Characterization of Aluminium-Silicon Carbide Composite using Stir Casting Technique

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Abstract— In order to enhance the performance of materials used in applications like transportation, electrical and structural applications, composite materials have been used in recent days. Properties like high specific strength; specific modulus and good wear resistance of composite materials make them to be applied in various fields compared to unreinforced materials. Solid state production, semi solid state and liquid state production route are among the various techniques that are followed to produce composites. The best technique in terms of cost and simplicity in production is the stir casting technique which belongs to liquid state production. The objective of the project is to fabricate Al-SiC composite by using stir casting method and study its mechanical properties. For this purpose aluminium 6061 alloy is casted and its mechanical properties are compared with composite with silicon carbide reinforced in the percentage of 2, 4, 6 and 8% respectively.

Key words: Aluminium-Silicon Carbide Composite, Stir Casting

I. INTRODUCTION

In the stir casting method, the ceramic particles are introduced into a molten matrix using various techniques, followed by mixing or pressing, and casting the resulting metal matrix composite. In this process, a strong bond between the matrix and reinforcement is achieved by using high processing temperatures, and often, alloying the matrix with an element which can interact with the reinforcement to produce a new phase which improves wetting between the matrix and the reinforcement material. There is variation in stir casting methods, in the way the liquid metal is stirred in fully liquid state, such as by vortex method, or in a partially solidified state such as in the compocasting method. In the vortex method, the reinforcement is introduced into a vortex created in the liquid metal by stirring Reinforcement is efficiently distributed throughout the melt, and the resulting composites can be cast. Whereas in the compocasting, or rheocasting technique, the melt is vigorously stirred as it cools below the liquidus temperature. This produces slurry in which the metal solid has a non-dendritic or rounded form. The mixture is cast, often using pressure to ensure the flow of the viscous material.

II. METHODOLOGY

- Synthesis of aluminium alloy with SiC composite using stir casting technique.
- Preparation of specimens for testing.
- Characterization of the test specimen by SEM.
- Testing of specimen.

A. Analysis of the Results:

Initially, aluminium 6061 alloy in the form of bars are introduced into the graphite crucible and heated to its melting point (to about 650°C to 700°C).

The crucible is maintained in a nitrogen gas atmosphere to make sure that there are no oxides that may affect the casting process.

The aluminium melts in the crucible which is stirred manually to make sure uniform distribution of aluminium alloy in the crucible after manual stirring the stirrer is immersed into the molten bath.

The stirrer is set to rotate to about 500 rpm which is the optimum speed for stir casting of aluminium silicon carbide composite.

Next, the Silicon Carbide powder (220) is added to the crucible containing molten aluminium. Different proportions of silicon carbide reinforcement, i.e. 2,4,6 and 8% is added to the molten bath to obtain different castings.

The molten metal is poured through the sprue into the mould prepared to suit the shape of the specimen required. The specimens after solidification are removed from the mould and subject to annealing.

The specimens were machined to required standards needed for testing.

The specimens of different reinforcement percentage were then subject to SEM analysis. Then tensile, compression, impact and hardness tests were conducted

III. EXPERIMENT DETAILS

A. Materials used

1) Aluminium 6061

The major alloying elements present in precipitation hardening aluminium alloy 6061 are magnesium and silicon. It was developed in 1935 also called "alloy 61S".the major reason for using this alloy is because of desirable mechanical properties and good weldability. This alloy is most commonly used for commercial applications.

2) Silicon Carbide

Silicon and carbon contain silicon carbide as a compound. The chemical name of silicon carbide is SiC. Silicon carbide in the form of grains are sintered which forms a very hard material known as ceramics. Ceramics have got good electrical, mechanical, chemical thermal properties. The property of silicon carbide to resist high temperatures initiates it use in the electrical circuit boards, semiconductor diodes, etc.

B. Fabrication of Composite by using Stir Casting Technique:

Aluminium 6061 was used as a matrix metal for the MMC and silicon carbide was used as reinforcement. Aluminium 6061 alloy in the form of bars, silicon carbide (220 meshes)

was selected as the materials for the composite. In order to carry out the casting process stir casting set was used which is as shown in the Fig.

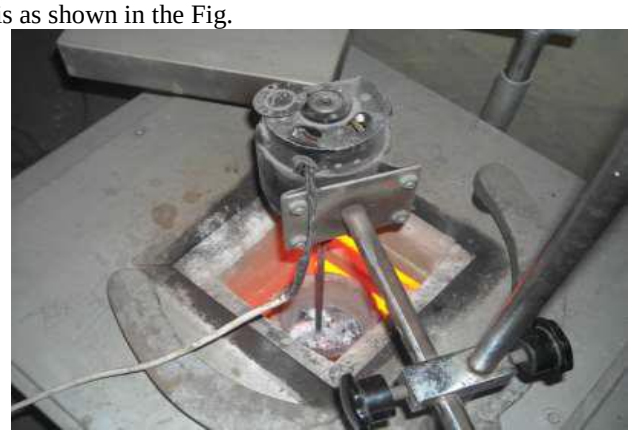

Fig. 1: Stir Casting Set Up.

