International Journal for Innovative Engineering and Management Research

PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL

www.ijiemr.org

IJIEMR Transactions, online available on 13th Apr 2023. Link :http://www.ijiemr.org/downloads.php?vol=Volume-12&issue=Issue 04

10.48047/IJIEMR/V12/ISSUE 04/133

Title EXPERIMENTAL INVESTIGATION ON MICROSTRUCTURE AND MECHANICAL BEHAVIOR OF MMC AL-6063 REINFORCED WITH SIC

Volume 12, ISSUE 04, Pages: 1040-1047

Paper Authors

Mrs. M Vinitha, M Venkata Subbarao, K Chetan Chandra, T Jai Surya Teja, M Vinay Kumar

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Experimental Investigation on Microstructure and Mechanical Behavior of MMC AL-6063 Reinforced With SiC

Mrs. M Vinitha, Assistant Professor, Department of Mechanical Engineering, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.

M Venkata Subbarao[2], **K Chetan Chandra**[3], **T Jai Surya Teja**[4], **M Vinay Kumar**[5]
[2,3,4,5] UG Students, Department of Mechanical Engineering,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.
[1,2,3,4,5] mlvinitha82@gmail.com, venkatsr102m@gmail.com, chetanreddykonda333@gmail.com, tummalajaisurya@gmail.com, vinaykumarmaddiboyina@gmail.com

Abstract:

Advanced composite materials, specifically the Al/SiC metal matrix composite, have become increasingly important in the aerospace and automotive industries due to their superior properties. In this study, various weight fractions of silicon carbide (SiC) were utilized to examine the mechanical properties of metal-matrix composites made of aluminum (Al-6063) and SiC. Stir casting was utilized in an air environment to create these (Al-6063)/SiC reinforced particle MMCs, with different reinforced particles added in weight fractions ranging from 2% to 10%. The SiC reinforced particles varied in size from 25 to 40 microns. Microstructure investigation revealed that particle distribution improved as the weight fraction of SiC increased. Mechanical parameters including ultimate tensile strength (MPa), percent elongation, hardness (HRB), and yield strength (Nm) were evaluated for the prepared specimens of MMCs. Results showed a gradual increase in composite hardness between 2-6% and a significant increase between 8-10%. With an increase in the weight fraction of reinforcement, tensile strength and ultimate break load also improved by 15.8 to 27% and 2-15%, respectively.

Key words: Aluminum, SiC, Metal Matrix Composite, stir casting, weight fraction

I. INTRODUCTION:

Metal Matrix Composites (MMCs) are a recent significant advancement that involves a designed combination of metal (Matrix) and hard particles (Reinforcement) to enhance mechanical properties. MMCs have become increasingly popular in the automotive industry due to their high strength, light weight, and improved resistance to corrosion, oxidation, and wear. The improvement of tribological properties of materials has been investigated to increase the load-bearing capacity of materials. Al6063 reinforced with SiC particles at volume fractions of 5%, 10%, and 15% has been studied for the impact of wire electrical discharge machining (WEDM) parameters. The fatigue resistance of Al-MMC is particularly significant for automotive applications, which cannot be achieved by lightweight monolithic titanium, magnesium, and aluminum alloys. The mechanical behavior of particulate metal matrix composites is almost isotropic compared to long fiber reinforced composites. The mechanical behavior of the composite depends on the matrix material, size, weight percentage of the reinforcement, and the process used to build the composite. Uniform distribution of the reinforcing material throughout the matrix and optimum wettability or bonding between the components is crucial. In this research, the microstructure and mechanical behavior of reinforced aluminum with various SiC weight fractions are studied, and the resulting aluminum-silicon carbide metal matrix composite has a low density and light weight, high temperature strength, hardness and stiffness, high fatigue strength, and wear resistance.

