Effect of RRA treatment on SCC susceptibility of Al-1.1Mg-1.0Si-0.5Cu alloy.

Yoshikazu Katoh*, Kenji Tomita*, Masashi Sakaguchi* and Yasushi Nakazawa**

*Research Laboratory, R&D Department, Showa Aluminum Corporation, 480 Inuzuka, Oyama, Tochigi 323 Japan.

**Honda R&D CO., LTD. Tochigi R&D Center, 4630 Shimotakanezawa, Haga-machi, Haga-gun, Tochigi 321-33 Japan.

Abstract

An effect of RRA treatment on the strength and SCC resistance in highly Al-1.1Mg-1.0Si-0.5Cu alloy was investigated, using extrusion of 40 mm width and 2 mm thickness with T6 treatment (823K×1h→W.Q.→443K×11h). Rapid heating treatment of salt bath at 513K×0.5-5 minutes makes retrogression, and subsequent aging at 443K×11h recovery of strength. Moreover, this improves SCC resistance greatly, too. It is found to be related to the distribution of precipitates of Mg_2Si on the grain boundary.

Keywords: *Al-Mg-Si-Cu, SCC, Heat treatment, Precipitates distribution*

1 Introduction

Stress corrosion cracking (SCC) is remarkable brittle fracture that is occurred only when corrosive environment and tensile stress act simultaneously, it does not occur when they act separately.

In general, SCC susceptibility increases if aluminum alloy strength increases. Therefore, it becomes very important in the industrially and has studied in basic and practical area. Also, SCC of Aluminum alloys is necessarily occurred only on grain boundary so that microstructure and structure factor relate to grain boundary and itself have studied [1] .

In practical aluminum alloys, age hardening alloys (Al-Cu, Al-Cu-Mg, Al-Zn-Mg, Al-Zn-Mg-Cu, high Si content Al-Mg-Si) which tend to precipitate on grain boundaries are always concerned to occur of SCC. However, as adjusting process and heat treatment conditions, SCC resistance increases so that these alloys apply to the aircraft, the ship and other vehicles. In Al-Zn-Mg-Cu alloys, over-aging process which is called T76 or T73 often adopted to improvement of SCC resistance. However 10 - 15% of strength sacrifice will be occurred. Recently, RRA treatment which improves SCC resistance without strength sacrifice is remarked. In this process of the treatment, the growth of the precipitates on the grain boundary and then resolution of the G.P. zone and subsequent precipitate in grain occur. SCC resistance and the strength can be compatible consequently. Even if it is the high SCC resistance alloy, recent works has shown that the SCC susceptibility becomes sharp with the increase of the content of Mg, Si [2] .

In this study, an effect of RRA treatment on the recovery of the strength and the improvement of

SCC characteristic compatibility when doing heat-treatment corresponding to RRA comparatively to highly in Al-1.1Mg-1.0Si-0.5Cu alloy was investigated [3] .

2. Procedure

2.1 Specimen

The chemical composition of specimen is shown in Table 1. The flat bar of 40 mm width and 2mm thickness extruded from 3 inches diameter billet after homogenization treatment at 823K×16h were used. They were T6 treated (823K × 1h→W.Q.→443K × 11h). The microstructure is recrystallization of about 1 mm in grain diameter.

Table 1 Chemical composition of specimen/mass%

Si	Mg	Cu	Al
1.0	1.1	0.5	Bal.

2.2 Setting of retrogression and reaging conditions

In order to fix retrogression temperature, an endothermic change by the thermal analysis in the specimen (heating rate: 20K/min) was investigated. A result is shown in Fig.1. The area A which seems to be solution (G.P. I) of intermetallic compound from the approximately 475K was admitted and peak to seem to precipitate was admitted around 551K. Retrogression temperature to 3 standards of 473, 493, and 513K was set from this result.

A condition of RRA :443K×11h + (473, 493, 513) K×X min + 443K×11h

Specimens of (473, 493, 513)K×X min and 443K×11h after that are called T7 and RRA The researcher decide to call each heat-treatment materials as follows after that.

