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Original Research Article

EVALUATION OF MECHANICAL RESPONSE OF GRAPHITE REINFORCED METAL MATRIX COMPOSITE

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Abstract:
In the present investigation, aluminium alloy 6061 was used as the matrix material. Al6061 alloy has the highest strength and ductility of the aluminium alloys with excellent machinability and good bearing and wear properties The Al6061-graphite composites were prepared by the vortex method. The graphite contents used for the preparation of the composites were 0%, 1.5%, 2%, 2.5% and 3%..The effect graphite was studied by varying the percentage on ultimate tensile strength, percentage of elongation, compressive strength and hardness of the composite.

Key words: Matrix, Graphite, Strength, Response

1. Introduction

Metal matrix composites (MMCs) are increasingly becoming attractive materials for advanced aerospace applications because their properties can be tailored through the addition of selected reinforcements. In particular, particulate reinforced MMCs have recently found special interest because of their specific strength and specific stiffness at room or elevated temperatures. It is well known that the elastic properties of metal matrix composites are strongly influenced by micro structural parameters of the reinforcement such as shape, size, orientation, distribution and volume fraction.

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Aluminium-based MMCs have received increasing attention in recent decades as engineering materials. The introduction of a ceramic material into a metal matrix produces a composite material that results in an attractive combination of physical and mechanical properties which cannot be obtained with monolithic alloys. There is an increasing need for knowledge about the processing techniques and mechanical behaviour of particulate MMCs in view of their rising production volumes and their wider commercial applications. Interest in particulate reinforced MMCs is mainly due to easy availability of particles and economic processing technique adopted for producing the particulate-reinforced MMCs. Aluminium alloy-based particulate-reinforced composites have a large potential for a number of engineering applications. Interest in reinforcing Al alloy matrices with ceramic particles is mainly due to the low density, low coefficient of thermal expansion and high strength of the reinforcements and also due to their wide availability. Among the various useful aluminium alloys, aluminium alloy 6061 is typically characterized by properties such as fluidity, castability, corrosion resistance and high strength-weight ratio. This alloy has been commonly used as a base metal for MMCs reinforced with a variety of fibres, particles and whiskers.

In the present investigation, aluminium alloy 6061 was used as the matrix material. Al6061 alloy has the highest strength and ductility of the aluminium alloys with excellent machinability and good bearing and wear properties. Most of the particulate reinforced Metal matrix composites (MMCs) are increasingly becoming attractive materials for advanced aerospace applications because their properties can be tailored through the addition of selected reinforcements. In particular, particulate reinforced MMCs have recently found special interest because of their specific strength and specific stiffness at room or elevated temperatures. It is well known that the elastic properties of metal matrix composites are strongly influenced by micro structural parameters of the reinforcement such as shape, size, orientation, distribution and volume fraction.

In recent years, considerable work has been done on graphite reinforced metal matrix composites which exhibit low friction, low wear rate and excellent antiseizing properties. The graphite in these composites presumably imparts improved tribological properties to the composites through the formation of a graphite-rich film on the tribo-surface which provides solid lubrication. Journal bearings made of graphite particle dispersed composites perform much better than conventional bearing alloys. Graphite particles of size ranging from 50 to 200 μm yield the best results. Manufacturing automotive pistons out of graphite reinforced composites instead of other conventional materials resulted in a saving of 5-7% on fuel and lubricating oil. The presence of graphite in the matrix improves its oil spreadability over the contact surface, thus reducing the tendency to score or seize. Graphite, which consists of carbon atoms arranged in a layer-like structure, displays a very low coefficient of friction while sliding on another clean surface, thus suggesting that it can be used as solid lubricants. Because of this solid lubricative property, graphite in the form of particles has a wide range of applications in composite materials which are used to make components requiring great wear resistance such as engine bearings, pistons, piston rings and cylinder liners. Although fibre reinforcements lead to mark high-volume applications are being increasingly sought. The most widely used reinforcements have been SiC, alumina, graphite, B4C and TiC. These have been metal matrix composites are produced by liquid metallurgy, sometimes known as the 'vortex method', although many different processes for fabricating these cast composites are also available which have been reported by various researchers. In the present work, the 'vortex method' of producing AMC's , in which graphite particulates have been used as the candidate reinforcements of particulate sizes ranging from 5 μm and added to the vortex formed in the Al6061 melt above its liquidus temperature. Since the hardness, ultimate tensile strength (UTS), compressive strength, ductility, wear rate, and also thermal fatigue strength of the composite material are all vital properties of a structural material, the present investigation aims at studying these properties in the Al6061 alloy-particulate composites.

2. Experimental detail

The properties of materials adopted and methods followed for the fabrication and testing of MMCs in the present studies are presented in the following sections.

