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SYNTHESIS & CHARACTERIZATION OF RHA (RICE HUSK ASH) PARTICULATES REINFORCED A7075 COMPOSITES

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ABSTRACT

There has been an increasing interest in composites containing low density and low-cost reinforcements. Composites find a major usage in society with the advancement of the technology and research. A7075 is an Aluminum alloy series which is the strongest alloy of the aluminum present anywhere. This makes it find its usage in aerospace (making of space ship hulls) and defense sectors (M-16 rifles etc).This research paper is aimed to increase the properties of the alloy further by adding a reinforcement which is agriculture based and is abundantly available. The alloy ingot was cast and tested for basic mechanical properties, compressive strength and also for the strain hardening rate after the heat treatment properties. The composite was cast using stir casting technique. The composite formed was A-7075 with 5% RHA (RICE HUSK ASH). The reinforcement (preheat treatment), composite and the base alloy was subjected to T6 heat treatment condition and then tested for further mechanical properties.

Keywords: *Aluminum alloys, A-7075 metal matrix, Stir casting route, Agricultural waste composites, Rice Husk Ash, Ageing Studies.*

1.Introduction

The major commercial volumes of MMC's are being observed in the Aluminium matrix composites due to its major advantage over other ferrous or non-ferrous metal alloys. These Aluminium matrix composites are called AMC's, which are responsible for the annual 69% of the MMC's production [9]. There are different methods of producing the MMC's. They are mostly solid, (*Siva Ramakrishnan, Journal of manufacturing engineering, march 2017:41)* and liquid ways of processing methods [1].

The reason for considering this alloy is to find improvement in synthesizing, characterization and improve its already existing properties so that it is helpful in the defense and aero space industry. The aluminum zinc alloy makes it the hardest known alloy in the whole aluminum series. The decrease in density and increase in its properties might be of great help in the following sectors; which are now a days are major areas of investment in developing countries like India. The following experimentation has been carried out in order to find the possibilities of enhancing the properties of the A-7075 alloy, mostly pertaining to the defense and the aero space section. The present investigation is carried out for the synthesis of Aluminium composites, using Rice Husk Ash as reinforcement.

2. Materials and Methods

2.1. Synthesis of A-7075 alloy and Rice husk ash reinforced composite

The alloy ingot of A-7075 of whose composition is shown in **Table 1** (received from Bharat Aerospace, New Delhi) was cut into pieces in a stationary pot type electrical furnace having a refractory material crucible (no.4) at nearly 710°C. The following study included the synthesis of A-7075 composite which was used as the matrix material, while the Rice Husk ash was used as reinforcement. The required amount of rice husk ash was calculated according to the ratio of Al/rice husk ash. The metal matrix composites were produced by using Stir casting method.700 g of the A-7075 alloy was charged into the crucible made from refractory material, and heated up to 710°C (above the liquidous temperature) for melting. **Fig. 2** shows the after cast figures of alloy and the composite [2].

Rice Husk as we know is an agricultural waste which is abundantly available and is used as additional fuel for household cooking purposes. The

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rice husk was obtained from nearby “Sri Lakshmi Rice mill” near Etcherla, Vizag; shown in **Fig. 1**. The composition of the Rice Husk as received condition is shown in **Table 2**. The Rice husk had to be cleaned thoroughly and kept in sun to dry for nearly 4 – 5 hours. It was made into ash at nearly 700°C in a muffle furnace for nearly 5 hours. After that, sieve analysis on the rice husk was carried out using Rotap sieve shaker for 15 mins. The maximum weight was gained/ collected at -250 to +300 sieves The dried rice husk ash was then kept in furnace at 935°C for nearly 3 hours (preheating). [3]

Fig. 1 Showing the reinforcement Rice Husk and Ash. (a) Rice Husk as received condition. (b) Rice Husk Ash in granulated form after Heat treatment (Preaheating)

Table 1. Chemical composition of Al-87.1% Zn-6.15% alloy, wt%.

Al	Zn	Cr	Cu	Fe	Mn	Si	Ti	Mg
87	6	0.2	1.9	0.5	0.3	0.2	0.4	2.9

Table 2.Composition of Rice husk in as received condition, wt%.

