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Fabrication and Characterization of Al356.2, Rice Husk Ash and Fly Ash Reinforced Hybrid Metal Matrix Composite

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Abstract

The light weight hybrid composites are the most promised materials of the today's engineering world. They have high strength to weight ratio and they find wide range of applications in aviation and automobile sectors. The production of these potential hybrid composites is cheaper when the selected reinforcements are economical. The aim of the paper is to investigate the mechanical properties on Al356.2 alloy reinforced with locally available inexpensive rice husk ash & fly ash reinforcements. The effect of these reinforcements on the mechanical properties of Al356.2 were studied at 4:6, 5:5 and 6:4 weight% of Fly Ash (F.A) and Rice Husk Ash(R.H.A) respectively. The reinforcement's F.A and R.H.A are added to Al356.2 through stir casting technique. Interesting facts brought into light that the hybrid cases have prominent mechanical properties than pure Al356.2 alloy.

Key words*: Al356.2, F.A & R.H.A, Stir casting and hybrid metal matrix composite*

1. Introduction

The composite is a combination of two materials *i.e.*, Matrix and Reinforcement. Matrix is the structure providing material. Reinforcements provide strength and modulus. They are binded / reinforced into a matrix with distinct interface between them. Most of the research work is carried out to developed composites using various industrial and agricultural wastes. RHA is an abundantly available agricultural waste and it is a great threat to the environment causing damage to the land where it is dumped. FA is the industrial waste collected at the chimney of coal thermal power plant. They have higher percentage of silica which will offer higher thermal, electrical resistance and superior mechanical properties. The hybrid composite is a combination of two or more reinforcements in the matrix materials. A combination of drawn properties that can be achieved because of combined effect of both the reinforcements. Over the past few years there has been increase in the use of R.H.A, F.A as reinforcements due to their advantages like plenty availability, low cost and good mechanical properties like strength, ductility and wear resistance.

The economical requirements of the industries will be satisfied with this kind of naturally available reinforcements and by adopting most effective fabrication techniques. Here the two natural reinforcements F.A and R.H.A were incorporated in Al356.2 matrix

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melt by stir casting route which is most economical and widely used method for the fabrication of metal matrix composites.

2. Literature Review

[1] Madakson PB, Yawas DS, Apasi A. found that few number of agro waste have been processed into ashes and their suitability for use as reinforcing phase material have been studied. Agro waste derivatives are believed to be very promising materials for the development of AMCs on a commercial scale. This is because there are limited synthetic reinforcing materials available.

[2] Rohatagi, P. K., stated that addition to lowering cost, incorporation of fly ash into aluminum provides decrease in the materials density, increase their hardness, abrasion resistance and stiffness.

[3] Loh YR, Sujan D. Rahman ME. Das CA., in their investigation, concluded that Industrial and agro waste derivates are some of the alternate reinforced materials. The results obtained from the investigation carried out on alternate reinforcements have been promising as they show significant improvement in the properties of composites developed over the unreinforced alloy.

[4] K. K. Alaneme, T. M. Adewale revealed that the use of hybrid reinforcements SiC/ Al_2O_3 and the ashes of agro waste as a means of improving the properties of AMCs with encouraging results.

[5] Shivaraja H B, B S Praveen Kumar evaluated the impact strength of Al 356 alloy matrix hybrid composites reinforced with Zirconium Silicate and Silicon Carbide particles has been successfully synthesized by the stir casting method. The results from the study reveal that there is considerable increase in the fracture toughness in the presence of both silicon carbide and zirconium silicate reinforcement in the matrix alloy. The matrix alloy with 2%SiC and 6%ZrSiO reinforcement has shown high toughness for fracture.

[6] Prasad SD, Krishna RA carried out an investigation on stir cast aluminium hybrid composite containing equal amount of rice husk ash and silicon carbide from 2% to 8% in step of 2.They found out that there was homogeneous distribution of the reinforcements in the matrix. Hardness, yield strength increased with increase in the reinforcement while percentage elongation decreases.

