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Rice Husk Ash Reinforced in Aluminium Metal Matrix Nanocomposite: A Review

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***Abstract:** The present work entitled "Rice Husk Ash Reinforced in Al Metal matrix nanocomposite" was taken up to study the optimum operating conditions at laboratory scale. In this process the rice husk ash reinforced into the metal composite it's also called metal matrix composite (MMC's). Nanocomposites are materials with a nanoscale structure that improve the macroscopic properties of products. Different weight fractions of reinforcement were used to fabricate the composites. Ball milling is used to synthesis the rice husk ash from micro to nano. Scanning electron microscope equipped with particle size analyzer is used for macro & nanostructure characterization. The results reveal that the percentage re-inforcement of RHA will increase ultimate tensile strength, compressive strength and hardness of the composite.*

***Keywords:** Rise Husk Ash, Ball Milling, Particle size Analyzer, Raman Spectroscope, SEM, NanoComposites.*

1. INTRODUCTION

Metal matrix composites are engineered materials with a combination of two or more dissimilar materials to obtain enhanced properties. Nanocomposites show much improved properties over their micro sized composites. A small amount of nanofiller is sufficient to improve the properties. This is due to their nano size and nano materials have high surface area to volume ratio. These are capable of advanced structural, aerospace, automotive, electronic thermal management and wear applications. In general, the reduced weight and improved strength and stiffness of the metal matrix composites 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 [1]. Among various reinforcements used like fly ash, fibers, rice husk ash etc.

Now most of the work is carried out to develop composites using rice hush ash[2].

Rice husk ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste byproduct. During milling of paddy, about 80% of weight is received as rice, broken rice and bran. Rest of the 20% weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for parboiling process. The husk contains about 75% organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process is known as rice husk ash (RHA)[3]. Approximately, 20 kg of rice husk is obtained for every 100kg of rice, 5kg of rice husk ash is obtained for every 100kg of rice.

The recent research studies reported that RHA in turns contains around 85%-95% amorphous silica [4]. On thermal treatment, the silica converts to crystallite, which is a crystalline form of silica. However, under controlled burning conditions, amorphous silica with high reactivity, ultra-fine size and large surface area produced.

In present work the ultra-fine size amorphous silica powder is again crushed by using ball milling finally the powder is in nano range. An attempt is made to utilize the abundantly available RHA as reinforcement in metal matrix composites to improve the mechanical properties and decrease the density of the material.

2. LITERATURE REVIEW

In year 1927 MMC Materials began as "Mississippi concrete and Material Company" in Jackson, Mississippi, formed by the company now known as "Dunn Investment Company in Birmingham.

Saravanan explained, "The possibilities of reinforcing aluminum alloy (AlSi10Mg) with locally available inexpensive rice husk ash for developing a new composite material." They developed metal matrix composite using a liquid metallurgy route. In this process they prepared MMC with different weight fraction of reinforcement material of (RHA). Finally they observed the percentage reinforcement of RHA will increase ultimate tensile strength, compressive strength and hardness of the composite [3].

Anlit Mittal concludes that Rice husk ash is the only agricultural waste containing largest amount of silica in it. For increase wettability between metal matrix and reinforcing particles magnesium is used. Finally they observed that the hardness is increased linearly with increasing the weight percentage of reinforcing particles.

D Lingaraju explained that, “The Effects of nanoparticle as fillers in glass-epoxy composite system on the mechanical and Tribological properties”[6].

Nano composite means combination of two or more constitutes at least any one of the constitute in the nanorange (1 to 100 nano meters). Therefore in the present investigation,

The size of reinforcement material (RHA) is reduced from micro to nano range by using the high energy ball milling. Finally we reinforced the nano range RHA into Al alloy metal and observed the mechanical properties. The results reveal that when compared to the previous papers we observed much improvement of mechanical properties like tensile strength, hardness of the composite and decrease the density of the material.

Synthesis

There are three key steps in the development of nanoscience and nonotechnology: material preparation, characterization, and device fabrication. Preparation of nanomaterials is being advanced by numerous physical and chemical techniques.

In this present study, rice husk was procured from source in Kakinada (India) and was thoroughly washed with water to remove the dust and dried at room temperature for one day.

