Evaluation of Microstructure and Hardness of Al-Sic Metal Matrix Composite Material

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***Abstract*— One of the most commonly utilized MMCs in industrial sectors like aerospace, auto sport, automotive, medical science, and other production sectors is aluminium 6061. Due to its unique mechanical and chemical qualities, including as its resistance to corrosion, indentation, and weight as compared to other metals, aluminium 6061 is frequently utilized as the matrix in MMC. In this present study, silicon carbide (30 microns) was used as reinforcement material while aluminium 6061 alloy was used as the matrix. In comparison to Al 6061, silicon carbide castings of 0, 6, 8, and 10 weight percent were made. The manufacturing procedure/technique utilized to create the cast is called stir casting. This aids in distributing the cast's particles evenly. The microstructure of cast products is examined using a scanning electron microscope, which reveals that reinforcement is evenly distributed throughout the product and enhances its varied mechanical qualities. To analyse the hardness, various hardness tests are applied to various composited MMCs.**

Keywords*— *Aluminium 6061, Silicon Carbide, Stir Casting and Hardness

I. INTRODUCTION

The metal that is most readily available and makes up the majority of the earth's surface is aluminium. Due to its unique qualities, aluminium is employed in a wide range of items, including industrial machinery and automobile components. Bauxite is a mineral from which the alloy aluminium is obtained. The key characteristics of aluminium are ductility, malleability, softness, corrosion resistance, and others. Co Carborundum is another frequent term for silicon carbide. It has a powerful chemical composition with Silicon and Carbon as the primary ingredients. This chemical is created by combining silicon powder with carbon powder and a plasticizer. Powdered silicon carbide is frequently on hand. Silicon carbide is widely utilised in automobile parts like car cluthes, car brakes, and other parts due to its grain bonding properties.

A composite material is one that is created from the components of two or more different materials. The components that make up the composite material possesses a variety of chemical and physical characteristics. worked together to develop a material with unique qualities from each individual constituent. Metal matrix composites are materials that combine fibres with other metallic matrixes, such as steel, copper, and aluminium. Aluminum alloy Al 6061 alloy reinforced with silicon carbide in the range of 0%, 6 %, 8 %, and 10% by weight with an average particle size of 30 microns were created for the continuing experiment utilising stir casting. This experiment's primary application is to investigate and concentrate on improving the properties.

A mechanical stirrer is used in the stir casting process to mix the reinforcing matrix material. Aluminum 6061 Alloy is heated in the crucible to a temperature of 250° before being heated to melting point, at which point it transforms from a solid to a liquid at a temperature of 660°c. For each specimen, different amounts of silicon carbide were added to the molten metal to determine what percentage of reinforcement had good hardness qualities. These amounts ranged from 0% to 10%. aluminum and silicon carbide are heated for a while, agitated for 15 minutes at 500 rpm, and then the molten metal is poured into a cavity of a sand mould with dimensions of 200 x 200 x 50 mm. The hardness of the composites were investigated, and their relation with the corresponding microstructures and processing parameters were discussed.

Some allowances like machining allowance, shrinkage allowance, and draught allowances are given for ease of further process.

II. LITERATURE REVIEW

Sijo & Jayadevan [1] have discussed on analysis of stir casted aluminium silicon carbide metal matrix composite. The main limitation of stir casting Al-Sic MMC are improper distribution of Sic reinforcement in matrix and less wettability of Sic reinforcement particles with molten aluminium. Arun Kumar S et.al [2] have investigated on the effect of porosity of al 6061 alloy reinforced with silicon carbide metal matrix composites through stir casting process. Casted specimens were tested for chemical composition using Spectro analysis , micro image and micro hardness are conducted. Wankhade, L. N et.al [3] have discussed on metal matrix composites are composite material in which nano or micro sized particels has reinforced with other base metals using stir casting a total of three specimens are prepared, i,e., 0, 2.5, & 5% by wt of silicon carbide respectively, in aluminium as a base metal.

