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EFFECT OF POST HEAT TREATMENT ON MECHANICAL PROPERTIES OF SELECTIVE LASER MELTED POROUS ALUMINUM ALLOYS

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It is proposed to use porous Al-10Si-0.3Mg manufactured by 3D selective laser melting process for the impact absorbing system of the landing gears of the Smart Lander for Investigating Moon (SLIM) currently developing projected by JAXA. Since this alloy shows age hardening behavior, its energy absorption capacity largely depends on post heat treatment. In this study, by conducting the hardness test, microstructure observation and quasi-static compression test on as 3D Al-10Si-0.3Mg, the heat treatment conditions of furnace cooling after maintaining at 803 K for 2 h is effective for enhancing the energy absorption properties.

INTRODUCTION

In recent years survey of extra-terrestrial planets, demand for high-precision landing technology is increasing, and JAXA is progressing with SLIM plan to demonstrate pinpoint landing to the moon (Sakai, 2013) and the development of shock absorbing material is necessary for pinpoint landing. Porous Al-Si-Mg alloy manufactured through 3D selective laser melting process is superior as an impact absorbing material (Gokuldoss, 2017). However, in the case of the as-built material, its hardness is high (101.4 HV) and it breaks brittle and the energy absorption capacity is low. It was found that the hardness decreases after annealing the as-built material (42.6 HV) and a material is exhibiting ductile compression behavior. In this study, by investigating how heat treatment conditions affect dense Al-Si-Mg alloy, influence on post-heat-treated porous Al-Si-Mg alloy on impact absorbing ability.

EXPERIMENTAL PROCEDURE

A dense cube of 10×10×10 mm^3 Al-10Si-0.3Mg alloy manufactured by the selective laser melting method was used as specimens. The electric furnace was used for heat treatment. The heat treatment history is shown in Figure 1. The Vickers hardness tester was performed at test load HV2 for As-built material and HV1 for others. The scanning electron microscope (SEM) and the X-ray diffraction (XRD) were used for observing microstructure. The XRD measurement conditions were 40 kV, 20 mA, CuKα ray. For the quasi-static compression test, a crosshead speed was fixed at 10 mm/min.

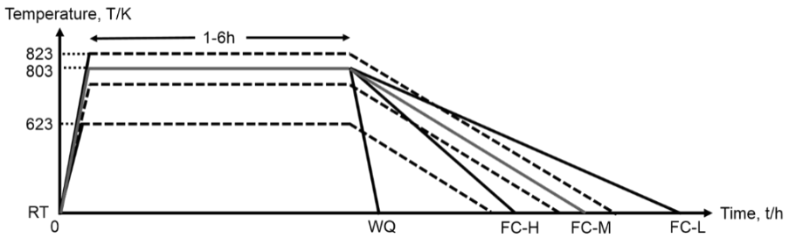

Figure 1. Heat treatment diagrams for Al-10Si-0.3Mg alloys.

RESULTS AND DISCUSSION

As the annealing temperature increases, the hardness decreases due to granulation of dendritic Si and coarsening of Mg_2Si, and at 823 K, the eutectic temperature is close to 830 K, so liquefaction occurs and voids are observed (Figure 2a). The anisotropy of the structure due to the difference in laminating direction observed with Al-built material was resolved by annealing. The hardness did not change when the annealing time was longer than 2 h (Figure 2b). The cooling rate was almost the same for furnace cooling (Figure 2c). Annealing temperature 803 K, furnace cooled hemispherical porous Al-Si-Mg alloy quasi-static test results of annealing time 2 h and 6 h show the same compressive behavior (Figure 3).

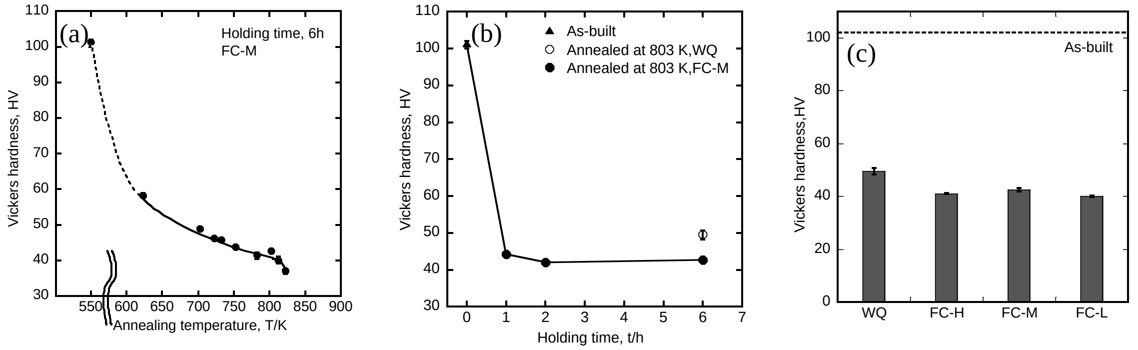

Figure 2. The Vickers hardness at varying (a) annealing temperature, (b) holding time, and (c) cooling rate

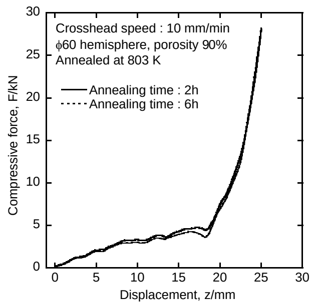

Figure 3. Force-displacement curves of annealed porous hemi-sphere Al-Si-Mg alloy

CONCLUSIONS

The hardness decreased with increasing annealing temperature, but voids occurred at 823 K, so the maximum usable temperature is 803 K. A holding time of 2 h or more was sufficient for ductile compressive deformation. As for the cooling rate, as long as the cooling method was furnace cooling, hardness was equal.

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KEYWORDS

Heat treatment, Compression test, Microstructure, Selective laser melting