II. MATERIALS AND METHODS

A. Aluminum with silicon carbide:

Based on the AL6063 matrix alloy source of materials in Table.1, the reinforced metal matrix composite material chosen for this experiment is shown in Table (2). Pure aluminum was used as the matrix material in this experiment. For this experiment, a silicon carbide particulate aluminum alloy (6063) composite with various volume fractions was utilized. A set of equipment consisting of a crucible furnace, a stainless steel stirrer with a motor, a thermocouple, a heat treatment furnace, and testing equipment for tensile, impact, is required for this experiment and hardness testing instruments, as well as an optical microscope for microstructural examination, are among the tools utilised. [11-15].

Table(1):Source of Materials

S.No	Materials	Supplier
1	Aluminum 6063	TAAN METAL SUPPLIERS,VIJAYAWADA
2	Silicon carbide	SIGMA ALDRICH, HYDERABAD

Table(2):Chemical composition of Alloy(AL6063)

Element	Composition	Element	Composition
Si	0.4430	Zn	0.0001
Fe	0.1638	Cr	0.0024
Cu	0.0041	Ti	0.0078
Mg	0.5382	Ca	0.0003
Mn	0.0132	Al	98.751

The following fabrication and testing procedures are used to create the final metal matrix composite material:

a) Stir Casting Method
b) Hardness Test
c) Tensile Test

B. Manufacturing Process

a) Stir Casting Method:

To develop a stirring system for this experiment, a motor was coupled with a gearbox and a mild steel stirrer as shown in Figure (1). The melting process was carried out in an oil-fired furnace with a graphite crucible. Prior to melting and combining the SiC powdered particles, scraps of aluminum were heated to 450^0 C for 3 to 4 hours to oxidize the surfaces of the particles. To fully melt the alloy scraps, the furnace temperature was raised above the liquids and then lowered to a temperature just below the liquids to maintain the slurry in a semi-solid form. The preheated SiC powdered particles were manually blended since it was difficult to mix the alloy in a semi-solid state using automatic equipment. After adequate manual mixing, the composite slurry was reheated to a fully liquid condition, and then automatic mechanical mixing was performed for around 10 minutes at a typical stirring rate of 600 rpm. The furnace temperature during the final mixing operation was maintained within a range of 760 to 1000^0 C. The composite slurry was poured into a sand mould that was constructed for this purpose.

Figure(1):Stircastingunit

b) Hardness Test :

On test pieces measuring 15 mm by 10 mm, the cast samples underwent the Brinell hardness test. Beginning with coarse filing and ending with an emery belt driven by a motor, both grinding and

polishing were done. The test component received a 125 kg load for 15 seconds, and the diameter of the impression was measured. Table (2) presents the test pieces' average hardness values.

c) Tensile Test:

The evaluation of tensile strength was conducted utilizing an instron computerized tensile compression testing

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

machine in accordance with ASTM B557M standard. The test sample was machined in accordance with ASTM B557 specifications. The samples prior to and post-testing are depicted in Figures (3 and 4), respectively. By using automated instrument software, the graph of strength versus strain was generated. It was observed that the ultimate breaking load, elongation, and ultimate stress increased with the weight percentage of SiC. The cup and cone fractures produced during the tensile test demonstrated that the tensile strength rises with the increase in SiC weight percentage. It is demonstrated that the composites possess a higher tensile strength than the matrix alloy. The graph also reveals that the tensile strength trends increase as the SiC percentage of the composites increases. The increased strength of the SiC filler and/or the stronger bonding strength caused by less-finely distributed particles may both contribute to the composites' improvement in tensile strength.

Figure(2):Tensile Testing Equipment

Figure(3):Testspecimens

Figure(4):Testedspecimens

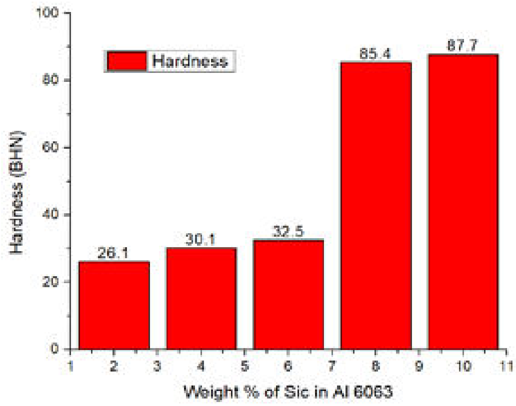
iii. RESULTS AND DISCUSSIONS

It is investigated how varying weight fractions of SiC used to reinforce aluminum affect the material's microstructure and mechanical properties. It is recognised that the Hardness, Tensile Strength, Yield Strength, and Maximum Break Load all increase with more reinforcement.