III. MATERIAL SELECTION AND METHODOLOGY

A. Material Selection

In this study, the matrix material is aluminium alloy 6061. As reinforcements, silicon carbide is used. The properties of the matrix material and the reinforcements are listed in Table 1. For the fabrication of Aluminium Metal Matrix Composite, commercially pure Aluminum 6061 alloy is used as the matrix and 0, 6, 8, and 10 wt% 0f Silicon Carbide was used as reinforcement. The below picture shows the pure SiC powder with a scale of 30 microns.

Fig 1: Silicon Carbide powder.

Table 1 : Composition

Samples	6061Al (%)	SiC (%)
1	100	0
2	94	6
3	92	8
4	90	10

A. Fabrication process

One of the crucial techniques utilised in the metallurgical process is the stir casting technique. Metals such as copper, aluminium, magnesium, and others are melted using this technique. It is a popular and cost-effective technique for creating and treating metal matrix composites. Fig depicts the stir casting schematic diagram. In this study, stir casting, a straightforward and affordable method, is used to create composites made of aluminium metal matrix materials. By continually stirring the molten base metal, composite is created. The final step is to add the reinforcements. After that, the slurry is placed into the die to solidify. The agglomerates can be successfully dissolved by vigorous stirring at a high temperature.

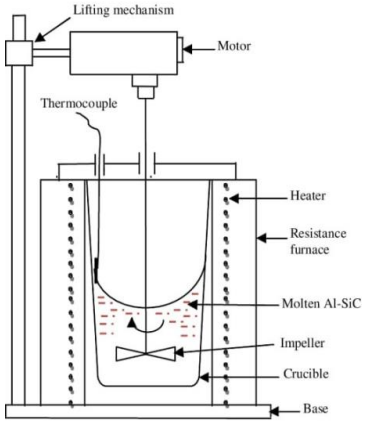

Fig 2: Stir Casting Machine

IV. RESULTS AND DISCUSSION

B. Hardness Test

The results of the various hardness test are displayed in Table 2. Sample 4 has a harder surface than the other samples because it contains a lot of silicon andAfter performing different tests, the following conclusions is drawn:

Due to the presence of a high quantity of carbides as reinforcement, sample 4 (90 % 6061Al and 10 % SiC has harder than the other samples.

Table 2 : Hardness Values

Particulars	RHN	VHN	BHN
Sample 1	79	39.28	74.85
Sample 2	81	47.25	76.94
Sample 3	84	49.25	80.75
Sample 4	87	56.82	86.35

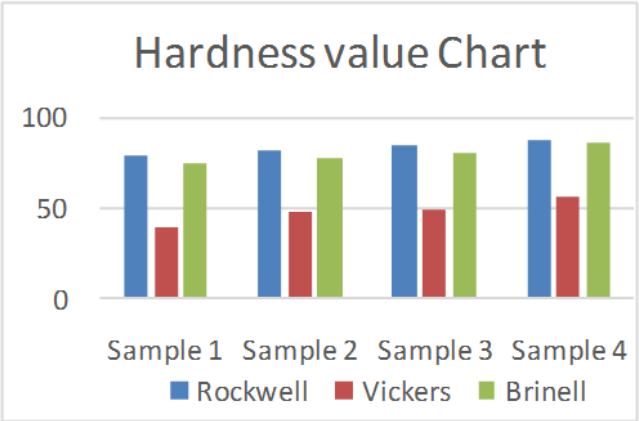

Chart 1: Hardness value chart

C. Morphological Examination

Using a scanning electron microscope, morphological examination was done on the examined specimens to identify internal surface flaws such blow holes, cracks , and the accumulation of reinforcement (SEM). In SEM, an image is created from the bombardment of electrons that reflect. The microstructure of a composite 6061 aluminium alloy made by stir casting with various weight fractions of silicon carbide is examined using scanning electron microscopy.

