iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2026 **Issue:** Conference **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83166

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com
National Conference on Integrated Approaches to Sustainable Innovation 2026 (IASI 2026)

A Brief Glimpse of Development and Characterization of Aluminium Metal Matrix Composite Reinforced with Rice Husk Ash

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Abstract: ***Aluminium Metal Matrix Composites (AMMCs) are widely used in aerospace, automobile, marine, and structural applications due to their lightweight nature, high strength-to-weight ratio, and improved wear resistance. In recent years, agricultural waste materials have gained considerable attention as reinforcement materials because of their low cost, environmental sustainability, and availability. Rice Husk Ash (RHA), a by-product obtained from the combustion of rice husk, contains a high percentage of silica and exhibits excellent thermal and mechanical properties. In the present study, Aluminium-based Metal Matrix Composites reinforced with Rice Husk Ash were fabricated using the stir casting process. Different weight percentages of RHA were added to the aluminium matrix to investigate the effect of reinforcement on mechanical and tribological properties. The fabricated composites were tested for hardness, tensile strength, impact strength, and wear behavior. Microstructural analysis was performed using optical microscopy and scanning electron microscopy. Experimental results revealed that the addition of Rice Husk Ash significantly improved hardness and wear resistance while slightly reducing ductility. The study concludes that Rice Husk Ash can be effectively utilized as an eco-friendly and economical reinforcement material in aluminium metal matrix composites.***

Keywords: Aluminium Metal Matrix Composite, Rice Husk Ash, Stir Casting, Hardness, Wear Resistance, Sustainable Composite.

I. INTRODUCTION

Metal Matrix Composites (MMCs) are advanced engineering materials composed of a metallic matrix reinforced with ceramic particles, fibers, or whiskers to improve mechanical and physical properties. Aluminium Metal Matrix Composites have become increasingly popular because aluminium possesses excellent corrosion resistance, lightweight characteristics, high thermal conductivity, and good machinability.

Traditional reinforcement materials such as silicon carbide (SiC), alumina (Al2O3), and boron carbide (B4C) provide excellent strength enhancement but are relatively expensive. Therefore, researchers are exploring low-cost and environmentally sustainable reinforcement alternatives derived from industrial and agricultural waste materials.

Rice Husk Ash (RHA) is an agricultural waste generated after burning rice husk. It contains approximately 85–95% silica along with small amounts of alumina, iron oxide, calcium oxide, and magnesium oxide. Due to its high silica content and low density, RHA has emerged as a potential reinforcement material in composite fabrication.

The utilization of Rice Husk Ash in aluminium composites provides several advantages:

- Reduction in material cost
- Improvement in hardness and wear resistance
- Lightweight composite development
- Utilization of agricultural waste
- Reduction in environmental pollution

The present work focuses on the fabrication and characterization of Aluminium-Rice Husk Ash Metal Matrix Composite using the stir casting technique and evaluates its mechanical and microstructural properties.

II. LITERATURE REVIEW

Several researchers have investigated the effect of agro-waste reinforcement in aluminium composites.

A. Aluminium-RHA Composites

Previous studies reported that the incorporation of Rice Husk Ash in aluminium alloys improves hardness and wear resistance due to the presence of silica particles. Stir casting has been identified as an economical method for fabricating such composites.

B. Effect on Mechanical Properties

Researchers observed that increasing the weight percentage of RHA enhances hardness and compressive strength. However, excessive addition of reinforcement may lead to clustering and reduced tensile strength.

C. Wear Behavior

The wear resistance of AMMCs reinforced with RHA increases because the hard silica particles resist abrasion and reduce material removal during sliding.

D. Microstructural Characteristics

Microstructural studies revealed relatively uniform distribution of RHA particles in the aluminium matrix when proper stirring speed and temperature are maintained during fabrication.

III. OBJECTIVES OF THE STUDY

The main objectives of the present investigation are:

1) To fabricate Aluminium Metal Matrix Composite reinforced with Rice Husk Ash.
2) To study the effect of Rice Husk Ash on mechanical properties.
3) To evaluate hardness, tensile strength, and wear resistance.
4) To analyze the microstructure of the fabricated composites.
5) To investigate the feasibility of using agricultural waste as reinforcement.