2.1 Matrix and Reinforcement Materials Details

The matrix for the present studies selected was Al6061 alloy and were procured from Ananth rao enterprise, Bangalore, in the form of ingots. The chemical composition of Al6061 alloy is given in Table 2.1. The reinforcing material selected were graphite (Gr) of 5 µm particle size and the properties of the matrix and reinforcement material used are presented in the Table 2.2.

Table 2.1 Chemical Composition of Al6061 by Weight percentage.

Chemical Composition	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Al6061	0.60	0.25	0.22	0.03	0.82	0.24	0.10	0.1	Bal

Table 2.2 Properties of matrix and reinforcement materials.

Material	Elastic Modulus (Gpa)	Density(g/cc)	Hardness (HB500)	Tensile Strength (Mpa)
Al6061	70-80	2.7	30	115
Graphite(Gr)	8-15	2.09	1.7kg/mm^2	20-200

3.2 Preparation of Composites

The Al6061-graphite composites were prepared by the vortex method. The graphite contents used for the preparation of the composites were 0%, 1.5%, 2%,2.5% and 3%. This is because graphite compositions of 7% and above would lead to rejection from the melt. Addition of graphite into the molten aluminium alloy melt above its liquidus temperature of 500 °C was carried out by creating a vortex in the melt using a mechanical stainless steel stirrer coated with aluminite (to prevent migration of ferrous ions from the stirrer material into the aluminium alloy

3.3 Testing of Specimens

Carefully machined specimens are conducted Tensile tests at room temperature using a universal testing machine (UTM) in accordance with ASTM Standard E 8-82. The tensile specimens of diameter 16 mm and gauge length 100 mm were machined from the cast composites with the gauge length of the specimens parallel to the longitudinal axis of the castings. For each composite, four tensile test specimens were tested and the average values of the UTS, and ductility were measured. The hardness tests were conducted in accordance with ASTM Standard E 10 using a Brinell hardness tester with a ball indenter of 5 mm diameter and a load of 250 kg. The load was applied for 30 sec. three hardness readings were taken for each specimen at different locations to circumvent the possible effects of particle segregation. Compression tests were conducted on a UTM in accordance with ASTM Standard E 9 at room temperature. In this test the compression loads were gradually increased and the corresponding strain was measured until the specimen failed. Each result is an average of four readings.

3. Results and discussion

3.1 Ultimate Tensile Strength

Figure 3.1 is a graph showing the effect of reinforcement content on the Ultimate Tensile Strength (UTS) of cast Al6061-graphite particulate composites. Each value represented is an average of three measurements. The results are repeatable in the sense that each individual result did not vary more than 5% from the mean value.

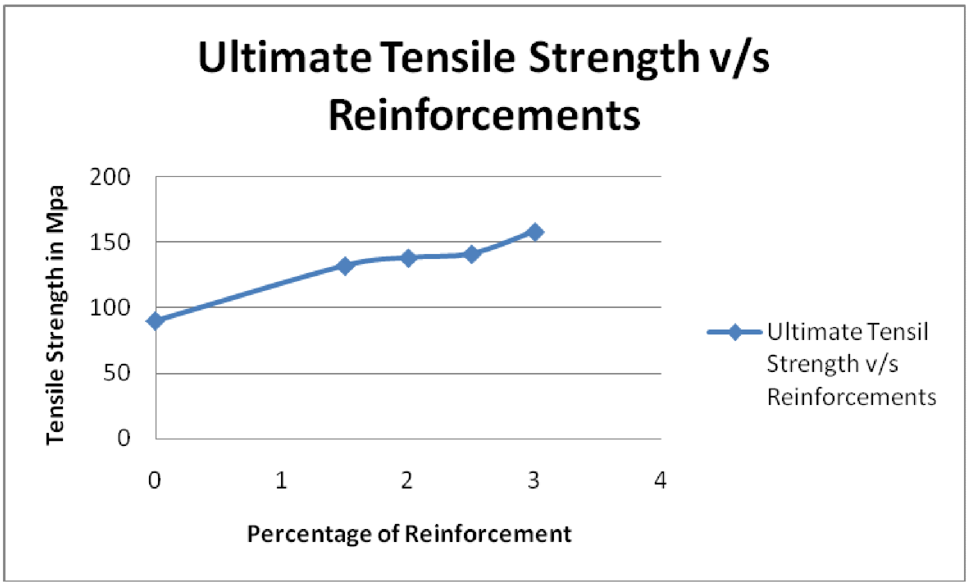

Figure: 3.1 Effect of graphite on Ultimate Tensile Strength.