Washed rice husk was then heated at 200°C for 40 minutes to remove the moisture and organic matter. During this operation, the color of the husk changed from yellowish to black because of charring of organic matter. It was then heated at 600°C for 20min to remove carbonaceous material [5]. After this process the loss of ignition in RHA occur and the color changed from black to grayish white.

Figure 1.a) Rice Husk Ash after drying and mixture.

Figure 1.b) Rise Husk Ash with organic matter.

Figure 1.c) Rice Husk Ash with (85-95% of silica).

The total heating process was done by using Electrical Muffle Furnace see the fig2.

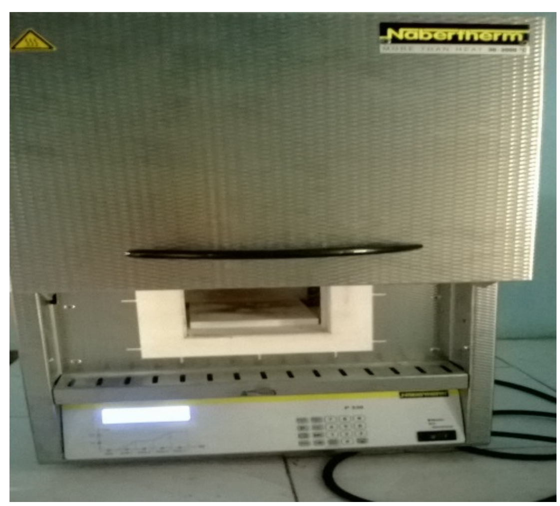

Figure 2:Muffle Furnace

After completion of this process the size of the rice husk ash approximately is in the micro range. This rice husk ash size again reduced from micro to nano by using high energy planetary ball milling.

The principle of ball milling is continuous welding fracturing and re-welding of powder particles. The working principle of high energy planetary ball milling is shown in figure-3.Such a process can result in the formation of an alloy with nanometer-sized grains. During the mechanical alloying process, the powder particles are periodically trapped between colliding balls and are plastic deformed [6]. Such a feature occurs by generation of a large number of dislocations as well as other lattice defects. The working principle of high energy planetary ball milling is shown in figure-3.

Figure 3.a) High energy planetary ball milling.

Figure 3.b) Inside tungsten carbide jar and balls.

Inside planetary ball milling the jar and balls are made up of tungsten carbide, because they have high hardness compared to the other materials. The ball collisions cause fracturing and cold welding of the elementary particles, forming clean interfaces at the atomic scale. This leads to an increase in the interface number while the sizes of the components area decrease from millimeter to sub millimeter dimensions. Concurrent to this decrease of the elementary distribution, some crystalline and nanocrystalline intermediate phases are produced inside the particles involving chemical changes. Different types of materials include ceramic, metallic, polymer and composites are synthesized by ball milling.

There are different parameters involved under this process they are ball to powder ratio, rotating speed, grain size and time. This type of ball milling equipment is used to produce less than hundred grams of powder. Its name represents the planet-like movement of its jar on a rotating support disk. The jar rotates around its own axes. The diameter of the ball we are taken 10mm and weight of the ball is 8grams.

Initially 20grams rice husk ash and 10 tungsten carbide balls is taken into the jar. Therefore we are maintaining ball to powder ratio 4:1. At the time of synthesis collected samples for every one hour shown in figure-4 nearly 38 samples we are taken.