443K×11h : T6

T6 + (473, 493, 513) K×X min : T7

T7 + 443K×11h : RRA

Also, as the heating method when retrogressing, two of the ways by usual batch furnace and salt-bath were used.

Solution of G.P. zone whether or not influenced by the temperature rising speed was investigated. And, water quenching was used to them.

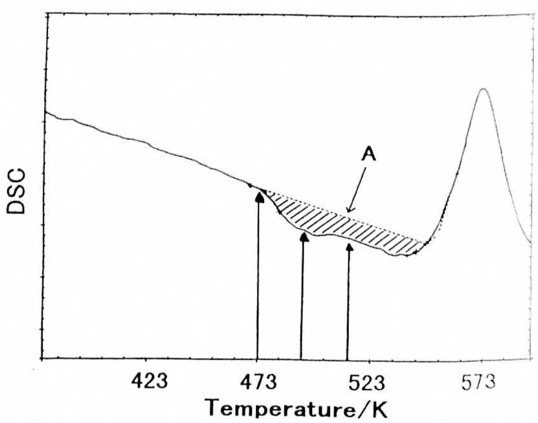

Fig.1: DSC vs. temperature curve of specimen (heating rate:20K/min)

2.3 Evaluation item

2.3.1 Vickers hardness

The decline of the hardness which accompanies solution in the G.P. zone in the T7 treatment, and the rise of the hardness by the precipitate in the RRA in the time change were investigated by Hv with 10 kg weight. Specimens for Hv were cut to about 10mm×10mm×3mm.

2.3.2 SCC

Specimens for SCC were cut to $40mm^L \times 4mm^W \times 2mm^T$ from the flat bar of LT direction and attached to the SUS 304 jig. Then, they were loaded 100% of the proof stress and sunk to in boiled Cr acid liquid (CrO_3: 36g/l, $K_2Cr_2O_7$: 30g/l, NaCl: 3g/l) and the surface of specimens was observed every 30 minutes by using opticalmicroscope (40×) on the presence of crack.

2.3.3 Microstructure

The size and distribution of precipitates of T6, T7 and RRA were observed with the transmission electron microscope (TEM).

3 Results and discussion

3.1 Change in hardness

Change in hardness on the T7 treatment at 513K is shown in Fig. 2 by the batch furnace (heating rate: about 60K/min) and salt-bath (heating rate: about 960K/min). For the batch furnace, the change in hardness is hardly admitted from the early stages of the treatment time and only a rapid hardness decline is found in the last stages. In another hand, for salt-bath, the change in hardness to seemed that it retrogresses of intermetallic compound from 0.5 to 5 minutes are admitted (It is thought some intermetallic compound dissolved).

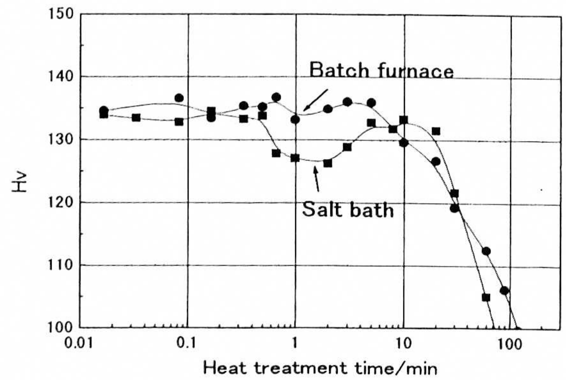

Fig.2: Change in hardness at 513K for T7 treatment by batch furnace and salt bath.

From above, it is found the rapid heating has a great effect on the retrogression of Al-Mg-Si-Cu system alloy. Fig.3 shows hardness for T7 by salt bath (same as Fig.2) and RRA when aging at 443K×11h after T7 treatment (513K×Xmin). Moreover, aging at 443K×11h after T7 treatment by using salt bath, hardness recovers approximately to the T6 level except for the over-aging area.

