Effect on Mechanical Properties of Aluminium 6063 Reinforced with Silicon Carbide – Graphite Hybrid Composites
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Abstract—The use of multiple reinforcements (hybrid) has been growing interest because of increase in mechanical as well as tribological properties. The present work focuses on Al6063 composite reinforced with Silicon Carbide(SiC) and graphite(Gr) hybrid as a to study the change in mechanical properties of composite material. Al6063 find its applications mainly in architectural, pipes and aluminium furniture. Hardness, tensile and compressive strength test has been performed to study the influence in properties of composite developed using liquid metallurgy reinforced with variations of SiC and Gr (2+2) %, (4+2) % and (6+2%). The microscopic images were taken to analyze the distribution of particles in microstructure.

Key words: Aluminium 6063 Reinforced, Silicon Carbide – Graphite Hybrid Composites

I. INTRODUCTION

Metal matrix composites(MMCs) emerged as advanced materials designed and engineered to exhibit properties such as light in weight, inexpensive, energy saving, stiff and strong materials which results in increase in consumption of MMCs commercially in sectors like aircraft, space, defense and automotive sectors. Aluminium matrix composites (AMCs) are emerging as promising materials in this direction. AMCs offer such superior combination of properties which is better than existing monolithic material. Recently researchers show more interest in hybrid such as SiC and Al2O3, SiC and zirconium and much more. Further, there are many fabrication technique used for composite making but out of all the processes, research reveals stir casting technique is the economical, effortless and most commercially adopted technique for fabrication of the composite (M.K. Surappa, 1981).

In stir casting process, distribution of reinforcement particles is the key element which depends on the mixing process done by mechanical stirrer. Further, 30% volume fractions of reinforcement in a composite can be suitably manufactured using stir casting fabrication route (Luo (1995); Saravanan et al.(2000). In present research various weight fractions of SiC particles are considered for the study. Al–SiC composites reinforced with Gr particulates are referred as Al–SiC–Gr hybrid composites. SiC particles shows good wettability with aluminium alloys which results in Excellent Mechanical properties such as increase in hardness and strength. Graphite particles when added with SiC particle improves the machining as well as wear resistance of Al–SiC composites. Experiments like tensile strength, compressive strength and hardness are conducted to study the mechanical behaviour 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. MATERIALS

A. Matrix Material

Aluminium 6063 is used as a matrix material for fabrication of composite, in which silicon and magnesium plays major role as per composition. Al is the predominant metal ranging about 97.85%-98.76%.

- 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 Aluminium (97.85%–98.76%)

B. Reinforcing Material

Silicon carbide is an excellent abrasive and has been used into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties such as,

- Low density
- High strength
- Low thermal expansion
- High thermal conductivity

Graphite is the most stable form of carbon under standard condition. Carbon exists in two crystalline allotrop forms one is diamond and second is graphite.

<table>
<thead>
<tr>
<th>Reinforcement</th>
<th>Density (g/cc)</th>
<th>Melting point</th>
<th>Compressive Strength(Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiC</td>
<td>3.21</td>
<td>2200-2700</td>
<td>345</td>
</tr>
<tr>
<td>Gr</td>
<td>2.7</td>
<td>3650-3700</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 1: Mechanical properties of SiC and Gr

III. EXPERIMENT PROCEDURE

A. Specimen Preparation

In this study, MMC is being prepared by liquid metallurgy route. Initially 500gm of Al 6063 was melted in a crucible by heating it in a muffle furnace at 700°C for two to three hours. A stainless steel stirrer is lowered into the molten melt slowly up to 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 150 to 200 rpm. The silicon carbide particles and Graphite particles were preheated at 800°C and 700°C respectively for one to two hours to make their surfaces oxidized. Then, the preheated SiC particles and Graphite particles 1-2gm per stroke were added manually to the vortex. After complete addition of Particles, the speed of stirrer raises upto 200-300 rpm so that better mixing takes place. After 10 minutes of stirring, mixture is poured into a
mould and the required casting has been obtained. The casting obtained is of circular cross section of length 15mm and diameter 24mm. Process is repeated for other specimens with composition of 2, 4, 6 and 8% of SiC and with a constant weight fraction of 2% Graphite. Microscopic test helps to examine the presence of reinforcement at different location of casting.

<table>
<thead>
<tr>
<th>Composite</th>
<th>AL6063</th>
<th>SiC</th>
<th>Gr</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>A2</td>
<td>96%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>A3</td>
<td>94%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>A4</td>
<td>92%</td>
<td>6%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 2: Composition of matrix and reinforcement in wt%

B. 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 2%,4%,6% and 8% Wt. fraction of SiC and 2% of Gr as reinforcement is conducted.

