Investigation of Microstructural and Mechanical Properties of Al Based Alloys Produced by Normal Solidification

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Abstract

In this work, AlMgTiB light alloys were produced at different rates and their structure and mechanical properties were examined. This alloys, 2 different alloys Al76Mg15Ti6B3 and Al75Mg15Ti6B4 were produced by changing the proportions of "AlMgTiB" (metals form of the purity of 99.99%) alloy elements. “AlMgTiB” alloy were produced by metal casting method. These alloys were characterized the crystal and phase content of the samples by X-ray diffraction (XRD), scanning electron microscopy (SEM) for their morphological properties, the alloys compositions as well as the concentrations of elements impurities were controlled by Energy-dispersive X-ray spectroscopy(EDX), mechanical properties for Vickers microhardness measurement. Xray diffraction analysis has revealed that all the prepared compositions had strongly crystal structures. The highest value of microhardness of Al75Mg15Ti6B4 ingots were determined.

1. Introduction

Aluminium-based alloys, due to its important properties such as high corrosion resistance, low specific weight, conductance of electricity and heat and easy shaping, have been expansively used in the industry in recent years[1]. Moreover, Al-based alloys have new application areas in every day and are spread over a large area from the house goods to space technology[2].

The most prominent feature of aluminum-based alloys, which takes place widespread use in industrial applications and human life, is lightness[3]. Therefore, alloying elements in aluminum have further been improving the physical, mechanical and thermal properties that provide superior compared to other metals[4]. Especially, the adding magnesium, titanium and boron into aluminum plays a very important role in improving the properties of the alloys[5]. There is a lot of Al based work in the literature[6][7]. The researches carried out in these studies have been to determine the changes of mechanical properties by making microstructure studies[8]. In microstructure changes and crystal structure formation, Al Mg and Al Ti binary alloys have been observed to develop in mechanical properties by changing crystal structure of pure aluminum metal in different compositions and works in the literature[4][9].

2. Experimental Procedure

"Al-Mg-Ti-B" alloys are produced by metal die casting method in different ratios, melted in graphite pot of 2kg capacity. Manufactured compositions Al76Mg15Ti6B3 and Al75Mg15Ti6B4 alloys. Al, Mg, Ti, B elements (purity 99%) were weighed in metal forms according to the proportions of the experimental work to be done. After the cleaning process, the metals are placed in the graphite pot. The test against
oxidation was carried out under an argon atmosphere. The metal mold was cast from room temperature. At the end of the solidification, the alloys removed from the mold were given to the mills and burrs were removed.

The Philips X’Pert PRO brand X-Ray Diffraction (XRD) instrument was used under monochromatic CuKα radiation (λ = 0.154056 nm) with a setting of 40 kV and 30 mA. XRD analyzes were performed for all samples; Measurements were taken at 293 K from 20° to 110° in 0.02° steps and 1 s in each step. Scanning Electron Microscopy (SEM) and Energy-dispersive X-ray spectroscopy (EDS) studies were performed on the ZEISS EVO LS10 SEM device. Furthermore, the composition ratios of the alloys produced are determined by the Bruker Quantax 200 brand EDS, which is connected to the SEM device. The mechanical properties of the Shimadzu HMV-2 microhardness device with Vickers tip are used. Measurements were carried out at 988 kN (HV0.01) at a load of 98.07 mN for 10 s. Surface hardness values are calculated.

3. Results and Discussion

(Fig.1) shows the XRD patterns of the Al76Mg15Ti6B3 and Al75Mg15Ti6B4 alloys. The phases in the as-cast microstructures indicated that alloys mainly consisted of β-Al13Mg2 solid solution and the compound of intermetallic TiAl3 phases. Due to the low boron content in the alloy composition, no xrd pattern was detected.

(Fig.2a and 2b) shows the microstructures of SEM image of alloys produced by boron doping in two different ratio. Titanium and Boron are distributed in solid phase. The phase structure of the SEM images, grain boundaries and morphology of the alloys were determined by magnifications of 500 times.

Table 1. Vickers MicroHardness results of Al76Mg15Ti6B3 and Al75Mg15Ti6B4

<table>
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<tr>
<th>Alloys</th>
<th>Vickers Microhardness (HV)</th>
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<tr>
<td>Al76Mg15Ti6B3</td>
<td>106.1 ±11</td>
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<tr>
<td>Al75Mg15Ti6B4</td>
<td>125.3 ±3</td>
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</table>

Figure 1: XRD pattern of Al76Mg15Ti6B3 and Al75Mg15Ti6B4 Alloys
The measurements were carried out at 298 K at 98.07 mN (Hv0.01) and at a load of 15 s. Surface hardness values were obtained as 125.3 ± 3 HV and 106.1 ± 4 in alloys. As the boron content increased, there was a noticeable increase in the vickers hardness values. The MicroHardness vickers chart is given in Figure 4.

![Figure 3: Vickers MicroHardness of Al76Mg15Ti6B3 and Al75Mg15Ti6B4 Alloys](image)

In the SEM images, the intermetallic phase in aluminum was observed homogeneously of the magnesium element, where the titanium had rod-like phase structure. EDX analysis was performed by screening area.

![Figure 4: EDX results of Al76Mg15Ti6B3 Alloys](image)

### Table 2: EDX results of Al76Mg15Ti6B3 Alloys

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<td>2.8</td>
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</table>

![Figure 5: EDX results of Al75Mg15Ti6B4 Alloys](image)

### Table 3: EDX results of Al75Mg15Ti6B4 Alloys

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<td>2.3</td>
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<tr>
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<td>100.00</td>
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4. Conclusion

The conclusions drawn from this study are as follows:

1. Alloys have been successfully produced in the direction of research.
2. Al Mg Ti B composition, which is composed of the lightest metals, is costly and costly to produce with conventional methods.
3. The addition of Magnesium in the composition risks the risk of oxidation.
4. As the boron content of the alloys produced by the casting method increased, the microhardness vickers values increased.

The morphological structures of the alloys are homogeneously dispersed in solid...
solution Titanium.

6. It is fixed with the literature that the elements forming the alloy composition are composed of intermetallic phases of the XRD-forming peaks.

Acknowledgment

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Reference


