

Microstructure and Mechanical Properties of Mg-12Gd-2Y-1Sm-0.5Zr Alloy

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Abstract. The microstructure and aging precipitated phases of Mg-12Gd-2Y-1Sm-0.5Zr alloy have been studied by micro-analysis XRD and EDS. Through the analysis it is found that the precipitated phases in the alloy contains $Mg_{24}Y_5$, Mg_5Gd and $Mg_{41}Sm_5$. The tensile strength peak of Mg-12Gd-2Y-1Sm-0.5Zr alloy appears at 250°C.

Introduction

As we all know, magnesium alloy is the lightest metal structural materials at present, it has many advantages. Such as: low density, high specific strength and stiffness, good plasticity, dimensional stability, good mechanical properties and casting properties, which not only attract the attention of the aerospace industry, but also become the most promising alternatives of the aluminum alloy car. Magnesium alloy has good thermal conductivity, electromagnetic shielding, damping and easy recycling advantages, it also has been gradually replaced plastic to become the best material of the portable electronic communication products' casing and parts of the interior accessory[1]. Therefore, magnesium alloy is called " The green engineering material of twenty-first Century ". But the common magnesium alloy at high temperature has poor mechanical properties, which further expand the severely limits of its range of application[2]. So researching and developing magnesium alloy with excellent heat resistance to expand the application of magnesium alloy, become an important subject of magnesium alloy.

The addition of rare earth elements in the magnesium alloy can significantly improved its strength and heat resistant temperature, and it is also a good way to improve the mechanical properties of magnesium alloy[3]. There are many types of rare earth magnesium alloy in industrial applications with a lot of researchs at present, however, reports on microstructure and properties of Mg-12Gd-2Y-1Sm-0.5Zr magnesium alloy is still very few. This experimental studied Mg-12Gd-2Y-1Sm-0.5Zr magnesium alloy, in order to provide new ideas and methods to develop new heat resistant magnesium alloy[4].

Experimental

The raw materials for the test: the pure Mg ingot(99.95%), Mg-30%Gd, Mg-20%Y, Mg-25%Sm and Mg-30%Zr. We use ZGJL0.01-4C-4 induction furnace in the smelting process whose rated power is 40KW. SF_6 and CO_2 (volume ratio 1:99) mixed gas were used to protect the melt during the smelting process.

The experiments of heat treatment of the alloy: Insulation in the box furnace 6 hours at 525°C for solid solution treatment. Then take out from the stove, put into the room temperature water for quenching quickly, follow the aging treatment at 225°C for 10 hours in the constant temperature drying box, then air cooling.

Using SHIMADZU AG-I 250KN precision universal electronic tensile testing machine tensile

specimen, tensile rate is 1mm/min, the tensile temperature respectively at room temperature (20°C), 200°C, 250°C and 300°C, measure the tensile strength, and elongation of the experiment alloy. Using Olympus-PMG3 type optical microscope to observe the microstructure morphology of the alloy. Analyse the content elements in alloy phase and micro zone from the microstructure of the alloy with a JSM-5610LV type scanning electron microscope with spectrometer (EDAX) on it. Test equipment using on alloy phase analysis were the D8 ADVANCE X ray diffractometer German.

Results and analysis

From the XRD spectra of Mg-12Gd-2Y-1Sm-0.5Zr alloy after solution heat treatment in Fig.1, we can see there are Mg_5Gd and $Mg_{24}Y_5$ diffraction peaks in addition to the diffraction peaks of the base phase of α -Mg in solid solution alloy. They are strengthening phases in the alloys[5,6].

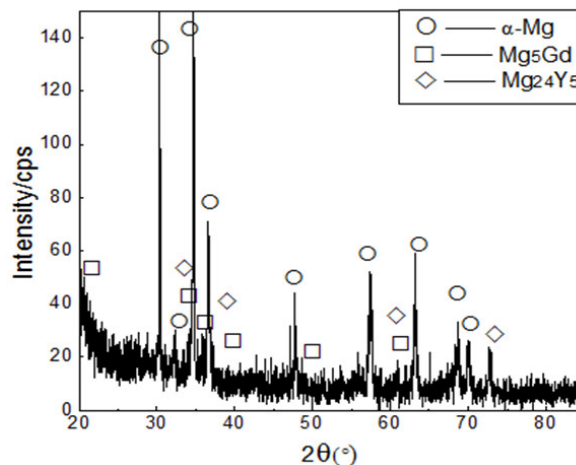


Fig.1 The XRD spectra of Mg-12Gd-2Y-1Sm-0.5Zr alloy after solution heat treatment

Fig. 2 is the metallographic microstructure photo of the test alloy after solid solution. As can see from the graph, the vast majority of second phase have been dissolved in the α -Mg matrix, undissolved phases dispersed in the alloy grains and grain boundaries in a granular form. Alloy grains become smaller and relatively even, while grain boundary outline clear. Alloy mainly contents α -Mg solid solution matrix and the second phase decreased obviously in small particles dispersed in the grain boundary and inside the grain.

