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EFFECT OF SOLID SOLUTION TREATMENT ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF EXTRUDED MgY12Zn2,5 MAGNESIUM ALLOYS

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The microstructural evolution of MgY12Zn2,5 magnesium alloys was observed, and the strengthening and toughening mechanism of the alloys were studied. The results showed that the MgY12Zn2,5 alloy after solution treatment with higher content of 14H - LPSO (long - period stacking - ordered structures) could more effectively inhibit the recrystallization and growth of recrystallized grains, and the microstructure was more fine and uniform. And its tensile strength (R_m), yield strength (R_v) were 395 MPa, 308 MPa and elongation (A) 17,5 %, respectively. In contrast, the MgY12Zn2,5 alloy treated at 470 °C for 24 h, whose Rm, Rv, were only 376 MPa, 282 MPa and A 15,5 %, respectively.

Keywords: MgY12Zn2,5, extrude, solid solution treatment, microstructure, mechanical properties

INTRODUCTION

In 2001, Kawamura et al. prepared a Mg - 2Y - 1Zn alloy by a rapidly solidified powder metallurgy process, and its R_m, R_v reached 628 MPa, 610 MPa and A 5,0 % at room temperature, respectively [1,2]. After that, the Mg - Y - Zn wrought magnesium alloys have drawn much attention due to their excellent performance. Based on many reports about Mg - Y - Zn and Mg - Y - Zn - Zr system alloys [3-6], the LPSO phase is widely believed to play an important role in the ultra-high properties of the Mg - Y - Zn alloys. Meanwhile, it has been widely examined that the phase composition of the Mg - Y - Zn alloys should depend on the Y/Zn mole ratios [7,8], and the transformation of the LPSO phase depends largely on the solution treatment process [9,10]. However, little attention has been paid to the effect of the solid solution treatment on the type, quantity, distribution, size of the LPSO phase in the same rare earth magnesium alloys during the processing process, and the final effect on the comprehensive properties of the alloys. In this paper, the effect of the solid solution treatment on the microstructure and mechanical properties of the MgY12Zn2,5 magnesium alloys was studied from the perspective of solid solution treatment on the conversion of the 14H - LPSO in the MgY12Zn2,5 magnesium alloys.

EXPERIMENTAL MATERIALS AND METHODS

The material used in the experiment was a Φ90 mm ingot made by a semi continuous casting. The chemical compositions of the prepared alloys are listed in Table 1. After the casting process, the ingots were solid solution treated at 470 °C for 24 h and 520 °C for 24 h respectively and were indirectly extruded into Φ28 mm rods at 370 °C with the same extrusion process.

The chemical compositions of the MgY12Zn2,5 alloys were determined through an inductively coupled plasma atomic emission spectrum (ICP - AES) apparatus. The metallographic structure was observed by a ZEISS - Axiovert 200 optical microscopy (OM). The phase compositions of the as - cast alloys were analyzed by a Philips X - pert X - Ray Diffractometer (XRD). The extruded samples were characterized and analyzed using a FEI Nova 400 thermal field emission scanning electron microscope (SEM) equipped with an HKL channel 5 Electron Backscattered Diffraction (EBSD) system and the experimental data were analyzed by the HKL channel 5 software package. The mechanical properties of two solid solution treated as extruded alloys were tested by an electronic universal material testing machine.

RESULTS AND DISCUSSION

OM and XRD analysis of as - cast alloys are reported in Figure 1. As shown in Figure 1, the as - cast microstructure of the MgY12Zn2,5 alloys was composed of equiaxed - crystal solid solution α - Mg (arrows labeled "1" in Figure 1) and a large number of second lamellar phases (arrows labeled "2" in Figure 1) distributed along

Table 1 **Chemical composition of MgY12Zn2,5 magnesium alloy / mas. %**

Y	Zn	Mg
12,03	2,45	Bal.

