IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, January 2026
Impact Factor: 7.67

Investigation of Mechanical Properties of Aluminum Reinforcement with SiC Prepared through Stir Casting Technique

Sandeep K, Charan Kumar S, Pradeepa T, Pratheek V Y, Theertha Kumar
Department of Mechanical Engineering
Kalpataru Institute of Technology, Tiptur, India

Abstract: *Aluminum metal matrix composites have great corrosion resistance, light weight, and durability. Because of these characteristics, metal matrix composites made of aluminium can be used in a variety of automotive, marine, and aviation applications. The mechanical characteristics, microstructures, and wear properties of silicon carbide metal matrix composite aluminum are investigated in this study. In the current investigation, the matrix was aluminum and the material used for reinforcement was silicon carbide (30 microns). The various compositions involume fraction—100% Al -0%Sic, 98% Al -2%Sic, 96% Al-4%Sic and 94%Al-6%Sic were selected. Stir casting was utilized in the fabrication process. Analysis was done on the produced composites microstructures, Vickers hardness, tensile strength, and wear behaviour. The hardness, tensile strength, and weight % of an aluminum (Al) matrix were all improved by the addition of silicon carbide (SiC) reinforcements, as indicated by the results. By observing the microstructure, silicon carbide (SiC) particle collection and The Al matrix's non-homogeneous distribution was verified. In aluminum matrix composites, porosities were seen in the microstructures and increased as the weight percentage of silicon carbide (SiC) reinforcements increased. A pin-on-disc wear test discovered that the Al matrix had been reinforced with silicon carbide (SiC) particles, improving wear rate.*

Keywords: Metal Matrix Composite (MMC), Aluminium Alloy (Al-6061), Silicon Carbide (SiC),Stir Casting, Mechanical Properties, Tensile Strength, Compression Strength, Hardness, Microstructure

I. INTRODUCTION

Metal Matrix Composites (MMCs) are advanced engineering materials formed by combining a metallic matrix with hard reinforcement materials to obtain improved mechanical and physical properties. Among various MMCs, aluminium-based composites have gained significant importance due to their low density, high strength-to-weight ratio, good wear resistance, and excellent thermal conductivity. These properties make aluminium MMCs highly suitable for applications in the automotive, aerospace, marine, and structural industries.

Aluminium alloys such as Al-6061 are widely used as matrix materials because of their good castability, corrosion resistance, and mechanical performance. However, the mechanical properties of monolithic aluminium alloys are often insufficient for high-load and wear-resistant applications. To overcome these limitations, ceramic reinforcements such as Silicon Carbide (SiC) and are added to the aluminium matrix. SiC is preferred due to its high hardness, high elastic modulus, and excellent thermal stability, which significantly enhance the strength and hardness of the composite.

II. PROBLEM STATEMENT

Conventional aluminium alloys such as Al-6061 are widely used in engineering applications due to their low density and good corrosion resistance. However, their mechanical properties such as strength, hardness, wear resistance, and load-bearing capacity are insufficient for advanced automotive and aerospace applications. Improving these properties without significantly increasing weight remains a major challenge.

Although metal matrix composites (MMCs) reinforced with ceramic particulates like Silicon Carbide (SiC) and have shown potential improvements in mechanical performance, there is limited experimental data on the influence of different reinforcement weight percentages on the tensile strength, compression strength, hardness, and microstructural characteristics of Al-6061 composites fabricated by the stir casting method

III. PROJECT OBJECTIVES

- To fabricate aluminium metal matrix composites using Al-6061/ as the matrix material and Silicon Carbide (SiC) as reinforcement by the stir casting method..
- To analyze the microstructure of the composites and observe the distribution and bonding of reinforcement particles within the aluminium matrix.
- To evaluate the mechanical properties of the fabricated composites, including:
- Tensile strength, Compression strength and Hardness
- To analyze the microstructure of the composites and observe the distribution and bonding of reinforcement particles within the aluminium matrix.

IV. SCOPE OF PROJECT

The project covers the development of aluminium-based metal matrix composites (MMCs) using Al-6061 alloy as the matrix material due to its good mechanical properties, corrosion resistance, and industrial relevance.

Silicon Carbide (SiC) particulates are used as reinforcement to enhance mechanical properties such as strength, hardness, and load-bearing capacity..

