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Assessment of Mechanical Properties of Aluminium 6061 Metal Matrix Composite Reinforced with Graphite and Rice Husk Ash (RHA)

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***Abstracta*:** In this present investigation, efforts are made to study the mechanical properties of Rice Husk Ash and Graphite reinforced with Al6061 metal matrix composites. The vortex method of stir casting was employed, in which the reinforcements were introduced into the vortex created by the molten metal by means of a mechanical stirrer. Castings were machined to the ASTM standards on a highly sophisticated lathe. The degree of improvement of mechanical properties of MMCs is strongly dependent on the kind of reinforcement. Mechanical properties are improved compared to unreinforced MMC alloys.

Keywords –, Metal Matrix Composites, Aluminium alloy, Graphite, Rice Husk Ash

I. INTRODUCTION

Recently metal matrix composites (MMCs) are increasingly used for critical structural and wear resistant applications because of their excellent strength to weight ratio [1] and interesting physical properties. Normally MMCs are reinforced with continuous fibers, discontinuous particles or whiskers. However, particle-reinforced MMCs possess some distinct advantages over fiber-reinforced composites in terms of low cost and isotropic mechanical property.

Aluminum alloys have a great diversity of industrial applications because of their low density and good workability, but the use of these alloys is limited due to their relatively low yield stress. Recently, the interest to increase aluminum strength for applications in the aerospace and aeronautic industries has motivated the study of aluminum matrix composites. One of the most important characteristics of aluminum matrix composites is its high specific stiffness while maintaining a low density. Self-lubricating materials offer many improvements over the materials to which lubricant needs to be applied periodically. Among these materials, considerable work has been done on aluminum alloy–graphite particulate composites (Al/Gr MMCs). The processes used to synthesize the Al/Gr composites can be classified into three main categories: (i) liquid phase (ii) solid phase and (iii) two phase (solid–liquid) routes. It has been documented that the production method has a strong influence on the mechanical and tribological properties of the composite via its effects on the matrix grain size, porosity and distribution of graphite particles and the interfacial properties of the Al/Gr couple.

The main reasons to produce Al/Gr composite are to increase the strength, stiffness and wear resistance of aluminum or aluminum alloys, but this is usually achieved at the expense of other properties such as ductility. Aluminum and aluminum alloys can be strengthened by dispersing hard particles like carbides, oxides or nitrides into the aluminum matrix by using solid or liquid state techniques. The reinforcement can be done by adding continuous or discontinuous fibers, particles, or whiskers. The last three are usually ceramic materials such as alumina, silicon carbide, or silicon nitride. The composites so developed are called ex-situ MMCs. It is reported that accumulation of reinforcement particulates may occur during processing of most ex-situ composites leading to inferior mechanical strength and toughness. Therefore, uniform distribution of reinforcement particulates in the matrices of MMCs is essential to achieve effective load bearing capacity of the composite. Another production route that is attracting a number of researchers is the in-situ process. In this route, particles are obtained in the matrix due to chemical reaction or diffusion, which usually occur under isothermal conditions.

Reinforcement increases the strength, stiffness and the temperature resistance capacity and lowers the density of MMC. In order to achieve these properties, the selection depends on the type of reinforcement, its method of production and chemical compatibility with the matrix and the following aspects must be considered while selecting the reinforcement material.

II. Experimental Work

2.1 Material selection

2.1.1. Aluminium 6061(Al 6061):

In this Study Al 6061 alloy with theoretic density 2.7g/cm^3 is used as matrix material. This alloy is best suited for lightweight metal castings. 6061 has abundant benefits like formability, corrosion resistance weld ability and low cost. Table-1 shows the chemical composition of Aluminium alloy

Table 1: Shows the chemical composition of Aluminium alloy:

Component	Amount (wt.%)
Aluminium	Balance
Magnesium	0.8-1.2
Silicon	0.4-0.8
Iron	Max. 0.7
Copper	0.15-0.40
Zinc	Max. 0.25
Titanium	Max. 0.15
Manganese	Max. 0.15
Chromium	0.04-0.35
Others	0.05

2.1.2 Graphite

It is a solid lubricant which enhances the wear and anti-frictional properties. The acoustic and thermal properties of graphite are highly anisotropic. Graphite's high thermal stability and electrical and thermal conductivity facilitate its widespread use as electrodes and refractories in high temperature material processing applications. Graphite and graphite powder are valued in industrial application for their self-lubricating and dry lubricating properties.