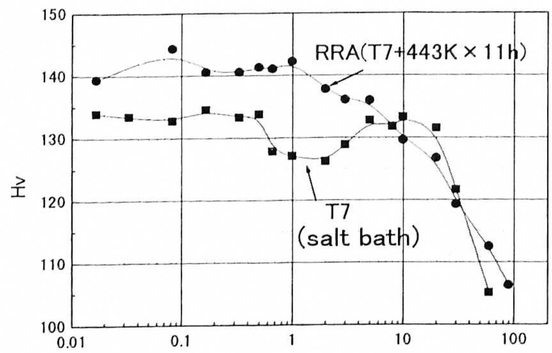

Fig.3: Change in vickers hardness when aging at 443K × 11h(RRA) after T7 treatment.

3.3 SCC resistance

The result of SCC resistance in the boiled Cr acid acceleration liquid is shown in Fig.4. The life time to the crack is improved in T7 and RRA treatments comparing to T6 treatment. A microstructures on the grain boundary of T6, T7 and RRA are shown in Fig.5(a)-(d) and distribution of precipitates on grain boundary are shown in Fig. 6(a)-(b). In T7 and RRA treatments, precipitates grow largely and average interval of precipitates increases, and the covering percentage on grain boundary decreases comparing with T6 from the results of Fig.5 and Fig.6.

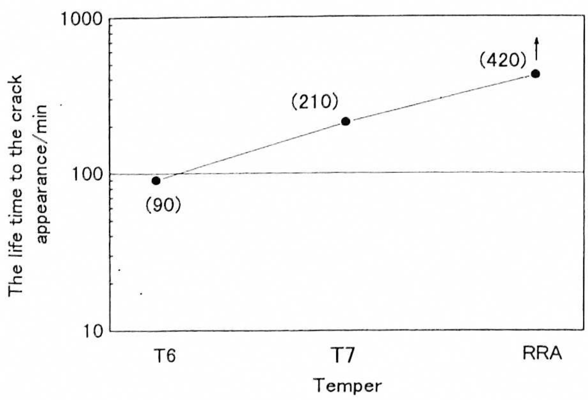

Fig.4: The result of SCC resistance of T6,T7 and RRA treatments.