C. Preparation of Mould

The next step was preparation of mould in order to cast the MMC. According to the project requirement, it was necessary to obtain a square cross section specimen of dimension 100×40×40 (dimension in mm) and henceforth a sand mould was prepared as per the requirement. Every mould was prepared to obtain two specimens and the mould prepared is as shown in the below Fig.

Fig. 2: Mould prepared to suit the specimen dimension to be obtained.

In the next step, the molten aluminium was poured to the mould through the sprue till the mould was completely filled with the molten aluminum. The pouring of aluminium is as as shown in the Fig.

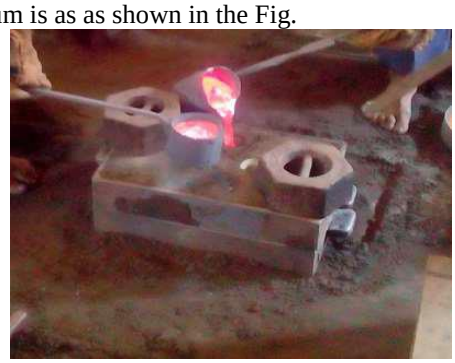

Fig. 3: Pouring of molten Al-SiC composite into the mould.

D. Designation of Aluminium (Matrix Material) and Silicon Carbide (Reinforcement Material)

Si. No.	Composite (A-Aluminium Alloy 6061), (Sic-Silicon Carbide)	Reinforcement (Wt%)
1.	A	Aluminium alloy 6061
2.	A-2SiC	2% of Silicon Carbide
3.	A-4SiC	4% of Silicon Carbide
4.	A-6SiC	6% of Silicon Carbide
5.	A-8SiC	8% of Silicon Carbide

Table 1: Designation of Aluminium (Matrix Material) and Silicon Carbide (Reinforcement Material)

IV. RESULTS & DISCUSSION

A. Microstructure:

The composite was examined under the optical microscope to determine the microstructure. It was first belt ground, followed by polishing with different grade of embryo paper, then they were washed and polished in cloth and then washed, dried and etched with the Keller‟s solution and then examine through the optical microscope

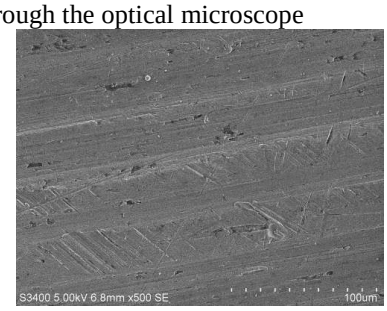

Fig. 4: Microstructure of aluminium reinforced with 2% silicon carbide.

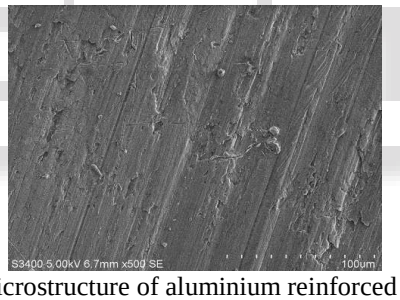

Fig. 5: Microstructure of aluminium reinforced with 4% silicon carbide.

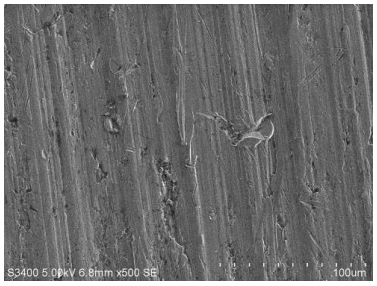

Fig. 6: Microstructure of aluminium reinforced with 6% silicon carbide.

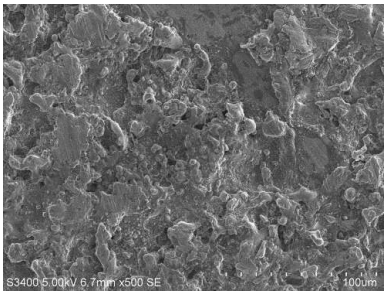

Fig. 7: Microstructure of aluminium reinforced with 8% silicon carbide.

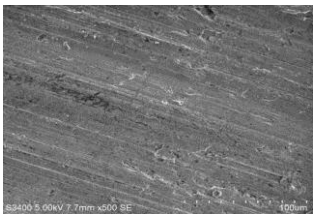

Fig. 8: Microstructure of cast aluminium alloy 6061

The casted aluminium alloy 6061, its microstructure shows uniform distribution all over the composite. The aluminium added with silicon carbide reinforcement shows some amount of porosity. It may be due to the air bubbles formed while pouring of molten cast from crucible into the mould. Fine grain structure has be revealed when the specimen was subject to microscopical analysis.

