PREPARATION AND EVALUATION OF MECHANICAL PROPERTIES OF Al-6061 REINFORCED WITH GRAPHITE and FLY ASH OF SEED HUSK (Honge) PARTICULATE METAL MATRIX COMPOSITE

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Abstract

The aim of this work is to study the mechanical properties of Aluminium alloy Metal Matrix Composites (MMCs) as they are gaining wide spread acceptance for automobile, industrial, and aerospace applications because of their low density, high strength and good structural rigidity. In the present work an attempt has been made to synthesize Al-6061 with Graphite and fly ash of seed husk (Honge seeds) particulate metal matrix composites by using stir casting technique. The addition level of reinforcement is being varied from 0,4,6,8wt%. Preheated particle reinforcements are added to Al 6061 Alloy to improve wettability and distribution. Microstructural analysis was carried out for the above prepared composites by taking specimens from central portion of the casting to ensure homogeneous distribution of particles. Micro-hardness, tensile properties of the composites were studied as per the ASTM (E8M) standards. Microstructural characterization revealed fairly uniform distribution in the matrix. The Micro-Vickers hardness of the composite was found to decrease with increase in filler content in the composite. The density of both theoretically and experimentally of FA is higher then Gr. The tensile strength of the composites was found to increase confirming the dispersed graphite and fly-ash in Al-6061 alloy contributed in enhancing the tensile strength and wear resistance too of the composites.

1 Introduction

Metal matrix composites (MMCs) are increasingly becoming an attractive materials in advanced aerospace applications because of their properties, can be tailored through the addition of selected reinforcements [1]. Metal matrix composites have a market potential for various applications, particularly in the automotive industry, where the pressure is to use light weight materials & has increased because of environmental issues. Examples of components that have been manufactured using metal matrix composites include pistons for diesel engines and connecting rods [2]. These materials have also been shown to possess great potential for applications in the brake disks for railway brake equipment [3]. Aluminium-based Metal Matrix

Composites (MMCs) have received increasing attention in recent decades as engineering materials. The introduction of a ceramic material into a metal matrix to produces a composite material that results in an attractive combination of physical and mechanical properties which cannot be obtained with monolithic alloys [4]. The various reinforcements that have been tried out to develop aluminium matrix composites(AMCs) such as graphite, silicon carbide, titanium carbide, tungsten, boron, Al203, fly-ash, Zr, TiB2, etc. Addition of hard reinforcements such as silicon carbide, alumina, and titanium carbide improves hardness, strength and wear resistance of the composites [1, 2-4]. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze, to manufacture wear resistant parts. Previous studies have shown that mechanical properties of Al-matrix composites would be enhanced with particulate reinforcement [5]. The particulate reinforced MMCs is mainly used due to easy availability of particles and economic processing technique adopted for producing the particulate reinforced MMCs. Al alloy has been commonly used as a base metal for MMCs reinforced with a variety of fibres, particles and whiskers [6-7]. Amongst different kinds of the recently developed composites, particle-reinforced metal matrix composites and in particular aluminium base materials have already emerged as candidates for industrial applications .

Investigation of mechanical behavior of aluminum alloys reinforced by micro hard particles such as Graphite, fly ash is an interesting area of research. Therefore, the aim of this study is to investigate the effects of different factors such as: (i) weight percentage of the particles (ii) Fabrication process on the microstructure, mechanical properties of the composites. Mechanical properties were evaluated as per ASTM standards using computerized universal testing machine,pin on disk test.

2 Experimental Details

The following section highlights the materials used, their properties, method of composite preparation and evaluation of microstructural and mechanical properties.

Materials Used

The matrix material for present study is Al-6061. Table.1 gives the chemical composition of 6061Al. The reinforcing material selected was Graphite and Fly Ash of particle size 125 µm&125-150 µm. Table.2 gives the properties of Matrix and Reinforcing materials used in the present study.

Table.1. Shows the Chemical Composition of Al 6061

Si	Fe	Cu	Mn	Ni	Pb
0.43	0.7	0.24	0.139	1.05	0.24
Zn	Ti	Sn	Mg	Cr	Al
0.25	0.15	0.001	0.802	0.25	Balance

Table.2. Shows the Properties of Matrix and Reinforcing Materials Used in the Study.