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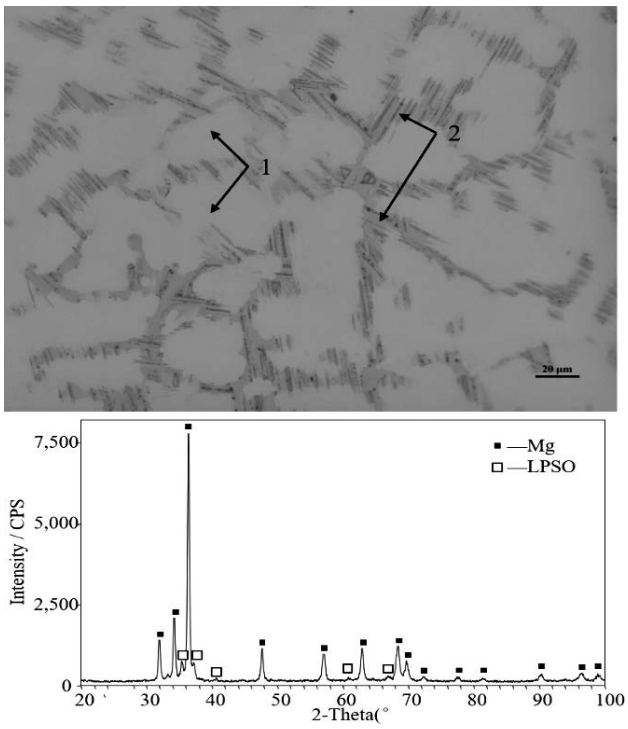

Figure 1 Microstructures and corresponding XRD pattern of the as - cast MgY12Zn2,5 alloys

grain boundaries. The second intergranular lamellar phases were randomly distributed along different directions. The Figure 1 showed the XRD pattern of the as - cast MgY12Zn2,5 alloys. From the diffraction pattern, it could be confirmed that the microstructure of the as - cast MgY12Zn2,5 alloys was composed of solid solution α - Mg + 18R - LPSO phase (Mg12YZn) [1-3, 5-6].

Figures 2,3 showed the microstructure of the MgY12Zn2,5 alloys after solid solution treatment at 520 °C for 24 h and 470 °C for 24 h respectively. Compared with the as - cast microstructure in Figure1, a large number of lamellar structures could be observed in the grains after the solid solution treatment, which indicated that the α - Mg solid solution was transformed into the lamellar 14H - LPSO + 2H - Mg structure after heat treatment [3,9,10]. Compared Figure 2 with Figure 3, the content of the lamellar 14H - LPSO + 2H - Mg formed by high temperature solid solution treatment (520 °C for 24 h) in Figure 2 was significantly higher than that in Figure 3 (470 °C for 24 h) alloys.

After the solid solution treatment, the lamellar second phase 18R - LPSO distributed at the grain boundaries in the as - cast state merged and grew up. Massive phases with similar orientation were formed (arrows labeled "2" in Figure 2). At the interface of some intergranular 18R - LPSO / α - Mg grains, the layers direction of the18R - LPSO was parallel to the stacking layers of adjacent α - Mg grains, and the grain boundaries were obviously wetted. The 18R - LPSO grew zigzag into the edge of the α - Mg grains (arrows labeled "3" in Figure 2). The 18R - LSO phase was coexisted in the 2H - Mg with certain crystallographic relationships [3]. However, there was no wet at the interface where the layers direction of 18R -

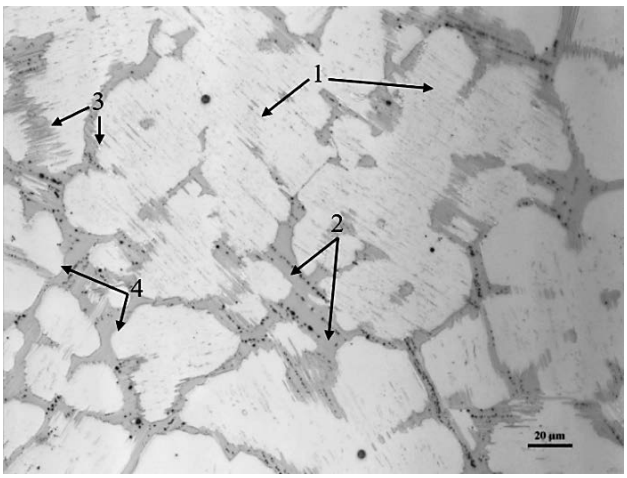

Figure 2 Solid solution microstructure of the MgY12Zn2,5 alloy at 520 °C for 24 h

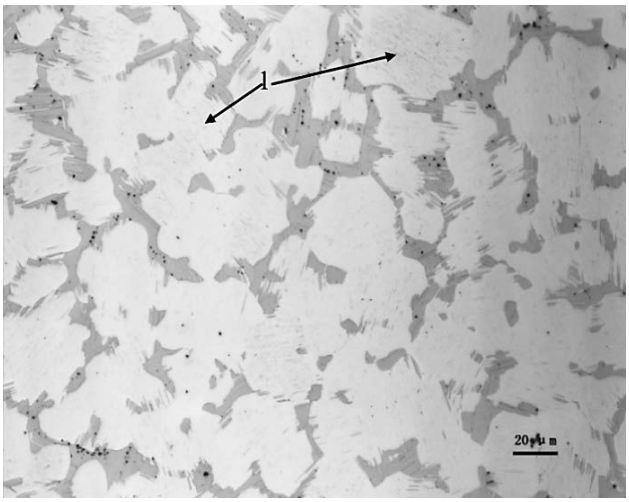

Figure 3 Solid solution optical microstructure of the MgY12Zn2,5 alloy at 470 °C for 24 h

LPSO was not parallel to the adjacent α - Mg grains stacking layers, forming a smooth adjacent interface (arrows labeled "4" in Figure 2).