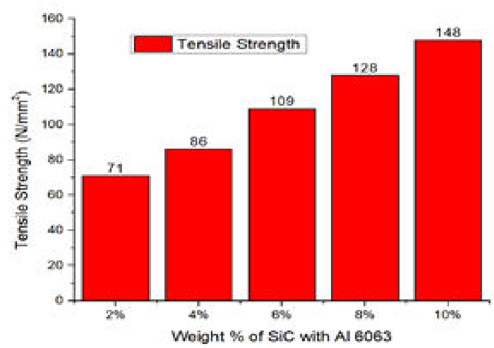
Experimental findings show that composites eventually exhibit less elongation than non reinforced aluminium. Figure (5) demonstrates that as the weight percentage of silicon carbide in aluminum 6063 grows, so does the hardness. It was found that the composite's hardness increases gradually from 2 to 6 weight percent and dramatically from 8 to 10 weight percent. Table presents the Al6063+SiC hardness values for various SiC weight fractions (3). Figures 6 and 7 also demonstrate that the tensile strength and ultimate break load increase with the weight percentage of SiC in aluminum. Tensile strength improvement and ultimate break improvement ranges from 15.8 to 27% and 2 to 15%, respectively. This can be attributed to the fact that when SiC weight fraction is raised during pouring and solidification, particle uniformity of dispersion in the reinforcement is better.Figure (8) demonstrates how the variations in yield strength are improved as the weight fraction of SiC increases. Moreover, Figure (9) shows that the percentage of elongation steadily reduces as the weight fraction of SiC in aluminum increases. It states that increasing the weight fraction of SiC in aluminum will improve yield strength and that this percentage ranges from 22 to 35%. This is because the particle dispersion has been more uniform while pouring and agglomeration has been prevented during solidification.

Table(3):HardnessvaluesofAl6063+SiC

I.D no.	2%	4%	6%	8%	10%
1	25.3	29.5	32.6	88.2	83.8
2	23.9	30.2	33.3	87.0	87.8
3	25.8	29.8	32.2	85.1	87.1



Figure(5):HardnessofAl6063+SiC.



Figure(6):TensileStrengthofAl6063+ SiC.

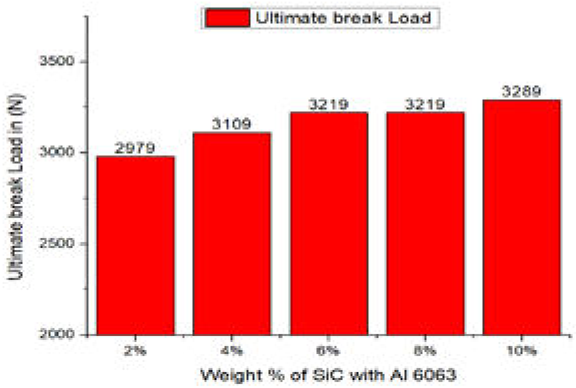
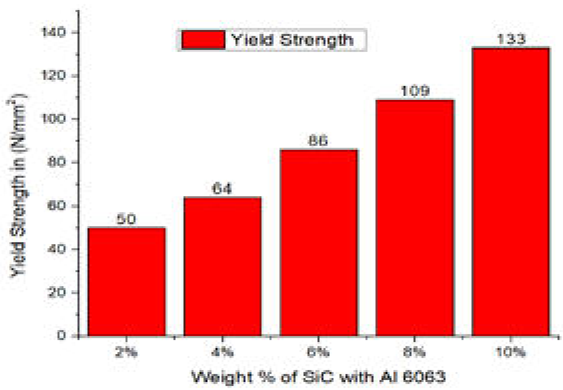
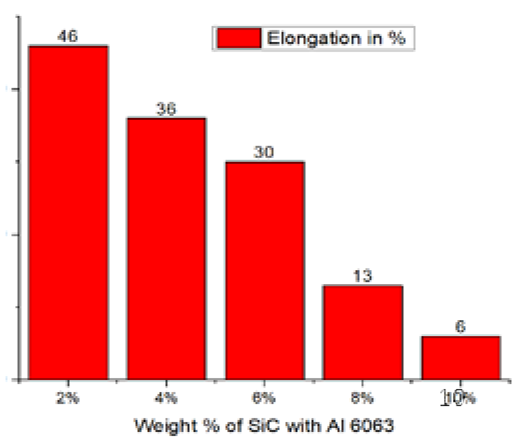


