International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Fabrication and characterization of Mechanical Properties of Al-RHA-Cu Hybrid Metal Matrix Composites

Ankit Mittal[Ȧ*] and Ramnarayan Muni[Ȧ]

[Ȧ]Department of Mechanical Engg, Devi Dyal Institute of Engineering and Technology Barwala, (Panchkula) India

Accepted 05 November 2013, Available online 01 December 2013, **Vol.3, No.5 (December 2013)**

Abstract

Metal matrix composites are engineered materials with a combination of two or more dissimilar materials to obtain enhanced properties The widwspread acceptance of particulate metal matrix composites(mmc) for engineering application has been hindered by the high cost of producing components Advance composite materials metal matrix composite is gradually becoming very important materials in manufacturing industries e.g. aerospace, automotive and automobile industries due to their superior properties such as light weight, low density, high strength to weight ratio, high hardness. In the present investigation Al(6061) alloy was used as the matrix and rice husk ash and copper as reinforcements. The RHA used here because it is the only agricultural waste containing largest amount of silica in it. And it is abundantly produced in india every year. For increasing wettability between metal matrix and reinforcing particles magnesium is used here. The hybrid metal matrix composite was produced using stir casting techniques. The rice husk ash were added in 8%, 16%, 24%, 32% by weight and copper 3% by weight to the molten metal. The MMCs bars are prepared with varying the reinforced particles by weight fraction and with/without copper. It was observed that specimens containing copper shows improved values for hardness than specimens containing only rice husk ash. The hardness increased linearly with increasing the weight percentage of reinforcing particles.

Keywords: *MMC, Al6061, RHA*

1. Introduction

The aim of designing metal matrix composite materials is to combine the desirable attributes of metal and ceramics The addition of high strength, high modulus refractory particles to a ductile metal matrix will produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement Metals have a useful combination of properties such as high strength, ductility, and high temperature resistance, but sometimes some of them have a low stiffness value, whereas ceramics are normally stiff and strong, but brittle For example, aluminium and silicon carbide have very different mechanical properties with Young's moduli of 70 GPa and 400 GPa, coefficients o f thermal expansion o f 24 x 10'6/°C and 4 x 10'6/°C , and yield strength of 350 MPa and 600 MPa By carefully controlling the relative amount and distribution of the ingredients of the composites, as well as the processing conditions these properties can be further improved. Aluminum and its alloys normally solidify in columnar structure with large grain size which results in deterioration of their surface quality and mechanical strength. the influence of Cu addition to commercially pure aluminum results in in improvement on microstructure, microhardness, grain size, impact energy, strain, mechanical behavior. Fatigue resistance is an especially important property of Al-MMC, which is essential for automotive application. These properties are not achievable with lightweight monolithic titanium, magnesium, and aluminium alloys. Aluminum-silicon carbide metal matrix composite has low density and light weight, high temperature strength, hardness and stiffness, high fatigue strength and wear resistance etc. in comparison to the monolithic materials. Fine grain size is often desired for high strength. Fine particles may be added to increase strength and phase transformations may also be utilized to increase strength. Mechanical properties of Al-Cu alloys depend on copper content. Copper is added to aluminum alloys to increase their strength, hardness, fatigue and creep resistances and machinability. Some researchers have been studied that the addition of copper and/or silicon carbide to the Al–4wt%Mg metal matrix tends to improve the machinability of aluminum metal matrix material as aluminum metal is very soft. A significant reduction in torque and thrust force during dry drilling was observed as copper content increased in the metal matrix. Similarly, the addition of silicon carbide

*Corresponding author **Ankit Mittal** is a Research Scholar and **Er. Ramnarayan Muni** is working as Asst. Prof.

particles improves the machinability of the Al-Mg metal matrix.

