Study of Mechanical Properties and Wear Behaviour of Heat Treated A356 Reinforced with Silicon Carbide

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Abstract: The effect of heat treatment on mechanical behaviour of silicon carbide reinforced aluminium matrix composites has been investigated. Hardness values increased with the increase of silicon carbide addition in heat treated composites. Peak hardness values are about 20-25% higher than as-cast hardness values. The flexural strength increased with increasing reinforcement content up to 10wt% silicon carbide in both as-cast and heat treated composites. Development of hybrid metal matrix composites of silicon carbide (4%, 6%, 8%, and 10%) combination stir casting method was used for fabrication of aluminium metal matrix composites. To investigate the properties of AlSiC for varied % of silicon carbide under heat treatment and test like tensile test, hardness test, wear test were conducted. The result obtained indicates the properties of AlSiC were quite beneficial according to the requirements.

1. INTRODUCTION

Composite materials are composed of a matrix phase and are reinforcement phase. In most composites, added the reinforced to increase the strength and stiffness of thematrix the main advantages of the composite materials decreases in materials density, or increase in stiffness of the matrix yield strength, ultimate tensile strength can be directly translated to reductions in structural weight composites are made up of two material they are matrix and reinforced. The matrix surrounds and binds together a cluster of fibres, particles, or fragments of a much stronger material called reinforcement. In the aerospace industry to develop new materials with combinations of low density, improved stiffness and high strength as attractive alternatives to existing high-strength aluminium alloys and titanium alloys. These high strength metal matrix composites combine the high strength and hardness of reinforcing phase with ductility and toughness of light metals. The most common particulate composite system is aluminium reinforced with silicon carbide. So far most of the alloys that have been employed as matrices in aluminium have been focused on the A356, 3xxx and 6xxx series alloys. Although very few studies have been reported on the 7xxx series alloys reinforced with silicon carbide particles, much less attention has been paid to the 7xxx Al alloy matrix composites, which show the highest strength of all commercial Al alloys and widely used for structural applications. Stronger matrix alloys tend to produce stronger composites, but within these composite systems there are many variables such as ageing conditions, weight/volume fraction of particulate, particulate size, which can affect mechanical properties. Hence, the objective of this paper is to investigate the effect of heat treatment on mechanical behaviour of silicon carbide reinforced aluminium matrix composites.

2. MATERIAL and METHODOLOGY

2.1 Material Selection
Aluminium is chosen as the base material because of its wider engineering application. Aluminium A356 was purchased through online at amazon. Silicon carbide is used as reinforcement for its good temperature resistance and abrasive resistance. Silicon Carbide 1kg (80 microns) was bought at Ananya Flour polymer Coating 2nd stage Peenya3

2.2A356 alloy
Aluminium A356 alloys has very important applications because of its high strength-to-weight ratio ex: construction, automotive and marine application. A356 alloy has been used as the matrix material because of its excellent mechanical properties, manufacturing properties and good formability.

CHEMICAL COMPOSITION
Magnesium (Mg): 0.25%
Silicon (Si): 7.00%
Aluminium: 92.75%

Where
A → Modification of alloy 356
3 → Combination of Silicon & Copper (or) Magnesium Series
56 Identifies the alloy within 3XX series.

2.3 Silicon Carbide (Sic)
Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality, A356 and its composites are casted in the form of cylindrical bars. The chemical composition of the alloy is obtained using Optical Emission Spectrometer. Reinforcing of alloy with varied percentage of size Silicon carbide, as grain refiner modifier. The specimens for hardness and wear are prepared and tested as per ASMT standards.

Wear test is conducted as per ASTM G99 Standards, using Pin on Disc apparatus, % weight loss is calculated.
Hardness test is conducted as per ASMT E10 standards, using Brinell hardness Tester.
Tensile test is conducted as per ASMT E8 standards, using tensonometer Tester.

3. EXPERIMENTAL WORK

3. A. Tensile Test: Tension test is carried out; to obtain the stress-strain diagram, the find out the tensile properties and hence to get valuable information about the mechanical behaviour and the engineering performance of the material. The Tensile test was conducted on A356 with silicon reinforced composite specimens prepared as per ASTM E-8 standard using a computerized Universal Testing Machine of tensonometer.

