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Two-Step Aging Behavior of Solution Treated Al-7-10mass%Si-0.3mass%Mg Alloys

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Two-step aging behavior of solution treated Al-7%Si-0.3%Mg and Al-10mass%Si-0.3mass%Mg alloys were investigated by micro-vickers hardness measurement and optical microscopy. The hardness of Al-10%Si-0.3%Mg alloy after the solution treatment was higher than Al-7%Si-0.3%Mg alloy one. In this reason, it was considered due to the increasing Si contents 7 to 10%. In the both alloys, the peak hardness of final aging stage after pre-aged at 423K in under aging region was higher than pre-aged at room temperature for 45s. The tendencies were estimated due to the influence of precipitate phases, such as clusters and G.P. zones during pre-aging region.

Keywords *Al-Si-Mg alloy, casting, solution treatment, pre-aging, two-step aging,*

1. Introduction

In recent years, lightweight material is required in the automobile industry. Especially, the hypo-eutectic Al-Si alloy which containing 7 to 10 mass% Si and a small amount of Mg has characteristics of higher ductility, mechanical properties and excellent castability. For the reasons, the alloy can be applied to die-casting components, such as rear frame of the automobile. Such actual die cast components were often applied to T5 treatment (artificial aging after casting) for the purpose of improving the mechanical properties. On the other hand, T6 treatment is expected to improve the higher than mechanical properties of the components with T5 treatment. These components are held at room temperature until heat treatment. In this process, the holding at room temperature is considered pre-aging treatment, heat treatment is considered final aging treatment. Therefore, the mechanical properties of the components in final-aging stage might change by pre-aging temperature and its time. However there are few reports about the effect of the pre-aging and final aging treatment on two step aging behavior of the hypo-eutectic Al-Si-Mg alloys.

In this study, we have investigated the two-step aging behavior of Al-7-10mass% Si-0.3mass%Mg alloys after solution treatment.

2. Experimental

The target composition of the alloys were Al-7mass%Si-0.3mass%Mg and Al-10 mass%Si-0.3mass%Mg. Small amount of Sr were added in order to modify of the Al-Si eutectic. The Ar gas was supplied to the molten metal for the degasification. Pouring was performed at 973K or 953K into cupper mold with a Y-block shaped cavity held at 433-443K. 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.

After the water-quenching, the specimens having dimensions of 10×10×2.5mm were cut out from the obtained casting. Solution treatment was carry out at 813K for 36.0ks and then the specimens quenced into ice water. The specimens pre-aged at 273K, room temperature(298K), 348K, 373K and 423K and then final-aged at 473K for various times. The hardness of specimens were measured by micro-vickers tester (load: 2.94N, holding time: 10s). The microstructure of specimens were observed by optical microscope after etched by 0.5% HF.

Table 1 Chemical compositions of the alloys (mass%)

alloy	Si	Mg	Fe	Ti	Sr	Al
Al-7%Si-0.3%Mg	6.91-6.98	0.31	0.12-0.13	<0.01	0.012-0.016	bal.
Al-10%Si-0.3%Mg	9.92-10.24	0.27-0.31	0.09-0.15	<0.01	0.009-0.0015	bal.

3. Results and discussion

The microstructures of Al-7%Si-0.3% Mg and

Al-10% Si-0.3% Mg alloy in the as-cast condition are shown in Fig.1. The microstructures of the both alloy mainly consists of the primary crystallized α-Al phase of white color and eutectic Al-Si phase of gray color on grain boundaries and cell gaps. With increasing Si contents from 7 to 10%, the volume of eutectic Al-Si phase were increased.

Fig.2. shows age hardening curves of the Al-7%Si-0.3%Mg and Al-10%Si-0.3%Mg alloy pre-aged at 423K after solutionized at 813K for 36.0ks. The as-quenched hardness of Al-10%Si-0.3%Mg alloy was slightly higher than Al-7%Si-0.3%Mg alloy one. In this reason, the defference of hardness was considered due to the volume of eutectic Al-Si phases in both alloys. The hardness of both alloys began to increase for about 0.5ks and then reach to peak for about 60.0ks. Moreover in the case of continue to aging process, the hardness was observed monotonically decreased.

