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AFFECT OF MECHANICAL PROPERTIES ON GROUNDNUT SHELL ASH REINFORCED AL6063

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Abstract: The extensive work is carried out on the inexpensive fabrication of the aluminum metal matrix composite material due to its growing applications in aerospace industry and automobile industry. The Al6063 is the most commonly used alloy of aluminum and find its applications mainly in architectural and building products. The composite fabricated by this alloy, with improved properties will have more applications. To develop the inexpensive composite material locally available groundnut shell ash is used as reinforcement and mechanical properties were analyzed at 3, 6, 9&12% weight percentage of ash. Composite was developed using liquid metallurgy route and mechanical properties such as tensile strength, compressive strength, hardness and percentage elongations are studied. The microstructure images were taken by using microscope for analyzing distribution of groundnut shell ash. The results revealed that with the percentage reinforcement of groundnut shell ash will increase ultimate tensile strength, compressive strength and hardness of composite.

I. INTRODUCTION

In today's world we all are looking to optimize things as maximum as possible in each field. While we are going to towards optimizing things in one or other way our environment is affected. The lot of work has been carrying out to develop low cost composite material using eco-friendly material. The aluminum alloys reinforced with ceramic particles exhibit better properties than the base alloy. Recently most of the research work is carried out to develop composites using various recycled wastes [1, 2]especially the environmentally friendly agro wastes as reinforcement. Among these the groundnut shell ash (GSA) is abundantly available by product. The groundnut shell ash has considerable amount of the ceramic content which is going to affect properties of the matrix aluminum alloy. Approximately by burning 28 Kg of the groundnut shell 1.5 Kg of ash is obtained. For fabrication of the composite the stir casting route lines is used because it is one of most cheap and best way for developing composites. In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Stir casting of metal matrix composites was initiated in 1968, when S.Ray introduced alumina particles into aluminum melt by stirring molten aluminum alloys containing the ceramic powders. Mechanical stirring in the furnace is akey element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement (Pradeep et al. 2007).Prabu et.al (2006) studied the Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite. Microstructure analysis revealed that at lower stirring speed with lower stirring time, the particle clustering was more.Increase in stirring speed and stirring time resulted in better distribution of particles. The hardness test results also revealed that stirring speed and stirring time have their effect on the hardness of the composite.Alaneme & Bodunrin et.al (2010) studied the mechanical behaviour of Alumina reinforced Al6063 MMC developed by Two Step Stir Casting Process. The tensile strength, yield strength, and hardness increased with increase in alumina volume percent while the strain to fracture and fracture toughness decreased with increasing volume percent alumina. In present research various weight fractions of groundnut shell ash are considered for the study. Experiments like tensile strength, compressive strength, ductility, hardness and impact strength are conducted to asses mechanical behavior of the composite. Further microstructure studies is done to check the distribution of the reinforcement in matrix metal by using microscope, images are taken at 100X.

II. MATERIAL AND EXPERIMENTAL PROCEDURE

A. Matrix material

The matrix metal which is used for development of the composite material is the alloy of aluminum i.e., Al6063 used whose composition and mechanical properties is given below.

- Silicon minimum 0.2%, maximum 0.6% by weight
- Iron no minimum, maximum 0.35%
- Copper no minimum , maximum 0.10%
- Manganese no minimum, maximum 0.10%
- Magnesium minimum 0.45%, maximum 0.9%
- Chromium no minimum, maximum 0.10%
- Zinc no minimum, maximum 0.10%
- Titanium no minimum, maximum 0.10%
- Other elements no more than 0.05% each, 0.15% total
- Remainder Aluminum (97.85%–98.76%)

Al 6063 is the most commonly used alloy for the Architectural and Building products, Electrical Components Pipe and Tube for irrigation system Door and Window frames Railing and Furniture

B. Reinforcement material

The Groundnut Shell which is obtained from the local factory is burnt openly in atmosphere to obtain the ash. Approximately by burning 28 kg of the groundnut shell the ash obtained is nearly 1.5 Kg. The color of the ash obtained is grayish black. But this ash cannot be used directly for composite preparation as it contains un burnt carbon so we have to do carbonization of the ash obtained, for this we kept the ash obtained from burning of shells of groundnut in the furnace at 600°C for 6 hours the mass of the ash left out after doing this is approximately 990 grams and the color of the ash changed into grayish white after this process. Now the reinforcement obtained can be used for development of composites. The reinforcement is pre heated to the temperature of 600°C before incorporating to the molten metal in furnace. The composition of the Groundnut Shell is checked by doing the XRF of the ash after carbonization, the result of the XRF of the groundnut shell ash is shown in table (2.1) and figure 2.1 shows the reinforcement after carbonization.

