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Effect of Misch-metal addition on Heat treatment of Semi-Solid Mg-7.5Al-0.3Mn alloy

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The misch-metal addition on the microstructure, aging behavior and hardness of semi-solid Mg-7.5Al-0.3Mn-based alloys were investigated. The semi-solid alloys used for the experiments were prepared by cooling plate casting. The microstructural analysis on heat treatment and semi solid casted alloys were carried out with the optical microscope, scanning electron microscope and energy dispersive spectroscopy. And, its mechanical properties were evaluated by Vickers hardness and tensile test. The microstructure of the as-cast alloys consists of α-Mg, $Mg_{17}Al_{12}$, phases formed by the addition of misch-metal, and the morphology of these intermetallic phases formed by the addition of misch-metal shows a shape of a needle.

Keywords: *Heat treatment, Misch-Metal, Semi-Solid, Mg alloy*

1. Introduction

In automotive industry, many studies for weight reduction of automotive parts have been conducted because it is possible to improve fuel efficiency of an automobile and reduce the emissions of carbon dioxide [1,2]. Magnesium alloys, as the lightest structural metal material, have excellent specific strength than that of other alloys such as aluminum and steel alloys. For this reason, it has a potential as a light-weight material for the application of the automobile parts [3,4]. The Mg-Al based alloys of Mg alloys is the most widely used commercial cast alloy due to their excellent castability and strength at room temperature. However, the alloys is limited to the use of the alloy because it has a low high temperature strength by the low melting point of β phases ($Mg_{17}Al_{12}$) formed by Al addition [5-7]. So, there are in progress many researches to improve the high temperature strength of the alloy by element addition (Si, RE, MM, etc.) and cast process [8-11]. Therefore, in this study, the effects of misch-metal addition on the heat treatment of semi-solid Mg alloys were investigated.

2. Design of Experiments

The used alloys for this study were prepared using Mg-7.5Al-0.3Mn alloys and misch-metal fabricated by a cooling plate method. The alloys were melted and stabilized at 720°C under a mixed CO_2 and SF_6 gas atmosphere. Heat treatment of the alloys was solution treated at 400°C for 8h. Then, aging treatment was performed at 200°C. And, the heated specimens were carried out the microstructure observation and Rockwell hardness test.

3. Results and Discussion

Fig. 1 shows the microstructure of Mg-7.5Al-0.3Mn-*x*MM alloys with the different casting method ((a,b) permanent mold casting and (c,d) semi-solid casting). As shown in Fig. 1, the alloys fabricated by permanent mold casting had coarse and dendritic grains by a relatively slow cooling rate but by semi-solid casting consisted of fine and global grains because of rapid cooling rate by inclined cooling plate method. And, addition of misch-metal to Mg-7.5Al-0.3Mn alloy (Fig 1(b), (d)) contributed to the formation of a rod or needle-like phases and reduction of β phases ($Mg_{17}Al_{12}$,) fraction. EDS analysis of the rod or needle-like phase, it shows that La, Ce and Al were the main constituents of the phase.

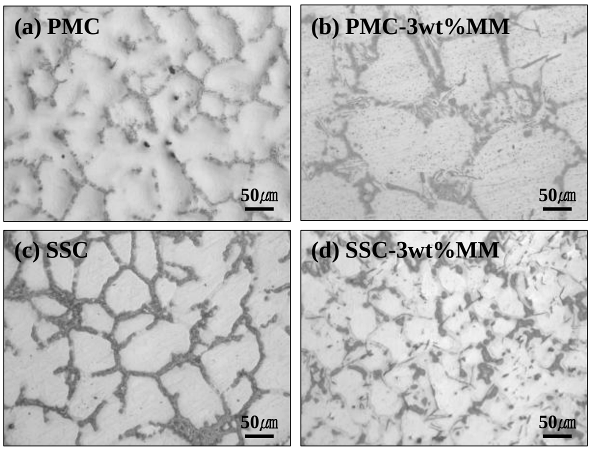

Fig. 1 Microstucture of Mg-7.5Al-0.3Mn alloys with different casting method

Fig. 2 shows the Hardness variation of Mg alloys after aging treatment at 200°C. With increasing aging time, the hardness of Mg alloys gradually increased and reached a maximum peak hardness of the alloys after 4hours.

