Production and Mechanical Properties of A356.2 /RHA Composites

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Abstract

In this present study, A356.2 Al/Rice hush ash (RHA) metal matrix composites (MMCs) were fabricated by vortex method. Different weight fractions of reinforcement were used to fabricate the composites. Scanning electron microscope equipped with energy dispersive X-ray analyzer is used for micro structural characterization. The properties like density, hardness, and ultimate tensile strength were investigated. The results of micro hardness revealed higher hardness of the matrix material in the immediate vicinity of rice husk ash particle. The addition of rice husk ash particles reduces the density of composite while increasing some of their mechanical properties.

Keywords: *Rice Husk Ash, MMC's A356.2.*

1. Introduction

Metal-matrix composites (MMCs) have emerged as a class of materials capable of advanced structural, aerospace, automotive, electronic, thermal management, and wear applications. The performance advantage of metal matrix composites is their tailored mechanical, physical, and thermal properties that include low density, high specific strength, high specific modulus, high thermal conductivity, and high abrasion and wear resistance. In general, the reduced weight and improved strength and stiffness of the MMCs are achieved with various monolithic matrix materials. In recent years there has been an increasing interest in composites containing low density and low cost reinforcements. Among various reinforcements used like SiC, Al_2O_3 etc, rice husk ash [1-3] is one of the most inexpensive and low density reinforcement available in large quantities as solid waste byproduct. Rice husk is an agricultural residue from the rice milling process. Approximately, 20 Kg of rice husk are obtained for 100 Kg of rice. Rice husks contain organic substances and 20% of inorganic material. Rice husk ash (RHA) is obtained by the combustion of rice husk. Many researchers used RHA as a blending material in concrete as a substitute of cement. In the present work, an attempt is made to utilize the abundantly available RHA as reinforcement in MMC's to improve the mechanical properties and decrease the density of the material.

2. Experimental Work

The ash, obtained by burning rice husk was thoroughly washed with water to remove the dust and dried at room temperature for 1 day. Washed rice husk was then heated to 200 ° C for 1 h in order to remove the moisture and organic matter. It was then heated to 600 ° C for 12 h to remove the carbonaceous material [4]. The silica-rich ash, thus obtained, was used as a filler material in the preparation of composites. Chemical composition of the rice husk ash after the above treatments is shown in Table I. X-ray diffraction patterns of the ash samples were taken using Ultima IV X-Ray diffractometer. Only peaks corresponding to SiO_2 and carbon in graphite form are observed to RHA as shown in fig1.

