International Journal of Advanced Mechanics and Control Systems

Volume 2 , Issue 2 2026

Manufacturing and Mechanical Characteristics of A356.2/RHA Composites

Ioakeim, Hassapis . Department of Mechanics, Iran

Research Article

Date of Submission: 16-03-2026 Date of Acceptance: 10-04-2026 Date of Publication: 11-05-2026

Abstract

The vortex technique was used in this investigation to create A356.2 Al/Rice husk ash (RHA) metal matrix composites (MMCs). The composites were made using various weight percentages of reinforcement. Microstructural characterisation is done using a scanning electron microscope with an energy dispersive X-ray analyzer. Properties such as ultimate tensile strength, density, and hardness were examined. The microhardness findings showed that the matrix material near the rice husk ash particle had a greater hardness. Particles of rice husk ash are added to composites to increase certain of their mechanical qualities while decreasing their density.

Keywords: Ash from rice husks, MMC's A356.Two.

Introduction

Metal-matrix composites (MMCs) are a new family of materials that may be used in wear, advanced structural, automotive, aerospace, electrical, and thermal management applications. Because of their unique mechanical, physical, and thermal characteristics—such as low density, high specific strength, high specific modulus, high thermal conductivity, and high abrasion and wear resistance—metal matrix composites provide a performance advantage. Generally speaking, several monolithic matrix materials are used to produce the MMCs' decreased weight as well as their increased strength and stiffness. Composites with inexpensive and low-density reinforcements have drawn more attention in recent years. Rice husk ash [1-3] is one of the most affordable and low density reinforcements accessible in large quantities as a solid waste byproduct, compared to other reinforcements as SiC, Al2O3, etc. An agricultural byproduct of milling rice is rice husk. For every 100 kg of rice, around 20 kg of rice husk are produced. 20% of the material in rice husks is inorganic, while the remainder is organic. Rice husk is burned to produce rice husk ash (RHA). RHA was used by several studies as a cement alternative in concrete. In the current study, an effort is made to use the widely accessible RHA as reinforcement in MMCs in order to enhance the material's mechanical qualities and reduce its density.

Experimental Work

After burning rice husk, the ash was completely cleaned of dust with water and allowed to dry for a day at room temperature. After washing, the rice husk was burned to 200 °C for one hour to eliminate the moisture and organic materials. The carbonaceous material was subsequently removed by heating it to 600 °C for 12 hours [4]. In order to prepare composites, the resulting silica-rich ash was used as a filler. Table I displays the chemical makeup of the rice husk ash after the aforementioned procedures. The Ultima IV X-Ray diffractometer was used to capture the ash samples' X-ray diffraction patterns. Figure 1 illustrates that only peaks belonging to SiO2 and carbon in graphite form are detected to RHA.