1.1Why RHA

The rice husk is only agro residue having maximum siliceous ash content and available in dry form. Rice husk (RH) is an agricultural waste material abundantly available in rice-producing countries. They are the natural sheaths that from on rice grains during their growth. Removal during the refining of rice, these husks have no commercial interest. The annual rice husk production in India amounts is generally approximately 12 million tons. Rice husk is generally not recommended as cattle feed since cellulose and other sugar contents are low. Worldwide production of rice husk is about 120 million tons per year. That makes the rice husk one of the largest readily available but also one of the most under-utilized resources. Increase of environmental awareness has led to a growing interest in researching ways of an effective utilization of rice by-product, from which rice husk is particularly valuable due to its high content of amorphous silica .But it is interesting to note that rice husk contains 20% ash, 22% lignin, 38% cellulose, 18% pentosans and 2% moisture. It is felt that the value of this agricultural residue can be upgraded by bonding with resin to produce composite suitable for tribological applications.

1.2Why Stir Casting

In this study stir casting is accepted as a particularly promising route, currently can be practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production

2. Experimental work

In the present study, rice husk was procured from local sources in Haryana (India) and 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. During this operation, the color of the husk changed from yellowish to black because of charring of organic matter. It was then heated to 600 ° C for 12 h to remove the carbonaceous material. After this operation the loss of ignition in RHA occur. After this operation, the color changed from black to grayish white. 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 1 and Table 2.Initially 8.7kg of rice husk was taken and 1.8 kg rice husk ash was obtained.it was approximately 22 percent of initial rice husk weight.figure 1 shows image for rha.

2.1 Loss of ignition

10g of ash heated at 700-800°C for 1.5 hour
Weight of ash obtained after heating for 1.5 hour was 6.7g
Hence loss of ignition(10g-6.7g=3.3g)approximately30%

Figure 1 Rice Husk Ash

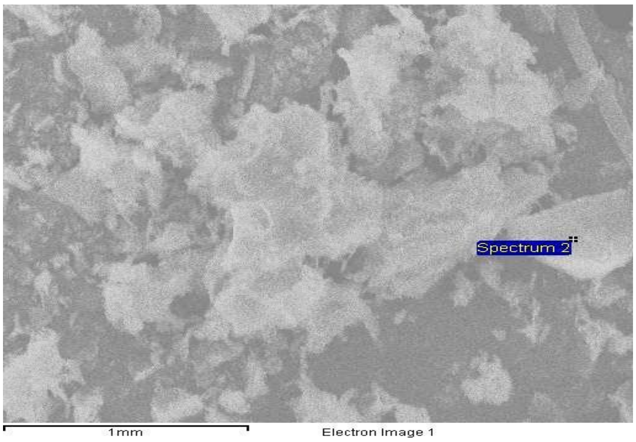

Figure 2 EDX Spectrum for RHA

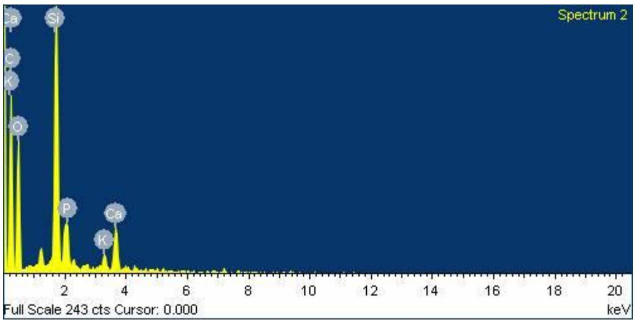

Figure 3 EDX Spectrum for RHA

3. Materials

3.1Material System

In this Study Al6061 alloy with theoretic density 2.7g/cm3 is used as matrix material and RHA of density 2.2g/cm3 is used as reinforcement. Copper(Cu)of density 8.96g/cm3 is also added to impart certain properties like hardness, and tensile strength .The chemical composition of AL6061 is shown in table. Test specimen are made which are classified based on wt%(8,16,24,32)+3%wt of copper and without copper.