Figure (7): Ultimate Break load of Al 6063+ SiC.



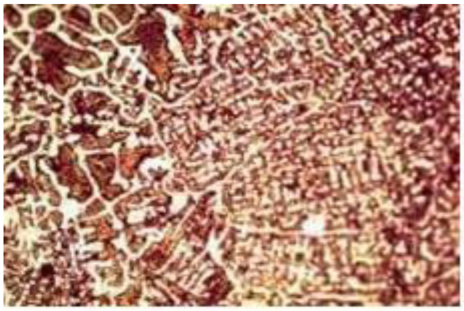
Figure(8):Yield Strength of Al 6063+SiC



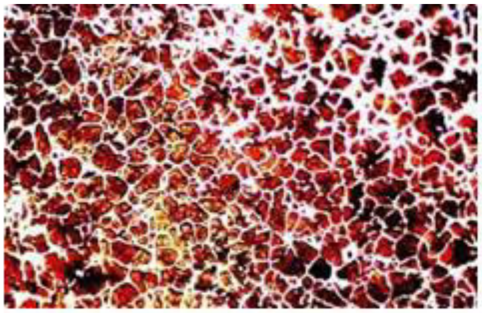
Figure(9):Elongation Percentage of Al 6063+SiC.

II. OpticalMicrographsofAl6063+Si CMMCs:

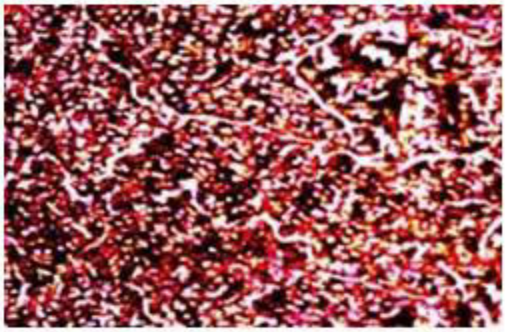
The form, kind, and distribution of the reinforcing particles have the greatest impact on the characteristics of particulate composites. Particle distribution is greatly influenced by the kind of reinforcement used and how it is included. Particles must be evenly distributed throughout the casting for making particulate composites. The primary objective of Metal Matrix Composites (MMCs) is to obtain a uniform distribution of particles in the liquid melt, and prevent clustering of particles during solidification and pouring. The particle distribution was analyzed by examining the microstructures of samples produced from castings at different locations, with reinforcement of silicon carbide particles at weight percentages ranging from 2% to 10% The samples were made of aluminum 6063. Figure displays the optical micrographs of metal matrix composites (10 – 14). After the etching procedure, well-formed nodules and grain boundaries were visible. Figures 10 and 11 show that samples of SiC with 2 and 4 weight percent show less similarity to the degree of particle distribution than samples with 6 weight percent. Because Figure (12) demonstrates that the distribution of the particles is slightly better.Due to reduced segregation during solidification, Figures (13 and 14) indicate that the distribution is more uniform than in the other situations. It amply demonstrates how improved mechanical behavior results from greater particle homogeneity.



