Supersonic rapid aging for quasicrystal reinforced Al light alloy

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The fracture toughness, indicated by fracture load ($P_{fr}$) of quasicrystal reinforced Al-Li-Cu alloy, can be largely controlled by heat treatment at 553K. Furthermore, supersonic heat treatment shortens the aging time and enhances the fracture toughness.

Keywords: Supersonic wave, Aging, Fracture toughness

1. INTRODUCTION

Quasicrystal nature is that it does not have a translational symmetry but only rotational. Thus, its distinct nature induces high electrical resistivity and high hardness. The hardness of the quasicrystal is attractive for the mechanical using. However, the brittleness is serious problem for practical uses of materials. To improve the ductility, the quasicrystal dispersed ductile alloys are expected. Figure 1 shows the illustration of quasicrystal dispersed Al$_{68}$Li$_{33}$Cu$_{11}$ alloy. Since the lithium element is very light (0.6g/cm$^3$), the Al$_{68}$Li$_{33}$Cu$_{11}$ quasicrystal precipitated alloy can be expected to be the highest specific strength per density of aluminum alloys. Namely, we would like to develop the new type of duralumin, which is easy to control electrical and mechanical properties. However it takes long time for aging of one week to get fracture toughness. To shorten the aging time, supersonic aging is performed. Therefore, the effects of supersonic aging on fracture toughness have been studied for quasicrystal reinforced Al$_{68}$Li$_{33}$Cu$_{11}$ super-light alloy.

Fig.1. Illustration of quasicrystal dispersed Al$_{68}$Li$_{33}$Cu$_{11}$ alloy.

2. EXPERIMENTAL

Al-33at%Li-11at%Cu samples were prepared by melting pure Li(99.9%) and Al-17at%Cu eutectic mother alloys. Sheet specimens were prepared by melting in an infrared furnace and then liquid quenching by the use of a piston-anvil type apparatus. The composition was not largely deviated on the solidification, because the maximum temperature of molten alloy was just above the melting point. The structure was determined by means of TEM. The sample was aged at 553K under N$_2$ atmosphere. To
shorten the aging time, supersonic wave treatment was performed at 36 kHz. Nishi has suggested Vickers indentation method of the critical fracture load (P_f) of crack. TTT behaviors of the prepared samples was found to have a C-shape protruding from the right hand side and its nose is at 560K. That means that the evolution of quasicrystalline phase at 560K is greater than at other temperatures. The fracture toughness was evaluated by using Vickers hardness testing machine.

III. RESULTS & DISCUSSION

Change in load (P_f) was studied against the diagonal (d_f) of a symmetric pyramidal hardness impression in a sample. The critical diagonal (d_f^min) and critical load (P_f^mid) can be found at the midpoint between the minimum (d_f^min and P_f^min) and maximum (d_f^max and P_f^max), respectively. P_f^mid is expressed by a following equation.

\[ P_f^{\text{mid}} = \frac{(P_f^{\text{min}} + P_f^{\text{max}})}{2} \]

P_f^min is the minimum load for which five impressions exhibit a crack. P_f^max is the maximum load and is suggested here as a convenient parameter to evaluate fracture toughness.

Figure 2 shows change in critical load (P_f^mid) against aging time (t_a). Normal aging at 553K enhances the P_f^mid value up to 125gf for one week. The supersonic heat treatment tremendously shortens the aging time and enhances the P_f^mid value. The supersonic aging time is about 12 min, when the P_f^mid value is over 125gf. Since the lattice defects were formed by means of the supersonic wave treatment, it shortened the aging time. Furthermore, the supersonic heat treatment enhances the P_f^mid value. The maximum P_f^mid value of supersonic treated sample is approximately 50% larger than that treated by normal aging. If lattice defects enhance the atom diffusion and enhance the precipitation rate of quasicrystal, the effects of supersonic rapid aging on P_f^mid value can be explained.

Fig.2. Change in critical load (P_f) against aging time (t_a) of Al_{56}Li_{33}Cu_{11} alloy aged at 553K with and without supersonic wave treatment.

IV. CONCLUSION

In summary, supersonic rapid aging shortened aging time and enlarged fracture toughness of quasicrystal reinforced Al_{56}Li_{33}Cu_{11} alloy.

REFERENCES


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