With this background, in the present work an attempt has been made to investigate mechanical properties of Al356.2, FA and RHA hybrid metal matrix composites.

3. Materials and Methods

3.1. Matrix Material (Al356.2)

Aluminum alloys are alloys in which Al356.2 is the predominant metal. The typical alloying elements are shown in Table 1.

Table 1. Chemical Composition of Al356.2 Alloy Matrix

Constituent	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

It has a melting point of 660^0C.It finds wide applications in automotive transmission cases, pump parts, air craft fittings and control parts. Excellent cast ability and good weld ability, good corrosion resistance are special properties of this alloy.

3.2. Reinforcements

3.2.1. Rice Husk Ash

Rice husk on burning gives 14 to 20% by weight of ash which contains 90% by weight silica and minor amounts of other elements. The chemical composition of the RHA is given by Table 2.

Table 2. Chemical Composition of Rice Husk Ash

Constituent	SiO_2	Al_2O_3	C	CaO	MgO	KaO	Fe_2O_3
(%)	90.23	3.54	1.23	1.58	0.53	0.39	0.21

The rice husk was obtained from local sources in S.K Rice husk industries, Nizamabad. Then it was washed with water to remove the dust and dried at room temperature for 1 day. Washed rice husk then heated to 200^0 C for 1 hr duration to remove moisture and organic matter. During this operation, the color of the rice husk is changed from yellow to black.

3.2.2. Fly Ash

Fly ash was obtained from NTPS, Vijayawada, India. Fly ash is one of the residues generated in the combustion of coal. It is generally captured at the chimneys of thermal power plant. Fly ash includes substantial amount of silica both amorphous and crystalline lime. Fly ash is commonly used in supplement to Portland cement in concrete production. The chemical composition of fly ash is shown in Table 3.

Table 3. Chemical Composition of Fly Ash

Constituent	SiO_2	Al_2O_3	MnO_2	Na_2O	K_2O	CaO	Fe_2O_3	TiO_2	CFA
(%)	63.95	26.07	0.02	0.02	0.04	2.43	4.88	0.68	1.91

3.1.4. Fabrication of the Composites

Initially, A356.2 Al alloy 89% by weight was charged into the graphite crucible and heated to about 750ºC till the entire alloy in the crucible was melted. The reinforcement particles RHA and FA were preheated to 800^0 C for 1 hour before incorporation into the melt.1wt % magnesium was added to enhance the wettability between rice husk, fly ash particles and the alloy melt. 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 preheated RHA and FA particles in 4 and 6 % by weight respectively were added into the molten metal at a constant rate. The stirring process was continued for 2 minutes, even after the completion of particle feeding. The mixture was poured into the mold allowed to cool to room temperature. Thus (89% Al356.2+1%Mg+4%RHA+ 6%FA) aluminum hybrid metal matrix composite was prepared. By repeating the same procedure the other compositions were prepared. Pure Al 356.2 samples are also under similar processing conditions.

Figure 1. Tensile and Compression Test Specimens as per ASTM Standards

4. Results and Discussions

4.1. Hardness Test

Rockwell hardness test was carried out on all four specimens. The results obtained were shown in the below Figure 2.