3.B Hardness Test: Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. Macroscopic hardness is generally characterized by strong intermolecular bonds. There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. But in our present work we considered only Brinell hardness test. The Brinell hardness test method as used to determine Brinell hardness, is defined in ASTM E10. The Brinell method applies a predetermined test load (F) to a 2.5 ball indentor diameter which is held for a predetermined time period and then removed. By using microscope to check the impression diameter.

3.C Wear Test: Wear is a process of removal of material from one or both of two solid surfaces in so stat contact. As the wear is a surface removal phenomenon and occurs mostly at outer surfaces, it is more appropriate and economical to make surface modification of existing alloys than using the wear resistant alloy.

3.D Microstructure
All technological properties of materials are directly merged to their microstructure. These properties are strength and stiffness, deformation characteristics, their hardness and high temperature behaviour, and also their corrosion behaviour and the failure behaviour under fatigue loads. The Specimens for microstructure analysis were prepared in the form of cylindrical pieces of 20 mm diameter, 15 mm thickness and polished to obtain mirror surface finish by proper grinding, polishing and etching.

4. RESULTS AND DISCUSSION

4.1 Compare tensile results of As cast and Heat treatment

<table>
<thead>
<tr>
<th>Reinforcement %</th>
<th>Engineering stress of Ascast N/sq mm</th>
<th>Engineering stress of heat treatment N/sqmm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>173.3</td>
<td>193.2</td>
</tr>
<tr>
<td>4</td>
<td>125.1</td>
<td>239.0</td>
</tr>
<tr>
<td>6</td>
<td>52.6</td>
<td>167.2</td>
</tr>
<tr>
<td>8</td>
<td>192.8</td>
<td>224.7</td>
</tr>
<tr>
<td>10</td>
<td>181.4</td>
<td>208.0</td>
</tr>
</tbody>
</table>
Table 1 shows the tensile test result of Ascast and heat treatment in above graph it shows that combinations of Al and 4% silicon is increases in heat treatment, for the combinations of Al & 6% silicon the tensile strength decreased, In As cast the combinations of Al & 8% silicon tensile strength increases, the 6% is decreases, variation of composition are shown in the graph.

### 4.2 Comparing the hardness result for ascast, heat treated

<table>
<thead>
<tr>
<th>Reinforcement %</th>
<th>ascast</th>
<th>Heat treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>173.3</td>
<td>193.2</td>
</tr>
<tr>
<td>4</td>
<td>125.1</td>
<td>239.0</td>
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<tr>
<td>10</td>
<td>181.4</td>
<td>208.0</td>
</tr>
</tbody>
</table>

From above table and graph As cast 10% more compare other composition and heat treatment 10% is more hardness compare Ascast So by graph proved to more result show increased hardness reinforcement silicon carbide.

### 4.3 Optical microscope results

In above figures directed the images showing the results for arrangement of grain structure of Aluminium with 0% reinforcement for ascast (Fig. a), heat treated (Fig. b)
In above figures directed the images showing the results for arrangement of grain structure of Aluminium with 6% reinforcement for as cast (Fig. c), heat treated (Fig. d).

In above figures directed the images showing the results for arrangement of grain structure of Aluminium with 10% reinforcement for as cast (Fig. e), heat treated (Fig. f).

<table>
<thead>
<tr>
<th>Reinforcement %</th>
<th>as cast</th>
<th>Heat treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0809</td>
<td>0.0314</td>
</tr>
<tr>
<td>4</td>
<td>0.0672</td>
<td>0.0336</td>
</tr>
<tr>
<td>6</td>
<td>0.0325</td>
<td>0.0325</td>
</tr>
<tr>
<td>8</td>
<td>0.0977</td>
<td>0.0973</td>
</tr>
<tr>
<td>10</td>
<td>0.0992</td>
<td>0.0694</td>
</tr>
</tbody>
</table>

In from above figure the 10% as cast are more wear compare other reinforcement percentage and compare heat treatment also more wear increasing.

5. CONCLUSION

A356 with Silicon carbide reinforcement metal matrix composite is fabricated successfully by using stir casting process. From this study the following mechanical properties and microstructure are observed. Tensile strength and hardness mechanical properties of composite material is enhanced as the result for the addition of SiC reinforcement in heat treatment is best compare to the As cast as shown tables 1 & 2. Microstructure in heat treated condition with grain refinement and grain modification compared to all other reinforcement percentage with A356 alloy.
6. REFERENCE

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