Fig 1. Groundnut shell ash (GSA) after carbonization

Table 1: Composition of groundnut shell ash

Constituents	Composition
Al_2O_3	5.93%
SiO_2	17.61%
Fe_2O_3	3.43%
MgO	9.79%
P_2O_5	16.31%
CaO	9.89%
Na_2O	4.85%
SO_3^-	3.67%
K_2O	18.26%
Cl	1.72%
ZnO	0.57%
TiO_2	0.22%
SrO	0.10%
Mno	0.08%

III. EXPERIMENTAL PROCEDURE

A. Specimen Preparation

The experiment is performed using advance composite manufacturing machine.The development of the metal matrix composite used in present study is carried out by using liquid metallurgy route. Initially the Al 6063 alloy is charged into the furnace of the stir casting machine and heated to the temperature of 680 °C. At a time 1 Kg of the alloy is used. The reinforcement particles are heated up to the temperature of 600°C for 1 hour before adding to molten alloy. After the metal alloy is completely melted, degassing tablets are added to reduce porosity and simultaneously 1% of magnesium is added to enhance the wettability between groundnut shell ash particles and matrix melt. A stainless steel stirrer is lowered into the molten melt slowly upto 2/3 of the height of the molten metal from the bottom of the crucible and the molten metal is stirred at a speed of 500 to 700 rpm. Then the preheated groundnut shell ash is added at very slow constant rate 1-2 gm per stroke. For proper mixing stirred speed is increased gradually from 500 to 700 rpm and stirring is continued for next 5 minutes after completion of reinforcement addition. The mixture is poured into metallic mould which is also preheated to temperature of 5000C for uniform solidification. The same procedure is repeated for 6, 9 and 12% weight fraction of reinforcement.

Fig.2. Stir casting setup

The three samples which are obtained is of same length of 300 mm but their cross section size is different two samples are of the circular cross section and one is of square cross section.

- The size of the square cross section sample is 1.5×1.5×30 cm. From this sample we prepared the sample for checking microstructure by using optical microscope and also we can prepare the sample for the impact test.
- The size of the one circular cross section sample is of diameter 20 mm. From this sample we prepared the samples for compression and hardness test.
- The size of the other circular cross section is of diameter 26mm. From this sample the specimen for the tensile testing is obtained.

Fig.3: Samples Prepared

B. Microstructure Characterization

Microstructure studies are conducted on the unreinforced and reinforced samples. This isaccomplished by using optical microscope. The objective to see the microstructure is to check the distribution of the reinforcement whether uniformly distributed or not. The images are taken at the 100X.

C. Mechanical properties observations

The experiment of tensile strength, ductility, compression strength, hardness and impact energy of the our base Al6063 alloy and composite fabricated with 3%,6%,9% and 12% Wt. fraction of groundnut shell as reinforcement is conducted.

3.3.1 Tensile Test

The tensile test of composite is done on the UTM (Universal testing machine) of the capacity 100Kn and resolution of 0.05 KN The standard used for the testing is Indian standard IS1608:2005. The comparison of the properties is made with Matrix metal. The drawing of the specimen of tensile test is given in figure-3

Fig.4. Tensile test specimen drawing

3.3.2 Compression Testing

The compression test of the composite material is also carried on the UTM (Universal Testing Machine) of capacity 100 KN and resolution of 0.05 KN. Indian standard IS: 1608:2005 is used for the compression testing. Compression test results of composite material are compared with compression result of Matrix metal. The size of the specimen is 10 mm diameter and length is 18mm.

3.6.3 Hardness Test

Bulk hardness measurements were carried out on the base metal and composite samples by using standard Vickers hardness test. Indian standard IS 1501-2002 is used for the hardness test. The results obtained are compared.

3.6.4 Impact test

The impact test is performed on the base metal and composite material prepared to check the impact energy required to fail the material. Comparison of results obtained is done between base and composite material. The Charpy impact test is used for impact testing. The drawing of specimen of impact test is shown in fig.5.