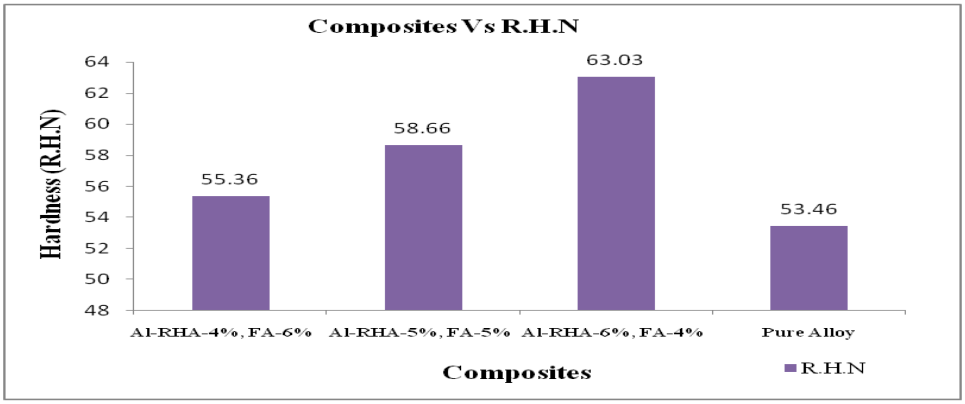

Figure 2. Variation of Hardness Number with the Weight fractions of RHA&FA

The above figure shows that rice husk ash 6% and fly ash 4% in Aluminum matrix showed maximum increase in hardness. It was observed that the hardness of the composite linearly increasing with increase in weight fraction of the rice husk ash particles. The presence of such hard surface area offers more resistance to plastic deformation which leads to increase hardness [6]. Rice husk ash particles in more weight percentage may occupy all dislocations and forms hard surface.

4.2. Tensile Test

The tensile test was carried out on all three compositions and pure alloy. The experimental results of all three compositions and pure alloy were shown below. It was inferred that the tensile strength increased with an increase in the weight percentage of rice husk ash. Because, the RHA particles act as barriers to the dislocations while taking up the load applied. The improvement in tensile strength of the composite is attributed to

the fact that the filler rice husk ash possesses higher strength by offering more resistance. The composition with rice husk ash 6% and fly ash 4% showed maximum ultimate tensile strength. From the graph it was clear that addition of rice husk ash improve the tensile properties of the composite.

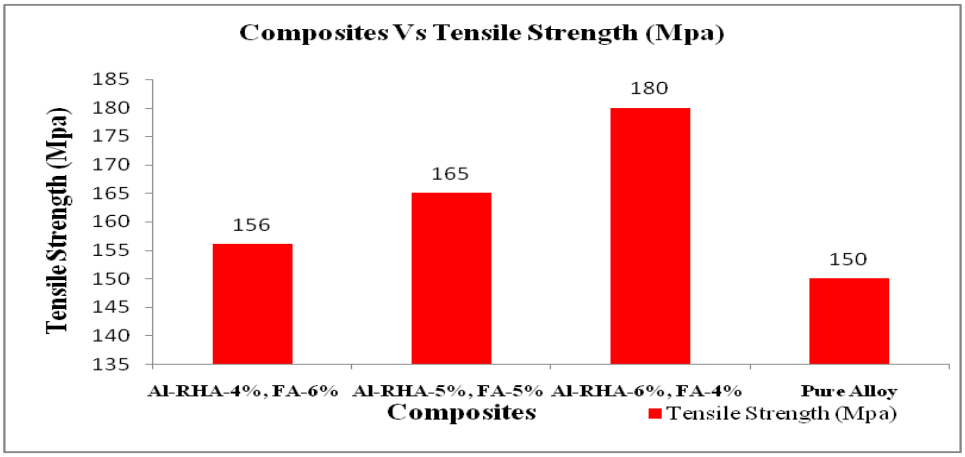

Figure 3. Variation of Tensile Strength with the Weight fractions of RHA&FA

4.3. Elongation

The percentage elongation or ductility of all four specimens was done and the observations were as shown below.