SiO_2	Al_2O_3	Fe_2O_3	C	CaO	Loss on ignition
67.3	4.9	0.95	12.9	1.3	12.65

(a)

(b)

Fig. 2 As cast condition of alloy and composite. (a) As cast condition of A7075 alloy. (b) As cast condition of the composite A7075 with RHA as the reinforcement.

The density was calculated using arithmetic principle of the reinforcement, base alloy, composite etc. [4]. The density calculated for heat treated Rice Husk Ash (RHA), A-7075 alloy and A7075-5%RHA are tabulated and shown in **Table 3.1**

$$\text{Density of composite} = \frac{Wt_1}{(Wt_2 - (Wt_3 - Wt_1))}$$

$$= V \times \sigma_{A\text{-}7075} + (1 - V_r) \times \sigma_{RHA}$$

Where,

V_r = Volume percentage of the particular sample.

σ = density of the part

$$\text{Porosity calculation} = 1 - \left(\frac{\text{Measured density}}{\text{Calculated density}}\right)$$

2.3. Compression Tests

Compression tests were carried out on cylindrical specimens of A7075 alloy samples (10 nos.) and A-7075 with 5% RHA samples (10 nos.) of 16 mm Ø with (L/D) ratio of 1.0 of whose the data is shown in (Fig. 12) [5]. These cylindrical specimens of standard dimensions were prepared using conventional machining operations of turning, facing and drilling. Specimen edges were chamfered to minimize folding. A CTM machine was used to follow the compression testing mechanism, of 200 T load. The loads vs. Displacement curve of the compression specimen are shown in graphical form in Fig. 9. This also shows the True Stress vs. True Strain curves for A-7075 alloy (Fig. 10) and A7075-5% RHA composite (Fig. 11) for different aging samples which shows the increase in the values with increasing aging time and decreasing at over aging temperature.

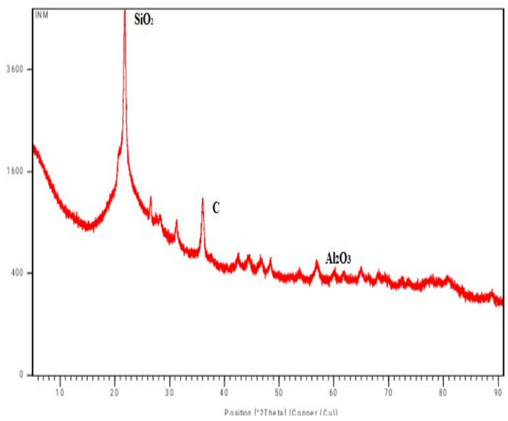


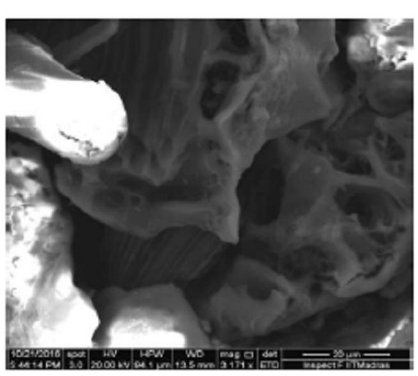
Fig. 3 X-ray diffractogram of Rice Husk ash particles used in the fabrication of A7075-RHA composites.

3. Results & Discussion

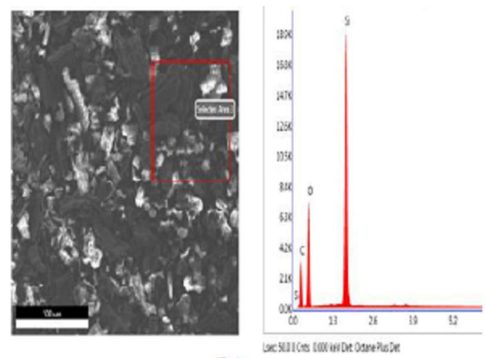
The morphology changes in the structure of the reinforcement added, which is RHA (Rice Husk Ash) has been tested for XRD, SEM and EDAX analysis. The powder size determines the amount of effect it could relay into the microstructure of the composite which is being made into. The XRD (**Fig. 3**), SEM and EDAX analysis (**Fig. 4**) of the RHA is described further.