Fig.5. Impact test specimen drawing

IV. RESULTS AND ANALYSIS

4.1 Microstructure studies

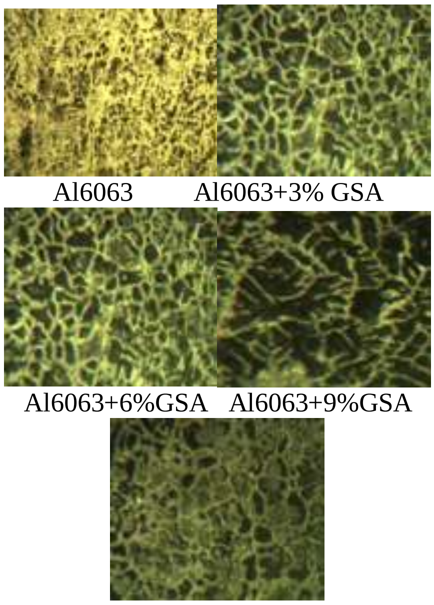

Fig.6. Microstructure images of Al60603+RHA (100X)

The microstructure images taken for the base sample and composite material with 3, 6, 9 and 12 % are shown in figure-6. A uniform distribution of groundnut shell ash without discontinuities can be observed from these microstructure images along with good bonding between matrix material and groundnut shell ash particles.

B. Tensile Strength

The relation between tensile strength of the aluminum composites with the different weight fractions of bagasse ash particles i.e. 3%, 6%, 9% are shown in figure 7. It is observed that the ultimate tensile strength increased with an increase in the weight percentage of groundnut shell ash. Since the groundnut shell ash particles act as barriers to the dislocations when taking up the load applied. The similar observation was found in Sarvanan et al. (2013), for rice husk ash particles. The observed improvement in tensile strength of the composite is attributed to the fact that the filler groundnut shell ash possesses higher strength by offering more resistance. There was a decrease in the tensile strength of the samples with groundnut shell ash weight fraction around 9%. It may due to the poor wet ability of the reinforcement with the matrix.

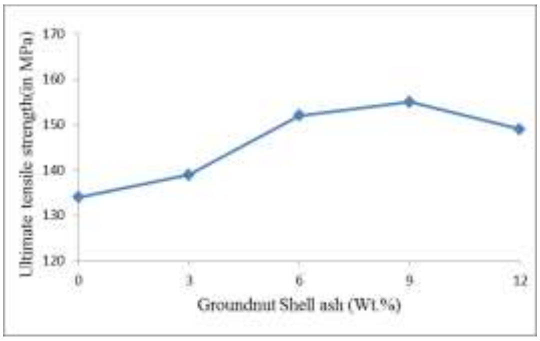

Fig.7.Variation of tensile strength with weight fraction of groundnut shell ash

C. Compressive Strength

Compressive properties of alloy and its composites are shown in the figure-8. It is clear that the compressive strength increased as the percentage of groundnut shell ash particles increases in the alloy. This may be due to the hardening of the matrix by groundnut shell ash particles. Similar findings are observed in Saravanan et al. (2013).

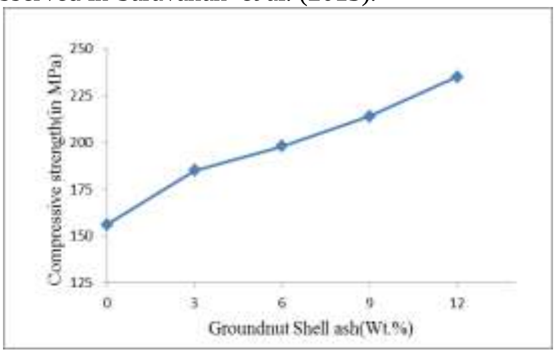

Fig.8.Variation of impact strength with weight fraction of groundnut shell ash

D. DUCTILITY

The percent elongation decreased with increase in weight fraction of groundnut shell ash particles. The reduction in the percent elongation of the composites could be attributed to the presence of particle clusters and weight fraction of second phase particles. These factors contribute to decrease in weight fraction of the ductile phase (weight fraction of the matrix phase) and there by leads to decrease in percent elongation.