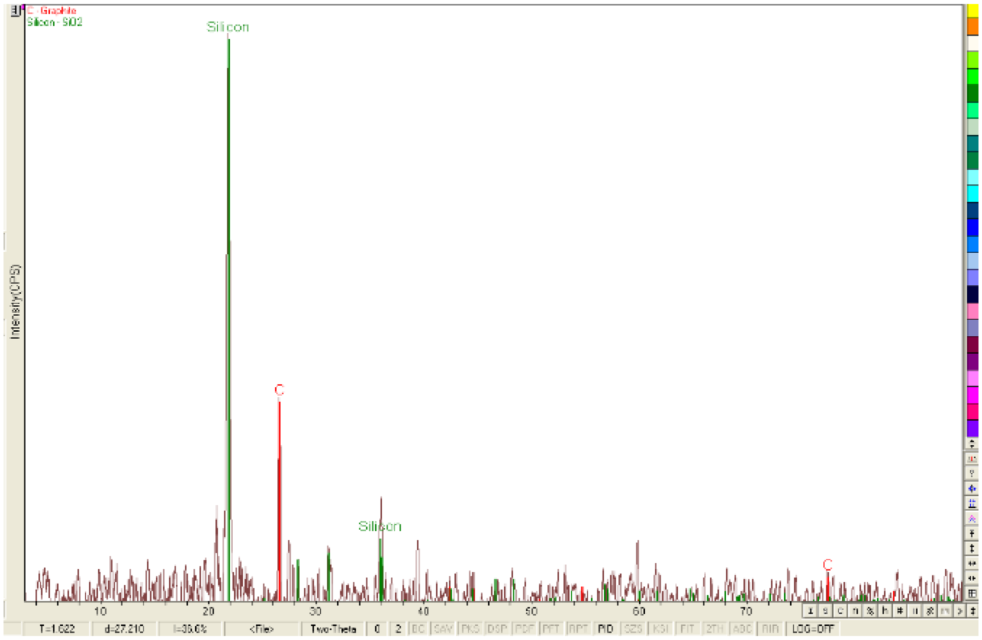

Fig 1: XRD Pattern of RHA Sample

2.1 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**

2.2 Specimen Preparation:

The matrix material for the preparation of composites is A356.2 and rice husk ash particles as the reinforcement. Initially, A356.2 Al with the theoretic density of 2760 kg/m^3 alloy was fed into the graphite crucible and heated to 750 ℃ till the entire alloy in the crucible was melted. The reinforcement particles (RHA) were preheated to 800^0C for 1 hour before incorporating into the melt. After the molten metal was fully melted degassing tablet was added to reduce the porosity. Simultaneously, 1 wt % magnesium was added to the melt to enhance the wettability between rice husk particles and the alloy melt. It was noticed that without the addition of magnesium, the particles of rice husk ash were rejected. The stirrer made up of stainless steel was lowered into the melt slowly to stir the molten metal at the speed of 500 -700 rpm. The speed of the stirrer can be controlled my means of regulator provided on the furnace. The preheated RHA particles were added into the molten metal at a constant rate during the stirring time. The stirring was continued for another 5 minutes even after the completion of particle feeding. The mixture was poured into the mold which was also preheated to 500 ℃ for 30 min to obtain uniform solidification. Using this method, 4, 6, and 8% by weight RHA particle-reinforced composites were produced. The cast MMC samples were examined in a Non destructive testing for blow holes.

Fig 2: Electric Furnace with Mechanical Stirrer

3. Results and Discussions:

JSM-6610LV Scanning electron microscope (SEM) equipped with energy dispersive X-ray analyzer is used to study the microstructure of the A356.2/RHA composites. The samples for SEM has been cut from tensile specimens and are ground by means of abrasive papers (P220, P400, P800, P1200) followed by rotating disc cloth polishing. Keller's reagent (95 ml water, 2.5 ml HNO_3, 1.5 ml HCL, 1.0 ml HF), very popular general purpose reagent for Al and Al alloys is used as an etching agent. The samples were immersed for 10-20 seconds in the above solution and then washed with warm water, followed by dipping in concentrated HNO_3. Good retention of rice husk ash particles was clearly seen in the microstructures of A356.2/RHA composites.

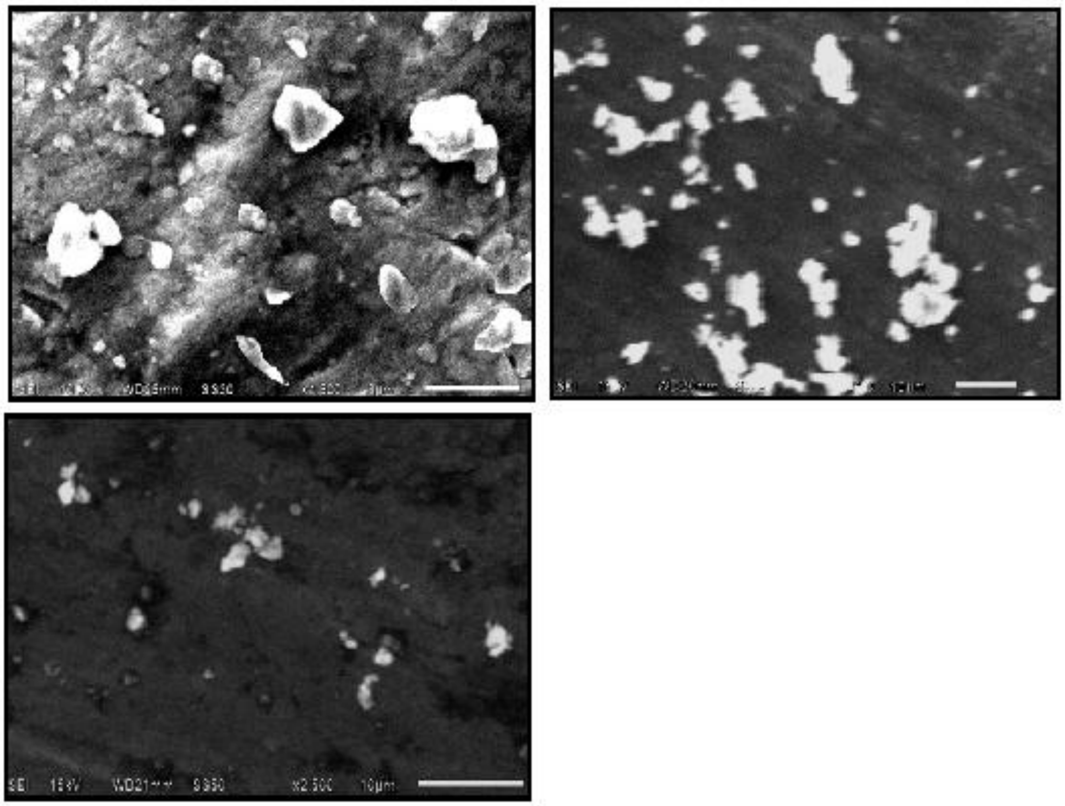

Fig2: a.SEM picture of A356.2/8%RHA Composites b. SEM picture of A356.2/6%RHA Composites c. SEM picture of A356.2/4%RHA Composites

3.1 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).