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.

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) Hardness Test

Bulk hardness measurements were carried out on the base metal and composite samples by using standard Vickers hardness tester on base metal and composite on Indian standard IS 1501-2002. Here the 4 and 6% of SiC gives optimum selection.

IV. RESULTS AND ANALYSIS

A. Tensile Strength

Tensile strength of Al6063 composites with the different wt. fractions of SiC and Gr particles are shown in figure 1.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Composition</th>
<th>Tensile Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Al6063</td>
<td>134</td>
</tr>
<tr>
<td>A2</td>
<td>Al6063 +2% SiC + 2% Gr</td>
<td>148</td>
</tr>
<tr>
<td>A3</td>
<td>Al6063 +4% SiC + 2% Gr</td>
<td>156</td>
</tr>
<tr>
<td>A4</td>
<td>Al6063 +6% SiC + 2% Gr</td>
<td>151</td>
</tr>
</tbody>
</table>

Table 3: Tensile strength of composite

It is observed that the ultimate tensile strength increased with an increase in the weight percentage of SiC upto 4% only. From this table, it is clear that addition of SiC improves the tensile properties of the composite up to specific percentage. Also, the strength of the material considerably reduces in increasing % age of SiC more than 4%. The graphite inclusion also tends to define the properties of material. The material tends to be brittle after the fracture. Therefore, further addition of SiC reduces the strength.

B. Hardness

Hardness test was carried out by using Vickers hardness tester on base metal and composite on Indian standard IS 1501-2002.

<table>
<thead>
<tr>
<th>Composites</th>
<th>Composition</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Al6063</td>
<td>59.3</td>
</tr>
<tr>
<td>A2</td>
<td>Al6063 +2% SiC + 2% Gr</td>
<td>62.5</td>
</tr>
<tr>
<td>A3</td>
<td>Al6063 +4% SiC + 2% Gr</td>
<td>64.8</td>
</tr>
<tr>
<td>A4</td>
<td>Al6063 +6% SiC + 2% Gr</td>
<td>65.3</td>
</tr>
</tbody>
</table>

Table 4: Variation of the hardness with weight fraction of SiC and Gr

The hardness values increased with an increasing percentage of SiC particle additions upto 4%. The mixture gives maximum hardness could be withstanded by the material. Here the 4 and 6% of SiC gives optimum selection.

C. Compressive Strength

Compressive properties of alloy and its composites are shown in the figure. It is clear that the compressive strength increased as the percentage of SiC particles increases in the alloy upto 6% weight fraction of SiC. This may be due to the hardening of the matrix by SiC particles.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Composition</th>
<th>Compressive Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Al6063</td>
<td>153</td>
</tr>
<tr>
<td>A2</td>
<td>Al6063 +2% SiC + 2% Gr</td>
<td>164</td>
</tr>
<tr>
<td>A3</td>
<td>Al6063 +4% SiC + 2% Gr</td>
<td>172</td>
</tr>
<tr>
<td>A4</td>
<td>Al6063 +6% SiC + 2% Gr</td>
<td>176</td>
</tr>
</tbody>
</table>

Table 5: Variation of compressive strength with weight fraction of SiC and Gr

Fig. 1: Variation of tensile strength with weight fraction of SiC and Gr

Fig. 2: Variation of hardness with weight fraction of SiC and Gr

Fig. 3: Variation of Compressive strength with weight fraction of SiC and Gr
V. CONCLUSION & FUTURE SCOPE

A. Conclusions

Experiments were conducted on aluminium 6063 alloy by adding various percentages of SiC and Gr reinforcements to it as discussed above. The specimen prepared was subjected to various mechanical tests like tensile test, compression test and hardness test. Results show that tensile strength increases up to 4 % weight percentage of SiC and then start decreasing whereas compressive strength increases upto 6% SiC weight fraction.

Following conclusions can be drawn:
1) Presence of SiC particles increases the tensile strength as well as hardness increases up to 4% of SiC weight fraction and then started decreasing due to improper mixing.
2) Compressive strength increases with increase in weight percentage of SiC particles upto 6% after which there is decline in compressive strength.
3) Hence it can be concluded that hybrid particles considerably affect the properties of aluminium 6063 alloy.

B. Future Scope

1) Use of Graphite as a part of trident hybrid can be done as it has not been reported in literature.
2) 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.
3) Some other tests like fatigue test, wear test, torsion test etc. can be done to assess the properties and favorable applications in this field.
4) Some experimental technique like DOE can be used in future experiments.

REFERENCES


