Effect of WC addition in Al7075 alloy to prepare the Aluminium matrix composite via liquid metallurgy route

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Abstract

Aluminium based metal matrix composites (AMMCs) are advanced materials having the properties of high specific strength and modulus, greater resistance, high elevated temperature and low coefficient of thermal expansion. These composites spread their applications in the field of automobiles, aerospace, defence, cutting tool materials etc. In the present work an attempt has made to synthesis the Al7075 matrix with harder ceramic particulates of Tungsten Carbide (WC). The method used to produce is the low cost efficient stir casting method. To achieve a homogeneous distribution of the reinforcement without any wetting agent a two step introduction of reinforcement was adopted. The prepared composites were subjected to characterization of SEM/EDX which reveals the fair uniform distribution of the ceramic particulates over the matrix.

Key words— Ceramic, Al7075, Stir casting

1. Introduction

A composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions. Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials: matrix (binder) and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination.

2. Experimental details

2.1 Raw materials

Al7075:

7075 aluminium alloy is an aluminium alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other aluminium alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use.
Table 2.1: Properties of Al7075

<table>
<thead>
<tr>
<th>Materials</th>
<th>Weight Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>5.6 – 6.1</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2.1 – 2.5</td>
</tr>
<tr>
<td>Copper</td>
<td>1.2 – 1.6</td>
</tr>
<tr>
<td>Silicon</td>
<td>&lt; half</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.17 - 0.26</td>
</tr>
</tbody>
</table>

Reinforcement- 1 (WC):

Tungsten carbide (WC) is mainly used in industrial purposes for its high wear resistance. It is famous for its hardness and erosion resistance properties. The below table shows the properties of WC.

Properties of Tungsten Carbide

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>16.1g/cm³</td>
</tr>
<tr>
<td>Hardness</td>
<td>1499 BHN</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>520 Mpa</td>
</tr>
</tbody>
</table>

2.2 Processing of composites.

Stir casting route is adopted to prepare the composite. To achieve the homogeneous distribution of the reinforcement into the matrix two step methodologies is considered, where the reinforcement is added to the liquid metal of the matrix in twice of equal proportion at the same temperature.

A batch of 400 grams of Al7075 matrix is kept for melting in a graphite crucible using resistance temperature. Once the temperature of the liquid metal reaches 730°C, solid hexachloroethane tablet of about 2 grams is added and degassing is carried to remove all the gaseous mixture present in the liquid metal. Vortex in the liquid metal is generated at 300rpm using a stainless steel rod stirrer for about 10minutes. The formed slag is removed from the melt using a spatula and kept the molten metal ready for adding reinforcement.

The chosen reinforcement of Tungsten Carbide particulates are preheated in an oven at 150°C to. Later the preheated particulates in an equivalent amount of 6Wt% are introduced in two batches with an interval of 30seconds gap into the liquid matrix. The stirring action is carried out for a period of 60 seconds to ensure homogeneous distribution of reinforcement over the matrix.

The EN8 steel permanent mould with dimension of 125mm length and Ø15mm diameter is kept ready by preheating and once the liquid melt temperature reaches 750°C the crucible taken out of the furnace and poured into the mould and allowed it to solidify

2.3 Specimen Preparation

To study the microstructure, the specimens were cut and prepared as per the standard metallographic procedure. The specimen surfaces were prepared by Polishing through 600 to 1000 mesh size grit papers followed by Velvet cloth polishing. After that the specimens were etched using Keller’s reagent (HCl+HF+HNO₃). The microstructures of etched specimens were observed using Optical Microscope (OM).

3. Result and Discussion

3.2 Microstructure Characterization.

The prepared composite samples were subjected to microstructural analysis using LEICA DM750M Optical microscopy. Characterization of the samples with etchant and without etchants was conducted at different magnifications.
The samples subjected for analysis without the etchant is shown in Figure 3.1 (a) and the specimens with etchants is shown in Figure 3.1(b-d), as it can be observed from the microstructure the homogeneous distribution of the reinforcement added to the aluminium matrix. The main reason for this is because of the use of Mg as a wetting agent and adopting of two step met stirring technique. The addition of reinforcement in two steps along with the wetting agent which made the hard ceramic particulates to distribute all over the matrix in an evenly manner.

4. Conclusions

- Al7075-6wt% WC based composite was successfully synthesized by conventional stir casting technique.
- Microstructural characterizations carried out using OM studies have revealed fairly uniform distribution of the reinforcement particles in the Al7075 matrix system.

References

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