3.1. Microstructure of Composites

A7075 alloy microstructure is composed of white (α) primary grains and a dark eutectic Zinc. It was known that there was the presence of rice husk ash particles in A-7075 alloy matrix fine structure in the base matrix of the Al-7075 alloy. The scanning electron micrographs of A-7075 alloy & A-7075- 5% RHA composite shown in figure7 [13] was carried out in order to understand the way the particles were bonding in the metal matrix.



(a)



(b)

Fig. 4 Figure shows (a) SEM image of Rice Husk Ash particulates;and (b) EDAX analysis of the Rice Husk Ash showing its composition.

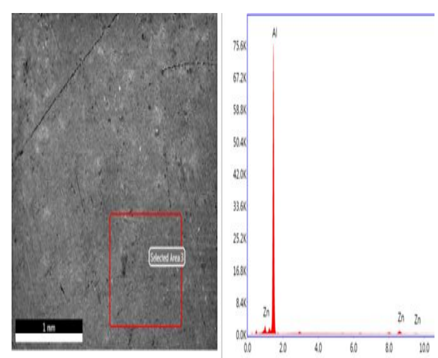


Fig. 5 EDAX analysis of the base A7075 alloy showing the selected area (full area) of the specimen and the graph showing the elements present in the alloy specimen.

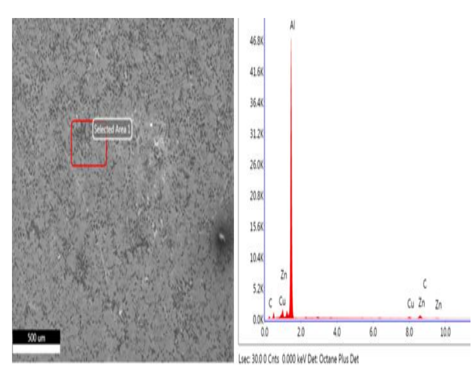


Fig. 6 EDAX analysis of the A7075-RHA composite of the selected area of the specimen and the graph showing the elements present in the composite (traces of Carbon).

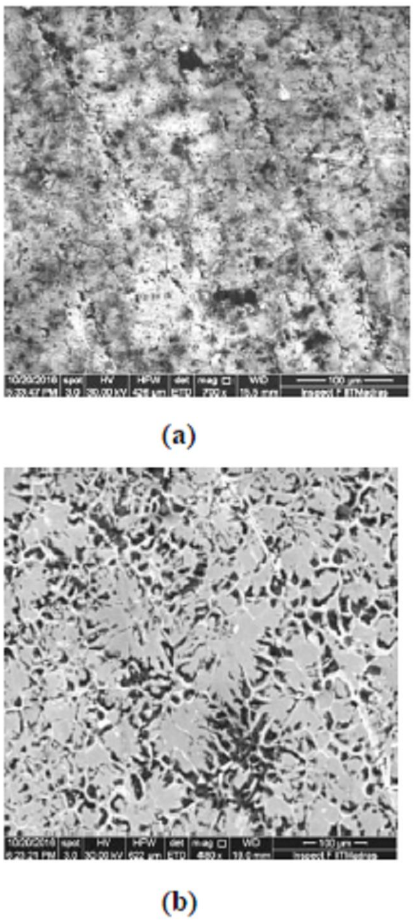


Fig. 7 SEM image at 100µm magnification.
(a) SEM micrograph of the A-7075 alloy.
(b) SEM micrograph of A-7075 RHA composite.

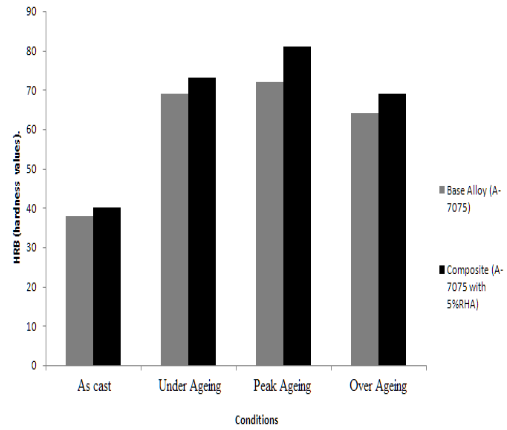


Fig. 8 The figure shows the Comparison of hardness at different peak points of A-7075 alloy and A7075-RHA composite.