IV. MATERIALS AND METHODS

A. Matrix Material

Commercially available Aluminium alloy was selected as the matrix material because of its lightweight characteristics, good corrosion resistance, and excellent castability.

Properties of Aluminium

Property	Value
Density	2.7 g/cm3
Melting Point	660°C
Thermal Conductivity	205 W/mK
Tensile Strength	90–150 MPa

B. Reinforcement Material

Rice Husk Ash was used as reinforcement material. The ash was collected from rice mills and processed by controlled burning and sieving. Chemical Composition of Rice Husk Ash

Component	Percentage
Silica (SiO2)	85–95%
Alumina (Al2O3)	0.5–2%
Iron Oxide	0.2–1%
Calcium Oxide	1–2%

C. Composite Fabrication

The stir casting process was used to fabricate the composite specimens.

Steps Involved in Stir Casting

- Aluminium alloy was melted in a graphite crucible at approximately 750°C.
- Rice Husk Ash particles were preheated to remove moisture.
- The molten aluminium was stirred mechanically.
- Preheated RHA particles were added slowly into the melt.
- Continuous stirring was carried out for uniform distribution.
- The molten composite was poured into metallic molds.
- The cast specimens were cooled and machined for testing.

Composition of Fabricated Samples

Sample	Aluminium (%)	Rice Husk Ash (%)
A1	100	0
A2	97	3
A3	95	5
A4	93	7
A5	90	10

V. EXPERIMENTAL PROCEDURE

1) Hardness Test

Hardness testing was conducted using the Brinell Hardness Testing machine. The test determines resistance against indentation.

2) Tensile Test

Tensile tests were performed using a Universal Testing Machine (UTM) according to ASTM standards.

3) Impact Test

Impact strength was measured using the Charpy impact testing machine.

4) Wear Test

Wear characteristics were analyzed using a pin-on-disc wear testing machine.

5) Microstructural Analysis

Optical microscopy and Scanning Electron Microscopy (SEM) were used to study particle distribution and bonding between reinforcement and matrix.

VI. RESULTS AND DISCUSSION

1) Hardness Analysis

The hardness of the composite increased with increasing RHA content due to the presence of hard silica particles.

Sample	Hardness (BHN)
A1	48
A2	54
A3	59
A4	64
A5	68

The increase in hardness indicates improved resistance to deformation.

2) Tensile Strength Analysis

Tensile strength initially increased with reinforcement addition due to better load transfer between matrix and reinforcement.

Sample	Hardness (BHN)
A1	48
A2	54
A3	59
A4	64
A5	68

The reduction at higher reinforcement percentages may be due to particle agglomeration and porosity.

3) Impact Strength

Impact strength decreased slightly with increasing RHA content because ceramic particles reduce ductility.

4) Wear Resistance

Wear resistance improved considerably with increasing Rice Husk Ash content. The silica-rich particles acted as hard barriers against surface wear.

5) Microstructural Observations

Microstructural examination showed fairly uniform distribution of Rice Husk Ash particles in the aluminium matrix. Minor porosity was observed at higher reinforcement percentages.

VII. ADVANTAGES OF ALUMINIUM-RICE HUSK ASH COMPOSITE

- Lightweight material
- Improved hardness
- Better wear resistance
- Economical reinforcement
- Environmentally sustainable
- Reduced waste disposal problems

VIII. APPLICATIONS

The developed Aluminium-Rice Husk Ash composites can be used in:

- Automobile brake drums
- Piston components
- Aerospace structures
- Marine applications
- Structural panels
- Machine components subjected to wear

IX. CONCLUSION

The present study successfully fabricated Aluminium Metal Matrix Composite reinforced with Rice Husk Ash using the stir casting process. Experimental results indicated that the addition of Rice Husk Ash significantly enhanced hardness and wear resistance of the aluminium matrix. Tensile strength improved up to an optimum reinforcement percentage and then decreased slightly due to particle clustering and porosity. The composite developed using Rice Husk Ash provides a low-cost, lightweight, and eco-friendly alternative for engineering applications. The investigation confirms that agricultural waste materials can be effectively utilized for producing sustainable composite materials with improved performance.