B. Hardness Test

Brinell hardness number (BHN) of aluminium reinforced with silicon carbide

SI No.	Material	BHN
1.	**A**	**65**
2.	**A-2SiC**	**66.3**
3.	**A-4SiC**	**67.6**
4.	**A-6SiC**	**68.8**
5.	**A-8SiC**	**67.4**

Table 2: Brinell hardness number (BHN) of aluminium reinforced with silicon carbide

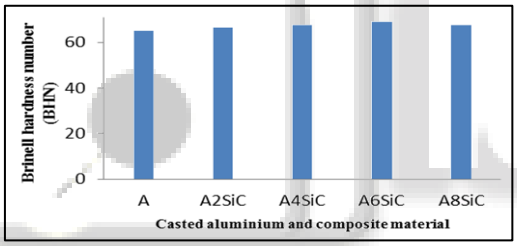

Fig. 1: Chart showing (BHN) of aluminium reinforced with silicon carbide

C. Compression Test

Table shows the compression strength of aluminium reinforced with silicon carbide

SI No.	Material	Compression strength, MPa	Peak load (kN)
1.	**A**	**496.71**	154.8
2.	**A-2SiC**	**775.72**	240.3
3.	**A-4SiC**	**781.08**	218.82
4.	**A-6SiC**	**693.06**	243.18
5.	**A-8SiC**	**656.23**	210.72

Table 3: shows the compression strength of aluminium reinforced with silicon carbide

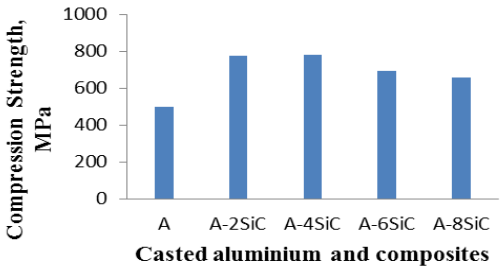

Fig. 2: Chart showing compression strength of aluminium reinforced with silicon carbide.

D. Tensile test

Table shows the tensile strength of aluminium reinforced with silicon carbide

SI No.	Material	Tensile strength, MPa	% Elongation (%)
1.	**A**	147.504	4.46
2.	**A-2SiC**	143.383	5.49
3.	**A-4SiC**	142.736	6.03
4.	**A-6SiC**	152.866	5.86
5.	**A-8SiC**	136.320	6.17

Table 4: Shows the tensile strength of aluminium reinforced with silicon carbide

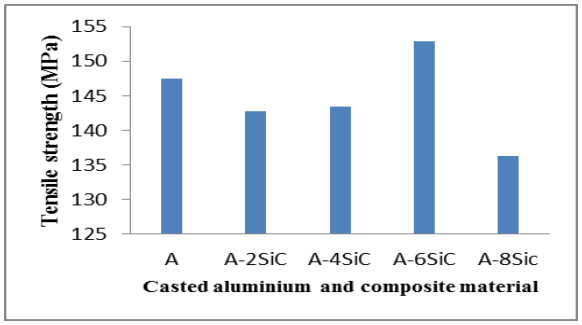

Fig. 3: Chart showing the tensile strength of aluminium reinforced with silicon carbide.

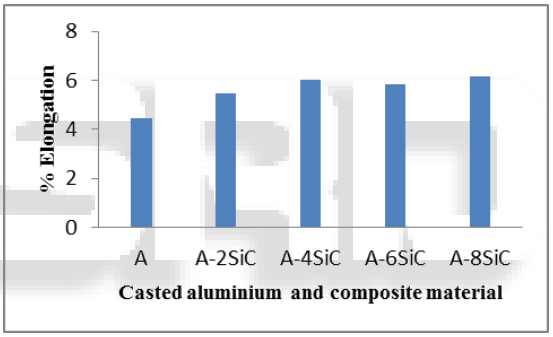

Fig. 4: Chart showing % elongation of aluminium reinforced with silicon carbide.

V. CONCLUSIONS

In this project, fabrication of Aluminium-Silicon Carbide composite by stir casting technique was carried out for different proportions of silicon carbide reinforcement i.e. 2,4,6 and 8% respectively by weight. The main objective of the project was to compare the test results of Aluminium alloy 6061 with different percentage of silicon carbide reinforcement material to the Aluminium alloy 6061 matrix material.

- By studying the microstructure its was found that the alloying element is dispersed in the matrix of aluminium with uniform distribution of silicon carbide reinforcement.
- When compared to the hardness value of aluminium 6061 alloy with the reinforced composites highest hardness value is obtained for 6% silicon carbide reinforcement. Further adittion of reinforcement resulted in decrease in hardness.
- The compression strength for different loads was found and the highest compression strength was obtained at reinforcement of 4% silicon carbide.

The compression strength reduced after further addition of reinforcement, i.e at 6%.

- Tensile strength was found maximum at a reinforcement of 6% silicon carbide. As compared to the tensile strength of aluminium alloy 6061 the tensile strength is more at 6% of silicon carbide reinforcement, after that i.e at 8% of reinforcement the tensile strength reduces.
- By studying the results, it is found that the mechanical properties like compession strength,tensile strength and hardness have improved by the addition of silicon carbide reinforcement as compared to the casted aluminium alloy 6061.

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