Effect of Temperature Variation on Al based Composites during T6 Heat Treatment

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Abstract: The heat treatment-T6 offers significant benefits for Aluminum Matrix composites due to changes of structure and material properties like strength, hardness and corrosion resistance. In this study, the preparation of reinforced Molybdenum Disulfide With Al-Zn-Mg alloy composites done by stir casting methodology. Three parameters like temperature (A), Time duration (B) and quenching medium (C) are considered for Heat Treatment Process (HTP). Quenching medium, time and temperature are reserved as constant. The main aim is to compare corrosion or wear characteristics (WC) and Hardness (BHN) of prepared samples before and after HTP. POD device used to conduct test of wear rate. 12 experiments are carried out by change of MOS2 particles volume (5-20 w.t %) and Temperature (400-700º C), the experimental outcomes are discussed and compare the mechanical properties for stir-casting and T6-HTP.

Keywords: Heat treatment, Al matrix composites and wear Rate

1. Introduction

Al-Zn-Mg alloys with high mechanical strengths include AA 7475. These alloys for use in parts including cylinder heads, pistons, and crank shafts [1]. Various methodologies such liquid metal processing with stir casting [2,3], rheo-casting, and infiltration technique [4] were proposed for the fabrication of AMCs. Stir-casting is one of the most popular and

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affordable techniques out of many techniques [5]. Pores or gaps [19], as well as grain size [20], structure, and density, all affect a material's characteristic. Heat treatment is became able to enhance the property of Al alloys, where T6 heat treatment may raise the strength and corrosion resistance, in order to solve this issue [6]. Stir casting process resolving the wettability issue and enhances the dispersion of the reinforcing particles [7]. Solution heat treatment, quenching, and age hardening are the three processes that make up the T6 heat treatment process [8]. After studying the effects of heat treatment on the mechanical characteristics of Al-FA-Sic Hybrid MMCS, it came to the conclusion that SiC [14] and fly ash might increase ultimate tensile strength. It is extensively studied that the eutectic modification the original elemental composition affected the morphological structure of microstructure and the size of the eutectic, leading to a tensile strength increase from 125 MPa to 215 MPa for composition Al6061 [9]. Shital Thakare et al. selected steel EN8 in their research. The specimen was annealed at 880 to 910 °C. After that, several heat treatment processes have been used including tempering, quenched in different media, and ultimately tempering at 200–300 °C to evaluate the hardness [10]. S.D. Vetrivel et al. learned about the tribological properties of medium carbon steel. He employed a pin-on-disc system to assess wear resistance. He boosted wear efficiency using nitriding and induction hardening and discovered that these processes were more effective in supplying corrosion resistance than conventional heat treatment techniques [11]. The quenching medium must be water in order to increase wear resistance over the raw material and get superior wear resistance on EN-8 steel [12]. From the studies of different literature, we investigated the comparison of the wear resistance of of Al-Zn-Mg/MOS2 composites before and after heat treatment.

2. Materials, methodology and testing:

In generally, the Al-Zn-Mg alloy used as the basic material is melted within a crucible at a high enough temperature and the reinforcing particles (MOS2) are supplied to the melt and optimal mechanical stirring is performed into the melt to create homogenous casting composites as Al matrix. An efficient mechanical stirrer thoroughly mixes the base Al 7475 and reinforcement [13]. After that pour the both melted Al alloy with reinforcements in to the desirable die or mold then remove solidify part from it. The complete setup of stir cast apparatus shown in in Figure.1. six different samples are made from variation of Molybdenum disulfide volume %.
Samples are sliced and a wear test on a POD device (Figure.2) is conducted in accordance with ASTM standard G-99 [15]. The tests were carried out at room temperature [21,22] with a continuous flow of lubricants in a wet environment across a distance of 400m, load of 100N, and speed of 5m/s. Al7475/MoS$_2$ specimens are subjected to T6 - heat treatment with varied parameter involving Solution Temperature (SC) followed by quenching and ageing. Only SC factor is changed from 400 to 650 ºC, quenching and aging time duration keep as constant 30 minute and 2hours respectively. The respective Table 1 indicates the levels of SC and other parameters in heat treatment conditions.
<table>
<thead>
<tr>
<th>s.no</th>
<th>Process variables</th>
<th>Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solution Temperature</td>
<td>400,450,500,550,600,650ºC (6 levels)</td>
</tr>
<tr>
<td>2</td>
<td>Quenching time</td>
<td>30 mins</td>
</tr>
<tr>
<td>3</td>
<td>Artificial Aging Time and temperature</td>
<td>2hrs &amp; 250 ºC</td>
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</tbody>
</table>

Table 2 shows wear rate values for casting and heat treatment process. We can be able to identify difference of mechanical properties from the experimental readings. If Wear Rate (W) is more, then sample has less corrosion resistance (C) which means $W \propto C$. The Brinell hardness also measured through Brinell tester [16,17,18] by pre and post heat treatment. Description of each sample chemical involvement displayed in Table 2.

**Table 2: contribution of Al alloy and MOS₂ on each specimens**

<table>
<thead>
<tr>
<th>S.no</th>
<th>Description of samples</th>
<th>With and without Heat treatment done on all 6 samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Al+5% wt MOS₂</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Al+7.5% wt MOS₂</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Al+10% wt MOS₂</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Al+12.5% wt MOS₂</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Al+15% wt MOS₂</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Al+20% wt MOS₂</td>
<td></td>
</tr>
</tbody>
</table>
3. Result and discussion
Al matrix composites (Al/Zn/Mg reinforced of Molybdenum Disulfide) samples are fabricated through SC method[19,20]. The samples are under heat treatment to check mechanical behavior of wear resistance and hardness then comparing results before and after HT process[21,22]. The experimental results for both casting with and without T6–HT are exposed in Figure 3 &4. The hardness of six samples are increased from 83 to 99 HBN in casting at the same time BHN values are varied from 87 to 105 HBN at HT process[23,24]. The maximum BHN is observed in HT sample-6 and lowest found at sample 1 (Figure.3). Similarly wear rate values also found for Al specimens[25,26]. It is noticed that black color indicates Wear rate for stir cast (with no treatment involved) and indication of red color in the figure .4 shows wear rate of heat treated samples. From the observation, maximum wear is attained sample 5 around 0.00925m$^3$/Nm whereas minimum wear amount is identified at samp-3 (with HT) about 0.0063 m$^3$/Nm which indicates that less corrosion resistance due to reinforcement is mixed uniformly at matrix and HT process helped to give strength on that particular composite.

4. Conclusion

The addition of 5 to 20 wt% of MOS2 powder in to Al-Zn-Mg alloy in stir casting which develop mechanical behavior of composite. Conduction of hardness and wear test are completed by brinell tester & POD kit. It si noticed that hardness values are improved at HT process compare to casting process. Maximum BHN attain value is found at sample 6 of HT. In case of wear examination, heat treatment that helps reinforcement particles melted and mixed with Al alloy properly. so that wear or corrosion resistance is increased more than the stir casting process. The lowest wear resistance is revealed in the sample-5 (without T6-HT) whereas maximum found at sample-3(with T6-HT). The conclusion of this work exposed that heat treatment mainly improve material and mechanical features.

5. References