It can be seen that as the graphite content increases, the UTS of the composite material increases monotonically by significant amounts. In fact, as the graphite content is increased from 0% to 3%, the UTS increases by about 56%. These results are in accordance with those

3.2 Ductility

Figure 3.2 is a graph showing the reinforcement content on the ductility of cast Al6061- graphite particulate composites (measured in terms of percentage elongation). As the graphite content increases, the ductility of the composite material increases monotonically by significant amounts, i.e., when the graphite content is increased from 0% to 3% the ductility was found to increases by about 65%. The effect of graphite is expected to be mechanical in nature since the particles are unreactive with the matrix phase. This considerable increase in ductility is due to the graphite additions, being an effective solid lubricant, eases the movement of grains along the slip planes.

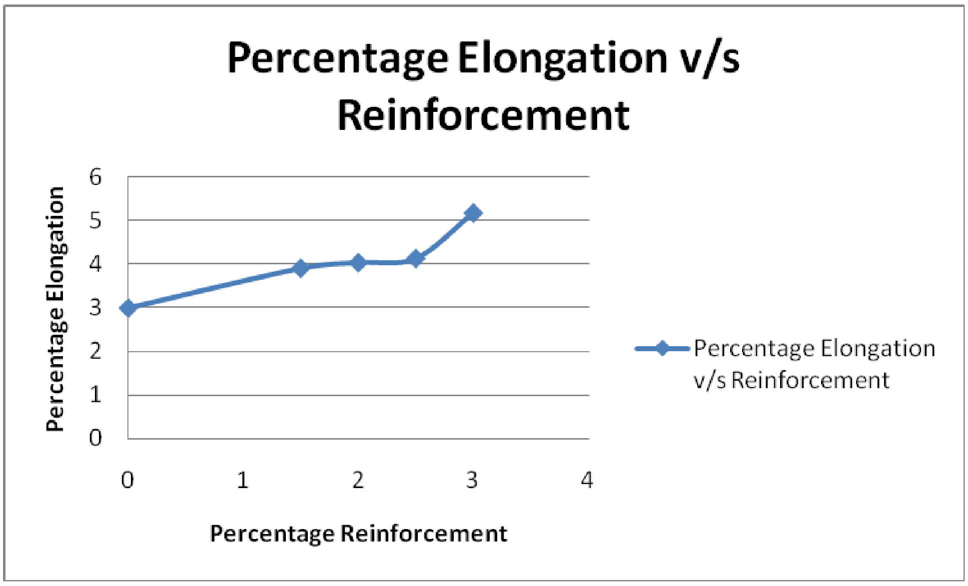

Figure: 3.2 Effect of graphite on Percentage of elongation

3.3 Compressive Strength

Figure 3.3 is a graph showing the effect of graphite content on the compressive strength of cast Al6061-graphite particulate composites. It can be seen that as the graphite content increases, the compressive strength of the composite material increases monotonically by significant amounts. In fact, as the graphite content is increased from 0% to 3%, the compressive strength increases by about 56% and this increase in compressive strength may be due to the graphite particles acting as barriers to dislocations in the microstructure.

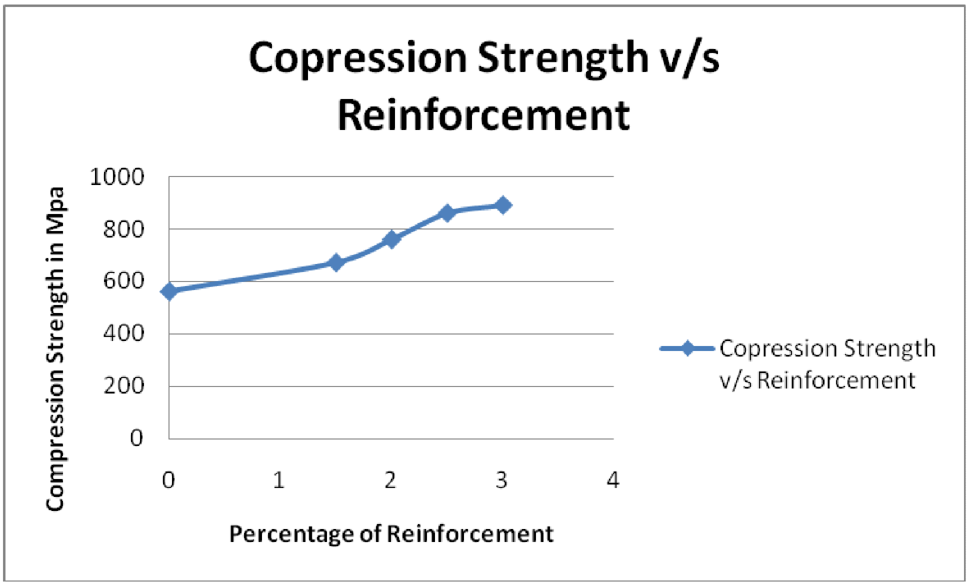

Figure: 3.3 Effect of graphite content on compression strength.

