Tensile and Compressive Properties of Mg-Li Alloys Subjected to Different Heat Treatment

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Abstract. Tensile and compressive tests were performed on Mg-Li alloy samples subjected to annealing and aging treatment respectively. The results show that the compressive strength of the alloy is obviously higher than the tensile strength. Meanwhile, it is found that the shear fracture angle of the compressive specimens is smaller than that of the tensile specimens.

Introduction

In recent years, Mg-Li alloy has been paid much attention, in view of its extremely low density, high ductility, excellent specific strength and rigidity. Therefore, Mg-Li alloys parts are utilized in several industrial fields, such as aerospace, weapon, automotive and electronics industries, etc. However, the reports about mechanical properties of the Mg-Li alloy is relatively rare and some useful data cannot be found, compared with the traditional magnesium alloys [1-8]. Especially, mechanical properties of the Mg-Li alloy after heat treatment should be further studied.

In the present work, Mg-Li alloy was subjected to annealing and aging treatment respectively, and tensile and compressive tests were performed on Mg-Li alloy specimens after heat treatment. It is expected that tensile and compressive properties of Mg-Li alloy can be clearly known.

Results and Discussion

Casting Mg-7wt.%Li-4wt.%Al-1wt.%Zn alloy ingots were used for the current experiments. Some of the ingots were annealed at 200°C for 10h, others were heated to 380°C, then quenched and subsequently aging at 150°C for 9h. After heat treatment, the microstructure of samples was observed by a Leica optical microscopy (OM).

Tensile specimens with cross-section of 3 mm × 5 mm and gauge length of 40 mm and compressive specimens of 10 mm in diameter and 12 mm in length were machined from the ingots after heat treatment. These specimens were subjected to load up to failure at room temperature using an MTS mini testing machine operating at a constant rate of cross-head displacement with a strain rate of about 5×10⁻⁴ s⁻¹.

Figure 1. Microstructure of Mg-7%Li-4%Al-1%Zn alloy samples, (a) annealed, (b) aging.
Figure 1 shows the microstructure of Mg-7%Li-4%Al-1%Zn alloy samples. It can be seen from figs. 1(a) that the microstructure of the annealed sample is mainly composed of \( \alpha \)-Mg phase and \( \beta \)(-Li) phase. The phase with the white colour represents the \( \alpha \) phase, while the grey phase is the \( \beta \) phase. For the aging sample, more precipitated phase can be observed within \( \alpha \)-Mg phase, besides \( \alpha \)-Mg phase and \( \beta \)(-Li) phase, as shown in Figure 1(b).

Figure 2 shows the tensile stress–strain curves of Mg-7%Li-4%Al-1%Zn alloy specimens subjected to annealing and aging treatment respectively. It demonstrates that the elongation of the annealed alloy is better than that of the aging alloy, while the strength of the aging alloy is obviously higher than that of the annealed alloy. Figure 3 shows the macro-scale fracture morphology of the tensile specimens. As shown in Figure 3(a), the annealed specimen fractures in shear mode, with a shear angle of about 70° to the load axis. Unlike the annealed alloy, the failure of the aging specimen is fracture normal to the tensile axis, as marked in Figure 3(b).

Figure 3. Tensile fracture morphology of Mg-7%Li-4%Al-1%Zn alloy specimens.

It can be seen from Figure 4 that the compressive strength of the alloy is obviously higher than the tensile strength, but the elongation of the compressive alloy specimens decreases, compared with that of the tensile alloy specimens. It is also clear that the elongation of the annealed alloy is better than that of the aging alloy, while the strength of the annealed alloy is lower than that of the aging alloy, which is similar to the result of the tensile test. Figure 5 shows the fracture morphology of the compressive specimens. It is obvious that the annealed specimen and the aging specimen both fracture in shear mode, and the shear fracture plane makes an angle of about 45° with respect to the
compressive direction. Therefore, the shear fracture angle of the compressive specimens is smaller than that of the tensile specimens.

Figure 4. Compressive stress–strain curves of Mg-7%Li-4%Al-1%Zn alloy specimens.

Conclusions

(1) The compressive strength of the alloy is obviously higher than the tensile strength, but the elongation of the compressive alloy specimens decreases, compared with that of the tensile alloy specimens. Meanwhile, it is known that the elongation of the annealed alloy is better than that of the aging alloy, while its strength is lower than that of the aging alloy, no matter the tensile test or compression experiment.

(2) The shear fracture angle of the compressive specimens is smaller than that of the tensile specimens.

Figure 5. Compression fracture morphology of Mg-7%Li-4%Al-1%Zn alloy specimens.

References