Figure 4: Ball milling Samples from one to eighty hours

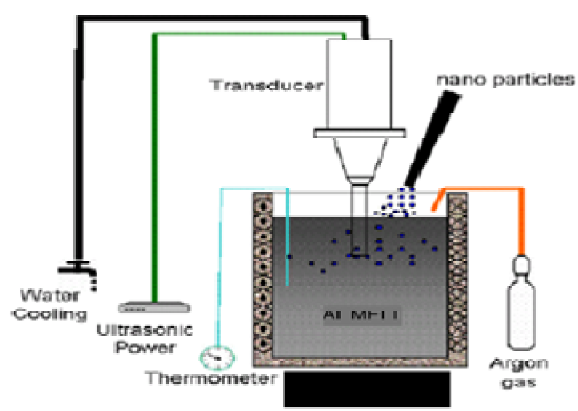

Figure 5: Proposed model is used for disperse the nanoparticle in MMC

The synthesis of metal matrix composite used in the present study is carried out by using the liquid metallurgy route. Initially, Al alloy is charged into the graphite crucible and heated to 800^0C till the entire alloy in the crucible is melted. The reinforcement particles are then preheated to 600^0C for three hour before incorporating into the melt. After the molten metal is fully melted degassing tablets was added to reduce the porosity. Simultaneously, 1wt% magnesium is added into the molten melt to enhance the wettability between rice husk ash and particles and alloy melt. It is noticed that without addition of magnesium, the particles of rice husk ash are rejected [7]. A stainless steel stirrer is lowered into the molten melt slowly to stir the molten metal at the speed of 500-700rpm. The speed of the stirrer can be controlled by using regulator provided on the furnace. The preheated RHA particles were added into 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. A sonicator will develop ultra sound wave vibrations in the mould melt so that the reinforcement RHA nano particles will dispersed uniformly. In the MMC the sonicator setup is shown in figure 5.The mixture was poured into the mold which was also preheated to 500^oC for 30 min to obtain uniform solidification. Using this method, 4, 8, 12% by weight RHA particle-reinforced composites were produced.

3. CHARACTERIZATION

The current most challenging task is property characterization and device fabrication. Characterization contains two main categories: Structural analysis and property measurements. Structure analysis is carried out using a variety of microscope and spectroscopy techniques, while the property characterization is rather challenging.

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	43.8 nm	11.7 nm	41.8 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	43.8 nm	11.7 nm	41.8 nm

Cumulant Operations

Z-Average : 30.3 nm

PI : 2.889

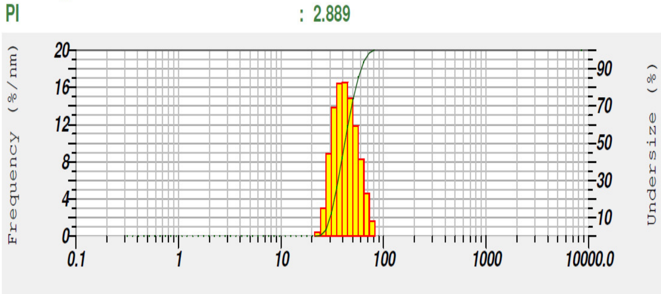

Figure 6: Size of the RHA particles at 38hours.

The properties of nanostructures depend strongly on their size and shape. The properties measured from a large quantity of nanomaterials could be an average of the overall properties, so that the unique characterization of individual nanostructure could be embedded.

In the present study, the size of the metal matrix composite and size of rice husk ash can be calculated by using particle size analyzer.

See the figure 6 the average size of the rice husk ash particles 43.8nm, therefore the size of the reinforcement material of Rice Husk Ash are in the nanorange.

The techniques for characterizing nanophase materials, including X-ray diffraction, transmission electron microscope, scanning electron microscope, scanning probe microscope. The aims at describing the physical mechanisms and detailed applications of these techniques for characterizations of nanophase materials to fully understand the morphology, surface and the atomic level microstructures of nano materials and their relevant properties. Hence, one of the current key objectives is to adapt and develop a range of techniques that can characterize the structural, electronics, magnetic and optical properties of nanostructure systems.

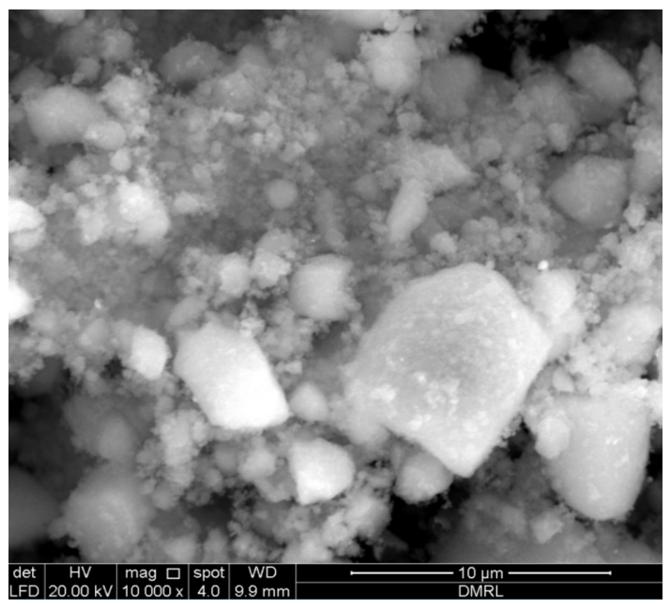

Figure 7:SEM Image of Rice Husk Ash at 38 hours.