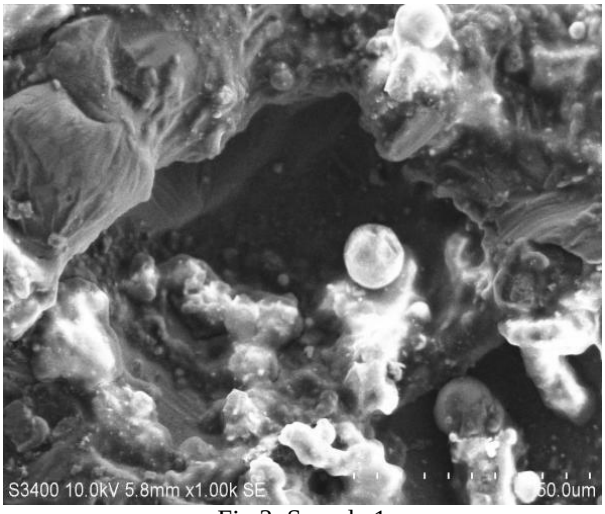

Fig 3: Sample 1

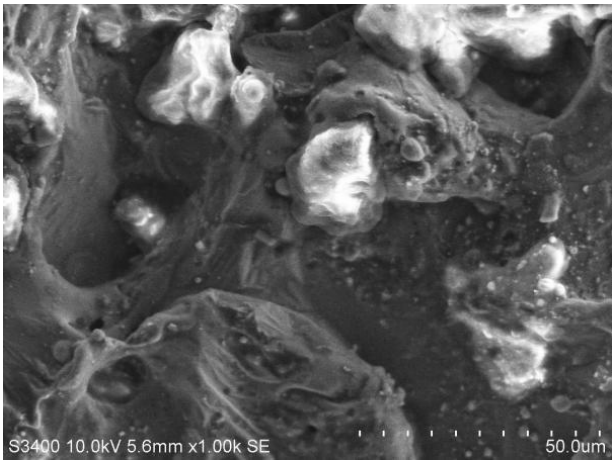

Fig 4: Sample 2

Fig 5: Sample 3

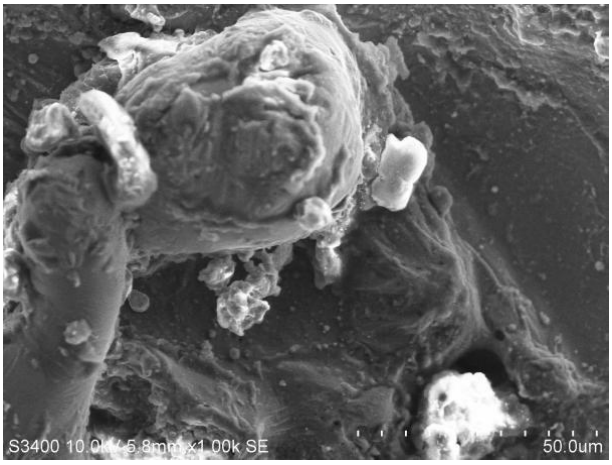

Fig 6: Sample 4

Using a scanning electron microscope, the microstructure of MMCs as depicted in Figures 3, 4, 5, and 6 was investigated. It is seen from the SEM images that the SiC contains particles of various sizes and shapes. The results of the SEM pictures reveal that the SiC particles are distributed quite uniformly, and that the matrix occasionally has cracks, blowholes, porosity, and other casting flaws. While the ceramic phase is represented by a dark phase, the metal phase is represented by a white phase.

V. CONCLUSION

In this work, the stir casting technique is used for fabrication of aluminum metal matrix composites with different compositions of silicon carbide reinforcement viz., 0% SiC, 6% SiC, 8% SiC and 10% SiC. The different samples were subjected for hardness test, sample 1 has RHN 80, VHN 42.54, BHN 75.98, sample 2 has RHN 82, VHN 48.64, BHN 79.1, sample 3 has RHN 85, VHN 53.73, BHN 83.93 and sample 4 has RHN 89, VHN 59.36, BHN 88.53. Sample 4 has highest hardness due to the presence of the high quantity of silicon carbides in the composite. It can be concluded that the hardness value of prepared specimens increases with the increase in reinforcement particles of silicon carbide.

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