The scope is confined to the stir casting technique, a liquid metallurgy process selected for its simplicity, cost-effectiveness, and suitability for mass production.The study investigates the influence of varying reinforcement weight percentages (0%, 2%, 4%, and 6%) on the performance of the aluminium composites.

The project evaluates the effectiveness of magnesium as a wetting agent in improving bonding between aluminium matrix and ceramic reinforcement.The scope includes a comparative study between unreinforced aluminium alloy and reinforced composites to highlight performance improvements.Testing and analysis are limited to room-temperature conditions, and results are interpreted for general engineering applications.

The findings are applicable to lightweight and wear-resistant components used in automotive, aerospace, and structural engineering sectors.Advanced testing such as fatigue, wear, corrosion, SEM/TEM analysis, and heat treatment effects are not included and are suggested as future scope for further research.

V. OUT OF SCOPE

- Detailed wear, erosion, and corrosion behavior studies under different environments
- Fatigue, creep, and impact strength analysis
- Optimization of stir casting parameters (stirrer design, speed optimization using DOE/Taguchi, etc.)
- Investigation of other reinforcement materials (fibers, whiskers, hybrid reinforcements beyond SiC)
- Study of particle size variation and shape effects of reinforcements
- Heat treatment effects on mechanical and microstructural properties
- Advanced microstructural characterization such as SEM, TEM, XRD, AFM, or EBSD
- Numerical modeling or simulation of casting, solidification, or mechanical behavior
- Machinability studies (tool wear, surface roughness, cutting forces)
- Tribological performance (friction coefficient, sliding wear tests)
- Thermal properties analysis (thermal conductivity, thermal expansion)
- Industrial-scale production and cost–benefit analysis
- Long-term service performance and reliability testing
- Environmental and life-cycle assessment (LCA) of the composite materials

VI. PROJECT CONTEXT AND STRATEGIC IMPERATIVE

Lightweight, high-strength materials are increasingly required in automotive, aerospace, and structural engineering applications to improve performance, fuel efficiency, and durability. Conventional aluminium alloys, though lightweight and corrosion-resistant, often fall short in terms of strength, hardness, and wear resistance for advanced engineering applications.

Metal Matrix Composites (MMCs), particularly aluminium-based composites reinforced with ceramic particulates such as Silicon Carbide (SiC) and offer a promising solution. These composites provide enhanced mechanical properties while retaining the advantages of aluminium, such as low density and good thermal conductivity.

This project focuses on the fabrication of Al-6061 alloy reinforced with SiC particulates using the stir casting method, which is one of the most economical and industrially viable liquid metallurgy techniques. The study evaluates the influence of different reinforcement weight percentages on microstructure, tensile strength, compressive strength, and hardness of the fabricated composites.

The strategic importance of this project lies in addressing the growing demand for cost-effective, high-performance, and lightweight materials suitable for mass production. Stir casting enables the use of conventional foundry equipment, making the process scalable and economically attractive for industrial applications.By systematically studying the effect of reinforcement content on mechanical properties, this project contributes.

VII. METHODOLOGY

The methodology adopted in this project involves the fabrication, testing, and characterization of Aluminium–6061 based metal matrix composites reinforced with Silicon Carbide (SiC) using the stir casting technique. The work is carried out in a systematic sequence as described below.

1. Material Selection

o Matrix material: Aluminium alloy Al–6061
o Reinforcement: Silicon Carbide (SiC) particulates (varying weight percentages)
o Wetting agent: Magnesium (≈1 wt%) to improve wettability between aluminium and SiC
o The materials are selected based on their availability, compatibility, and mechanical performance.

2. Preparation of Reinforcement

o SiC particles are preheated to remove moisture and surface contaminants.
o Preheating also improves wettability and prevents sudden temperature drop when added to molten aluminium.

3. Stir Casting Process

o Al–6061 alloy is melted in a crucible furnace at a temperature of about 720–740°C.
o Degassing is carried out using hexachloroethane tablets to remove dissolved gases.
o A mechanical stirrer is used to create a vortex in the molten metal.
o Preheated SiC particles and magnesium are gradually added into the vortex.
o Stirring is continued at a controlled speed to ensure uniform distribution of reinforcement particles.

