PRODUCTION AND MECHANICAL CHARACTERIZATION OF AL-7075-T6 AND FLY ASH COMPOSITE BY STIR CASTING HOT DIE PROCESS

F. Anand Raju
Assistant Professor, Siddharth Institute of Engineering & Technology, Puttur, A.P, India.

Dr. M.L.S. Deva Kumar
Professor & Vice Principal, JNT University College of Engineering, Anthapuramu, A.P, India.

ABSTRACT

Today the engineering metals are mutable their properties with high mechanical properties by the combination of different metals and other process. One of the most recent developments in the field of metals improves mechanical properties and reduce the weight density to utilize day-today life is composite materials. In this Aluminum metal matrix composite (AMMC) has gain more predominate role in metal matrix composite. After the usage of iron the second largest metal that use in the engineering, industrial, domestic works is aluminum. Fly ash (15%, 20% and 25%) particles are added in the Al-7075-T6 to produce Aluminum metal matrix composite by hot die casting process. Fly ash act as the reinforce metal in the aluminum metal matrix. This is added in the molten metal by stirring the ash particles to mix thoroughly and spared in the aluminum metal. Fly ash is the industrial waste by product converted in to usable metal so it reduce the storage problem and reduce the weight ratio of the AMMC. In this work the composition of the fly ash is varied to get the best mechanical properties and reduce the weight density of the AMMC. This type of AMMC is widely used in light weight vehicles, building elevation materials and aerospace application.

Key words: Aluminum 7075-T6, Fly Ash, Mechanical Properties, Stir Casting, Chemical analysis of Aluminum and Fly Ash.


1. INTRODUCTION

Aluminum is the second largest metal in the engineering materials. This is the oldest metal and most usable metal from house hold to aerospace. Aluminum fly ash metal matrix composite is strengthen composite in which soft and ductile aluminium matrix is strengthen by the hard and brittle fly ash particles. Discontinuously reinforced aluminium based metal matrix composites are improving their high strength, high isotropic and goodwear resistance. Discontinuously reinforcement aluminium composites have been developed in the various fields like aerospace, automotive and many other engineering applications [1].

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editor@iaeme.com
Fly ash particles are potential discontinuous dispersoids used in metal matrix composites due to their low cost and low density reinforcement which are available in large quantities as a waste by product in thermal power plants [2].

MMCs offer a unique balance of physical and mechanical properties. Aluminium MMCs have received increasing attention in recent years as engineering materials with improved strength, hardness and impact resistance. The stir casting method is widely used among the different process.

Fly ash is a naturally-cementitious coal combustion by-product. About 130 coal based thermal power plants that available in India are producing about 120 million tonne fly ash per year. Fly ash has been considered as an “Industrial waste” and was being disposed of in ash ponds. In Indian coal has high ash content and low calorific value as result huge amount of fly ash is generated. According to ASTM C-618 Fly ash is broadly classified into two major categories: Class F and Class C fly ash. The chemical content of the ash differ the type of ash i.e., the amount of calcium, silica, alumina and iron [4]. Fly ash utilization improved and reduces the pollution in environment, now in present day’s fly ash is focusing and improving their investigation in various fields like AMMC’s, brick, roads, agriculture and etc.

Production of AMMC’s has nemours advantages which are lightweight materials used in aerospace and automobile industry. The production of AMMC’s gives good mechanical characteristics and less in cost.

2. EXPERIMENTAL WORK

2.1. Raw Material

In this work, aluminum 7075-T6 alloy has been used as matrix and fly ash particle with average size of (1-53µm) were used as reinforcement material and its chemical composition was shown in the table 1. The fly ash is collected from Lanco Industry at Srikalahasti.

![Fly Ash](image1)

![Aluminum 7075-T651 plate](image2)

Figure 2.1 Fly Ash  
Figure 2.2 Aluminum 7075-T651 plate

2.2. Dimensions of the Die

The die is prepared by mild steel plate and square rods. The bottom plate is of 300×150×25mm and the top plate of 300×150×10 mm, the side bars on four side of different length, and two are 250×25×25 mm and the two short length of 150×25×25 mm is machined and polished to avoid the sticking of the cast. The bars were firmly bolted to the bottom and top plates to form as a rectangular cavity of size 250×100×15 mm. At the center of the top plate a 30mm diameter hole is drilled to pour the molten metal into the cavity. The one
side of the top plate a 10mm hole is drilled to form as a riser and escape the molten hot gases evolved in the casting.

2.3. Preparation of Specimen by Stir Casting Process
In this, the electric induction titling furnace is chosen to produce the specimens. The furnace is fully equipped with a stirrer and a DC motor to move the stirrer up and down. The motor movement is operated by pneumatic system. The control of temperature is done by digital control system. The speed of motor is controlled by DC regulator.

The aluminum of 7075-T6 was melted at the temperature of 800°C then the stirrer is start to stir the molten aluminium. Fly ash particles were added to the melt at the time of vortex formation (15%, 20%, and 25%) by weight %. The fly ash particles average size of (1-52µm) is obtained by sieving the collected ash from the industry. Before mixing the fly ash it is pre heated at the temperature of 600°C to remove the wettability in the muffle furnace. The melt temperature is maintained 800°C to 1000°C during the addition of the fly ash particles. The mixed AMMC is poured in the metal die which is maintained at hot condition. Then the die is allowed to solidification to produce the given specimen.
3. MECHANICAL TEST ON SPECIMEN

3.1. Tensile Test
The Al-7075-T6 is preparing according to the ASTM C-618 and also AMMC. The plate size of aluminum prepared in the die of 250×150×15 mm plate is cut to 250×25×12.5 mm to test tensile strength of the specimen at different composition with parent material.
Figure 3.1 Cutting of parent plate

Figure 3.2 Universal testing machine with specimen

Figure 3.3 Tensile Test specimen with Dimensions

Figure 3.4 Test Specimen before Test

Figure 3.5 Test specimen after test
3.2. 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. The hardness test was conducted on the Brinell hardness testing machine for all the samples with composite specimens.