2.1.3 Rice Husk Ash

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 covers 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.

III. Experimental details

3.1 Composite Preparation

Al6061, Graphite and Rice Husk Ash (RHA) composites were fabricated by melting in a crucible. Aluminum 6061 is maintained at 750°C. Figure 2 shows the aluminum 6061 alloys being melted in the crucible. According to the required percentage level of composition by weight percentage Graphite and Rice Husk Ash (RHA) are added. The compositions of samples that are to be made are as per the fig 3.1.

Fig. 3.1.1 Melting furnace.

Fig. 3.1.2. Al6061Billets

Fig.3.1.3. Graphite

According to the required percentage level of composition by weight Graphite and Rice Husk Ash (RHA) are taken and added separately at the corresponding temperatures and degas tablets is also added to the mixture. Then it is poured into graphite die of cylindrical shape as shown in Figure 3.1.5.

Fig 3.1.4 Rice Husk Ash

Fig. 3.1.5. Pouring of Molten Metal

3.2 Metallography Studies

The test samples for optical microscopy were prepared according to the ASTM E3 procedure. The specimens were first subjected to grinding and polishing followed by etching. After grinding operations, the specimens were rough polished utilizing 100, 200, 400, 600, 800 and 1200 coarseness silicon carbide papers. These papers are less defenceless to loading than emery papers. The specimens were held immovably close by and rubbed smoothly against the SiC papers, practicing adequate care to keep away from any profound scratches since the Al composites are relatively delicate. Unreasonable heat formation during cleaning was avoided as Al composites contain numerous metastable phases. Fine cleaning was performed utilizing magnesium oxide glue took after by diamond paste utilizing polishing machine which is appeared in Fig. 3.2.1. The stage was secured with billiard cloth. Isolate stages were utilized for magnesium oxide and precious stone cleaning. While fine cleaning with magnesium oxide glue, the samples were washed with water in the middle of to keep vestige of coarser grits from past advances. In the wake of cleaning with magnesium oxide, the examples were at long last cleaned with 1 micron thin diamond paste subsequent to changing the platform. The samples were then cleaned with alcohol and dried in air before seeing in metallurgical microscope instrument.

Fig.3.2.1. Photograph of Metallurgical Microscope

3.3 Tensile Test

Ultimate tensile strength, yield strength and ductility were estimated utilizing a 10 ton capacity servo hydraulic driven universal testing machine which is appeared in Fig.3.3.1. The tests sample is loaded in the direction parallel to the connected load. In a stress-strain graph the underlying segment of the curve is a straight line and speaks to the proportionality of stress strain as indicated by Hooke's law. The stress is then expanded past which the load is not any more corresponding to strain. Elastic limit is the most extreme stress that can be connected to the material without creating a permanent plastic deformation when the load is removed. Yield point is the most extreme stress value at which the sample is deformed without a noticeable increment in load.

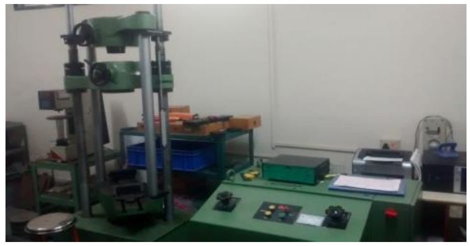


Fig.3.3.1 Photograph of Tensile Testing Machine

Ultimate Tensile strength (UTS) is a maximum stress value of a specimen can withstand before failure and it depends on actual area. All the tests were executed as per ASTM procedure. Tests were carried out at room temperature conditions as per standard methods of ASTM E8. The tensile test samples of diameter uses specimens of 20 mm grip diameter, 30 mm grip length, 62.5 mm gauge length, 75 mm length of reduced cross section, inner diameter of 12.5 mm fillet radius of 10 mm and total length 155 mm were machined from those cast composites for the gauge length of the sample parallel of the longitudinal axis of the castings. Five examples were tried and the average values of the ultimate tensile strength and ductility (in terms of percentage elongation) were measured.