X. FUTURE SCOPE

Future work may include:

- Hybrid reinforcement using RHA with SiC or Al2O3
- Optimization of particle size and reinforcement percentage
- Corrosion analysis of the composites

- Heat treatment studies
- Advanced machining analysis
- Finite element modeling of composite behavior

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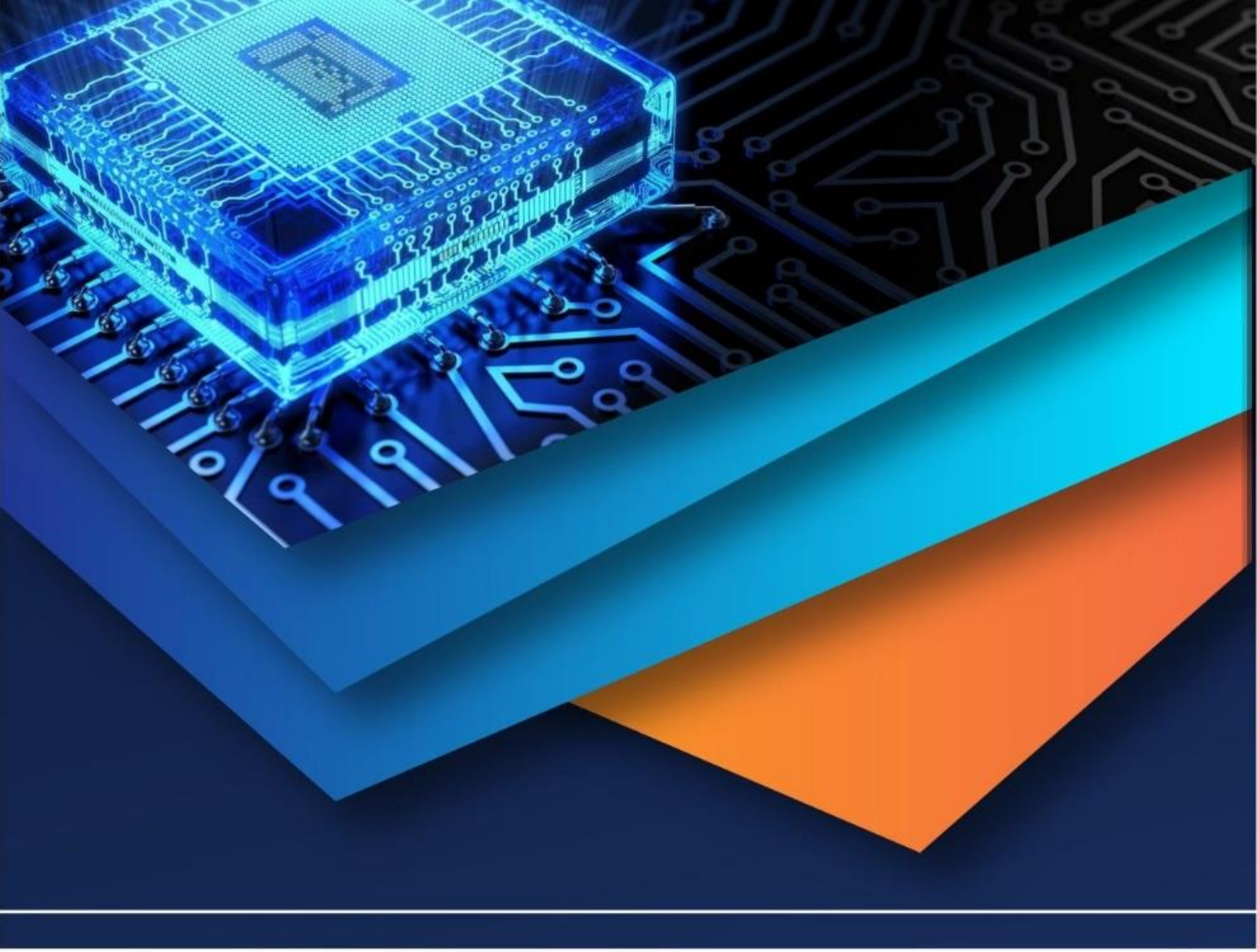

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