3.4 Hardness

Hardness, is the measure of a material's resistance to surface indentation, also it is a function of the stress required to produce some specific types of surface deformation. Figure 3.4 is a graph showing the effect of graphite reinforcements on the hardness of cast Al6061- graphite particulate composites. Each value represented is an average of three measurements. The results are repeatable in the sense that each individual result did not vary more than 5% from the mean value.

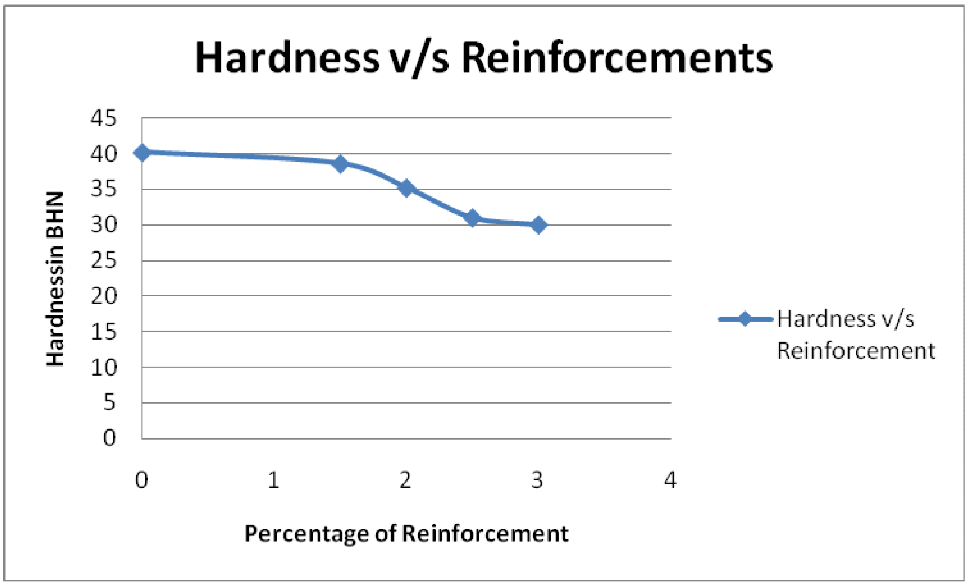

Figure: 3.4 Effect of graphite content on Hardness

4. Conclusions

It can be seen that as the graphite content increases, the hardness of the composite material decreases monotonically by significant amounts. In fact, as the graphite content is increased from 0% to 3% the hardness decreases by about 24%. In case of metals, as the Ultimate Tensile Strength (UTS) of a material increases, so would the hardness but the opposite is seen in this particular composite, whereby the hardness drops as the UTS increases. There is a good reason for this phenomenon, though, since graphite, being a soft dispersed, does not contribute positively to the hardness of the composite. K.H.W Seah et al., have reported a reduction in hardness from 107 BHN to 77 BHN (about 28% differences) on addition of similar weight percentages of graphite to ZA-27 (Zinc Aluminium) alloy. Such a monotonic decrease in the hardness of the composite as graphite content is increased poses a limit to how much graphite may be added to enhance its other mechanical properties, since hardness is directly related to wear resistance, a compromise is necessary when deciding how much graphite should be added to enhance the ductility, UTS, compressive strength, and Young's modulus of the composite without sacrificing too much of its hardness.

5. References

1. A. R. K. Swamy, A. Ramesha, G.B. Veeresh Kumar, J. N. Prakash.*Effect of Particulate Reinforcements on the Mechanical Properties of Al6061-WC and Al6061-Gr MMCs,Vol.* 10, No.12, pp.1141-1152, 2011
2. N. Radhika, R. Subramanian, S. Venkat Prasat**.** *Tribological Behaviour of Aluminium/Alumina/Graphite Hybrid Metal Matrix Composite Using Taguchi's Techniques*, Vol. 10, No.5, pp.427-443, 2011
3. Camelia pinca -bretotean, gelu-ovidiu tirian, *considerations on thermal fatigue internal Combustion engines*, tome ix (year 2011). Fascicule extra. Issn 1584 – 2673
4. Eun U. Lee. *Thermal Fatigue Analysis Of Metal Matrix Composite With Spherical Reinforcements.*, NADC-91059-60,1992.
5. Tsuyoshi-Takahashi, Katsuhiko Sasaki. *Low cycle thermal fatigue of aluminum alloy cylinder head in consideration of changing metrology microstructure*., vol.2, (2010), pp. 767–776.
6. J. Sobczak, Z. Slawinski, N. Sobczak, P. Darlak, R. Asthana, and P. Rohatgi. *Thermal Fatigue Resistance Of Discontinuously Reinforced Cast Aluminum-Matrix Composites.,Volume* 11(6) December 2002—595.
7. Dunia Abdul Saheb., *aluminum silicon carbide and aluminum graphite particulate composites.*, vol. 6, no. 10, october 2011.