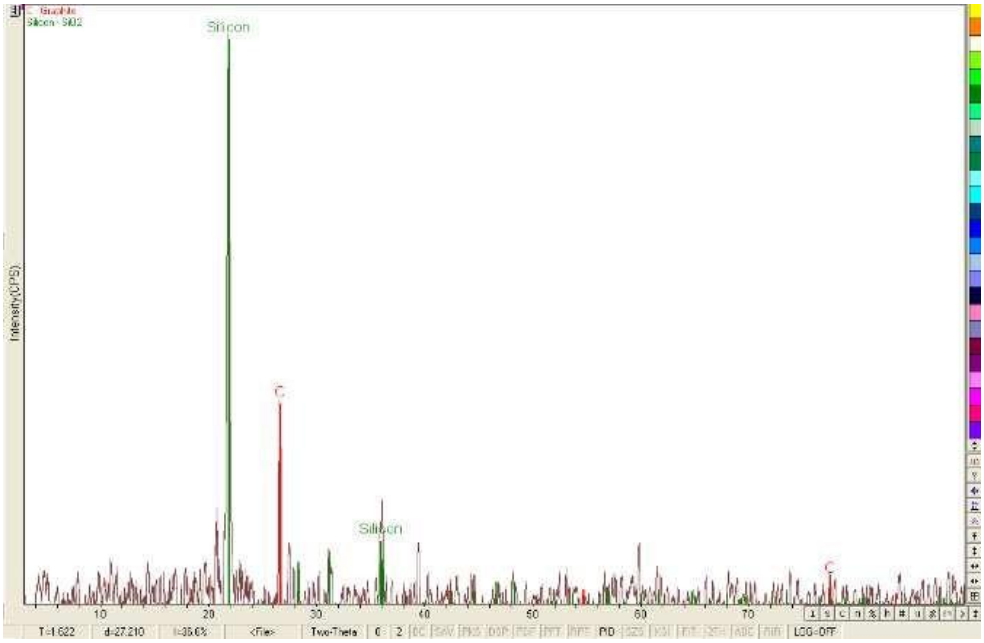


Fig 1: XRD Pattern of RHA Sample

Material System:

In this study, A356.2 alloy with the theoretic density of 2760 kg/m3 is used as the matrix material and RHA is used as the reinforcement. The chemical composition of A356.2 alloy is presented in the Table 2. Test specimens are fabricated which are classified based on the wt. %(4, 6 and 8) rice hush ash particles using vortex method [5-8].

Table 1: Chemical Composition of RHA

Constituent	SiO_2	Graphite	CaO	MgO	K_2O	Fe_2O_3
%	90.23	4.77	1.58	0.53	0.39	0.21

Table 2: Chemical Composition of A356.2 Alloy

Si	Fe	Cu	Mn	Mg	Zn	Ni	Ti
6.5-7.5	**0.15**	**0.03**	**0.10**	**0.4**	**0.07**	**0.05**	**0.1**

Specimen Preparation:
A356.2 is used as the matrix material and rice husk ash particles are used as reinforcement for creating composites. The graphite crucible was first filled with A356.2 Al, an alloy with a theoretical density of 2760 kg/m3, then heated to 750 oC until all of the alloy was melted. Before being added to the melt, the reinforcement particles (RHA) were heated to 8000C for an hour. To lessen the porosity, a degassing tablet was applied after the molten metal had completely melted. To improve the wettability between rice husk particles and the alloy melt, 1 weight percent magnesium was added at the same time. It was observed that the rice husk ash particles were rejected in the absence of magnesium. The stainless steel stirrer was carefully dropped into the melt to agitate the molten metal at 500–700 rpm. The furnace's regulator allows you to adjust the stirrer's speed. During the stirring period, the warmed RHA particles were introduced to the molten metal at a steady pace. Even after the particle feeding was finished, the churning remained for an additional five minutes. To achieve homogeneous solidification, the slurry was put into a mold that had been warmed to 500 oC for 30 minutes. RHA particle-reinforced composites with weight percentages of 4, 6, and 8% were created using this technique. A non-destructive test was used to look for blow holes in the cast MMC samples.



Fig 2: Electric Furnace with Mechanical Stirrer

Results and Discussions:
The microstructure of the A356.2/RHA composites is examined using a JSM-6610LV scanning electron microscope (SEM) fitted with an energy dispersive X-ray analyzer. After being sliced from tensile specimens, the samples for SEM are ground using abrasive papers (P220, P400, P800, and P1200) and then polished using spinning disc cloth. As an etching agent, Keller's reagent (95 ml water, 2.5 ml HNO3, 1.5 ml HCL, and 1.0 ml HF), a widely used general-purpose reagent for Al and Al alloys, is used. After being submerged in the aforementioned solution for ten to twenty seconds, the samples were cleaned with warm

water and then dipped in concentrated HNO3. The microstructures of A356.2/RHA composites demonstrated good retention of rice husk ash particles.

