P-41

Microstructure and Heat-Resistant Property in Mg-3%Al-1%Si Alloy Castings

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Magnesium alloys have the characteristic with high specific strength and lightweight property, it is widely used for auto mobile industry. Heat-resistant magnesium alloy is focused as a suitable material for weight reduction of the engine and power train parts in automotive field. In this study, microstructure and heat-resistant property in Mg-3mass%Al-1mass%Si alloy castings produced by permanent mold casting were investigated by optical microscope (OM), scanning electron microscopy (SEM) and measuring of bolt load retention at 423K. The specimens were prepared which simulated the bolt conclusion of true parts and investigated the change of the residual axis power when compressive stress was applied at a high temperature. As a result, bolt load retention of Mg-3mass % Al-1mass % Si (AS31) alloy was higher compared with conventional Mg alloy (e.g. AZ91 and AM60 alloys).

Keywords: *Mg-Al-Si alloy, microstructure, heat-resistant property, bolt road retention.*

1. Introduction

Magnesium alloys are lightest among practical alloys and have many good mechanical properties. Hence magnesium alloys draw attention as structural materials in automobile and railway industries. Mg-Al-Mn (AM) system alloys and Mg-Al-Zn (AZ) system alloys are used most frequently in magnesium alloys [1]. However, mechanical properties of these alloys are diminished at high temperature. Therefore, development of heat-resistant magnesium alloy was carried.

Table1 Chemical composition (mass%).

Coad	Target composition	Al	Si	Zn	Mn	Fe	Mg
AS31	Mg-3%Al-1%Si	3.60	0.90	—	0.09	0.018	Bal.
AM30	Mg-3%Al	3.05	—	—	0.07	0.001	Bal.
AM60	Mg-6%Al	5.31	—	—	0.06	0.003	Bal.
AZ91	Mg-9%Al-1%Zn	10.05	—	1.15	0.01	0.005	Bal.

In recent years, the rare metal-free heat-resistant Mg alloy attracts attention because it is highly recyclable. Among these, the most practical alloys are Mg-Al-Ca (AX) system alloys and Mg-Al-Si (AS) system alloys [2]. We have examined such as the casting of the AX alloys so far [3].

In this study, it is intended to focus on Mg-3mass % Al-1mass % Si (AS31) alloy, to clarify the microstructure and creep properties. We prepared the specimen which simulated the bolt conclusion of true parts and investigated the change of the residual axis power when compressive stress was applied at a high temperature. As a comparison, it was used Mg-3 mass % Al (AM30), Mg-6 mass % Al (AM60), Mg-9 mass % Al-1 mass % Zn (AZ91) and Al-10.5 mass % Si-2 mass % Cu (ADC12) alloys.

2. Experimental procedures

In this study, the specimens were cast as Mg-3 mass % Al-1 mass % Si alloy the target composition. Those were melted in an electric furnace under blowing protection gas (CO_2+SF_6). After that, these were gravity cast in a mold of iron having a cavity of the Y block shape. Table1 shows chemical composition of the samples.

The observation specimen cut from the castings. Then, those microstructure was observed by using OM and SEM. The phase of each alloys were identified using by X-ray diffraction (XRD).

Heat-resistant property was investigated by the high temperature bolt load retention test. The specimens were cut from the riser section of the Y-block shape casting. It was then processed into a ring-shaped outer diameter 20mm, inner diameter of 9mm, thickness 10mm. The test was measured between 10 ~ 12kN axial force, 64 ~ 256h holding time and 423K temperature. The length of the bolt was measured using a micrometer at room temperature.

3. Results and discussions

Fig.1 shows microstructure of the as-cast AS31 alloy, used by OM [a], [b] and SEM [c], [d]. AS31 alloy is compared matrix of alpha-Mg phase, the non-equilibrium crystallized beta-$Mg_{17}Al_{12}$ phases and Mg_2Si phases.

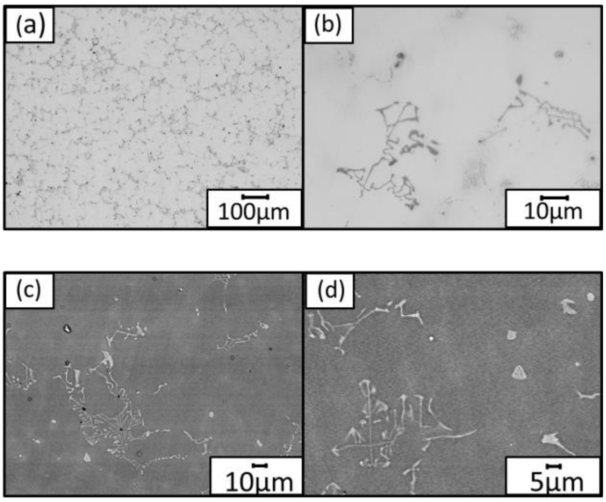

Fig.1 Optical microstructures [a] [b] and scanning electron micrographs [c] [d] of the as-cast AS31 alloy.

High temperature bolt load retention for 256h at 423K of AS31, AM system, AZ91 and ADC12 alloys are shown in Fig.2. Bolt load retention of Mg alloys were lower compared to Al alloy (Fig.2 [a]). In the Mg alloy, AS31 alloy showed the highest bolt road retention (Fig.2 [b]).

Conclusion

Microstructure and heat-resistant property in Mg-3%Al-1%Si alloy castings were investigated heat-resistant property is AS31 superior with AZ91 alloy due to crystallized Mg2Si phases on the grain boundary cell gaps.

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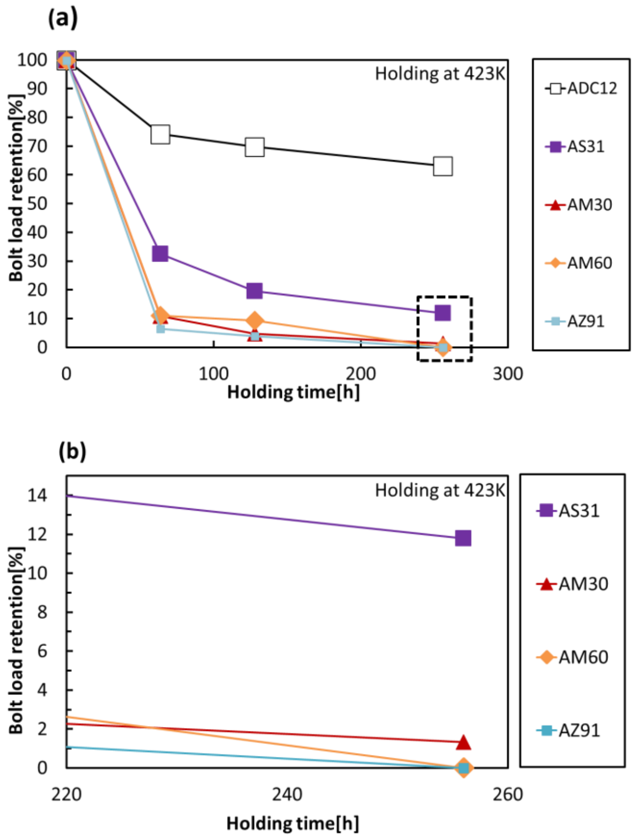

Fig.2 Bolt load retention of AS31, AM30, AM60, AZ91 and ADC12 alloys at 423K for 256h.
(b) shows an enlarged portion of square in (a).

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