Material/ Properties	Density gm/cc	Hard- -ness (HB500)	Strength(Tensile/Compression) (MPa)	Elastic Modulus(GPa)
Matrix Al 6061	2.7	30	115(T)	70-80
Reinforcement Gr. Particle	2.25	1.7mohs scale	89.63(C)	8-15

3 Preparation of Composites

The Aluminium 6061 alloy is used in this experiment as the matrix and graphite of 125 µm as reinforcement. The liquid metallurgy route has been adopted to prepare the cast of composites Al-6061+Gr. Preheated Graphite and Fly Ash powder of laboratory grade purity of particle size 125 µm was introduced into the vortex of the molten alloy after effective degassing using solid hexachloroethane (C_2Cl_6). Before introducing reinforcement particles into the melt they were preheated to a temperature of 250^0C. The extent of incorporation of Graphite particles in the matrix alloy was achieved in steps of 3. i.e Total amount of reinforcement required was calculated and is being introduced into melt 3 times rather than introducing all at once. At every stage of before and after introduction of reinforcement particles, mechanical stirring of the molten alloy for a period of 10 min was achieved by using Zirconia-coated steel impeller. The stirrer was immersed into the melt, located approximately to a depth of 2/3rd height of the molten metal from the bottom and run at a speed of 200 rpm. A pouring temperature of 750°C was adopted and the molten composite was poured into cast iron mould. The extent of incorporation of graphite in the matrix alloy was varied from 0,4,6& 8 wt%. Thus composites containing particles were obtained in the form of cylinders of diameter 12.5mm and length 125mm.

4 Testing of Composites

To study the microstructure of the specimens the central portion of the casting was cut by an automatic cutter device. The specimen surfaces were prepared by grinding through 200, 400, 600, 800 and 1000 grit papers and then by polishing with 3 m diamond paste and then etched by Keller's reagent to obtain better contrast. Microscopic examination of the composites was carried out by optical microscopy. To investigate the mechanical behavior of the composites the tensile tests was carried out using computerized uni-axial tensile testing machine as per ASTM standards. For tensile results, test was repeated three times to obtain a precise average value, which gave increased tensile strength, and the microstructural results shows good dispersions of reinforcement.

5 Results and Discussions

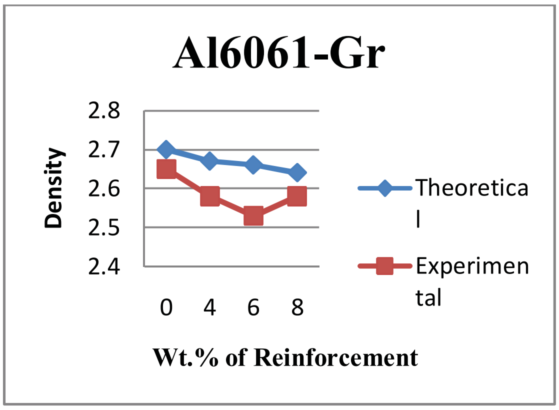
Density

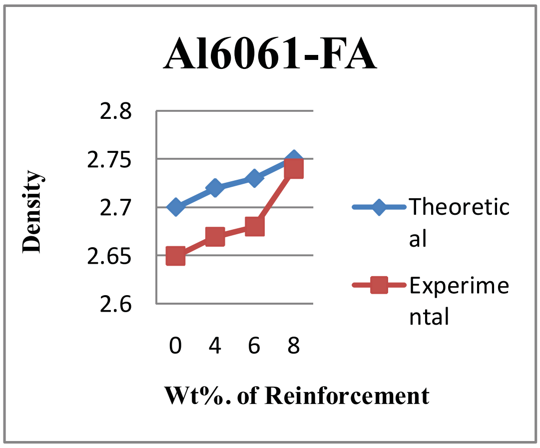
From the below table presents the comparison of theoretical density obtained by rule of mixture and measured density values by experiment for both the composites studied, further the graph shows the experimental density values of the both the composites containing various filler percentages. From the table it can be concluded that the experimental and the theoretical density values are in line with each other and confirms the suitability of the liquid metallurgy techniques for the successful composite preparation.

