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Fabrication and Characterization of Mechanical Properties of Al7003 Reinforced with 6% SiC Matrix Composite

Sathisha R C[1], Dr. B. S. Ravikiran[2], Dr. S. N. Lakshminarasimhan[3]

[1]Student, Department of Industrial Engineering and Management, SSIT, Tumakuru, Karnataka,
[2]Dr. B. S. Ravikiran, Associate Professor, Dept. of IEM, SSIT, Tumakuru, Karnataka,
[3]Dr. S. N. Lakshminarasimhan, Professor and HOD, Dept. of IEM, SSIT, Tumakuru, Karnataka,

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Abstract - *In the present work, Al7003 is taken as base material and then it is reinforced with Silicon Carbide (SiC). Aluminium Metal Matrix Composites are prepared by 6% percentage volume of SiC as reinforcement to the base material Al7003. Stir Casting Process fabrication method is used to prepare the samples. After the preparation of required samples tests are performed to assess the mechanical properties such as Tensile Strength, Compressive Strength, hardness value and microstructure behavior. Finally, comparative analysis of mechanical properties and microstructure behavior of base Al7003 material and the reinforced metal matrix composites are studied.*

Key Words: Al7003 alloy, Stir Casting, SiC, Al MMCs, Tensile Strength, Compressive Strength, Hardness value, Microstructure behavior.

1.INTRODUCTION

Composite materials are blend of two or more base materials. One material is the matrix, or binder. It surrounds and binds together fibres or fragments of the other material, which is called the reinforcement.

By mixing these materials, manufacturers can get the best properties of each. One material might give you enhanced strength and durability, while the other offers moisture or corrosion resistance. Put them together and you can get the best of both worlds. Think thermoplastics, fibreglass, or cement, and you've got some examples of composite materials.

The global composites market was USD $288 billion in 2014, and has been growing at around 15% to 20% a year. Here's why:

1) Flexibility in design
2) Lightweight
3) Strength
4) Corrosion resistance
5) Durability
6) Reduced maintenance
7) Good insulators

A metal matrix composite system is generally designated simply by the metal alloy designation of the matrix and the material type, volume fraction, and form of the ceramic reinforcement.

2. MATERIALS AND METHOD

2.1 Properties

Al7003 alloy which acts as a matrix is taken as the basic material. The details of composition and properties of the material are as follows.

Fig -1: Aluminium alloy 7003 sample.

Table -1: Chemical Composition of Al7003

Chemical Component	Weight by percentage
Si	0.4
Fe	0.5
Cu	1.6
Mn	0.3
Mg	2.5
Cr	0.15
Zn	5.5
Ti	0.2
Al	Bal

2.2 Reinforcement Selection

Many materials can be used as reinforcements with Aluminum alloys which provide strength, hardness, very high resistance to crack propagation, high fracture toughness to the design structure. But it is decided to take Silicon Carbide (SiC) powdered form as reinforcement for AMMC. The properties of reinforcement are as:

Table -3: Properties of Silicon Carbide

Properties	SiC
Density	3.1(g/cm3)
Elastic Modulus	410
Color	Black
Melting point	2200 to 2700
Hardness	2800(kg/mm2)
Density	3.1(g/cm3)
Co-efficient of Thermal Expansion	4.1(µm/m/°C)
Fracture toughness	4.6(MPa-m1/2)
Poisson's ratio	0.14
Melting Point	2072 0C
Mean Diameter Size	60µm(220 mesh)

2.3 Fabrication Method

Stir casting method was used to MMC of aluminium (Al7003) alloy and reinforcement particles. The particles are preheated at 600–800^{O} C for 2 h in order to remove the volatile substances and to maintain the particle temperature closer to melt temperature of 750^{O} C. Also, in SiC particles preheating leads to the artificial oxidation of the particle surface forming SiO2 layer. This SiO2 layer helps in improving the wettability of the particle. The Al 7003 billets were charged into the furnace and melting was allowed to progress until a uniform temperature of 750^{O} was attained, subsequently degassing was done by adding solid degasser. The melt was then allowed to cool to 600^{O} C (slightly below the liquidus temperature) to a semi-solid state. At this stage, the silicon carbide mixture was added to the melt and manual stirring of the slurry was performed for 20 minutes. An external temperature probe was utilized in all cases to monitor the temperature readings of the furnace. After the manual stirring, the composite slurry was reheated and maintained at a temperature of 750^{O} C±10^{O} C (above the liquid's temperature) and then mechanical stirring was performed. The stirring operation was performed for 10 minutes at an average stirring rate of 380-400 rpm. Casting was then performed on prepared sand molds at a pouring temperature of 720^{O} C. After effective degassing the molten metal was then poured into permanent molds for casting.

