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# Microstructure And Mechanical Property Of Mg−Al−Ca Alloys Produced By High Pressure Casting.

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The microstructure and the mechanical property was investigated using by Mg-Al-Ca castings which is an automotive engine component with different Ca contents. With increasing of Ca content, 0.2%P.S. was increased and elongation was decreased. It was thought to be an cause that the amount of γ-(Mg, Al)$_2$Ca phase was increased. With such change of microstructure, heat resistance was also improved.

***Keywords:*** *Mg-Al-Ca alloy, high pressure casting, microstructure, mechanical property.*

## 1. Introduction

In recent years, reducing the fuel consumption is getting a critical issue of the automobile industry. Reducing the weight of cars is one of the ways to improve the fuel efficiency, therefore the application of light materials such as Mg alloys to auto parts is highly expected. Mg alloys have the lowest density and the highest specific strength among practically used metals. Mg-6.0%Al-0.3%Mn (AM60) and Mg-9.0%Al-1.0%Zn (AZ91) are two typical alloys used in the auto industry. These alloys are applied for seat frames and door frames of some cars. The most effective parts in reducing the weight of cars are powertrain components [1].

However AZ91 and AM60 alloy are insufficient in heat resistance which is necessary for the powertrain components. Various heat resistant Mg alloys have been developed to improve the heat resistance. Mg-Al-Ca alloys are one of the promising alloy because it does not contain expensive rare earth elements and has high recyclability as well as high heat resistance [2, 3].

In this study, the effect of Ca contents on the microstructure and mechanical property of Mg-Al-Ca castings produced by high pressure casting was investigated.

## 2. Experimental procedure

The experimental alloys were Mg-7.0%Al-1.0% Ca (AX71) and Mg-7.0%Al-3.0%Ca (AX73). In addition, Mg-9.0%Al-1.0%Zn (AZ91) alloy was prepared as the comparative material. To achieve this composition, the following raw materials were weighed: pure Mg, pure Al, pure Ca, pure Zn, pure Sr, Mg-Mn and Al-Be master alloy. These alloys were melted in an electric furnace, while blowing protective gas to the surface of molten metal. The alloy codes and the chemical compositions of the castings are shown in Table 1. The samples were an automotive engine component of about 1 kg produced by cold chamber die-casting machine.

The microstructures of the castings were observed with optical microscope (OM) and scanning electron microscope with energy dispersed X-ray spectrum (SEM-EDS). The tensile test was carried out using by Instron Autograph tensile testing machine at R.T. with a cross-head speed of 1mm/min.

Table 1 The alloy codes and the chemical compositions of the castings (mass%).

| Alloy code | Al | Ca | Zn | Sr | Mn | Fe | Mg |
|---|---|---|---|---|---|---|---|
| **AX71** | 7.71 | 1.01 | - | 0.25 | 0.23 | 0.001 | Bal. |
| **AX73** | 6.90 | 2.78 | - | 0.25 | 0.20 | 0.006 | Bal. |
| **AZ91** | 8.97 | - | 0.65 | - | 0.19 | 0.001 | Bal. |

## 3. Results and Discussion

The optical micrographs of the castings in low and high magnification are shown in Fig.3 and 4, respectively. The microstructures mainly consisted of the primary crystallized α-Mg phase (white region) with dendritic shape and eutectic phase (dark gray region) crystallized at the last stage of solidification on the grain boundaries and the cell gaps in all the alloys. $Al_6Mn$ phases (black region) were dispersed uniformly in the matrix of all alloys.

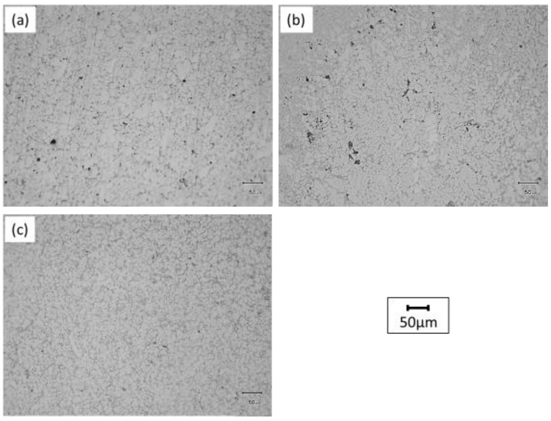


Fig. 1 Optical micrographs in low magnification of (a) AX71, (b) AX73 and (c) AZ91 castings.

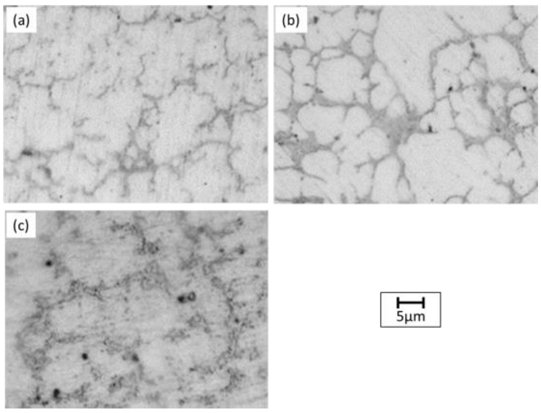


Fig. 2 Optical micrographs in high magnification of (a) AX71, (b) AX73 and (c) AZ91 castings.

Fig.3 shows the mechanical property of all the castings. Elongation was slightly low in all the castings. As the one of cause, it is thought that the castings included defect inside, because these castings were near-net shaped actual parts. With increasing of Ca contents from 1.0 to 3.0%, 0.2%P.S. was increased about 20MPa, on the other hand, elongation was decreased about 1.3%.

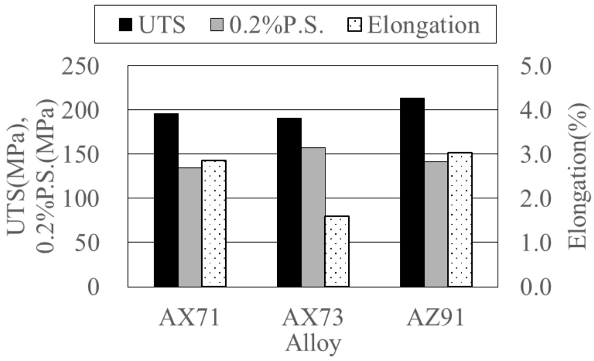


Fig. 3 Mechanical property of AX71, AX73 and AZ91 castings.

In order to clarify the cause of such changes of the mechanical property, crystallized phases were identified based on the observation results of microstructure. The amount and kind of crystallized phase of each castings are shown in Table 2. Because the amount of γ-(Mg, $Al)_2Ca$ phase was increased with increasing of Ca contents, the grain boundary and cell gaps were strengthened and heat resistance was improved.

Table 2 Amount and kind of crystallized phase in castings. (much) + + + + , + + + , + + , + , - (little).

| Alloy | Crystallized phase | | | |
|---|---|---|---|---|
| | α-Mg | β-$Mg_{17}Al_{12}$ | γ-$(Mg,Al)_2Ca$ | $Al_6Mn$ |
| AX71 | + + + + | + + | + + | + |
| AX73 | + + + + | - | + + + | + |
| AZ91 | + + + + | + + | - | + |

## 4. Conclusion

Mg-Al alloy was strengthened and heat resistance of this alloy was improved by adding Ca, due to the generation of γ-(Mg, $Al)_2Ca$ phase

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