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Heat Treatment Optimizing of MgZnZr Alloy

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***Abstract*— The effects of heat treatment on microstructures and mechanical properties of MgZnZr alloy have been investigated through the preparation of alloy, analysis of microstructure and test of mechanical properties. The results show that, the microstructures and mechanical properties of Mg-5.5%Zn-0.5%Zr alloy can be improved by solid solution(380℃×12h) and aging(190 ℃ ×12h) treatment. Compared with solid solution, direct aging treatment can be operated easily and optimize the heat-treatment process of MgZnZr alloy.**

Keywords-MgZnZr alloy；heat treatment；optimizing

I. INTRODUCTION

Magnesium alloy is the lightest of all the metallic materials. Magnesium alloy has advantages of high specific strength and rigidity, excellent damping effect, and thermal conductivity, so it is widely used in lots of fields, such as space flight, automobile manufacturing, electron industry, and 3C products[1~5]. MgZnZr alloy have much higher specific strength and corrosion resistance, so how to improve it's microstructures and mechanical properties has being studied at present. Excellent Strengthen effect can be obtained by aging treatment for MgZnZr alloy [6~8]. The effects of heat treatment on microstructures and mechanical properties and how to optimize the heat-treatment process of MgZnZr alloy have been investigated in this paper.

II. EXPERIMENTAL

Raw materials are metallic magnesium (purity 99.95 wt.%), metallic zinc (purity 99.98wt.%) and Mg-30%Zr master alloys. All the raw materials should be baked before melted. The chemical composition of the experimental alloys are designed as Mg-5.5%Zn-0.5%Zr. The alloys were melted in an induction furnace under the protection atmosphere of the combination gas of SF_6 and CO_2. When the liquid alloy was heated to 680°C, it was poured into a metallic mold which preheated at 150°C, and then the specimens were obtained. The specimens were heat treated divided into two parts, one part were heat treated for solid solution at 380°C for 12 h and aged at 190°C for 12 h covered with MgO powders, another part were direct aging treatment at 170°C, 190°C and 210°C, for4 h, 8 h, 12 h, 16 h, 20 h, 24 h and 28 h.

The tensile experiment was conducted on AG-I250kN precise universal test machine, with the rate of 1mm a minute. The hardness of alloy was studied on Vivtorinox hardness meter. The microstructure of alloy was observed by an Olympus optical microscope. The fracture morphologies were observed and analyzed by SEM (JSM-5610LV).

III. RESULTS AND DISCUSSION

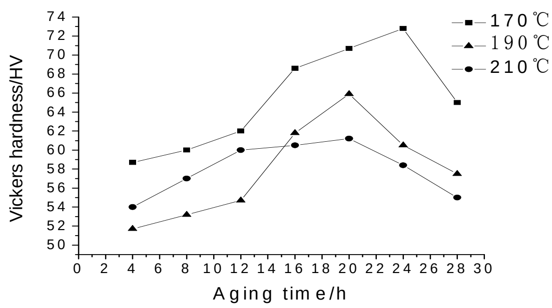


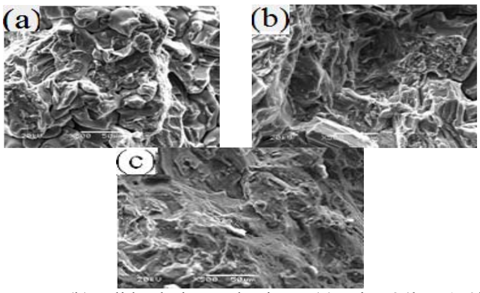
Fig. 1 The hardness of alloy with different aging treatment

Fig. 1 shows the hardness of alloy with different aging treatment. It can be seen that, the hardness of cast alloy is 52.3HV, which is 72.9HV for solid solution and aging treatment alloy. Compared with 190 ℃ and 210 ℃, the hardness of aging alloy is higher at 170℃ and increase with the aging time. The hardness of aging alloy for 24h at 170℃ is up to maximums 72.8HV. Higher hardness can be get by direct aging for MgZnZr alloy.