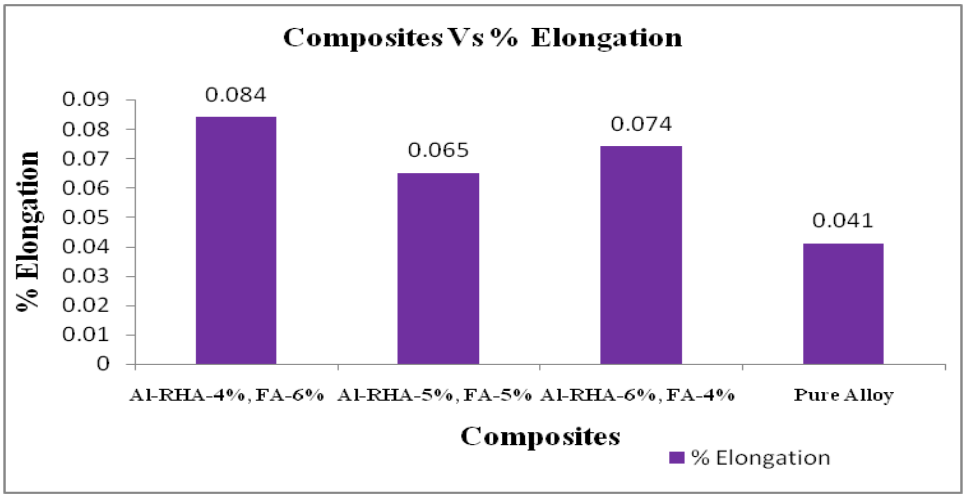

Figure 4. Variation of Tensile Strength with the Weight fractions of RHA&FA

The percentage elongation is more for the composite having rice husk ash 4% and fly ash 6%. The percentage elongation increases with increase in weight % of fly ash. The increase in percentage of rice husk ash forms much hard surface so it became much hard. The filler fly ash particles improve ductility due to the fact that they offer less resistance to load [8].

4.4. Compression Test

The compression test results of all test specimens were shown below. A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, “squashed”, crushed, or

flattened. The compression strength is maximum, when rice husk ash is 6% and fly ash is 4%. The compression strength increases with increase in weight % of rice husk ash because the rice husk ash particle acts as barriers while taking up the load and increases hardness.

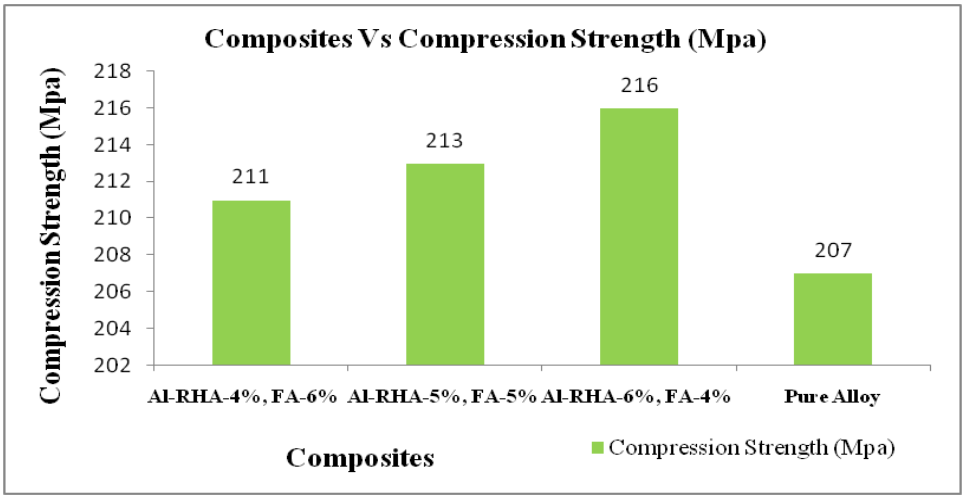

Figure 5. Variation of Compression Strength with the Weight fractions of RHA&FA

4.5. Impact Test

Impact tests were carried out on all test specimens as per ASTM –D790. Impact energy is a measure of the work done to fracture a test specimen. When the striker impacts the specimen, the specimen will absorb energy until it yields. At this point, the specimen will begin to undergo plastic deformation at the notch.