The recrystallization rate and grain size distribution of the extruded MgY12Zn2,5 alloys were analyzed by EBSD. Figure 4 showed that the recrystallization rate of the alloys treated at 520 °C for 24 h was 45,83 %, which was lower than that of 53,03 % in Figure 5 which treated at 470°C for 24h. The recrystallization of the high temperature solid solution treated alloys was obviously inhibited in the alloys treated at 520 °C for 24 h as shown in Figure 4, compared with the alloys treated at 470 °C for 24 h as shown in Figure 5. The grain size of high temperature solid solution treated alloys was obviously smaller than that of low temperature solid solution treated alloys.

Mechanical properties of extruded alloys were tested by an electronic universal material testing machine.

As shown in Figure 6, after extrusion deformation, the R_m, R_r and A of the alloys using solid solution treatment at 520 °C for 24 h were 395 MPa, 308 MPa and 17,5 %, respectively, and those of the alloys treated at 470 °C for 24 h were 376 MPa, 282 MPa and 15,5 %,

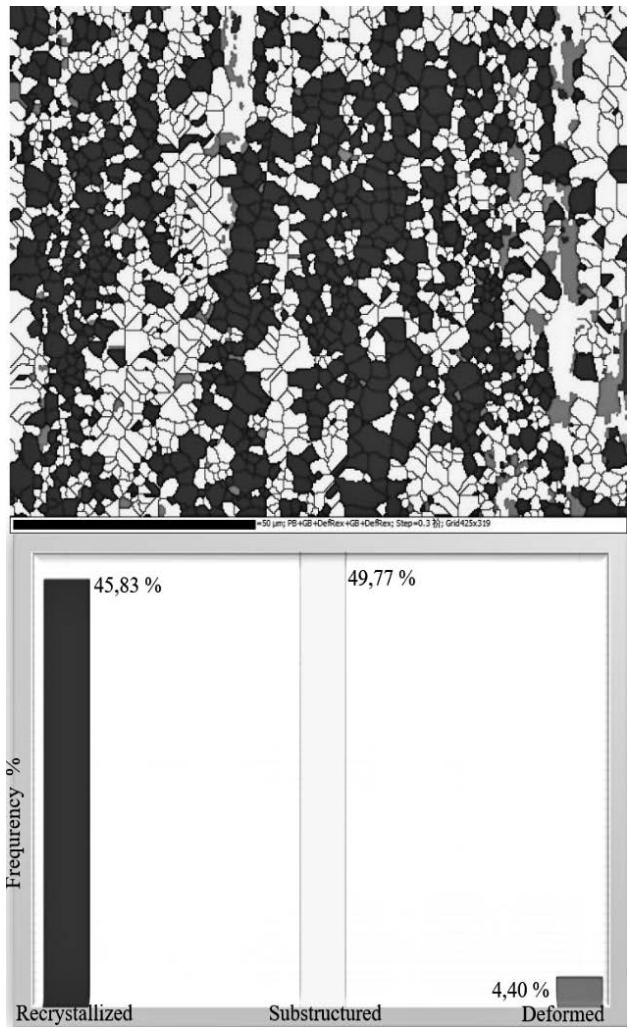

Figure 4 Recrystallization of the extruded MgY12Zn2,5 alloys solid solution treated at 520 °C for 24 h (recrystallized grains 45,83 %, substructured grains 49,77 %, deformed grain 4,40 %)