3.4 Hardness test

Hardness tests were led utilizing Brinell hardness analyzer demonstrated in the fig. 3.4.1. A load of 10 kg were applied into metallographically polished samples of Al6061 alloy and its composites. Five readings were considered during different areas from claiming every sample to the conceivable impact from claiming particle segregation and the average values have been determined and presented for each sample.

The indentation is measured and hardness calculated as:

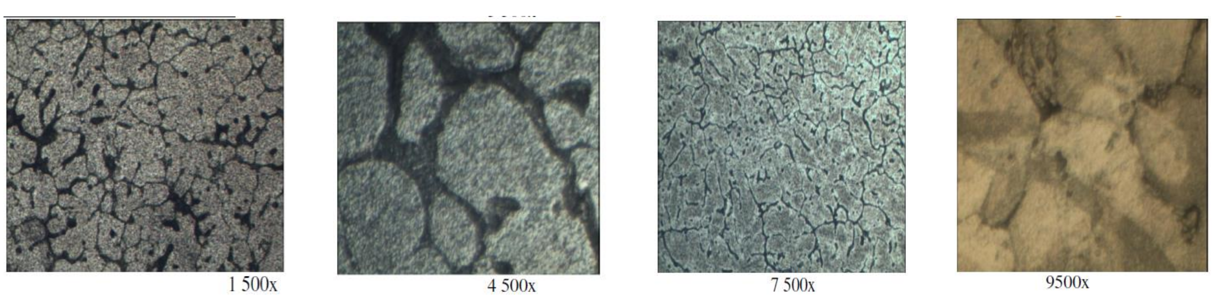
$$BHN= 2P/\Pi d\ (D\text{-}SQRT(D^2\text{-}d^2))$$

where:
BHN = Brinell Hardness Number (kgf/mm2)
P = applied load in kilogram-force (kgf)
D = diameter of indenter (mm)
d = diameter of indentation (mm)

Fig. 3.4.1 : Brinell hardness machine

IV. Results and discussion:

4.1 Microstructure



a) Al6061+2% Gr+1% RHA b) Al6061+2% Gr+3% RHA c) Al6061+2% Gr+5% RHA d)Al6061+6% Gr+5% RHA

Fig 4.1 Microstructure of composites

Microstructure tests are usually conducted on composites to analyze the distributions pattern of the reinforcements in matrix material. In this study, microstructure tests were carried out to analyze the distribution pattern of Graphite and RHA reinforcements in the matrix material Al606. The microstructure study shown in figure 3.1 clearly indicates the uniform distribution of graphite RHA particles in a matrix alloy. The porosity in both base alloy and the composite is very less. This Microstructure consists of fine inter-metallic precipitates in a matrix of aluminum solid solution. These precipitates are responsible for creating rough surfaces which resists the wear loss. From figure 2 (f) it can be observed that the excessive addition of reinforcements leads to poor binding strength and increase in porosity due to which the composite may lose its strength.

4.2 Tensile Test:

Table 4.2.1: Test results of UTS, Yield Strength, ductility and hardness for different composition of composites

Composition	Heat treatment duration, hours	Hardness in BHN	UTS in MPa	Percentage elongation in %	Yield Strength in MPa
Al6061+0% Gr+0% RHA	As Cast	60.2	115	14.5	110.2
Al6061+2% Gr+0% RHA	As Cast	65.2	135.2	13.5	124.3
Al6061+4% Gr+0% RHA	As Cast	69.2	140.65	12.1	135.6
Al6061+6% Gr+0% RHA	As Cast	67.4	137	10.2	131.2
Al6061+0% Gr+1% RHA	As Cast	63.2	136.5	14.2	122.6
Al6061+0% Gr+3% RHA	As Cast	65.4	145.6	12.5	132.1
Al6061+0% Gr+5% RHA	As Cast	66.1	150.32	11.4	138.5
Al6061+2% Gr+1% RHA	As Cast	69.3	170.45	13.88	125.63
Al6061+2% Gr+3% RHA	As Cast	72.33	203.61	9.56	137.13
Al6061+2% Gr+5% RHA	As Cast	74	219.9	10.28	141.72
Al6061+4% Gr+1% RHA	As Cast	74	209.5	9.88	140.12
Al6061+4% Gr+3% RHA	As Cast	78.33	222.3	9.08	180.14
Al6061+4% Gr+5% RHA	As Cast	80.66	240.78	8.96	201.31
Al6061+6% Gr+1% RHA	As Cast	71	205.3	9.48	180.14
Al6061+6% Gr+3% RHA	As Cast	75	210.5	9.08	190.3
Al6061+6% Gr+5% RHA	As Cast	76	221.1	8.71	210.2

