Concurrent Improvement of Strength, Formability and SCC Resistance of Al-Zn-Mg-Cu Alloy by Hot Stamping after Rapid Heating and Re-aging on Paint Baking Treatment

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In this study, the combined application of rapid heating for hot stamping and the subsequent re-aging during a paint baking treatment was newly developed for a T6-tempered A7075 Al-Zn-Mg-Cu alloy sheet. From a systematic investigation, rapid heating to 255-260 ˚C for ~120 s was found to give the best combination of formability, hardness, and stress corrosion cracking (SCC) resistance of the final products. In particular, the re-aging treatment at 170 ˚C for 1.2 ks was well exploited not only for further improving the SCC resistance but also for rebounding the decreased hardness by rapid heating. Therefore, the developed two-step heat treatment is regarded as a promising approach to producing high-strength, easily formable and corrosion-resistant Al-Zn-Mg-Cu alloy parts for automobiles.

Keywords: *high-strength aluminum alloy, hot stamping, rapid heating, stress corrosion cracking, Paint bake treatment*

1. Introduction

In the aviation industry, retrogression and re-aging (RRA) treatment has been applied to Al-Zn-Mg-Cu alloys for improving their strength and stress corrosion cracking (SCC) resistance, but the prolonged heat treatment time cannot be taken off for mass-manufactured products such as automobile parts. In this study, the effects of combined application of rapid heating for hot stamping and the subsequent re-aging during a paint baking treatment were assessed for producing high-strength, easily formable and corrosion-resistant Al-Zn-Mg-Cu alloy parts for automobiles. The rapid heating was intended to improve the formability of the T6-temperted high-strength alloy sheet while minimizing the decrease in hardness (strength), and the subsequent re-aging was exploited not only for further improving the SCC resistance but also for rebounding the decreased hardness (strength) by rapid heating.

2. Experimental procedures

In this study, 2 mm-thick sheets of T6-tempered A7075 Al-Zn-Mg-Cu alloy with a chemical composition in Table 1 were utilized as a starting material, and rapidly heated to 245-280 ˚C at a heating rate of ~10 ˚Cs^{-1} by a contact heating equipment for evaluating the formability of the high-strength alloy sheet by hot stamping (Figure 1). Some pieces of the sheets were just heated and held for 150 s maximum in oil baths, followed by water-quenching without hot stamping. The heating and cooling rates of the two experiments were assured to be almost comparable by monitoring their temperature changes with thermocouples. After stored at 20 ˚C for 86.4 ks, re-aging treatment at 170 ℃ for 1.2 ks was applied to the sheets with/without hot stamping, and the changes of Vickers hardness and electrical conductivity were measured. The two measured properties were regarded as indexes of mechanical strength and SCC resistance of the sheets, and thus utilized for optimizing heating conditions for the best combination of formability, hardness, and SCC resistance of the final products. Transmission electron microscopy observation and corrosion test by immersing into salt water were also conducted.

Table 1 Chemical composition of the utilized A7075 alloy sheet (in mass%).

Zn	Mg	Cu	Si	Fe	Cr	Mn	Ti	V	Al
5.9	2.6	1.6	0.06	0.14	0.19	0.01	0.02	0.01	Bal.

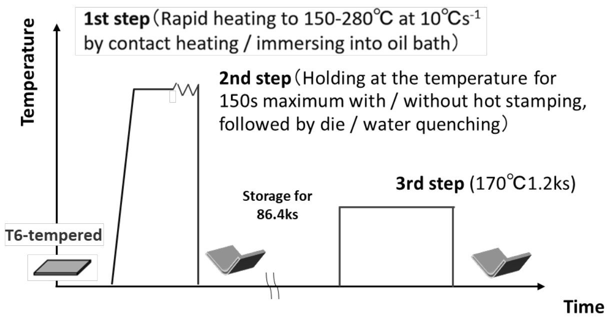

Figure 1 Heat treatment procedure with / without hot stamping applied to the investigated T6-tempered A7075 alloy sheet.

3. Results and discussion

From a systematic investigation of the effects of heating conditions, moderate decrease in hardness after rapid heating to ~250 ℃ was found to improve not only the formability (i.e. lower deformation resistance and larger elongation to fracture) but also SCC resistance (i.e. increased electrical conductivity). Furthermore, the subsequent re-aging treatment at 170 ˚C for 1.2 ks could successfully rebound the decreased hardness with further increase in electrical conductivity [1, 2]. From the plots of the resultant Vickers hardness and electrical conductivity after re-aging treatment, optimum heating conditions fulfilling our target were found to include 255 ℃ for 120 s and

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260 ℃ for 120 s, and thus compatible hardness and electrical conductivity to those of A7075-T76 or T73 could be obtained by the developed two-step heat treatment.

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References

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