4. Casting and Solidification

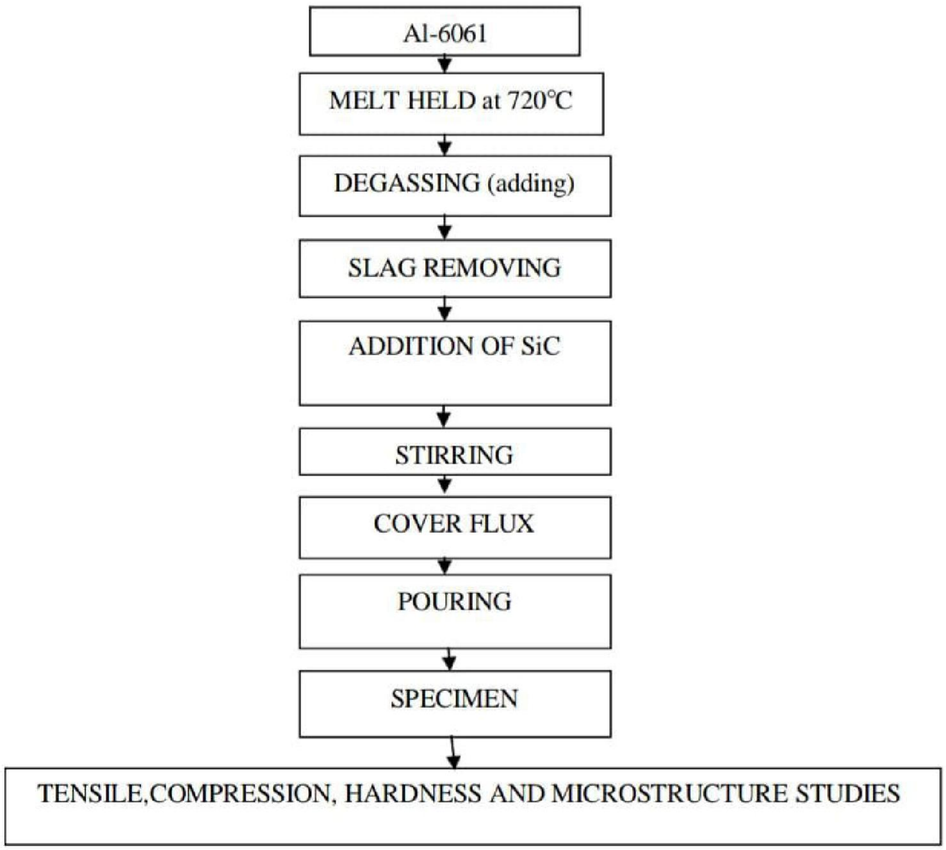
o The molten composite slurry is poured into a preheated graphite mould.
o Controlled cooling is carried out to reduce particle segregation and porosity.

5. Mechanical testing

O Tensile test: conducted using a computerized universal testing machine (utm) to evaluate ultimate tensile strength and elongation.
O Compression test: performed to determine compressive strength of the composites.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, January 2026
Impact Factor: 7.67

o Hardness test: brinell hardness test is used to measure surface hardness.
o Microstructural AnalysisSamples are polished and etched following standard metallographic procedures.

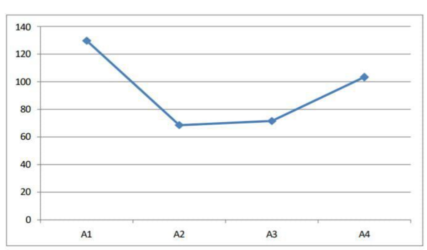


Flowchart: Casting process

VIII. RESULTS AND DISCUSSION

Tensile test

Alloys sample No.	Original Dia.(mm)	Original gauge length(mm)	Final gauge length (mm)	UTS(N/mm^2)	% Elongation
A1	8.72	35	37.06	129.604	5.89
A2	8.76	35	36.58	68.526	4.34
A3	8.75	35	35.95	71.509	2.71
A4	8.66	35	36.68	103.393	4.80

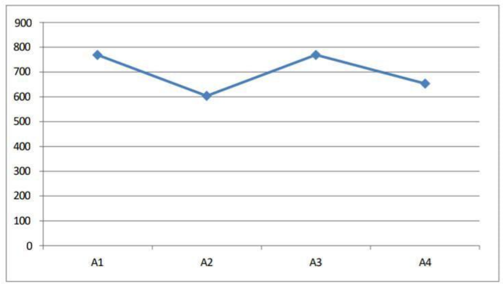


DOI: 10.48175/IJARSCT-30838

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, January 2026
Impact Factor: 7.67