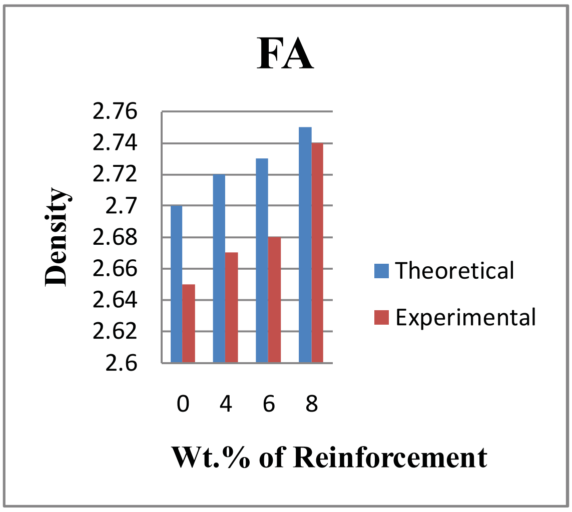
Table 3. Comparison of theoretical and experimental densities of the Al6061-FA and Al6061-Graphite composites

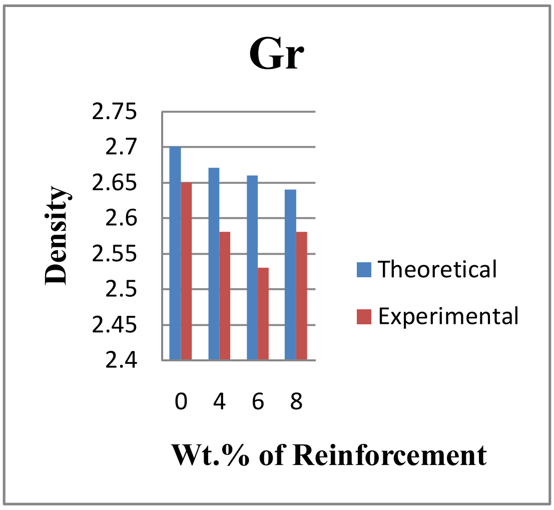
Material	Density (g/cc)	Weight % Reinforcement			
		0	**4**	**6**	**8**
Al6061-FA	Theoretical Density	2.70	2.72	2.73	2.75
	Experimental Density	2.65	2.67	2.68	2.74
Al6061-Graphite	Theoretical Density	2.70	2.67	2.66	2.64
	Experimental Density	2.65	2.58	2.53	2.58

From Figure, it can be observed that the densities of composites are higher than that of their base matrix, further the density increases with increased percentage of filler content in the composites [7, 8]. From the figure it can be concluded that Al6061-flyash composites exhibits higher density than that of the Al6061-Graphite and can reasoned for the higher density values of flyash