Scanning electron microscope equipped with energy dispersive X-ray analyzer is used to study the reinforcement material in metal matrix nanocomposite.

It is observed that the size of the particle nearly 100nm and little particle clusters are observed.

One more characterization technique is TGDTA Analysis.

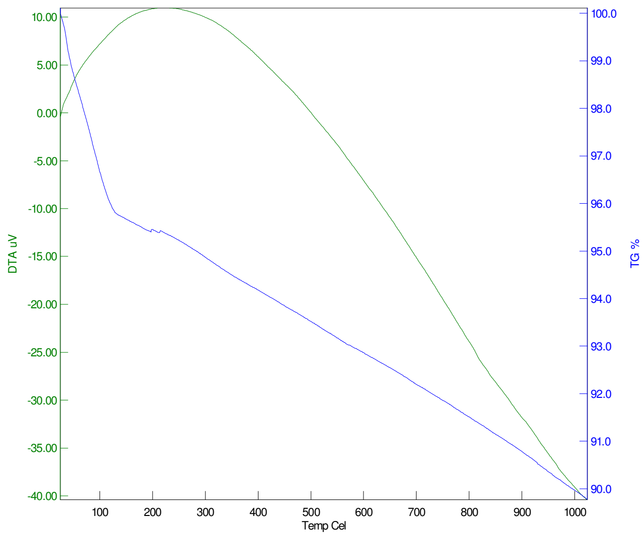

Figure 8.1: TGDTA Result at 0hr

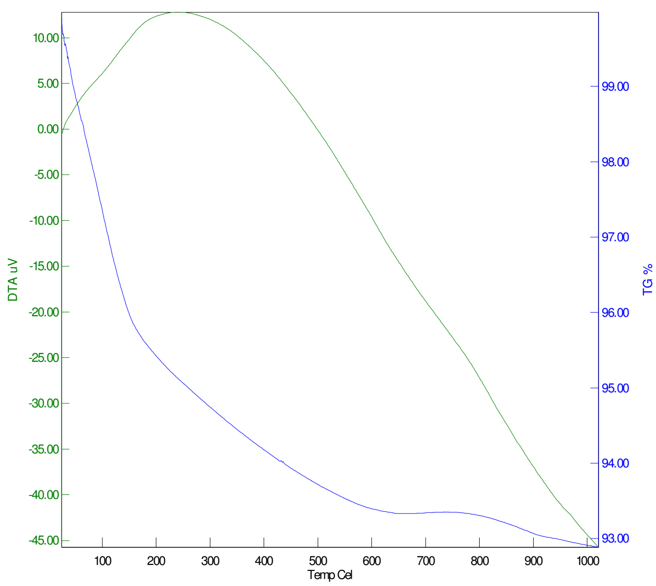

Figure 8.2: TGDTA Result at 38hr

By using the TGDTA analysis we can study the thermal analysis. See the figure 8.1 and 8.2 the thermal analysis of RHA at 0hr and 38hr respectively, Compared to the RHA at 38hr the loss of the material more at 0hr.

After calculated some of the properties observed difference between rice husk ash material in microrange and rice husk ash material in nanorange. When compared to the rice husk ash as reinforcement material in the micro range, rice husk ash as reinforcement material in the nano range can improve the properties drastically.

Mechanical properties are analyzed for the rice husk ash reinforced into the metal matrix composites. It is observed that there is a general increase in tensile strength and yield strength with increase in weight percent of the RHA-Sic hybrid reinforcement.

Hardness of the metal matrix nanocomposites were measured using Vickers's hardness test.

4. CONCLUSIONS

The conclusions drawn from the present investigation are as follows:

- Rice husk ash particles were successfully incorporated in aluminum alloy by using stir casting technique.
- The thermal stability of the material is more at nano level compared to micro level of the composite.
- The use RHA ash for the production of composites can turn agricultural waste into industrial wealth. This can also solve the problem of storage and disposal of RHA.
- From the experimental investigation, it was found that the mechanical properties of the metal reinforced composite shows improvement with the inclusion of nanoparticles.
- General properties like tensile strength, hardness will increase by increasing the reinforcement content in less quantity.

5. ACKNOWLEDGMENT

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