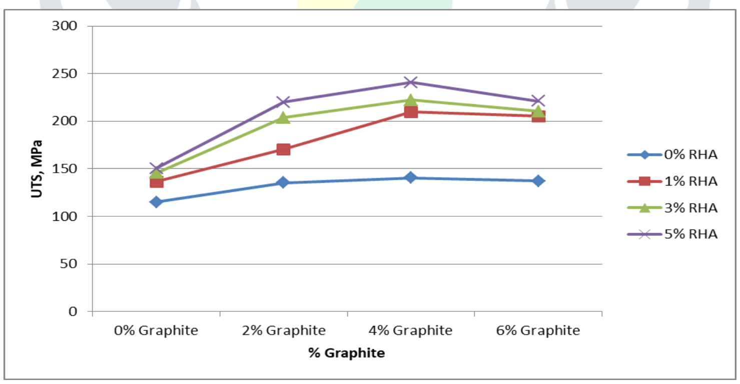


Fig. 4.2.2: Variation of UTS with respect to graphite and RHA

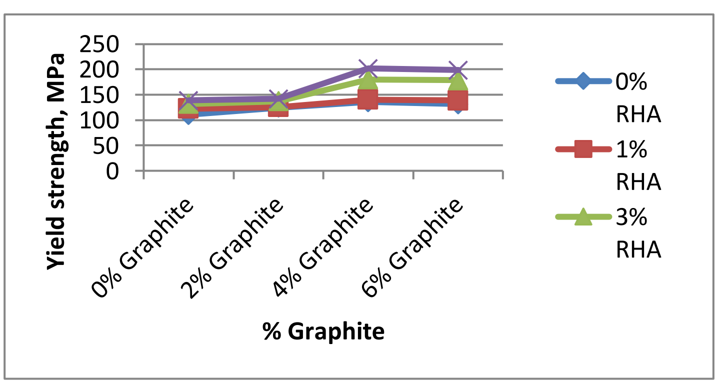


Fig. 4.2.3. Variation of YS with respect to graphite and RHA

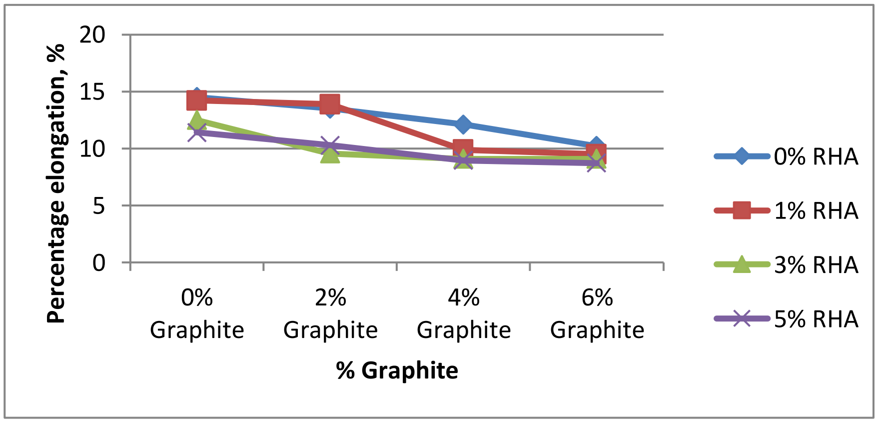


Fig. 4.2.3: Variation of percentage elongation with respect to graphite and RHA

By observing the tensile test report shown in fig 4.2.1,4.2.2 & 4.2.3, it can be seen that the Ultimate tensile strength along with yield strength increases up to a level on reinforcing graphite powder and RHA in Aluminium alloy 6061. Furthermore, the Ultimate tensile strength increases on increasing the graphite reinforcement in the Aluminium alloy, but would start to decrease after a certain level. Here, on adding graphite by the variation of 2% by weight to the aluminium alloy.
It is very clear that as reinforcement increase in base material, ductile tears occurs and ductility decreases as the reinforcement percentage increase in base material.