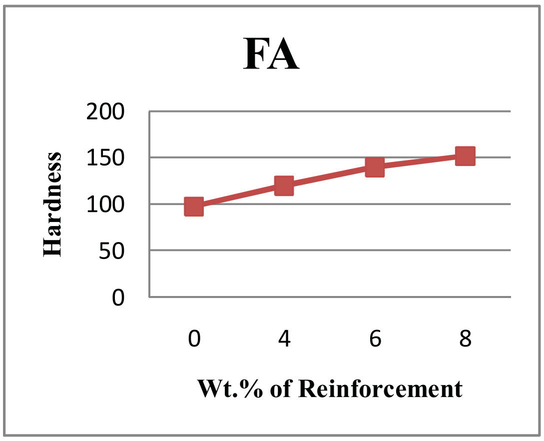


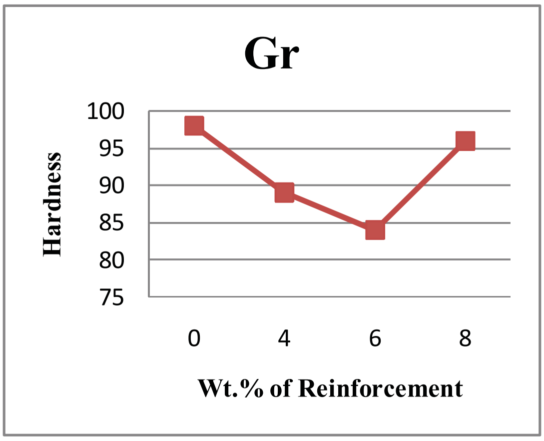
Micro – Hardness

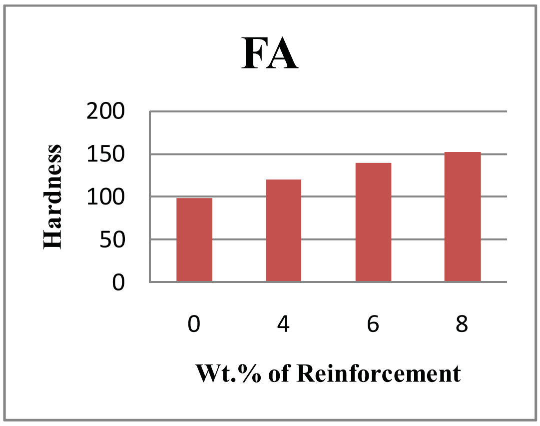
The Vickers micro-hardness of cast Al6061-Graphite and Al6061-Flyash matrix and their composites containing 0-8 wt. %'age of Graphite/Flyash are evaluated using diamond indenter at an applied load of 2N at 50X optical zoom with dwell time 10 secs for each sample at different locations.
It can be observed that the hardness of the composite is greater than that of its cast matrix alloy for Al6061-Flyash and the hardness of the composite is less than that of its cast matrix alloy for Al6061-Graphite. It can be observed that the hardness of the Al6061- Flyash composite are higher than that of the composite of Al6061-Graphite and is to the fact that the matrix Al6061 and Flyash possess higher hardness [19].

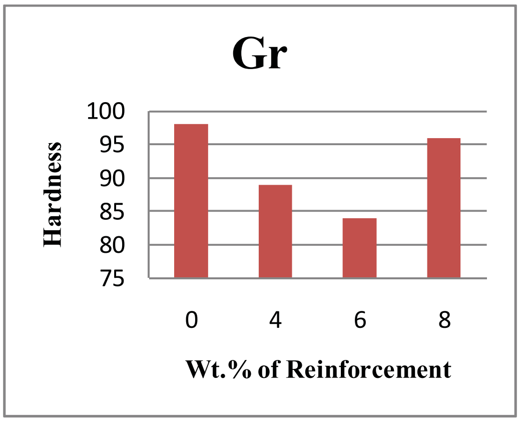
Table 4. Vicker's hardness test results for different wt% of FA/Graphite.

Wt% of Reinforcement (Al6061-SiC / Al6061-Graphite)	Al6061-Flyash Mean micro hardness no. (VHN)	Al6061-Graphite Mean micro hardness no. (VHN)
0	**98**	**98**
4	**120.32**	**89**
6	**139.88**	**84**
8	**152.01**	**96**









Graph: Hardness Vs Wt% of Reinforcement.(Line & Bar Graph)

6 Conclusions

The present work on synthesis and characterization of Al6061-Graphite composites led to the following conclusions

1. The composites containing Al-6061 with 0, 4, 6 and 8wt% of Graphite particulates were successfully synthesized by melt stirring method using three stages mixing combined with preheating of the reinforcing particles.

2. The addition of Graphite has resulted in increase in tensile strength. The tensile strength is a function of volume fraction of reinforcement. As volume fraction increases tensile strength of composite increases. However, addition of graphite has resulted more improvement in tensile properties.

3. The experimental densities were found to be lower than theoretical densities due to the presence of porosities in all the composites.

4. The density of Al6061 reinforced with Gr/FA, the experimental results are lower thenthe therotical values and the fly ash is superior to Gr.

5. 5. The hardness of the fly ash is higher then the graphite.

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