3.3. Impact Strength
The toughness is the energy requires breaking the material. The energy is calculated in jouls. The energy consumed is calculated by the difference between total energy supplied to the energy available at the end. The measure of toughness can be found with the help of Charpy and Izod impact tests. The standard specimen size for Charpy impact testing is 10mm×10mm×55mm.
Impact test was carried out at room temperature using Impact tester to calculate toughness. The specimen is supported at two end like a simply supported beam in the test and reading was taken by breaking the specimen due to the impact of the pendulum.

![Figure 3.10 Charpy Impact test specimen with dimensions](image)

### 4. RESULT AND DISCUSSIONS

#### 4.1. Chemical Analysis of Al7075-T6

The chemical analysis of the parent Aluminum is tested by Spark or arc atomic emission spectroscopy. Spark or arc atomic emission spectroscopy is used for the analysis of metallic elements in solid samples. The parent aluminum piece is ground up and burned during analysis. An electric arc or spark is passed through the sample, heating it to a high temperature to excite the atoms within it. The excited analyte atoms emit light at characteristic wavelengths that can be dispersed with a monochromator and detected. The detected elements are tabulated below.

**Table 4.1 Chemical Composition of Al 7075-T6**

<table>
<thead>
<tr>
<th>Element</th>
<th>Silicon Si</th>
<th>Iron Fe</th>
<th>Copper Cu</th>
<th>Manganese Mn</th>
<th>Magnesium Mg</th>
<th>Chromium Cr</th>
<th>Nickel Ni</th>
<th>Zinc Zn</th>
<th>Titanium Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>0.4</td>
<td>0.5</td>
<td>1.2-2.0</td>
<td>0.3</td>
<td>2.1-2.9</td>
<td>0.18-0.28</td>
<td>-</td>
<td>5.1-6.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Content</td>
<td>0.35</td>
<td>0.164</td>
<td>2.02</td>
<td>0.015</td>
<td>2.06</td>
<td>0.15</td>
<td>&lt;0.01</td>
<td>5.989</td>
<td>0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Zirconium Zr</th>
<th>Sodium Na</th>
<th>Tin Sn</th>
<th>Bismuth Bi</th>
<th>Plumbum Pb</th>
<th>Cobalt Co</th>
<th>Other Element Each</th>
<th>Total</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
<td>0.15</td>
<td>Remainder</td>
</tr>
<tr>
<td>Content</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
<td>&lt;0.002</td>
<td>0.05</td>
<td>0.15</td>
<td>Remainder</td>
<td></td>
</tr>
</tbody>
</table>
4.2. Mechanical Properties

Table 4 2Al 7075-T6 Metal matrix samples with different compositions by weight ratio.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight % of aluminum</th>
<th>Weight % of fly ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample-1</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Sample-2</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>Sample-3</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Sample-4</td>
<td>75</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 4.3 Mechanical properties of the samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tensile strength (N/sq mm)</th>
<th>Yield strength (N/sq mm)</th>
<th>Elongation on 50mm G.L (%)</th>
<th>Impact Test ‘V’ notch(J) Size 10x10x55mm</th>
<th>Hardness [ HBW /10 mm ball dia / 3000 kgf load]</th>
<th>Density g/cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample-1</td>
<td>586</td>
<td>543</td>
<td>15</td>
<td>9</td>
<td>58</td>
<td>2.89</td>
</tr>
<tr>
<td>Sample-2</td>
<td>150</td>
<td>141</td>
<td>6</td>
<td>7</td>
<td>66</td>
<td>2.73</td>
</tr>
<tr>
<td>Sample-3</td>
<td>60</td>
<td>55</td>
<td>2</td>
<td>4</td>
<td>78</td>
<td>2.58</td>
</tr>
<tr>
<td>Sample-4</td>
<td>73</td>
<td>66</td>
<td>5</td>
<td>6</td>
<td>64</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Figure 4.1 Samples Vs Tensile Strength

Figure 4.2 Samples Vs Yield Strength
Production and Mechanical Characterization of Al-7075-T6 and Fly Ash Composite by Stir Casting Hot Die Process

![Figure 4.3 Samples Vs Elongation](image1)

**Figure 4.3** Samples Vs Elongation

![Figure 4.4 Samples Vs Impact Strength](image2)

**Figure 4.4** Samples Vs Impact Strength

![Figure 4.5 Samples Vs Brinell Hardness (BHN)](image3)

**Figure 4.5** Samples Vs Brinell Hardness (BHN)
5. CONCLUSION

The investigation conducted, leads to the following conclusions:

Fly ash is added in the molten aluminum up to 25% by weight ratio by stir casting process for production of composite material. So the industrial waste turns into industrial wealth. Addition of fly ash as 15%, 20% and 25% by weight % the tensile strength of the samples reduces and hardness of the samples is increased. By comparing the four samples, the sample3 with 20% fly ash has highest hardness BHN 78. The weight density of the material is decreased by 20% fly ash addition. By increasing of the hardness, ware rates significantly reduced.

The study gives the further addition of fly ash and study of microstructure and tribological studies. Casting the materials in to blooms and slabs to be rolled and extruded as different components for all applications.

REFERENCE


[13] DRDO “Composite Materials”, Popular Science & Technology (PST) series is being published by DESIDOC, was published in the year 1990