3. EXPERIMENTAL PROCEDURE

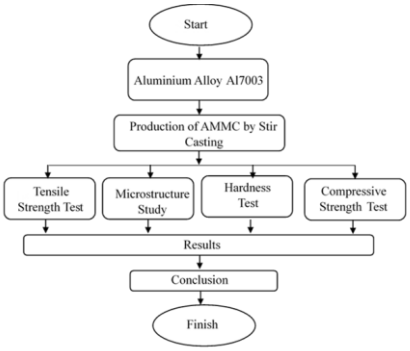

Fig -2: Tests conducted on composites.

3.1 Tensile Strength Test

Tension strength tests were performed on samples machined from the Al 7003 alloy composites with dimensions of 12 mm diameter and 70 mm gauge length as per ASTM Standards. Tests were performed by universal testing machine (UTM) linked with computer to facilitate analysis with the help of software. All specimens were test at room temperature. The specimens were placed at a specified grip separation between the fixed and moving crossheads and pulled until fracture occurred by applying incremental load through the movable crossheads. After yielding the tensile strength is measured.

3.2 Compressive Strength Test

Compression tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined as per ASTM standards. Universal testing machine used for testing the Compressive Strength of the specimen.

3.3 Hardness Test

A Brinnel hardness tester machine used for the hardness measurement. For hardness testing samples were prepared as per specification required for Brinell hardness Test (i.e. 10mm × 10mm × 25 mm).

3.4 Microstructure Study

Metallurgical Microscope integrated with software operation was used for microstructure examination. As per requirement samples were cut in desired size and prepared for testing using Diamond polishing machine. A series of emery papers of grit sizes ranging from 400µm – 1500µm were used to prepare sample surface for examination.

4. RESULTS AND DISCUSSIONS

4.1 Tensile Strength Results

TABLE -4: Load-Elongation Al7003 reinforced with 0,6 % SiC

Sl No.	Al7003+% Weight SiC	Load at Peak in kN	Maximum Elongation in mm
1	0 %	23.11	22.00
2	6%	27.732	26.60

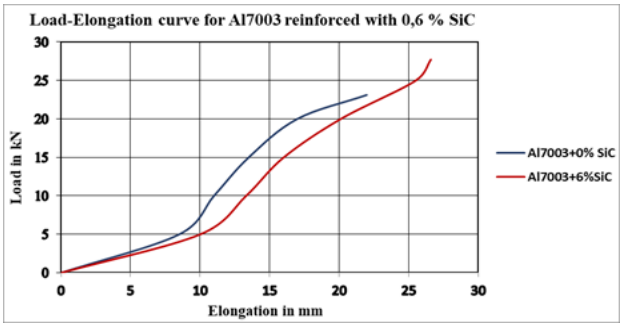

Chart -1:Load-Elongation curve for Al7003 reinforced with 0,6 % SiC

As shown in chart Fig.3 result predict that as the reinforcement with weight percentage volume increases, Tensile strength also increases. This happens may be due to SiC and Al7003 which create hinderance to dislocation motion. This may results increase in tensile strength of Al7003 alloy.

4.2 Compressive Strength Results

TABLE -5: Load-Compression Al7003 reinforced with 0,6 % SiC

Sl No.	Al7003+% Weight SiC	Load at Peak in kN	Maximum Compression in mm
1	0 %	155.44	12.67
2	6%	186.53	8.42

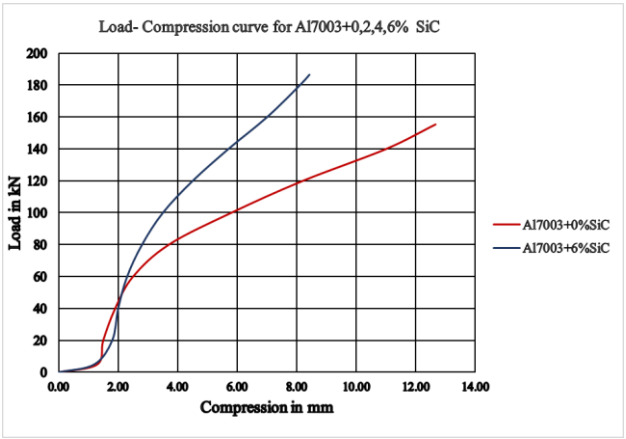

Chart -2: Load- Compression curve for Al7003 reinforced with 0,6 % SiC

As shown in chart Fig.4 result shows that as the reinforcement with weight percentage volume increases, Compression strength also increases with base material. This happens may be due to proper dispersion of SiC and Al7003 into the matrix or strong interfacial bonding in between the Al alloy and SiC interface.

