STUDIES ON CHARACTERIZATION OF AL 6061/ MOS₂ METAL MATRIX COMPOSITE

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ABSTRACT

The investigations on the characterization of Al 6061 base metal matrix composite (MMC) reinforced with Molybdenum disulphide (MoS₂) samples are reported in this paper. Aluminium MMC prepared with MoS₂ powder of particle size of less than 2µm, with weight ratios of 1, 2, 3, 4, 5 & 5.5 %. These composites were prepared by using stir casting technique. A series of tests were conducted to evaluate mechanical properties such as tensile strength, yield strength, impact strength and hardness for the specimen. The results were compared with base alloy. The results are revealing that the hardness and tensile strength increased with increase in wt. % of reinforcement particles in the matrix up to 4% and the hardness and tensile strength decreased for 5 %, 5.5% addition of reinforcement in the matrix. Investigations show that the MMC with 4% of MoS₂ have better mechanical properties i.e. hardness and tensile strength yield strength.

Keywords: Al-6061, Mechanical properties, MMC, MoS₂ powder, Stir casting


1. INTRODUCTION

In the last two decades, research has shifted to composite materials to meet the global demands. This led to the concept of combining different materials. 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 [1-2]. Composite material is a material composed of two or more distinct phases are combined. MMC is prepared with the help of introducing reinforcement particles in the matrix of any metal. These particles increases the properties like abrasive wear resistance, hardness, strength to weight ratio, stiffness and many thermal properties. [3]. The commonly used metallic matrices include Al, Mg, Ti, Cu, Si and their alloys. These alloys are preferred matrix materials for the production of MMCs. The reinforcements being used are fibers, whiskers, and particulates [4].

In the present investigation Aluminium 6061 alloy was used as the matrix material. Among the various Aluminium alloys, Aluminium 6061 alloy is typically characterized by properties such as fluidity, corrosion resistance, cast ability, and high strength-weight ratio. [5]. Due these good properties Al 6061 is used in construction of aircraft structures, such as wings and fuselages and SCUBA tanks.

The chemical composition of Al6061 is shown in Table 1.

<table>
<thead>
<tr>
<th>Component</th>
<th>Si</th>
<th>Mg</th>
<th>Fe</th>
<th>Cu</th>
<th>Cr</th>
<th>Mn</th>
<th>Ti</th>
<th>Zn</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight %</td>
<td>0.679</td>
<td>0.309</td>
<td>0.218</td>
<td>0.183</td>
<td>0.094</td>
<td>0.041</td>
<td>0.047</td>
<td>0.048</td>
<td>Balance</td>
</tr>
</tbody>
</table>

2. EXPERIMENTATION

2.1 Molybdenum Disulfide Reinforcement

MoS$_2$ is a new graphene which is having attractive layered structure. It is very strong and light weight. It gained interest in the scientific community as a potential replacement for silicon.

2.2 Preparation of the metal matrix composite:

Al-6061 was used as the matrix and molybdenum disulphide (MoS$_2$) as reinforcement. The metal matrix composites were prepared using stir casting technique (fig.1), by varying the MoS$_2$ in wt.% of 1%, 2%, 3%, 4%, 5% and 5.5% of 2µm particle size.

![Molten metal in the furnace](http://www.iaeme.com/IJMET/index.asp)

Figure 1 Molten metal in the furnace

Appropriately estimated amount of Aluminium alloy was fed into the electric furnace and was melted at 700$^\circ$ c. An appropriate amount of (1% of the wt. of base metal) MoS$_2$ particles were added slowly to the molten Aluminium metal.

The MoS$_2$ powder was pre-heated up to 500$^\circ$ c to remove the moisture (if any) and then it was added to the molten metal. The stirring process takes place at a speed of 300 rpm with a
stirrer. Then the mixture is transferred to a die casting mould to get the required specimens shown in fig.4. The same procedure was followed to get the MMCs of other wt. % i.e. 2 %, 3 %, 4 %, 5% and 5.5%

2.3 Testing of the Material
The specimens were tested for their mechanical properties i.e. tensile strength, Impact strength and hardness and also tested for electrical conductivity for 4% MMC

2.3.1. Hardness Test
The hardness test was carried out on the base metal and metal matrix samples by using Brinell Hardness Testing Machine.

2.3.2. Impact Test
The specimens were subjected to Charpy impact test to measure the impact strength. (figure 2)

2.3.3. Tensile Testing
Test was carried out on a computerized UTM. The tested specimens were shown in fig.3

3. RESULTS AND DISCUSSIONS

3.1 Microstructure
The microstructure of the specimen was observed by using computerized microscope. The structures were shown in Fig.4 for different compositions of MoS$_2$.

Microstructure studies clearly reveal that the distribution of MoS$_2$ in the matrix in fig 4(a), 4(b) is poor. It is observed from the fig 4(c) and 4(e), the reinforced particles are in the form of small lumps. Figure 4 (d) clearly reveal that there is fairly uniform distribution of MoS$_2$ throughout the MMC. From the microstructures it is observed that Al 6061 is able to dissolve MoS$_2$ particles up to 4% with effectively. There after by increasing the wt % Al 6061 is having less capability of dissolving the MoS$_2$
4.2 Tensile strength:
The tests revealed that, the ultimate tensile strength gradually increased by the increase in wt % of the reinforcement added to the metal matrix. The maximum tensile strength of 96.7 N/mm² was observed at 4 % MoS₂. The increasing trend of ultimate tensile strength is shown in figure 5.

![Figure 5 Tensile strength of MMC](image)

![Figure 6 Tensile Yield strength of MMC](image)
4.3 Tensile Yield Strength:
The test results reveal that the tensile yield strength is highest at 4% of MoS$_2$ reinforcement of the particles. From the microstructure it is observed that the distribution of reinforcement is good at 4% of MoS$_2$. For the remaining wt % the distribution shows some voids. Due to this, there is decrement in the Tensile Yield Strength (figure 6).

4.4 Impact strength:
The test results reveal that the impact strength is highest at 4% of MoS$_2$ reinforcement of the particles. From the microstructure it is observed that the distribution of reinforcement is good at 4% of MoS$_2$. For the 1%, 2%, 3%, 5% and 5.5% the distribution of reinforcement particles are not uniform. Due to this, the variations in the Impact strength is observed in figure 7.

4.5 Hardness:
The tests revealed that, the hardness of the composite specimen had increased gradually with increase in the wt % of MoS$_2$ powder incorporated in the MMC up to 4%, and then decreased on further increment of reinforcement i.e 5% and 5.5%. The trend of increase in hardness is shown in fig 8. This is due to the reinforcement of MoS$_2$ particles are not uniformly distributed.

4. CONCLUSIONS
The present work deals with the preparation and characterization of Al- MoS$_2$ Metal Matrix composite. The following conclusions are made from the study.

1. Al 6061 / MoS$_2$ MMCs were successfully fabricated.
2. The hardness of the MMC is found to be maximum for 4% MoS$_2$.
3. The tensile strength of the MMC is found to be maximum for 4% MoS$_2$.
4. MMC with 4% MoS$_2$ is found to be the best material based on the characterization of the mechanical properties.

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REFERENCES