4.5.1. Izod Test

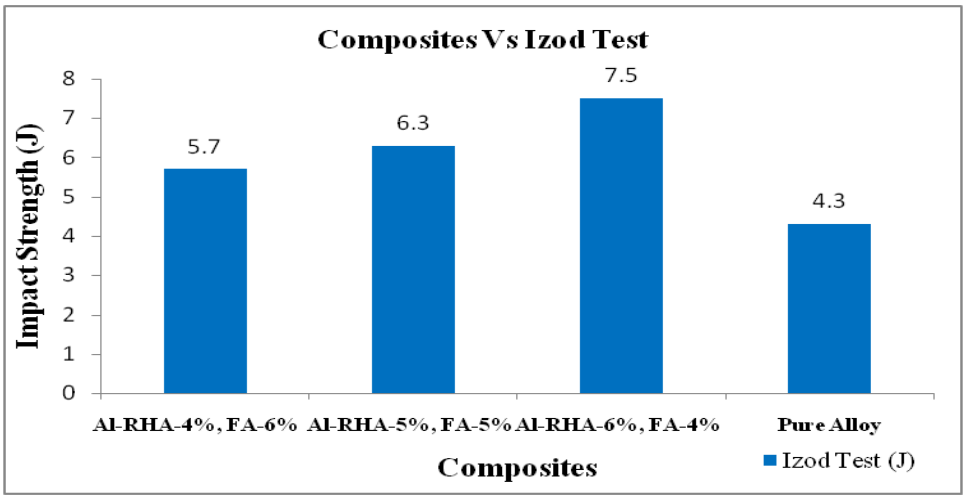

Figure 6. Variation of Impact Strength with the Weight Fractions of RHA&FA

4.5.2. Charpy Test

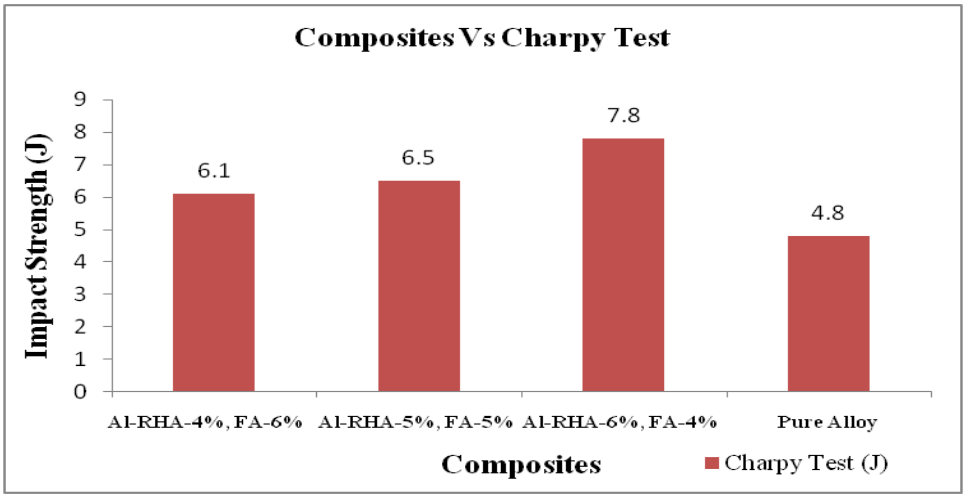

Figure 7. Variation of Impact Strength with the Weight fractions of RHA&FA

Impact strength in Izod test for pure alloy was 4.3 joules. With the addition of 4% of Rice Husk Ash the impact strength was 5.7 joules. When the 5% FA and 5 % RHA was added impact strength was 6.3joules and with 4% FA, 6%RHA the impact strength investigated was 7.5 joules. The impact strength was more when rice husk was more in the composite because rice husk ash particles forms hard surface. In Charpy test also the similar trend was observed [9].

5. Conclusions

Based on the results, the following conclusions can be drawn

- Rice husk ash and Fly ash particles were successfully incorporated in Al 356.2 alloy by stir casting technique.
- The hardness of Al356.2/RHA/FA composites increases with increase in Rice Husk Ash content.
- The Ultimate tensile strength increases with increase in rice husk ash content.
- The percentage of elongation increases with increase in Fly Ash.
- The Compressive strength increases with the increase in the percentage of Rice Husk Ash.
- The impact strength increases with increases in the percentage of Rice Husk Ash.
- All the hybrid cases shown better improvement in mechanical properties than pure alloy.
- The poor wettability of the phases in the matrix is the major problem at higher weight fraction of reinforcement, due to this problem the strength decreases after certain limit. We can overcome this problem by adding small amount of Magnesium and by pre heating the reinforcements and the molding die.

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