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Age-hardening behavior of Al-7~10%Si-0.3%Mg alloy castings with water quenching and direct quenching

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The solvus temperature of G.P. zones and/or clusters during the early stage of aging after solution treatment in Al-7%Si-0.3%Mg alloy was investigated by micro-vickers hardness measurement and transmission electron microscopy. In addition, the obtained result was compared the previous reported result of the Al-10%Si-0.3%Mg alloy. The alloys were cast by permanent mold process, homogenized at 813K for 36ks, cold rolled up to 68%, solution treated at 813K for 36ks, and then artificially aged at 348-523K after water-quenched (W.Q.) or direct-quenched into oil-bath at 348-523K for artificially aging (D.Q.). In the case of the aging temperature was highest, the peak hardness for the W.Q. condition was clearly higher than the D.Q. condition. This tendency is considered due to the difference of formation such as G.P. zones and/or clusters between W.Q. and D.Q. conditions. Also, these behaviors were similar to the previous reported result of the Al-10%Si-0.3%Mg alloy.

Keywords: *Al-Si-Mg alloy, casting, aging, direct quench, transmission electron microscopy*

1. Introduction

Al-7-10mass%Si alloys were added a small amount of Mg, such as AA356 and AA365 alloy which are widely applied to automotive components because of that has excellent castability and higher strength and ductility. Such actual components were often subjected to heat treatment for the purpose of improving the mechanical properties. However, there are few reports about precipitation behavior of the hypoeutectic Al-Si-Mg alloys.

From this reason, we previously investigated the solvus temperature of G.P. zones after solution treatment in Al-10%Si-0.3%Mg alloy [1]. As a result, its temperature in this alloy was estimated it is between from 373 to 423K.

In this study, we have investigated the solvus temperature of G.P. zones and/or clusters during the early stage of aging after solution treatment in Al-7%Si-0.3%Mg alloy. In addition, the obtained result was compared the previous reported result of the Al-10%-0.3%Mg alloy [1].

2. Experimental procedures

The target composition of the alloy was Al-7%Si-0.3%Mg-0.015Sr. The molten metal of this alloy was degassed by inserting Ar gas via a lance pipe and then poured into copper mold with a Y-block shaped cavity. Pouring and mold temperature were 973K and 433-443K, respectively. Immediately after casting, the castings was removed from the mold when the temperature of casting had dropped to 773K. And then, the castings quenched in ice water for 10s. Table 1 shows chemical composition of the alloy.

The bottom of obtained castings was homogenized at 813K for 36ks and then slow cooled in the electric furnace. Subsequently, it was cold rolled up to 68%, solution treated at 813K for 36ks, and then aged at R.T.(298K)-523K after quenched in ice water (hereafter referred to as the “W.Q. specimen”). On the other hands, it was quenched into oil-bath held at 348-523K or water of R.T. and then aged at its temperatures (hereafter referred to as the “D.Q. specimen”). The heat patterns of W.Q. and D.Q. specimens are shown schematically in Fig.1.

The hardness of specimens was measured by micro-vickers hardness tester (load: 2.94N, time: 10s). The transmission electron microscope (TEM) observation was performed by the accelerating voltage of 120kV.

3. Results and discussions

The age-hardening curves of the Al-7%Si-0.3%Mg alloy aged at 523K after water-quenched and direct-quenched are shown Fig.2. The peak-hardness of W.Q. and D.Q. specimens were measured the value of about 80HV and 57Hv, respectively, the both specimens were indicated that the clear difference of hardness was occurred.

Fig.3 shows the transmission electron micrographs of specimens peak-aged at 523K, it were observed along the [100] or [110] direction of the matrix. In the case of W.Q. specimens were observed, rod-shaped precipitates were aligned in the [100] direction of matrix in Fig.3 (a) and (b). The length of precipitates were approximately 200-300nm. In contrast, D.Q. specimens were occurred rod-shaped precipitates which were clearly coarser than W.Q. specimens. In addition, as shown by the arrow, the heterogeneous precipitates were also observed on dislocation lines in Fig.3 (d). From these result, it is estimated that the peak-hardness of D.Q. specimen was lower than W.Q. specimen. These age-hardening behaviors were similar to the previous reported result of the Al-10%Si-0.3%Mg alloy.