Table 1 Chemical Composition of Al6061

Si	.4-.5
Fe	0.7
Cu	.15-.40
Mn	0.15
Mg	.8-.12
Cr	.04-.35
Zn	0.25
V	-----
Ti	0.15
Bi	------
Ga	------
Pb	------
Zr	-----
Al	remainder

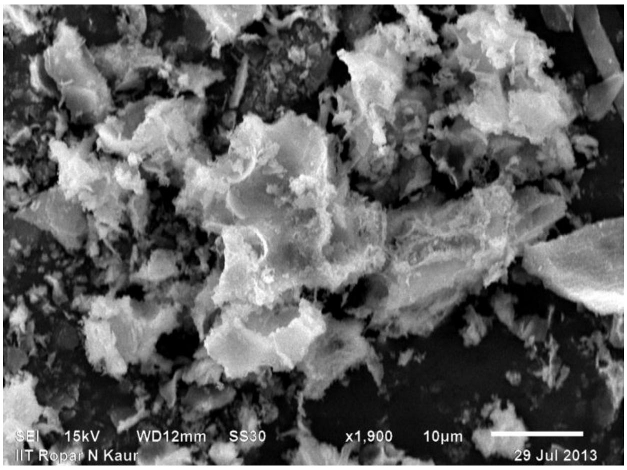

Figure 4 SEM Image for RHA

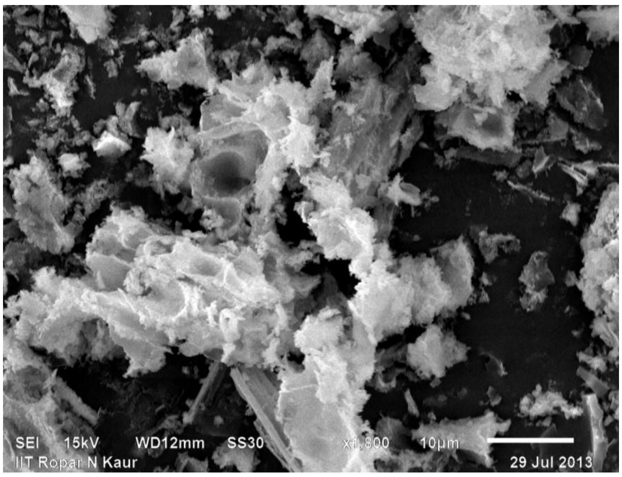

Figure 5 SEM Image for RHA

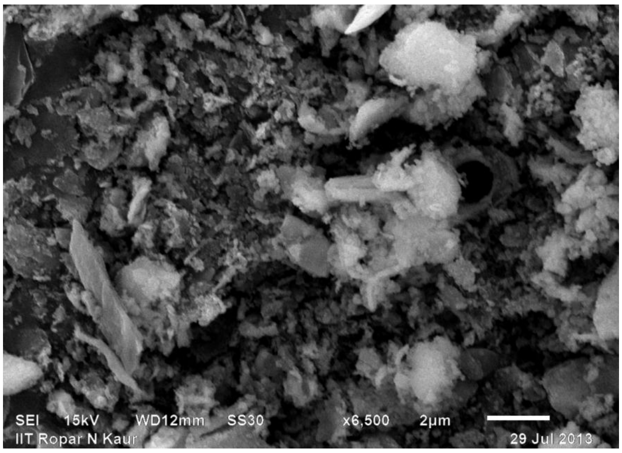

Figure 6 SEM Image for RHA

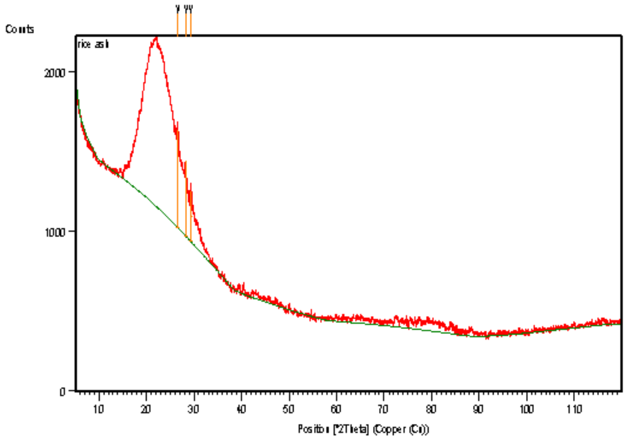

Figure 7 XRD Plot for RHA

Table 2 Chemical analysis of rice husks Element Analysis Mass Fraction %

Carbon	41.44
Hydrogen	4.94
Oxygen	37.32
Nitrogen	0.57
Silicon	14.66
Potassium	0.59
Sodium	0.035
Sulphur	0.3
Phosphorus	0.07
Calcium	0.06
Iron	0.006
Magnesium	0.003

Table 3 Compositional analysis of rice husks Compositions Mass Fraction (%)

Silica (SiO2)	80 – 90
Alumina (Al2O3)	1–2.5
Ferric oxide (Fe2O3)	0.5
Calcium oxide(CaO)	01-02
Magnesium oxide MgO)	0.5-2.0
Sodium oxide(Na2O)	0.2-0.5
Potash	0.2
Titanium)	Nil

4. Specimen preparation

Initially Al6061 Al alloy was put into the crucible made of graphite. The alloy inserted was then heated to about 750°c till the entire alloy was melted. The RHA prepared was used as a reinforcement material here is preheated to 850°c for 1 hour before mixing in melt.Simultaneously,3 wt% of magnesium was added to improve the wettability between rice husk ash particules and aluminium particles. The magnesium metal turnings are used here. If magnesium was not added then it was noticed that reinforcing particles were rejected. Copper melts separately at about 1100°c. Copper