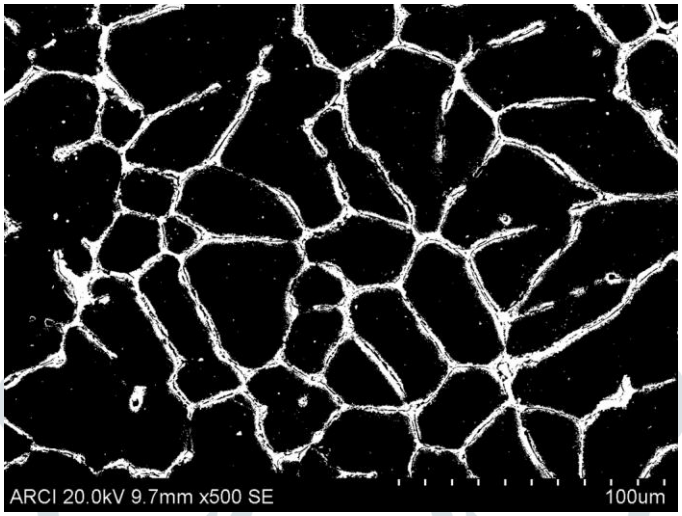


Fig.4.1.1: Microstructure of Al 6061 Alloy

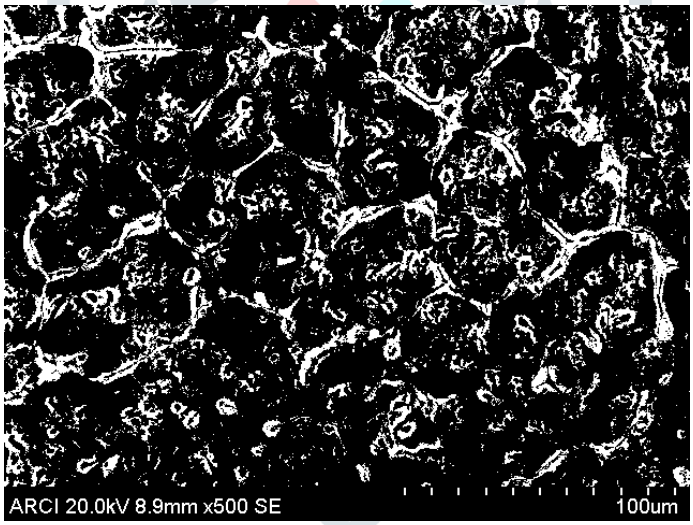
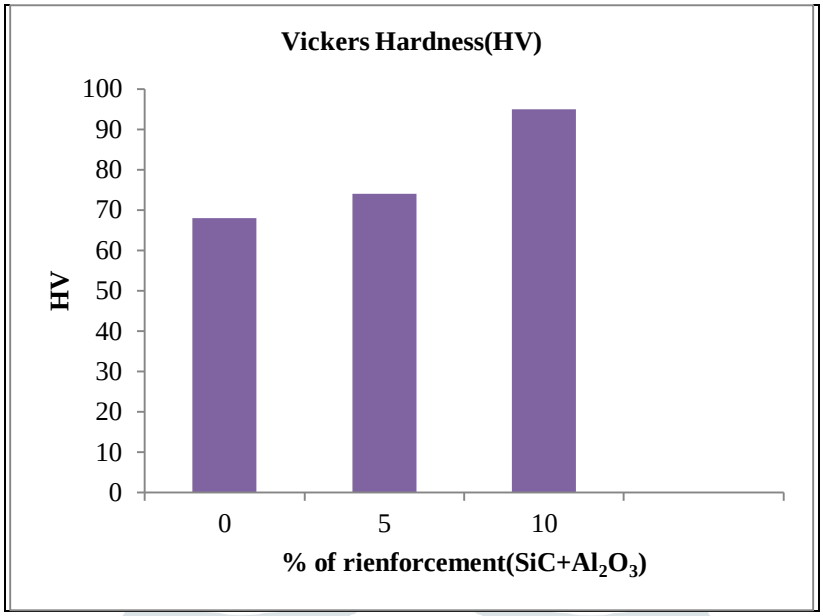


Fig.4.1.2: Microstructure of 10% (SiC+Al2O3) Composite

By using scanning Electron microscope, the microstructures of Base metal and10% Composite Samples were investigated. From the fig.4.2, we observed that uniform distribution of reinforcement particles in the Al6061 Matrix was made.