4. Conclusion

In the case of Al-7%Si-0.3%Mg alloy aged at 523K, the peak-hardness of W.Q. specimens were higher than D.Q. specimens. It is due to the difference of size and density of precipitation.

Reference

[1] S. Saikawa, R. Morioka, K. Matsuda, S. Ikeno, E. Yanagihara and S. Orii : J.JILM 64 (2015) 218-223.

Table 1 Chemical composition of the alloy

(mass %)

Alloy	Si	Mg	Fe	Ti	Sr	Al
Al-7%Si-0.3%Mg	6.90-7.30	0.29-0.32	0.11-0.13	<0.01	0.012-0.015	Bal.

Mn, Cu and Zn:<0.01

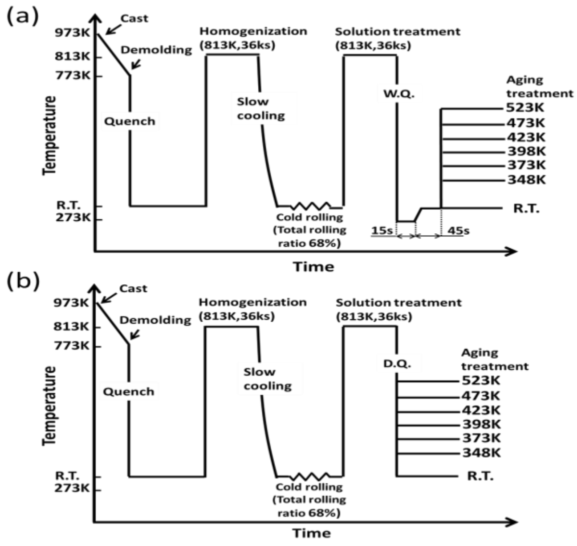

Fig.1 Heat-treatment procedure for the casting, homogenaization, cold rolling, solution treatment, quench and subsequent aging treatment. (a)water-quench and (b)direct-quench methods.

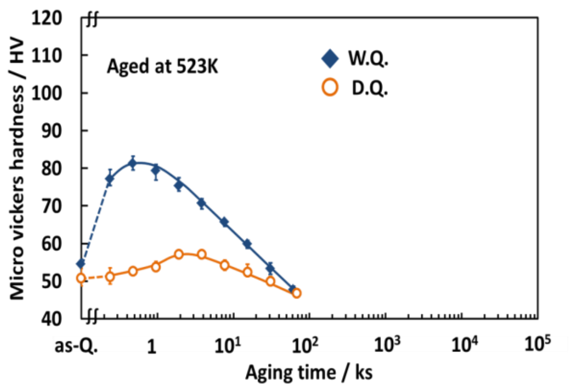

Fig.2 Age-hardening curves of the specimens aged at 523K after water-quenched and direct-quenched.

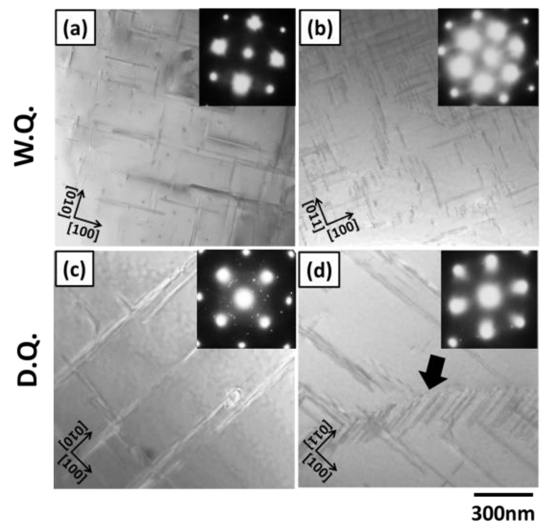

Fig.3 Transmission electron micrographs of the specimens peak-aged at 523K. (a) and (c) incidented beem direction parallels $[100]_m$, (b) and (d) incidented beem direction parallels $[110]_m$.