Abstract

In this study, the effect of Ti addition on microstructure of Zamak-3 alloy investigated. For modifying the alloy with Ti, in amount of 10 and 20 g Al5TiB (Ti equivalent) were added to 1 kg alloy for adjusting Ti amount within the alloy to be 0.05 and 0.1 wt.%, respectively. The microstructural evaluation of the samples were observed by using optical and SEM-EDS analyses. As casting materials were subjected to mechanical characterizations such as Brinell and micro hardness, Charpy toughness experiment in order to investigate the changing of the mechanical properties by adding of Ti. According to optical and SEM observations, the amount of auectic phase in the microstructure was increased and interlamellar distance in the auectic was decreased, whereas the Al-rich, black coloured phase became bigger, localization of that phases were changed towards grain boundaries and distribution of it was restricted by raising of Ti amount. As Ti amount increased, the lower hardness and the higher toughness were observed in the samples.

1. Introduction

Zinc in its unalloyed form is relatively soft and brittle at low and ambient temperatures [1]. At the begining of 20th century, zinc alloys have been developed to meet the demand for press casting alloys that are durable and stable. As developed hypoeutectic Zn-Al alloys are called Zamak family and have two groups, the first one containing from 0.01% to 3% (Zamak alloys # 3, 5, 7, 2) and the second one containing from 5.2% to 6% (ACuZinc5 alloy) [2, 3, 4]. Zamak is bascially general name pure zinc having aluminum and copper additions. Zamak alloys distinguished from other zinc-aluminum alloys by having 4% Al [5]. Upon solidification these alloys form eutectic structure of dendritic primer \( \eta \) and \( \alpha+\eta \) phases. Among these \( \eta \) phase having hexagonal closed packed (HCP) crystal structure and rich in zinc whereas \( \eta \) phase having face centered cubic (FCC) structure and rich in Al [2,6]. Toughness, hardness, abrasion resistance and corrosion resistance of the alloy is increased upon the addition of copper,magnesium and silicon. HCP \( \epsilon \) phase is formed with addition of copper exceeding 1%. Small amount of Cu and Mg addition is beneficial for the optimum mechanical and casting properties of the alloy. Besides high amount of copper increases dimensional unstability limits the use of these alloys [1,2,4,6]. These alloys are used mostly in automotive industry for decorative and structural purposes [3, 7]. Also these alloys have limited castability in low temperatures and at high temperatures mechanical properties deteriorates. In order to compensate the disadvantages these alloys are combined with Ti, Mn, Zr and rare earth elements [7].

The aim of this study to investigate the effect of Ti addition on microstructure of Zamak-3 alloy.

2. Experimental Procedure

Two series of Zamak-3 alloys modified by Ti having morphology of 1kg ingots used in the experiments. Chemical composition of the Zamak-3 alloy used in this study is given in table-1 below.

<table>
<thead>
<tr>
<th>Chemical Composition (wt.%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>3.8-4.2</td>
</tr>
</tbody>
</table>

Zamak-3 alloys were casted by weight of 1 kg ingots and during casting 10, 20 g Al5TiB (as Ti equivalent) were added to adjust Ti amounts within the alloys as %wt. 0.05 and 0.1, respectively.

In order to investigate the effect of Ti and Sr addition on microstructure, samples taken from cast alloys grinded and polished followed by etching with 50% HCl and 50% distilled water. Samples etched are analysed via optical and SEM-EDS instruments. Other as-polished cast samples’ hardness measurements carried out by Brinell and Vickers microhardness to reveal the mechanical properties. Charpy impact toughness experiment is carried out to define the impact toughness of the alloys.

3. Results and Discussion

3.1. Optical microstructure

Figure 1-2 a-b showed the microstructure of the samples modified by different amount of Ti.
3.2. SEM-EDS analysis

SEM-EDS analysis carried out on the eutectoid lamellars showed that Ti addition do not have any substantial effect on the phase composition of the Zamak-3 alloys. It can be said that lamellar shaped black colored rods consist of Al and represent α phase whereas regions left between the lamellars with lighter colored consist of Zn and represent η phase. Besides it is observed that Ti addition makes the lamellar thinner and small spherical shaped(Figure 2- b).

3.3. Hardness (Brinell) results

Hardness of the samples modified by Sr and Ti and measured by Brinell hardness test given in Figure 4.

Figures given in Table 2 revealed that impact thoughtness of the alloys increases as the amount Ti increases. Depending on the increase in the amount of alloying element, decrease in the rate of hard dendritic phase, partially spheroidization
of lamellars belong to eutectoid phase and refinement of lamellars yields increase in toughness. Besides notched toughness of the alloy having 0.1% Ti is found to having same thoughness compared to the unnotched thoughness of the reference Zamak-3 [8] (58j) alloys.

### Table 2. Thoughness strength of as casted alloys according to Ti amount.

<table>
<thead>
<tr>
<th>Amount of alloying element (wt.%)</th>
<th>0.05 Ti</th>
<th>0.1 Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoughness Strength (joule)</td>
<td>54</td>
<td>58</td>
</tr>
</tbody>
</table>

### 4. Conclusion

The following results have been obtained from this study;

Optical micrographs showed that as the amount of Ti increases, amount of eutectoid phase, distance between lamels slightly decreases, and size of Al rich black coloured phase decreases. Besides eutectoid phases directed towards grain boundaries, limited the dispersion in microstructure. Also size of the eutectoid phase is observed to be increased.

It can be said from SEM-EDS that Ti addition makes the lamellar thinner and small spherical shaped.

Hardness measurements showed that alloys modified with 0.05% and 0.1% Ti having 83.55 and 74.13 HB hardness, respectively.

Thoughness tests revealed that impact thoughness of the alloys increases as the amount Ti increases. Also, notched thoughness of the alloy having 0.1% Ti is found to having same thoughness compared to the unnotched thoughness of the reference Zamak-3 (58j) alloys.

### References