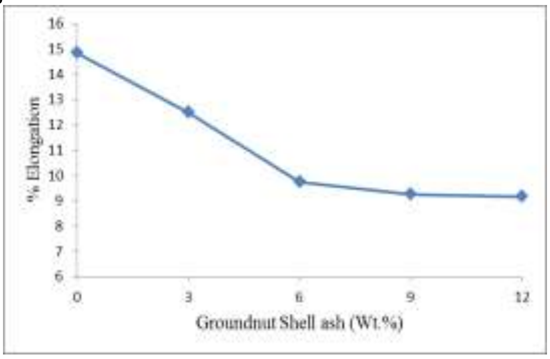

Fig.9.Variation of % elongation with weight fraction of groundnut shell ash

E. HARDNESS

The hardness values increased with an increasing percentage of groundnut shell ash particle additions. This may be due to the presence of hard ceramic phase of the groundnut shell ash in the ductile matrix. Similar findings were obtained by Sarvanan (2013) et al using rice husk ash. As far as hardening behavior of the composites is concerned, particle addition in the matrix alloy increases the strain energy in the periphery of the particles in the matrix and these tendencies may be due to the formation of the dislocation at the boundary of the ceramic particles by the difference in the thermo-expansion coefficient between the matrix and ceramic particles. It is thought that the higher the amount of the ceramic particles in the matrix, the higher the density of the dislocation, and as a result, the higher the hardness of the composite.

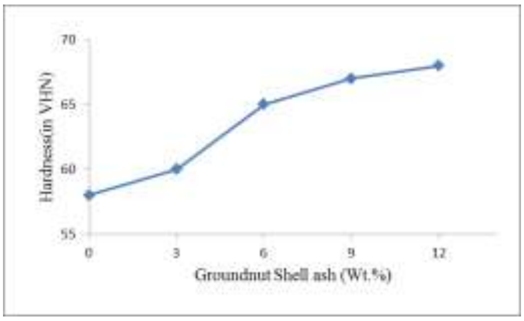

Fig.10.Variation of the hardness with weight fraction of groundnut ash

F. IMPACT ENERGY

The impact energy of the samples, decreased as the percent of groundnut shell ash particles addition increases in the alloy. The brittle nature of the groundnut shell ash plays a significant role in degrading the impact energy of the composite, since the unreinforced alloy and the alloy reinforced with 3wt% groundnut shell ash particles have the highest impact energy, indicating that they are the toughest of them all.

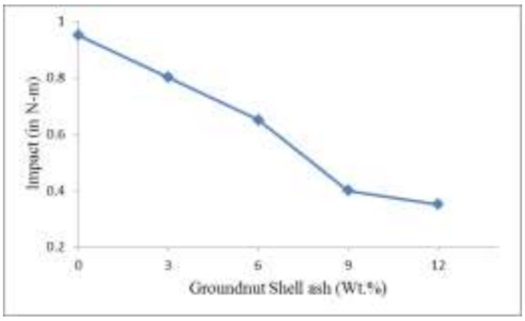

Fig.11.Variation of Impact energy with weight fraction of groundnut shell ash

V. CONCLUSION & FUTURE SCOPE

A. Conclusions

Experiments were conducted on aluminum 6063 alloy by adding various percentage reinforcements to it as discussed above. The specimen prepared were subjected to various mechanical tests like tensile test, compression test, hardness test, impact test and ductility test. Results show that tensile strength increases up to 9 % weight percentage of reinforcement and then start decreasing whereas compressive strength increases within selected range of parameters. Following conclusions can be drawn:

1).Presence of groundnut shell ash particles increases the compressive strength. Also the tensile strength increases up to 9% of reinforcement and then started decreasing due to improper mixing.

2). Impact energy decreases with increase in percentage weight of ground nut shell ash particles.

3).Hardness increases while ductility decreases with increase in weight percentage of groundnut shell ash particles.

4). Hence it can be concluded that groundnut shell ash particles considerably affect the properties of aluminum 6063 alloy.

B. Future scope

1). In the present work, groundnut shell ash was solely added to the aluminum matrix alloy.

2). Further work can be extended by adding some other reinforcement along with groundnut shell ash so as to fabricate a hybrid composite.

3).Hybrid composite is expected to improve the properties as it would include two reinforcements.

4). some other tests like fatigue test, torsion test etc. can be done to assess the properties and favorable applications in this
field.

5).Some experimental technique like DOE can be used in future experiments.

6). A comparative study on similar other Al MMC's can be done and possibly a hybrid alloy with better composition and better properties could be derived.

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