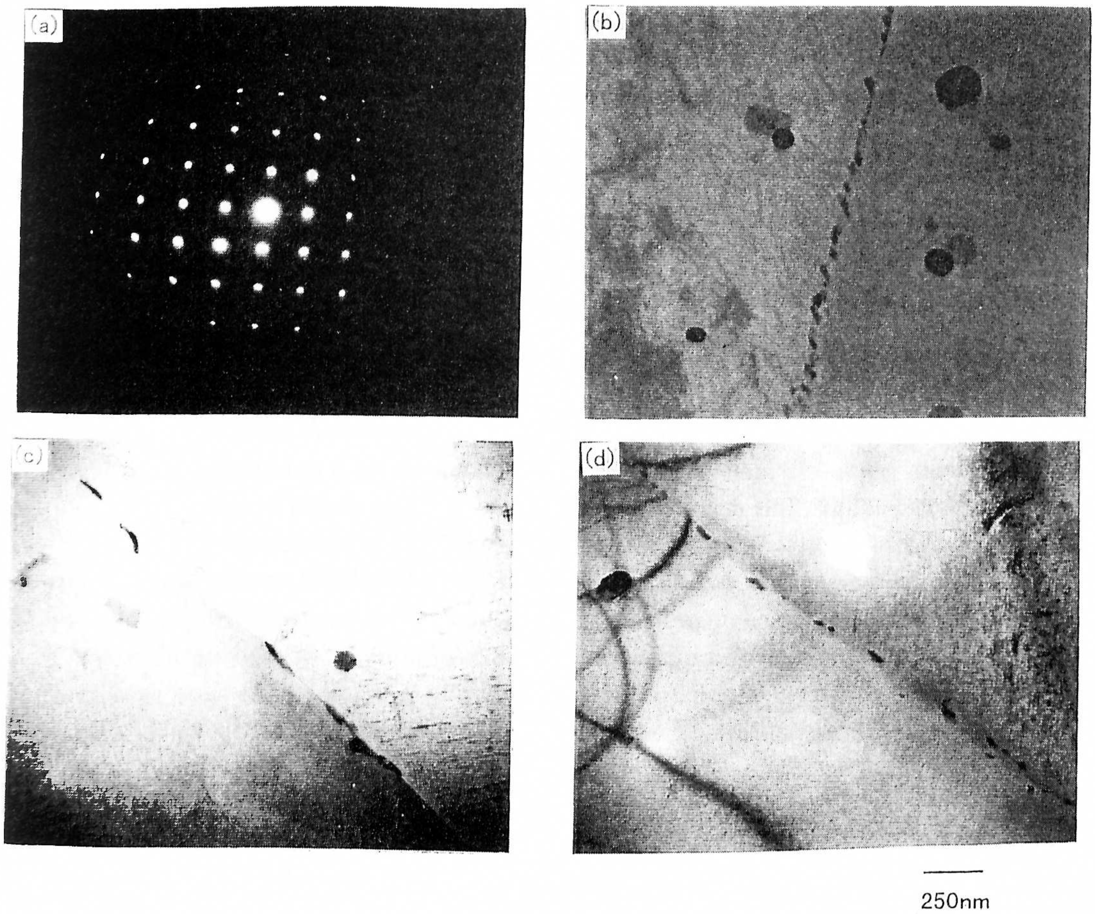

Fig.5: Typical TEM photographs of grain boundary.
(a)Observation lattice face (100) (c) T7 : 443K × 11h+513K × 2min
(b)T6 : 443K × 11h (d)RRA : 443K × 11h+513K × 2min+443K × 11h

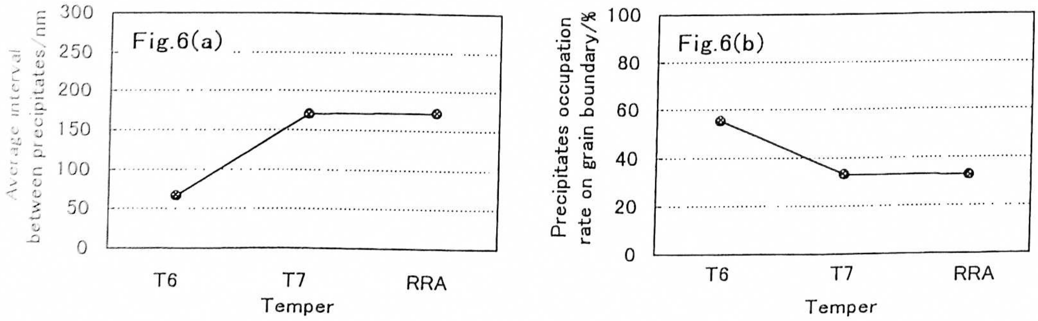

Fig.6: Precipitates distribution on grain boundary.

4. Conclusions

When using the T7 or the RRA heat treatments which is often used 7000 system applied to the highly Al-1.1Mg-1.0Si-0.5Cu alloy, The researcher investigated whether it is possible for SCC resistance to improve and compatible with the strength, following results are found.

1) The rapid heating rate is effect greatly to make retrogression as the decrease of the hardness occur in case of T7 treatment.
2) The RRA treatment improves to SCC resistance compared with the T6 treatment in the boiled Cr acid accelerated test and recovers strength to the T6 level.
3) By making T7 and RRA treatment, precipitates grow largely and an average interval increases comparing with the T6 treatment.

5. References

[1] Y. Murakami: Light metals., 31, No.11, 748 (1981)
[2] T. Onishi, H. Shiota: Light metals., 36, No.10, 647 (1986)
[3] H. Yoshida: Sumitomo light metal skill report, 24, No.3, 142 (1983)