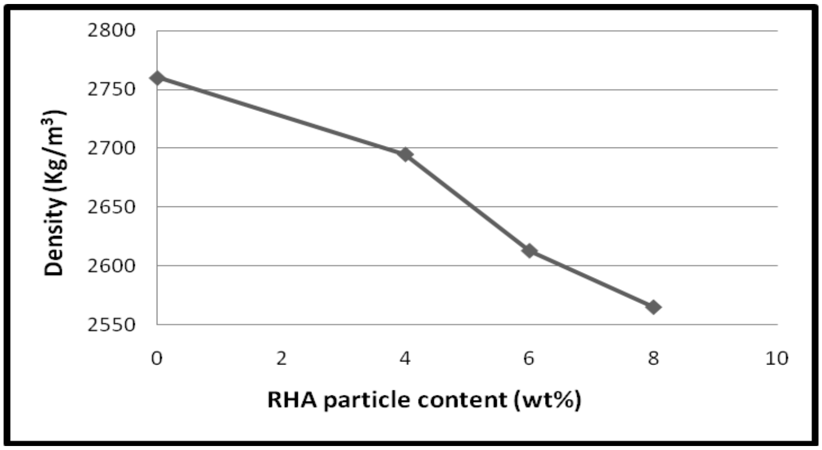

Fig3: Variation of Density with Weight % RHA

3.2 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.

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

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

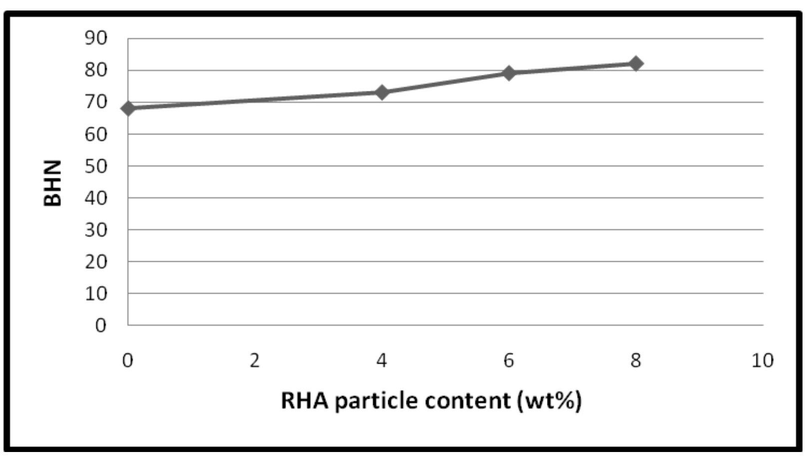

Fig4: Variation of Hardness with Weight % RHA

3.3 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

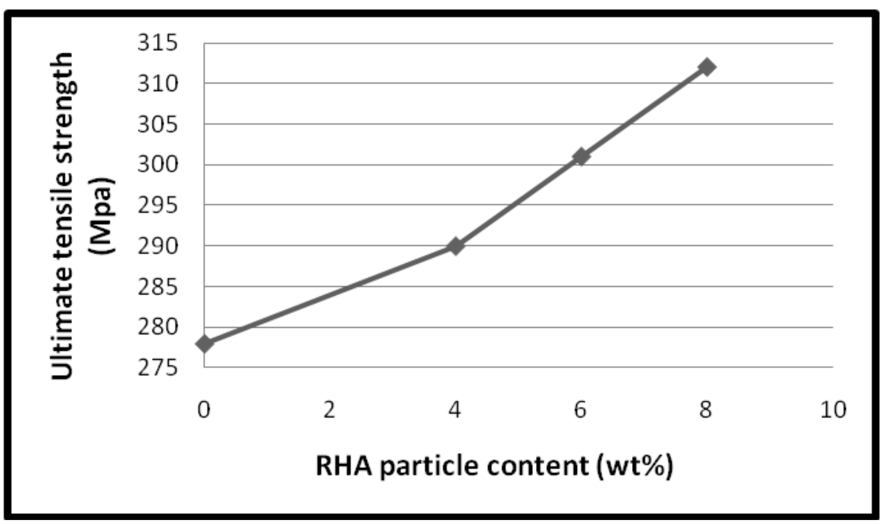

Fig6: Variation of UTS with Weight % RHA

4. Conclusions:

- **a.** Rice husk ash particles were successfully incorporated in A356.2 alloy by using stir casting technique.
- b. Micro structure analysis shows the uniform distribution of rice husk ash particles in the aluminium alloy. The microstructure also revealed good retention of rice husk ash particles in the matrix.
- c. The density of A356.2/RHA composites has decreased with increase in rice husk ash content.
- d. The hardness of A356.2/RHA composites increases with increase in rice husk ash content.
- e. The Ultimate tensile strength increased with increase in rice husk ash content.
- f. Incorporation of rice husk ash particles in aluminium matrix can lead to the production of low cost aluminium composites with improved hardness and strength. These composites can find applications in automotive components like pistons, cylinder liners and connecting rods. These composites can also find applications where light weight materials are required with good stiffness and strength.

Acknowledgments:

The authors would like to thank **GITAM University**, **Visakhapatnam, INDIA** for its financial support under Minor Research Scheme.

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