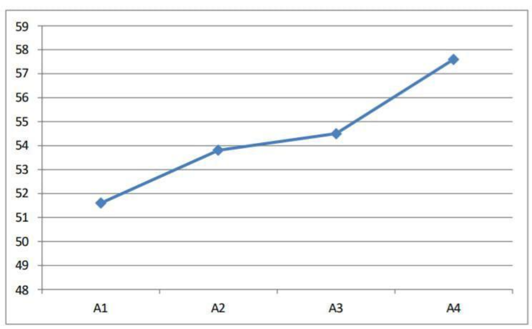
Compression test

Alloy sample No.	Compression strength in N/mm²
A1	768.738
A2	603.524
A3	769.166
A4	653.441



Haednees Test

Alloys sample number	BHN
A1	51.6
A2	53.8
A3	54.5
A4	57.6



Graph Results –Tensile Test

• A1 (Al–6061, 0% SiC) shows the highest tensile strength, indicating good ductility of the base alloy.
• A2 (2% SiC) shows a sharp decrease in tensile strength, mainly due to particle clustering and reduced ductility.
• A3 (4% SiC) shows a slight improvement compared to 2% SiC, indicating better load transfer between matrix and reinforcement.
• A4 (6% SiC) shows a significant increase in tensile strength, attributed to improved reinforcement distribution and strengthening effect of SiC particles.

Compression:
• A1 (0% SiC) has a compressive strength of 768.74 N/mm², the baseline for the alloy.
• A2 (2% SiC) shows a decrease to 603.52 N/mm², indicating initial weakening due to particle clustering or poor bonding.

DOI: 10.48175/IJARSCT-30838

• A3 (4% SiC) recovers to 769.17 N/mm², showing improved load-bearing as reinforcement distribution becomes more effective.

• A4 (6% SiC) slightly decreases again to 653.44 N/mm², possibly due to particle agglomeration at higher reinforcement content..

IX. CONCLUSION

- Stir casting method were successfully adopted in the preparation of composite.
- The micro structural studies revealed the uniform distribution of the particles in the matrix.
- The tensile strength is decreases with addition of reinforcement but its value increases with increase in percentage of SiC.
- The compression strength is decreases with addition of reinforcement but its value gets increases with 2% SiC.
- Hardness of composites increases with addition of reinforcement particulates(SiC)

X. ACKNOWLEDGMENT

We would like to express our sincere gratitude to our project guide and faculty members for their continuous support, valuable suggestions, and encouragement throughout the development of this work. Their guidance helped us understand the concepts and complete the project successfully .We also extend our appreciation to our institution for providing the necessary resources and a supportive learning environment. Finally, we thank all our friends and family members for their motivation and constant support during this project.

REFERENCES

[1] Hashim, J., Looney, L. and Hashmi,M.S.J., "Particle Distribution in Metal Matrix Composites,"Part-I,Journal of Materials Processing Technology,123:251-257. 2002.

[2] Nather, S., Brabazon, D. and Looney, L., "Simulation of the Stir Casting Process," Journal of Materials Processing Technology, 143-144: 567-571.2003.

[3] Nai, S.M.L. and Gupta, M. ,"Synthesis and Characterization of Free Standing, Bulk Al/Sicp Functionally Gradient Materials: Effects of Different StirrerGeometries," Material Research Bulletin, 38: 1573-1589. 2003.

[4] Hashim,J. ,Looney,L. and Hashmi,M.S.J., "Metal Matrix Composites: Production by the Stir Casting Method," Journal of Materials Processing Technology, 92-93: 1-7.1999.

[5] Manna, A. and Bhattacharyya, B., "Study on Different Tooling Systems during Turning for Effective Machining of Al/SiC- MMC," The Institution of Engineers (India) Journal-Production, 83: 46-50.2003.

[6] Allison, J.E. and Cole, G.S., "Metal Matrix Composite in Automotive Industry: Opportunities and Challenges," Journal of Mechanical Science, 19-24.1993.

[7] Surappa, M.K., "Microstructure Evolution during Solidification of DRMMCs: State of the Art," Journal of Materials Processing Technology, 63:325-333.3078 A. MANNA ET AL.1997.

[8] Yang, J., Pickard, S.M., Ctedy, C., Evans, A.G. and Mehrabian, T.,"The Stress/Strain Behavior of Aluminium Matrix Composites with Discontinuous Reinforcements," Acta Metallurgica Materialia, 39: 1863-1870.1997.