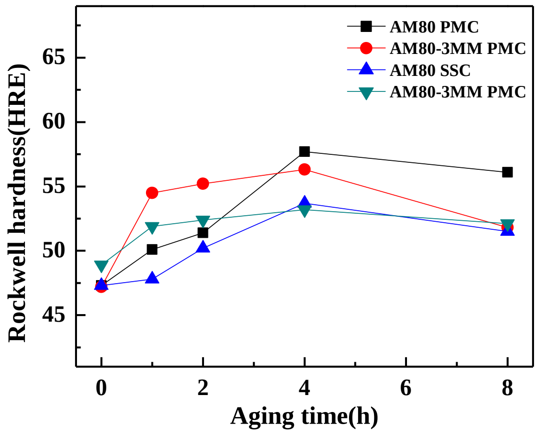

Fig. 2 Change in the Rockwell hardness of Mg-7.5Al-0.3Mn-*x*MM alloys after aging treatment

Fig. 3 shows the microstructure of semi-solid casted Mg-7.5Al-0.3Mn-*x*MM alloy aging heated at 200°C. In Fig. 3, the semi-solid cased Mg-7.5Al-0.3Mn alloy was gradually increased a discontinuous precipitate from the grain boundaries of Mg alloy with increasing aging time.

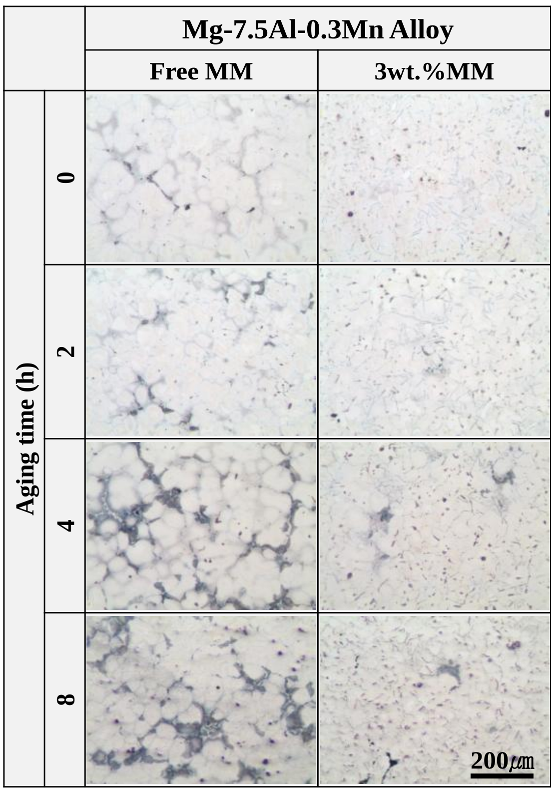

Fig. 3 Microstructure variation of semi solid casted Mg-7.5Al-0.3Mn-*x*MM alloys aging heated at 200°C

However, the semi-solid cased Mg-7.5Al-0.3Mn-3wt.%MM alloy was not observed a discontinuous precipitate from the grain boundaries in the early aging time. Also, it was confirmed that the discontinuous precipitation and growth of β phases was delayed by the addition of misch-metal during the heat treatment.

4. Summary

The addition of misch-metal to Mg alloy contributed to the formation of a rod or needle-like phases and reduction of β phase fraction.

The addition of misch-metal to Mg alloy was confirmed to delay the discontinuous precipitation of β phases and growth of the phases during the heat treatment of Mg alloy

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