4.1 Hardness Results

TABLE -6: Hardness Value for Al7003 Reinforced With 0,6 % SIC

Sl No.	Al7003+% Weight SiC	Hardness
1	0 %	68.70
2	6%	77.60

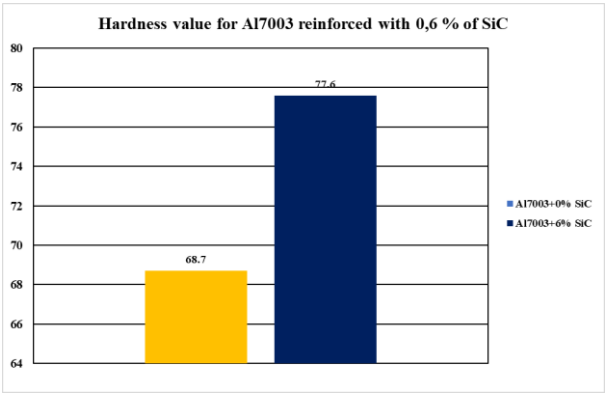

Chart -3:Hardness for Al7003+0% SiC 0,6 % SiC

As shown in chart Fig.4 result shows uniform increase in hardness. This is due to increase in resistance to deformation by adding SiC as reinforcement into Al7003.

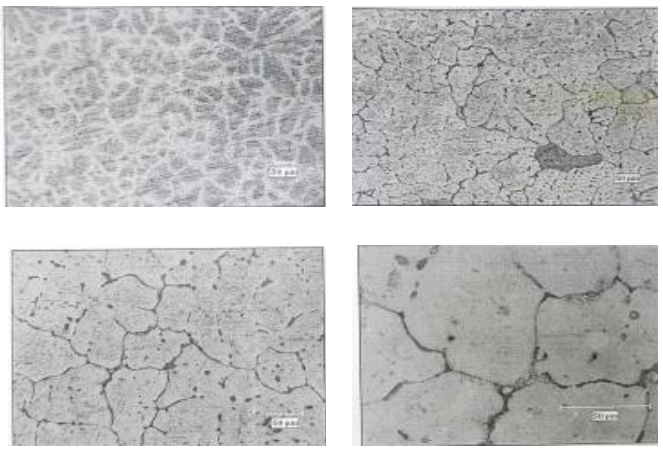

Fig -2: Microstructure behavior for Al7003+0% SiC

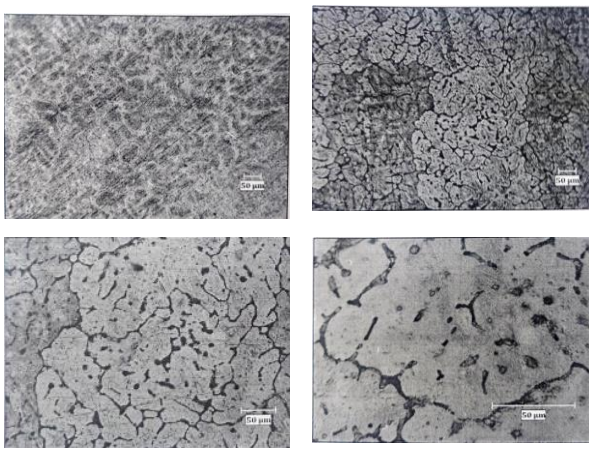

Fig -3: Microstructure behavior for Al7003+6% SiC

Fig.6 to 8 represents the microphotographs of Al7003 alloy reinforced with 0, 6 % of SiC respectively. Pictures taken under 100x. From figures it can be observed that, the distribution of reinforcements in the respective matrix are uniformly dispersed in the dendritic region.

3. CONCLUSIONS

From all the above characterization following conclusion were drawn:

1) Tensile strength increases in all the cases of Al7003 reinforced with 2 and 4% SiC when compared to base material.
2) Yield strength also increases in all the cases of Al7003 reinforced with 2 and 4% SiC when compared to base material.
3) Compression strength also increases as the percentage weight by volume of reinforcement i.e SiC increases by 2 & 4 %.
4) Hardness Value increases uniformly in all the cases of Al7003 reinforced with 2 and 4% SiC when compared to base material.
5) Microphotographs shows the distribution of reinforcements in the respective matrix are uniformly dispersed in the dendritic region in all the cases of Al7003 reinforced with 2 and 4% SiC when compared to base material.

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BIOGRAPHIES

Sathisha . R.C. currently pursuing Master degree in Product Design and manufacturing from SSIT, Tumakuru.

Dr. B. S. Ravikiran working as Associate Professor in Dept of IEM, SSIT, Tumakuru with teaching experience of 28 years.

Dr. S. N. Lakshminarasimhan, Working as Professor and HOD for the dept. of IEM, SSIT, Tumakuru with teaching experience of 30 years.