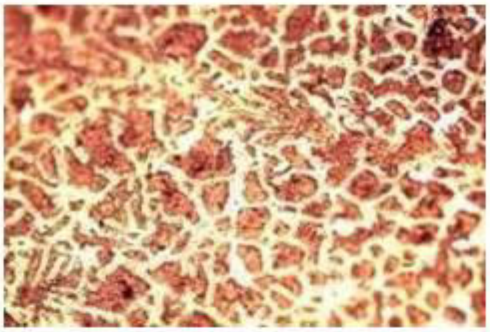
Figure(10):



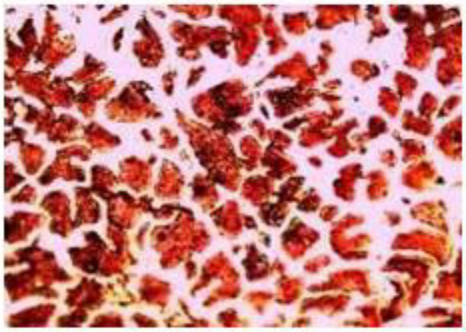
Figure(11):



Figure(12):



Figure(13):



Figure(14):

Figures(10 to14): A visual representation of Al6063 reinforced with 2,4,6,8 & 10 weight percent SiC was captured using an optical microscope at 100X magnification.

Conclusions

The study examined the microstructure and mechanical properties of aluminum reinforced with varying weight percentages of SiC. The stir casting method was used to prepare the specimens according to ASTM B557M standards, and the Brinell hardness test was conducted to determine the material's hardness. The microstructure was examined using an optical microscope at different specimen locations. Results showed that increasing the weight percentage of SiC led to a progressive increase in hardness from 2% to 6% and a significant increase from 8% to 10%. The tensile strength and ultimate break load also improved with increasing SiC content in aluminum, with improvements ranging from 15.8 to 27% and 2 to 15%, respectively. Yield strength also steadily improved with weight fraction, with the best results obtained with SiC content ranging from 22 to 35% by weight. The microstructure analysis revealed that samples with 2% and 4% weight percent of SiC had a lower degree of particle dispersion compared to samples with 6% weight percent of SiC. However, the distribution in the samples with 8% and 10% weight percent of SiC was more uniform due to less segregation during solidification. The results indicate that improved mechanical properties result from greater particle homogeneity. This study suggests that MMCs could be used in the aerospace and automotive industries in the future.

References:

[1]E.Candan,H.Ahlatci, H.Ç¨ımeno˘ glu Abrasive wear behaviour of Al–SiCcomposites produced by pressure infiltration technique. Wear 247(2001)133 –138.

[2] Daniel B. Miracle and Steven L. Donaldson, 'Introduction tocomposites', ASM Hand Book of Composite Materials, Volume-21.

[3] K.R.Suresh, H.B.Niranjan, P. Martin Jebaraj M. P. Chowdiah, 'Tensile and wear properties of aluminum composites', Wear 255 (2003)638 – 642.

[4] Ashok Kr. Mishra, Rakesh Sheokand,R.K.Srivastava,'Tribologicalbehaviourof Al-6061/SiCmetalmatrixcompositebyTaguchi's techniques", International JournalofScientific and Research Publications, 2(2012).

[5] D.Satishkumar, M.Kantha babu, V.Vajjiravelu,R.Anburaj,N. Thirumalai Sundarrajan, H. Arul, 'Investigationof wire electrical discharge machinin characteristics ofAl6063/SiC_pcomposites',TheInternational JournalofAdvancedManufacturingTechnology56/9-12(2011)975-986.

[6] Manjunath C. MelgiandG. K.Purohit, 'AStudyofMicrostructureandMechanicalPropertiesofAluminiumSiliconCarbideMetalMatrixComposites(MMC's)',InternationalJournalofEngineeringResearch&Technology2(2013)

[7] K. L. Meena, A. Manna, S. S. Banwait andJaswanti,'AnAnalysisofmechanicalpropertiesofthedevelopedAl/SiC-MMC's', American Journal of MechanicalEngineering1/1 (2013)14 –19.

[8] Balamurugan Adhithan, A.Syed bavabakrudeen and Hari Prasada RaoPydi,'Contemplation of mechanical and thermal properties of aluminum (1100) with siliconcarbide',InternationalJournalofEngineering and Advanced Technology 2/2(2012).