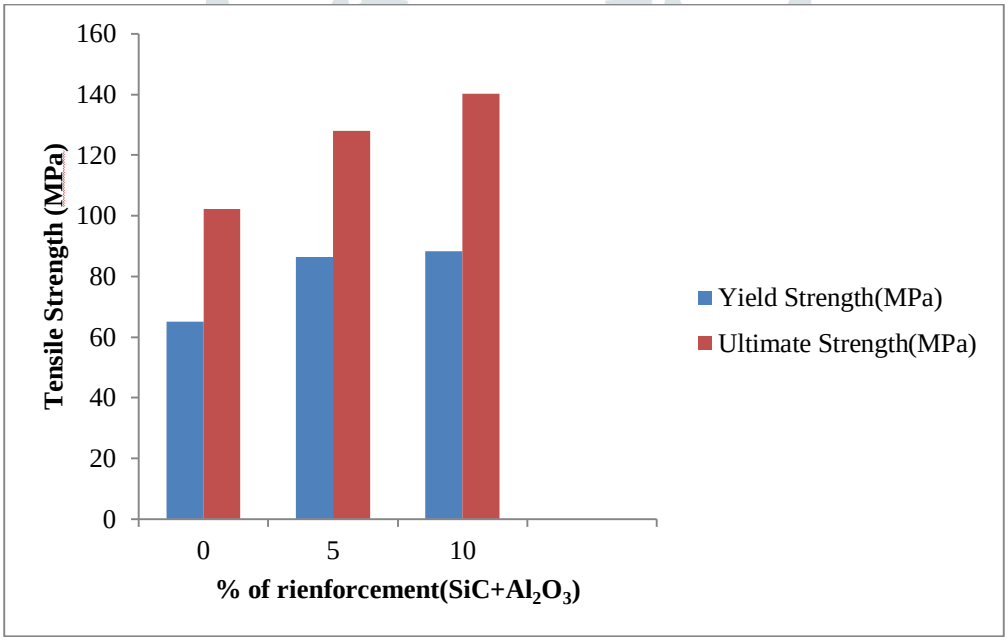
4.2. HARDNESS



Graph 4.2: % of Reinforcement vs. Hardness

Addition of reinforcement to the 6061 Al alloy, improvement in Hardness values of composite samples was observed through Vickers Hardness test.

4.3. TENSILE STRENGTH



Graph 4.3: % of Reinforcement vs Tensile Strength

From the graph 4.3, result shows that increment in Yield and Ultimate strength of composite samples as compared to base element by the addition of reinforcement.

5. CONCLUSION

SiC and Al_2O_3 /Al6061 composites were produced by stir casting route successfully. There was a uniform distribution of Al_2O_3 and SiC particles in the matrix phase. From the SEM figures, it clearly shows that there were novoids and discontinuities in the composites; there was a good interfacial bonding between theAl_2O_3 and SiC particles and matrix phase. The density of the composites increases with increasing the percentages of Al_2O_3 and SiC particulates compared to the density of the alloy 2.7g/cm^3.The measured densities were lower than that obtained from theoretical calculations. The extent of deviation increases with increasing Al_2O_3 and SiC content. The hardness and tensile strength of the composites were increased with increasing the amount of Al_2O_3 and SiC than the base alloy.

By the addition of 10 %(SiC+Al_2O_3) to Al6061 alloy, the following results were studied:

- Uniform distribution of reinforced particles in Al6061 was observed in microstructure.
- The Enhancement of 35.8% in Yield Strength and 66.8% in Ultimate Strength was achieved.
- Hardness was improved by 39.7%.

6. REFERENCES

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