4.3 Hardness Test:

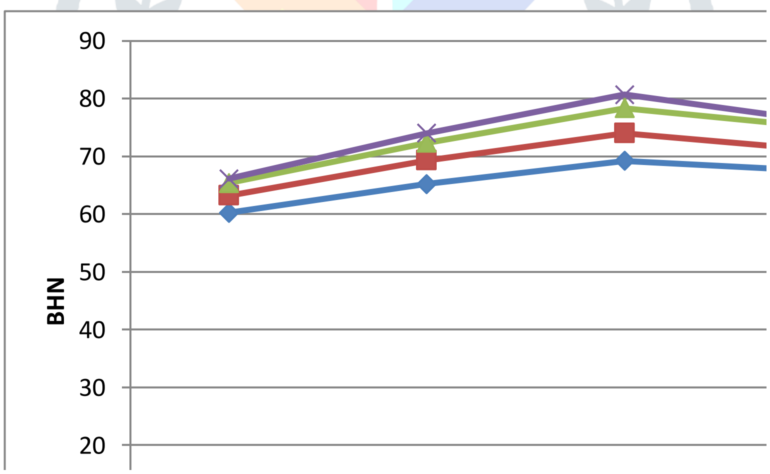


Figure 4.3.1 Variation of percentage elongation with respect to graphite and RHA

As observed from fig 4.3.1. that is, the hardness of base metal Al 6061 increases up to an optimum level on addition of graphite and RHA reinforcement in particular weight fractions. But again, after a particular composition, there has been seen a decline or fall in the hardness of the material. Such as, the hardness of the metal increases up to 4% of graphite reinforcement in the base metal Al 6061, but it is seen and observed that at 6% graphite weight there is a decrement in hardness of the metal. Thus, it has been concluded that the hardness of Al 6061 can be increased up to 4% graphite addition by weight and is reported to be maximum at this composition. Beyond this, the hardness decreases of the metal.

References

[1] Sinclair, I., and Gregson, P. J., 1997, "Structural performance of discontinuous metal matrix composites", Mater. Sci. Technol., 3, 709–726.
[2] Hanumanth, G. S., and Irons, G. A., 1993, "Particle incorporation by melt stirring for the production of metal-matrix composites", J. Mater. Sci., 28, 2459– 2465.

[3] Chen, Z. Z., and Tokaji, K., 2004, "Effects of particle size on fatigue crack initiation and small crack growth in SiC particulate-reinforced aluminium alloy composites", Mat. Lett., 58, 2314-2321.
[4] Murty, S. V. S. N. Nageswara, B., and Kashyap, B. P., 2003, "On the hot working characteristics of 6061Al– SiC and 6061–Al2O3 particulate reinforced metal matrix composites", Compos. Sci. tech., 63, 119-135.
[5] Barbara, P., Pocci, D., and Taccardo, C., 2008, "Application of traditional investment casting process to aluminium matrix composites", Compos: Part A, 39, 1606-1617.
[6] Mahesh, T. S., M.S. Sugin, A., and Muthukrishnan, N., 2012, "Investigation on the characteristics of surface quality on machining of hybrid metal matrix composite (Al-SiC-B4C)", Procedia Engineering, 38, pp. 26172624.
[7] Hartaj Singh, Sarabjit, Nrip Jit, Anand K Tyagi, "An Overview Of Metal Matrix Composite: Processing And Sic Based Mechanical Properties", Journal of Engineering Research and Studies, JERS/Vol. II/ Issue IV/October-December, 2011/72-78.