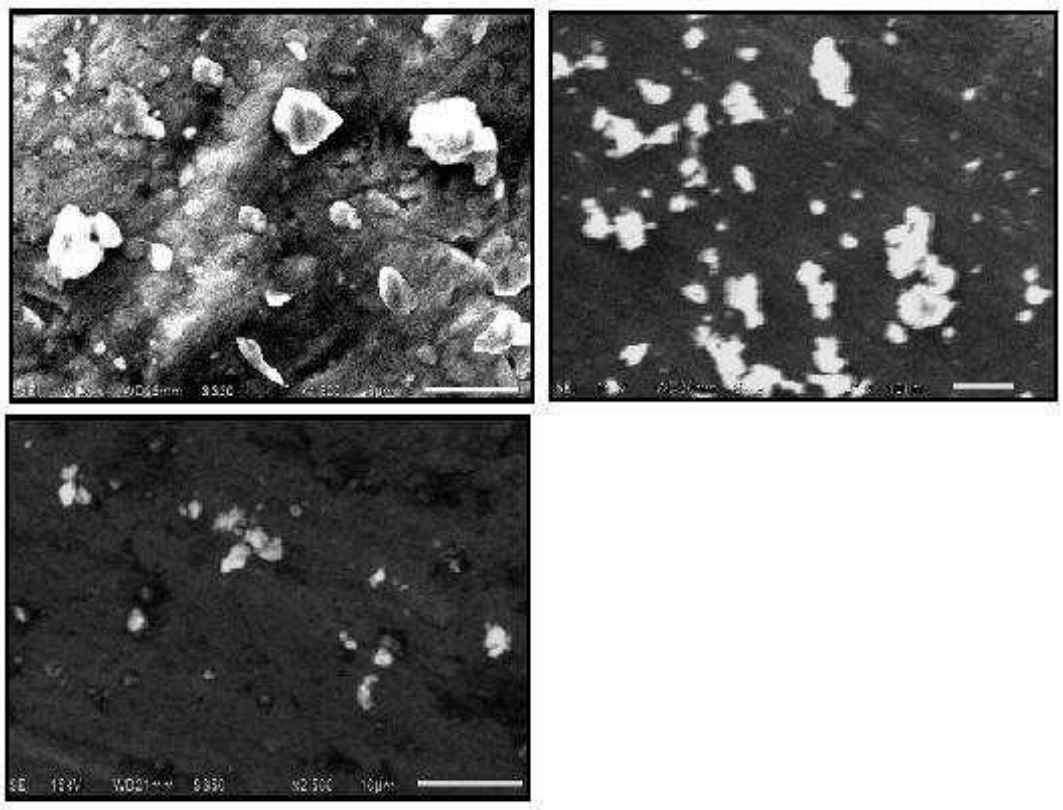


Fig2: a.SEM picture of A356.2/8%RHA Composites b. SEM picture of A356.2/6%RHA Composites c. SEM picture of A356.2/4%RHA Composites

Density Measurements:

The most reliable method of density measurement [9-11] simply involves weighing the sample in air and in another fluid of known density. Application of Archimedes' principle leads to the following expression for the density *(ρ)* of the sample in terms of measured weights *(W)*

$$\rho = (W_a \rho_L - W_L \rho_a)/(W_a - W_L) \quad (1)$$

Where the subscripts a and L refer to air and the second fluid (normally a liquid - water). In order to improve the precision, this liquid should have a high density. It must also be chemically stable, have a low vapour pressure and a low well-defined surface tension. It was observed that the density decreases with the increase in weight % of the reinforcement (Fig3).

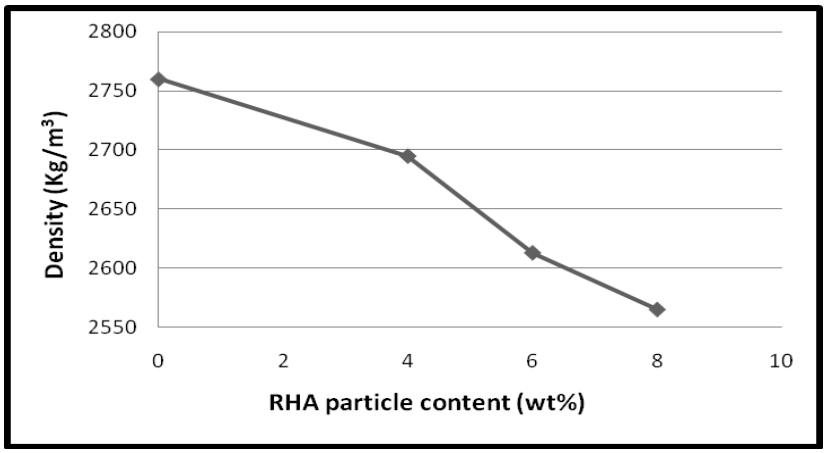


Fig3: Variation of Density with Weight % RHA

Hardness Measurements:

Hardness of the unreinforced and A356.2/RHA composites were measured using a standard Brinell hardness tester as per ASTM E10 standards. A test load of 500Kg is applied on the specimens for 30sec. The diameter of the steel ball indenter is 10mm. The size of the indent (d) is determined optically by measuring two diagonals of the round indent. The Brinell hardness number (BHN) is calculated for the unreinforced and A356.2/RHA composites using the equation 2. An average of five readings was taken of each sample for hardness measurements. Fig 4 shows the variation of hardness with weight % reinforcement. It was observed that the hardness increases with increasing weight fraction of the reinforcement. The increase in the hardness value results from the hard RHA particles in the matrix.

(2) $$BHN = \frac{2F}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

Where F is the applied load, D is the diameter of the steel ball and d is the size of the indent.

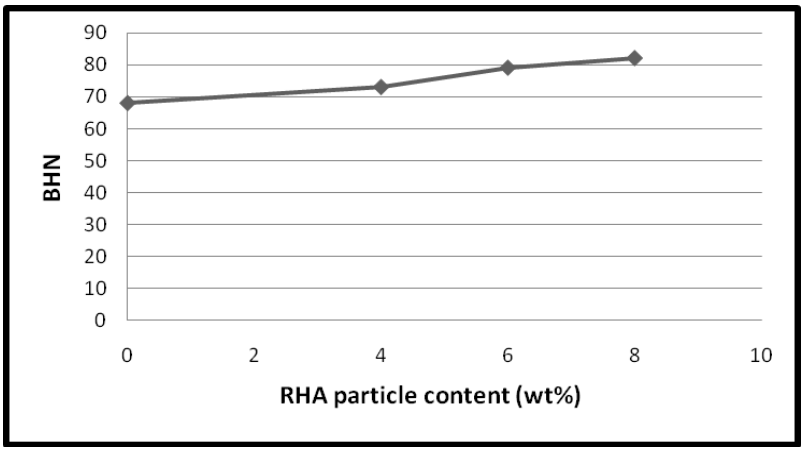


Fig4: Variation of Hardness with Weight % RHA

Mechanical Behavior:

The specimens for tensile test were prepared according to ASTM E8 standards. The tensile tests were performed on a universal material testing machine. The ultimate tensile strength obtained during tensile test is shown in Fig 6. It is found that the addition of rice husk ash has significant effect on the tensile properties. The addition of rice husk ash particles will increase the ultimate tensile strength (UTS) of the material. The addition of the rice husk ash particles increases strength mainly by the load transfer from matrix to the reinforcement due to the differences in the elastic constants. Fig 5 shows the die for tensile specimen.