metal turnings are used here. The molten metal was stirred to create a vortex and the particulates were introduced. The molten metal was placed below the stirrer and stirred at approximately 600 rpm. The stirrer used here was made of steel.

Figure 8

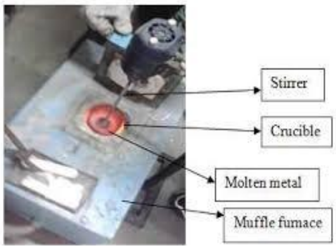

Figure 9

Figure 10

Figure 10

Table 4 Compositions of sample prepared

Sample no	Al6061 wt%	RHA wt %	Cu wt%	Mg wt %
2	91	8	----	1
3	83	16	----	1
4	75	24	----	1
5	67	32	----	1
6	88	8	3	1
7	80	16	3	1
8	72	24	3	1
9	64	32	3	1

The preheated RHA particles are than added slowly at constant rate of 5g/s. The stirring was continued for another 5minutes after completion of particle feeding. The mixture was then poured to mold which was also preheated to 550°c for 20 min. to obtain uniform solidification. By using this process 8,16,24 and 32% by weight RHA with copper and without copper particle reinforced composites are produced. The cavity formed in sand by mold was sprayed out with nitrogen gas to reduce casting defects. The pattern used here are of wood

4.2Pictures of prepared casting specimen

Figure 9 Dimensions of prepared specimen-40*40*170

5. Result and Discussion

5.1 Hardness measurement

The vicker's hardness test was carried out on vicker hardness tester at 'CITCO' The result of hardness measurement on prepared composites are chosen. The result reveals that percentage of rha increases mechanical properties like hardness. But specimen with copper shows greater values than specimens without copper. Figure 13 shows readings in HV.