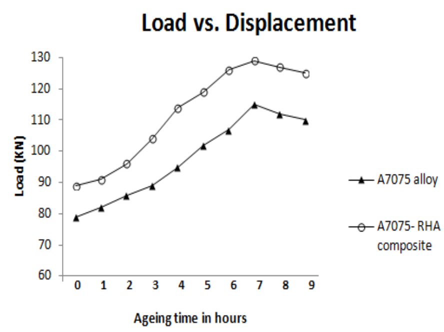


Fig. 9 Load vs. Displacement graph of A7075 alloy and A7075-RHA composite at various levels of aging temperature time.

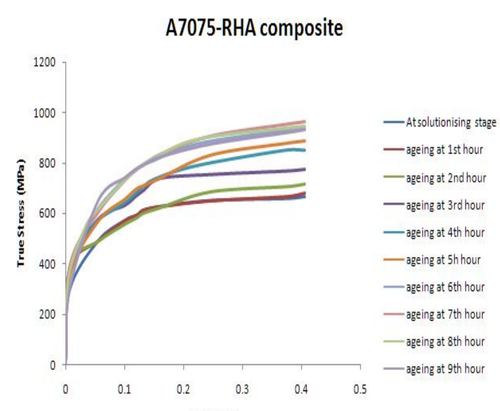


Fig. 10 True stress vs. True Strain curves of different samples at the different aging time as shown in the above graph for the A-7075 alloy samples.

3.2. Mechanical Properties of Composites

The density of the reinforcement, alloy, and the composite has a varied resemblance [9]. At any point of time, the density of the composite should be lower than the base alloy when the density of the reinforcement is lower than that of the alloy.

Hardness properties of the samples were taken into consideration and tested for various properties which affect the hardness of the material. The hardness of the samples was calculated using the Rockwell tester while the aging operation was performed.

The aging procedure involved heating up of the solutionized samples, 10 of each from base alloy and composite. The Ageing Studies properties (T6 heat treatment) is calculated and is shown in figure 8 and the under aging, peak aging and over aging processes were understood clearly [8].

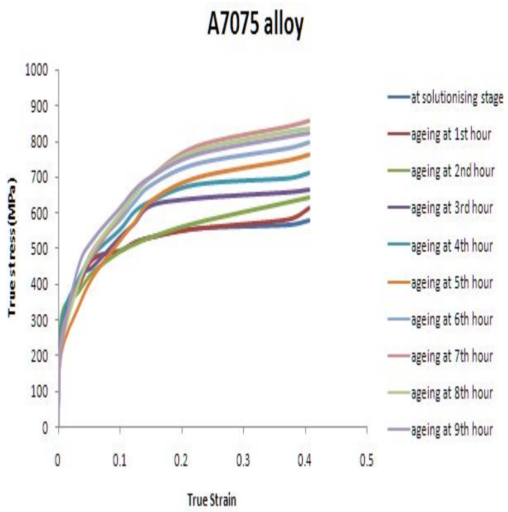


Fig. 11 True stress vs. True strain curves of different samples at the different aging time as shown in the above graph for A7075-5% RHA composite samples.

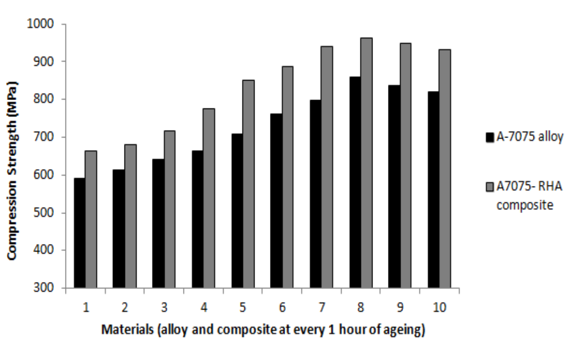


Fig. 12 Compressive strength Comparison between A-7075 alloy and A7075-5%RHA composite at various levels of aging temperature.

3.3 Comparison between Reinforcements and basic mechanical properties of the composites

The comparative data between the reinforcements of the Rice Husk Ash and the fly Ash shows the different mechanical properties. Table 3 shows the Comparison between RHA, Fly Ash and Silicon Carbide (SiC) [10] along with few of the mechanical properties of the respective composites with equal weight percentage.