Fig.3 shows Age hardening curves of the Al-7%Si-0.3%Mg and Al-10%Si-0.3%Mg alloy pre-aged at 423K for 0.48, 1.96 and 30.7ks and then final aged at 473K. As a comparison, the resalt of being pre-aged at 298K for 45s and then final-aging at 473K in those alloys. In the case of Al-7%Si-0.3%Mg alloy in Fig.3 (a).When the specimen pre-aged at 423K for 0.48 and 1.92ks, peak hardness in final aging stage was higher than the specimen pre-aged at 293K for 45s, the so-called positive effect was occured. In this reason, the two-step aging behavior was estimated due to the influence of precipitate phases, such as clusters and G.P. zones during pre-aging region. In case of pre-aged at 423K for 30.7ks, the hardness was constant until about 8ks and then decreased. Those behaviors were simmior to the result of the Al-10%Si-0.3Mg alloy.

4.Conclusions

In the both alloys, the occerrence of positive effect in the two-step aging behavior was revealed when the specimens pre-aged at 423K in the under-aging stage and then final-aged at 473K.

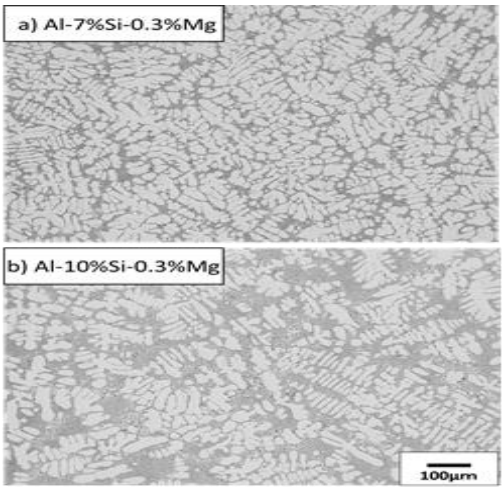

Fig1. The microstructures of Al-7% Si-0.3% Mg and Al-10% Si-0.3% Mg alloy in the as-cast condition.

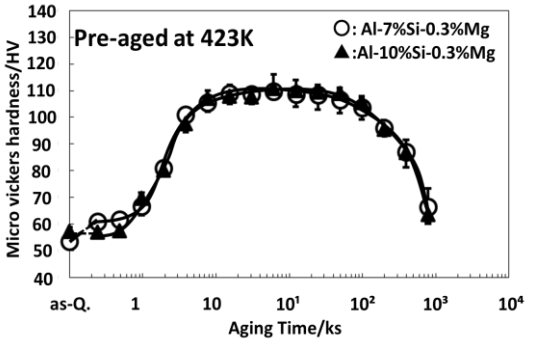

Fig.2 Age hardening curves of the specimens pre-aged at 423K solutionized at 813K for 36.0ks.

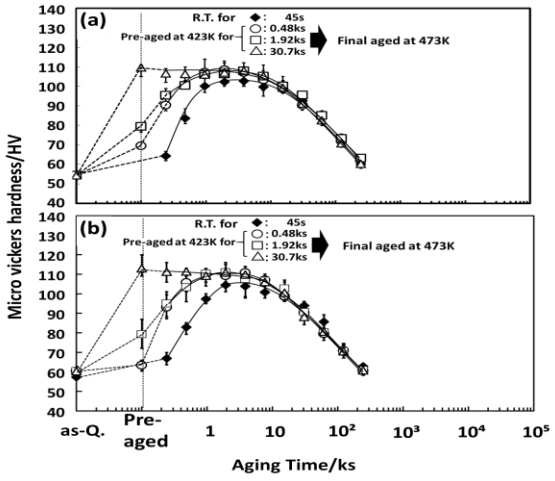

Fig.3 Age hardening curves of the specimens pre-aged at 423K for 0.48, 1.96and 30.7ks and then final aged at 473K.
(a)Al-7%Si-0.3%Mg alloy and (b) Al-10%Si-0.3%Mg allo