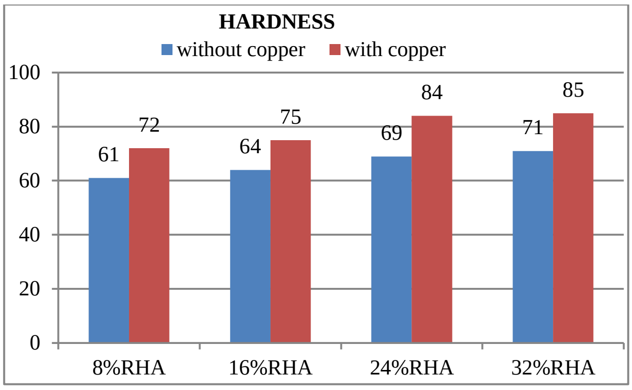

Figure 13 Variation of hardness with wt% rha with copper and without copper

Table 5 Results

Sample no	Al6061 wt%	RHA wt %	Cu wt%	Mg wt %	Hardness(HV)
2	91	8	----	1	61
3	83	16	----	1	64
4	75	24	----	1	69
5	67	32	----	1	71
6	88	8	3	1	72
7	80	16	3	1	75
8	72	24	3	1	84
9	64	32	3	1	85

6. Conclusion

1. AL6061, RHA and copper composites were prepared by stir casting technique.
2. The hardness of prepared composites are increased by increasing rice husk ash and copper content
3. Addition of rice husk ash particles in aluminium matrix can lead to production of economic composites with improved hardness. The addition of copper further increase hardness .addition of copper does not affect much on economics of low cost aluminium and rha composites. These composites can find application in automotive like piston, cylinder liners and connecting rods. These composites can also find application where light-weight materials are required with good hardness and strength

References

A.E. Al-Rawajfeh And S.M.A. Al Qawabah (2009), Investigation Of Copper Addition On The Mechanical Properties And Corrosion Resistance Of Commercially Pure Aluminum, *Emirates Journal For Engineering Research*, 14 (1), 47-52.

K. L. Meena, Dr. A. Manna, Dr. S. S. Banwait, Dr. Jaswanti (2013), An Analysis Of Mechanical Properties Of The Developed Al/Sic-MMC's, *American Journal Of Mechanical Engineering,* Vol. 1, No. 1, 14-19

Rollason,R (1973).Metallurgy for engineers,4th edition,Edward Arnold,Great Britain.

Abdalla Alrashdan, Ahmad T. Mayyas, Adel Mahamood Hassan And Mohammed T. Hayajneh (2011), Drilling Of Al+Mg+Cu Alloys And Al+Mg+Cu/Sic Composites, *Journal Of Composite Materials*, 45: 209

Ankur Jain,T.Rajeshwar Rao,S.S.Sambi And P.D.Grover (1995), Energy And Chemical From Rice Husk Ash, *Biomass And Bioenergy* Vol.7. Nos.1-6,Pp.285-289.

D.Siva Parsad,Dr.A.Rama Krishna (2010), Fabrication And Characterization Of A356.2-Rice Husk Ash Composites Using Stir Casting Technique)International *Journal Of Engineering Science And Technology* Vol.2(12),7603-760

Atunya,C.U.,Aigbodion,V.S.,Nwigbo,S.C., Charcterization of Breadfruit Seed Hull Ash For Potential Utilization In Metal Matrix Composites For Automotive Application, *Prople's Journal Of Science &Technology.*

Victor Sunday Aigbodion (2012), Development Of Al-Si-Fe/Rice Husk Ash Particulate Composite Synthesis By Double Stir Casting Method*, Usak University Journal Of Material Sciences* 2, 187-197

Manoj Singla,Lakhvir Singh,Vikas Chawla (June 2012), Synthesis A and Tribological Characterization o f Al-Sic Composites) *India Journal Of Material Science* Vol.2,Number 1.

K.V. Mahendra and K. Radhakrishna (2010), Characterization Of Stir Cast Al-Cu-(Fly Ash + Sic) Hybrid Metal Matrix Composites, *Journal of Composite Materials,* 44: 989