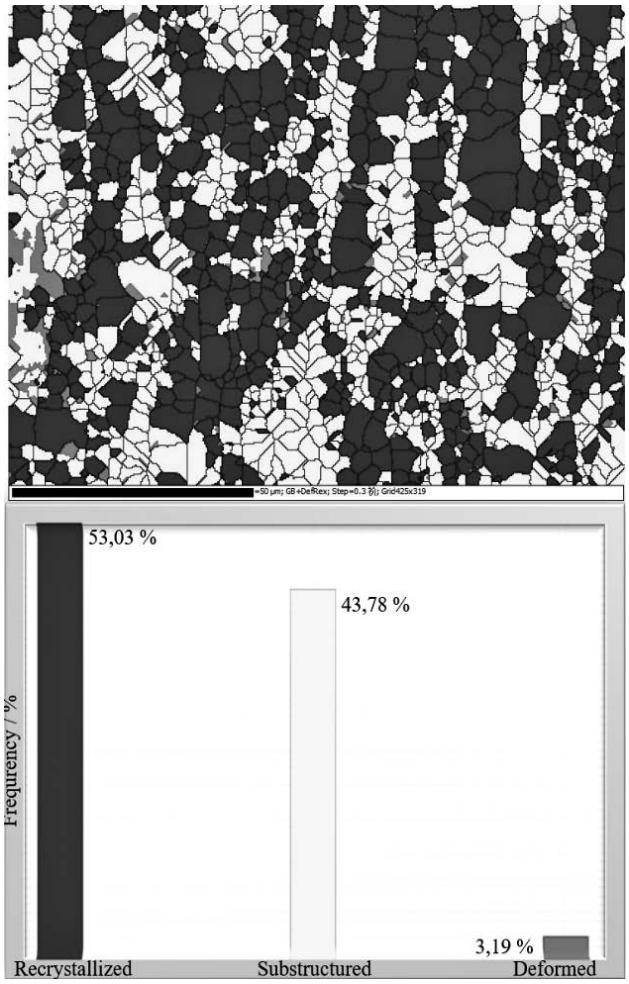

Figure 5 Recrystallization of the extruded MgY12Zn2,5 alloys solid solution treated at 470 °C for 24 h (recrystallized grains 53,03 %, substructured grains 43,78 %, deformed grains 3,19 %)

respectively. The high temperature solid solution treated alloys showed much better comprehensive properties in terms of tensile strength, yield and elongation.

The mechanical properties of the extruded MgY12Zn2,5 alloys showed obvious differences through different solid solution treatment temperatures. This was mainly attributed to the facts that the solid solution treatment significantly changed the transformation process of the14H - LPSO phase in the as - cast MgY12Zn2,5 alloys. Which made the alloys obtained different proportions of three-phase structure of 14H - LPSO, 2H - Mg and 18R - LPSO. On the one hand, a higher content of the14H - LPSO phase was obtained by higher solid solution treatment temperature. Due to fine 14H - LPSO phase was distributed in the 2H - Mg, together with the 18R - LPSO phase, the microstructure of the extruded MgY12Zn2,5 alloys was more uniform; On the other hand, due to the high temperature resistance of the LPSO phase [1, 10], the MgY12Zn2,5 alloys with high content of the 14H - LPSO phase was deformed by the same extrusion, the LPSO phase dispersed in the microstructure of the alloys could inhibit the recrystallization and the growth of the recrystallized grains, and the microstructure of MgY12Zn2,5 wrought alloy was refined significantly; At last but not least, the MgY12Zn2,5 alloys with 14H - LPSO + 2H – Mg + 18R - LPSO three - phase structure had a comprehensive coordinated deformation and composite strengthening ability [1-6,9]. So that, the extruded MgY12Zn2,5

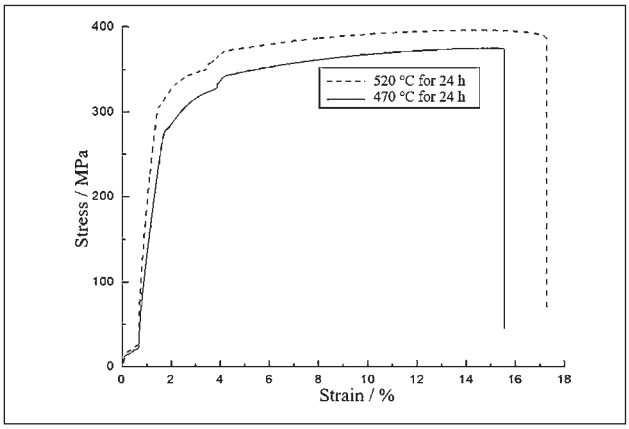

Figure 6 Stress-strain curves of the extruded MgY12Zn2,5 alloys

alloys of high temperature solid solution treatment showed much better comprehensive properties.

CONCLUSIONS

For the MgY12Zn2,5 magnesium alloys, the solution treatment temperature could significantly affect the transformation process of the LPSO phase.

The higher content of the LPSO phase had better homogenization and refinement effect on the MgY12Zn2,5 alloys.

Compared with the low temperature solid solution treated MgY12Zn2,5 alloys, the high temperature solid solution treated alloys showed much better comprehensive properties in terms of tensile strength, yield and elongation.

Acknowledgements

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