Table 3. Comparison between various reinforcements and mechanical properties of A 7075 alloy.

Properties/ Composites	A7075	A7075	A7075
Reinforcement	RHA	Fly Ash [12]	SiC [14]
Density of the Reinforcement (g/cc)	0.5	1.1	1.32
Grain size (μm)	53	0.22	-
Density of the composite (g/cc)	2.7286	2.6	2.726
Hardness (HRB)	81	75	82

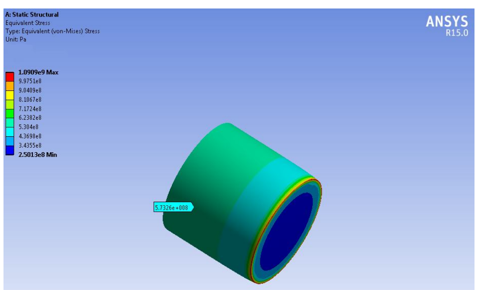
3.4 Comparison between the practical data and Analytical data

It was further taken to consideration to validate the following data using an analysis software which could further be observed as the deviation between the actual data and the analytical data, although the closeness of the values doesn't show that it's the ideal way of approach since many factors were excluded while calculating the analytical data as well. But, the analysis carried out also represents the values which could be nearby with not much deviation, hence validating the practical experimental values.

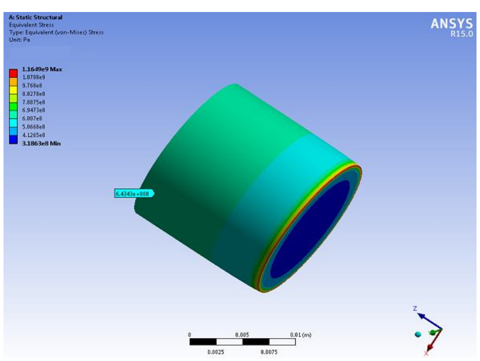
For carrying out stress analysis of A7075 and A7075 RHA samples, ANSYS version 15 was used with an environment of "structural analysis"; specifying the materials' young's modulus and poisons ratio for the base alloy and the composite; the samples were taken as cylinder in shape of (H/D) ratio to be 1; having dimensions of 16mm respectively. Fig. 13 shows the analysis of alloy and composite with the probe showing the stress value at the point where the load was applied. Table 4. shows the different values compared with the analysis and the experimental data at various points of aging studies. The various stages are, solutionizing, under aging, peak aging and over aging.

Table 4. Comparison between alloy and composite at various stages

	Solution -using	Under ageing	Peak ageing	Over ageing
A7075 EXP (N/mm^2)	393.113	507.56	572.2	547.35
A7075 Analysis (N/m^2)	3.97E+8	5.1E+8	5.7E+8	5.4E+8
A7075-RHA EXP (N/mm^2)	442.87	592.15	641.91	622.01
A7075-RHA Analysis (N/m^2)	4.4E+8	5.9E+8	6.4E+8	6.2E+8



(a) Image showing stress value of peak aging condition of the base alloy.



(b) Image showing stress value of the peak aging condition of the composite.

Figure 13 Showing the analysis done for validation.

3.5 Observations

There are few observations which can be clearly drawn from the table which shows the data Comparison between the reinforcements used in this experimentation procedure and also in few others (Fly ash and SiC). The density of Rice husk ash is lower than that of fly ash and SiC yet on the whole density of the composite is not much reduced. Though the density is not much reduced but the hardness has comparatively increased. The grain size refinement in the reinforcement helped the drastic decrease in the density and has lead to increasing the hardness of the alloy considerably.

4. Conclusions

- Al- RHA (A7075- 5%RHA) composite was successfully synthesized using stir casting route.
- There were a uniform distribution and bonding of the reinforcement in the metal matrix Enhanced mechanical properties were observed with 5% RHA as reinforcement.
- SEM and EDAX experimentation was implemented which contributed to the result of the observation of the alloy, composite, reinforcement and their microstructures
- Aging studies were carried out on the samples and properties were studied at under aging, peak and over aging temperatures.
- Analytical data with the help of ANSYS-15 showed the experimental data was within a percentage deviation of ±5%.

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