Fig5: Die for Tensile Test Specimens

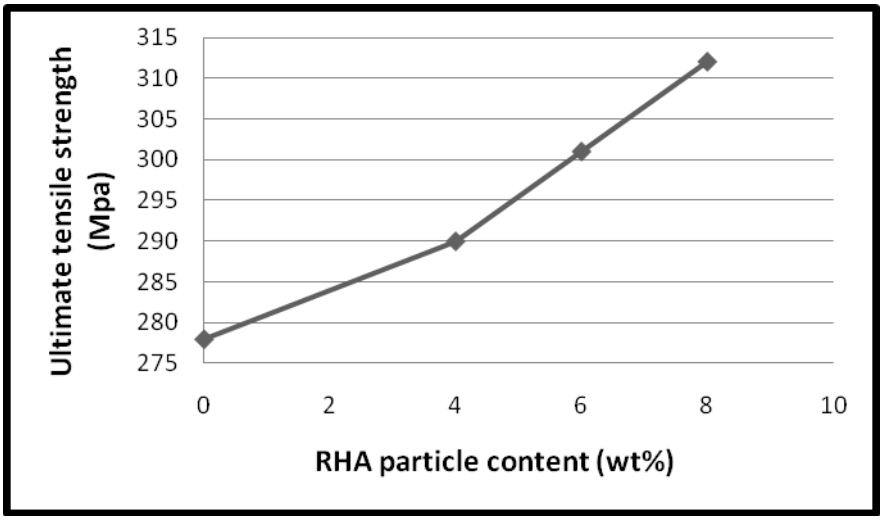


Fig6: Variation of UTS with Weight % RHA

Conclusions:

a. Stir casting was used to effectively include rice husk ash particles into the A356.2 alloy.
b. Rice husk ash particles are uniformly distributed throughout the aluminum alloy, according to microstructure studies. Additionally, the microstructure showed that the rice husk ash particles were well retained in the matrix.
C. As the amount of rice husk ash increased, the density of A356.2/RHA composites decreased.
d. As the amount of rice husk ash in A356.2/RHA composites rises, so does their hardness.
e. As the amount of rice husk ash grew, so did the ultimate tensile strength.
f. Low-cost aluminum composites with increased strength and hardness may be produced by incorporating rice husk ash particles into the aluminum matrix. These composites may be used in connecting rods, cylinder liners, and pistons, among other automobile parts. These composites may also be used in situations when strong, rigid, and lightweight materials are needed.

References

[1]. Sathy Chandrasekhar, P. N. Pramada ,Jisha Majeed, —Effect of calcination temperature and heating rate on the optical characteristics and reactivity of rice husk ash‖, J Mater Sci (2006) 41:7926–7933.
[2] P. Mishra, A. Chakraverty, H. D. Banerjee, —Production and purification of silicon by calcium reduction of rice-husk white ash‖, Journal of Materials Science 20 (1985) 4387 4391.
[3] Ubolluk Rattanasak, Prinya Chindaprasirt, and Prasert Suwanvitaya, —Development of high volume rice husk ash alumino silicate composites‖, International Journal of Minerals, Metallurgy and Materials Volume 17, Number 5, October 2010, Page 654.
[4]. Aluminum alloy-rice husk ash particle composites, S. Das, T. K. Dan, S. V. Prasad, and P. K. Rohatgi, Journal of Materials Science Letters (1986) 562 564.
[5]. A. Sakthivel R. Palaninathan R. Velmurugan P. Raghothama Rao, —Production and mechanical characteristics of SiCp particle-reinforced 2618 aluminum alloy composites — J Mater Sci (2008) 43:7047–7056.
[6]. The tribological properties of A356.2Al alloy/Gr(p) composites, J.B. Yang, C.B. Lin, T.C. Wang, and H.Y. Chub, Wear 257 (2004) 941–952.
[7]. Sanjeev Das V. Udhayabanu S. Das K. Das, —Synthesis and characterisation of zircon sand/Al-4.5 wt% Cu composite generated by stir casting route‖ J Mater Sci (2006) 41:4668–4677.
[8]. M. Ramachandra, K. Radhakrishna, —Synthesis-microstructure-mechanical properties-wear and corrosion behavior of an Al-Si (12%)—Flyash metal matrix composite‖ Journal of Materials Science 40 (2005) 5989–5997.
[9] N. A. Pratten (1981) Review: The Precise Measurement of the Density of Small Samples, J. Mat. Set, 16, pp. 1737-47.
[10]. H. A. Bowman and R. M. Schoonover (1967) Procedure for High Precision Density Determination by Hydrostatic Weighing, J. Res. Nat. Bur. Stand.,71 C, pp. 179-98.
[11]. D. Cawthorne and W. D. J. Sinclair (1972) An Apparatus for Density Determination on Very Small Solid Samples, J. Phys. E., 5, pp. 531-3.