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INVESTIGATION OF THE EFFECT OF HOMOGENIZATION PRACTICE ON THE MICROSTRUCTURE OF 6060 AND 6082 SERIES ALLOY BILLETS

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INTRODUCTION

6060 and 6082 aluminum alloys are highly used in automotive industry due to their impressive strength-density ratio. To achieve the best combination of high hardness and low ductility in the extruded profiles, the as cast billets are submitted to homogenization thermal treatment. In this paper, the effect of homogenization conditions at 585°C on the microstructure and hardness of 6060 and 6082 alloy billets is presented and discussed.

Effect of Soaking Time on Aspect Ratio and Mean Diameter of Intermetallic Particles

During homogenization the coarse plate-like β-AlFeMnSi intermetallics are transformed into more rounded α-AlFeSi particles, improving the extrudability of the material and preventing the generation of surface defects during extruision (Birol, 2004).

Regarding the homogenization of 6060 billet for 1 h soaking time, AlFeMnSi particles exhibited an aspect ratio value of 3.46, for 4 h 3.37, for 8 h 3.13 and for 24 h 2.71. The finest particle size was observed for 4 h soak (1.56 μm) and following that for 1 h and 8 h soak 1.93 μm, while for 24 h the value was 1.99 μm.

Regarding 6082 alloy billet 4 h soak resulted in the highest mean aspect ratio value (2.89) and lower mean diameter (2.58 μm), followed by 8 h (2.64 mean aspect ratio and 2.65 μm mean diameter), 1 h (2.55 mean aspect ratio and 2.87 μm mean diameter), and 24 h (2.49 mean aspect ratio and 2.76 μm mean diameter).

Effect of Cooling Rate on Hardness and Mg_2Si Precipitation

For both alloys, water quenching and air cooling after heat treatment prevented Mg and Si precipitation in the form of Mg_2Si particles. Mg_2Si precipitation was only detected with scanning electron microscopy in furnace cooled samples, especially in 6082, due to the higher alloying elements content (Figure 1). The alloying elements remained dissolved in the aluminum matrix with water quenching leading to higher hardness values (45 $HV_{0.2}$) as a result of solid solution hardening effect. Hardness values were lower for the air cooled and furnace cooled samples (40 $HV_{0.2}$).

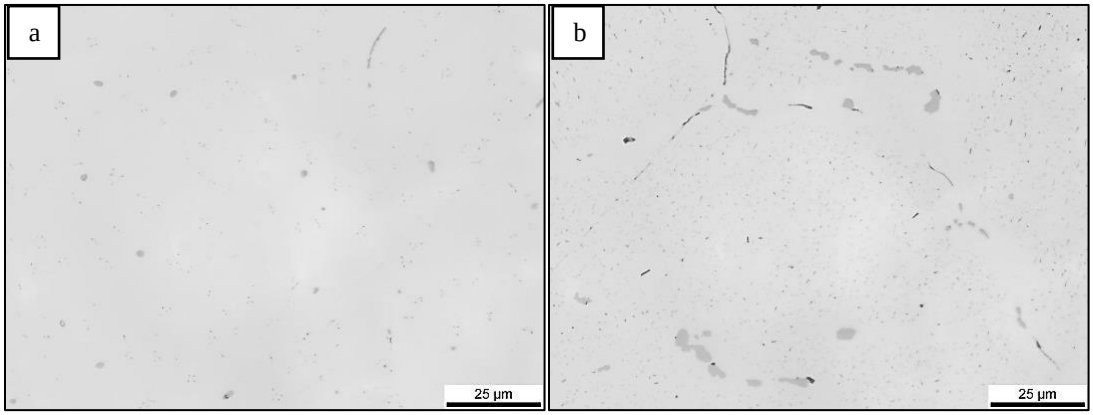

Figure 1. Microstructure of (a) 6060 and (b) 6082 billets after 24 h at 585°C and furnace cooling

Analysis of Variance (ANOVA)

Results of mean diameter and aspect ratio measurements of Fe-rich intermetallics were processed using ANOVA, with the aim to identify potential differences resulting from heat treatment parameters which could alter the extrudability of the billets. For both alloys, the categorization using Tukey and Fisher method was nearly identical. ANOVA verified that prolonged soaking (24 h) led to lower mean aspect ratio and mean diameter values in 6060 alloy billet. 6082 alloy samples soaked for 24 h showed the lower mean aspect ratio but not the higher mean diameter values.

Differential Scanning Calorimetry

Differential Scanning Calorimetry (DSC) tests were performed for determining i) the kind of the precipitate particles resulting from different cooling rates after homogenization treatment and ii) the potential for the precipitates to redissolve during billet preheating. Water quenched and air-cooled 6082 alloy billet samples exhibited two discrete peaks at 250 and 325°C signifying β″-Mg_2Si precipitation and β″ to β´ transformation. For 6060 alloy billet, continuous precipitation sequence up to 300°C was observed, while the solution temperature was lower (500°C) than that of 6082 alloy (530°C, Figure 2).

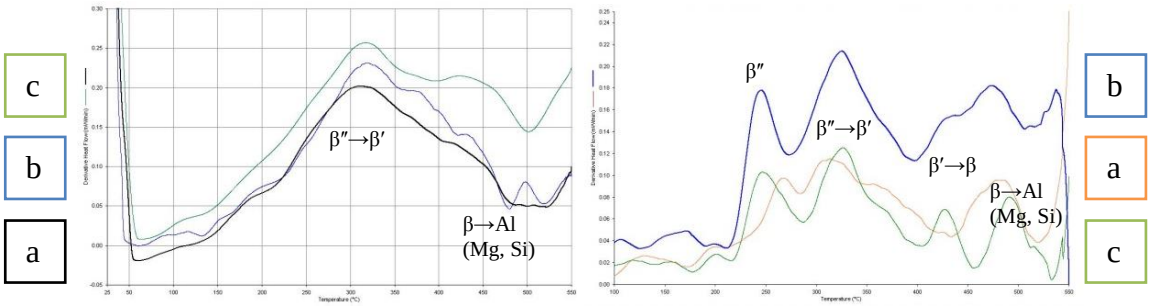

Figure 2. DSC spectra of 6082 billet samples, soaked at 585°C and a) furnace cooled, b) air cooled and c) water quenched

CONCLUSIONS

According to the findings of this research, it could be deduced that:

- Aspect ratio decreased constantly until 24 h, which is believed to improve extrudability.
- Higher cooling rates resulted in prevention of precipitation of Mg_2Si particles, while furnace cooled samples exhibited dispersion of non- and semi-coherent phases. Water quenching led to higher hardness values due to solid solution hardening.
- DSC produced useful information regarding re-solution of Mg_2Si during billets preheating (prior to extrusion).
- ANOVA constitutes a useful tool for processing a large group of data resulting from metallographic examination.

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KEYWORDS

6060, 6082, ANOVA, Cooling rate, Homogenization, Transformation