TABLE I. THE RESULT OF TENSILE EXPERIMENT

Heat treatment alloy	**25℃**		**150℃**	
	σb(MPa)	***δ(%)***	***σ b(MPa)***	***δ(%)***
cast	***159.2***	***6.93***		
solid solution and aging	***205.5***	***5.02***	***195.2***	***8.43***
aging 24h at 170 ℃	***221.2***	***6.66***	***200.9***	***8.91***

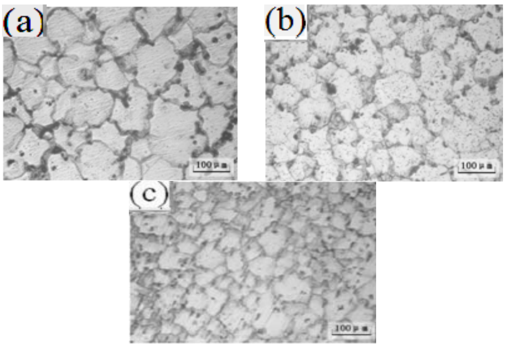
Table 1 shows the results of tensile strength and elongation of the alloy after different heat-treatment. At room temperature, the tensile strength of the cast is only159.2Mpa. After solid solution and aging or direct aging, the tensile strength increase obviously, they are up to 205.5Mpa and 221.2Mpa at room temperature and 150 ℃ respectly. We can see that, compared with solid solution and aging, the tensile strength and elongation of the direct aging alloy are better. So the mechanical properties of Mg-5.5%Zn-0.5%Zr alloy can be improved by aging treatment. Compared with solid solution, direct aging treatment can be operated easily and optimize the heat-treatment process of MgZnZr alloy.



(a) cast (b) solid solution and aging (c) aging 24h at 170℃

Fig. 2 The fracture morphologies of Mg-5.5Zn-0.5Zr alloy after different heat-treatment

Fig.2 shows the fracture morphologies of Mg-5.5Zn-0.5Zr alloy after different heat-treatment. The fracture morphologies of cast alloy has lots of inward depression facets, where many bend tear ridges exist. This shows features of quasi cleavage belong to brittle fracture. The fracture morphologies of solid solution and aging alloy has some tear ridges and dimples. There are a few inclusions in the middle of dimples and this fracture shows ductile fracture feature. The fracture morphologies of aging 24h at 170℃ alloy shows brittle fracture feature, which performance for the river pattern, quasi cleavage steps and smooth fracture surface can be seen. When the aging time extend to 24h, There are some tear ridges and dimples and inclusions in the middle of dimples, which shows ductile fracture.



(a) cast (b) solid solution and aging (c) aging 24h at 170℃

Fig. 3 The microstructures of Mg-5.5Zn-0.5Zr alloy after different heat-treatment

Fig.3 shows the microstructures of Mg-5.5Zn-0.5Zr alloy after different heat-treatment. It can be seen that, the microstructure of cast alloy is mainly constituted of α-Mg matrix, grain boundaries and continuous reticular eutectic structure. α-Mg matrix is gray white, the phenomenon of dendritic crystal is serious, eutectic structure is uneven. There are many eutectic products and the second phases exist along the grain and dendritic crystal boundaries.

The crystal grain size of solid solution and aging alloy is better. A large number tiny fine needle precipitated phase can be seen in the crystal and boundaries. The crystal boundary microstructures of alloy change a little, but most of unbalance eutectic structures disappear. Therefore the boundary thickness of solid solution and aging alloy is smaller than the cast.

What can be seen from the microstructure of direct aging alloy is that, part of unbalance eutectic structures on boundaries disappear and very tiny alloy compounds precipitated phase appear in the crystals, reticular boundaries become coarsening and clear. Because the energy of crystal boundaries is higher [9,10], meanwhile with the increase time of aging, precipitated phases increase and new phases nucleate along crystal boundary and grow toward crystal, all these cause boundaries become coarsening and clear as well as the crystal grains size of the alloy is remarkably refined, improve the comprehensive properties of alloy extremely.

IV. CONCLUSIONS

(1) Solid solution(380℃×12h) and aging(190℃×12h) treatment or direct aging(170℃×24h) treatment can improve the microstructures of Mg-5.5%Zn-0.5%Zr alloy, and promote its mechanical properties.

(2) After Solid solution(380℃×12h) and aging(190℃×12h) treatment, the values of tensile strength of the alloy at room temperature and 150℃ are up to 205MPa and 195.2MPa respectively. After direct aging(170℃×24h) treatment, the values of tensile strength of the alloy at room temperature and 150℃ improve relatively, up to 221.2Mpa and 200.9MPa respectively.

(3) Compared with solid solution, direct aging(170℃×24h) treatment can optimize the heat-treatment process of Mg-5.5Zn-0.5Zr alloy.

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