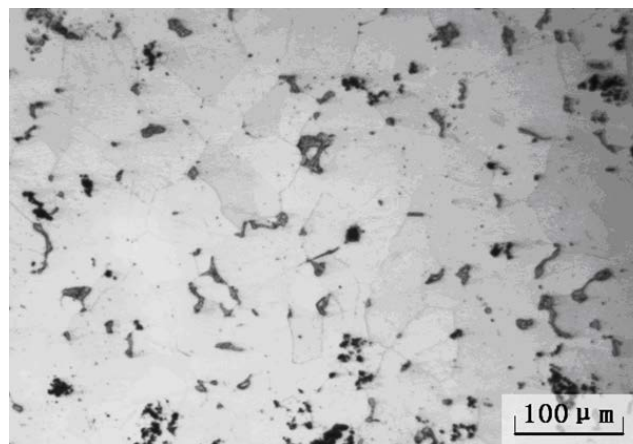


Fig. 2 Microstructure of Mg-12Gd-2Y-1Sm-0.5Zr alloy after solution heat treatment

The SEM observation and EDS analysis of Mg-12Gd-2Y-1Sm-0.5Zr alloy after aging treatment are shown in Fig. 3. In the picture we can see the boundaries exist with the phenomenon of phase segregation in the grain boundary. The results of EDS analysis of aging Mg-12Gd-2Y-1Sm-0.5Zr alloy showed that in the alloy region A point only the presence of Gd element besides supersaturation of solid solution matrix phase α -Mg, while no detectable of Sm and Y elements. Therefore we

judged the two elements are partly formed intermetallic with Mg as $Mg_{41}Sm_5$ and $Mg_{24}Y_5$, and precipitated from the magnesium matrix after solid solution and aging treatment[7,8]. Thus resulted in lower concentration of Sm and Y which could not be detected. The elements atomic ratio of particles phases at B point in the alloy phase region is $x(Mg)=65.01\%$, $x(Y)=19.35\%$, $x(Sm)=1.24\%$, $x(Gd)=14.40\%$. It can be considered as a mixed phase which should contain the $Mg_{24}Y_5$ and Mg_5Gd phase. At the same time, there should be also part of the Gd, Y, Sm elements dissolved in the phase[9].

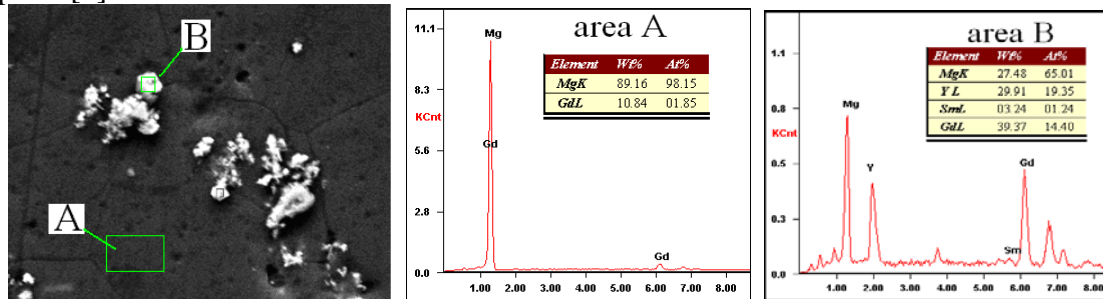


Fig.3 Microstructure and energy spectrum analysis of Mg-12Gd-2Y-1Sm-0.5Zr after aging treatment

In the tensile tests, as temperature increasing from room temperature (20 °C) to high temperature (200°C, 250°C and 300°C) the maximum tensile strength of alloys increased at first and then decreased. The tensile strength of the alloy reached the maximal at 250°C then greatly lowered with increasing of tensile temperature. This is obviously different with the general magnesium alloy whose tensile strength decreased sharply as tensile temperature increasing, which means that the mechanical properties appeared abnormal behavior[10].

Table.1 The mechanical properties of aging alloy

Temperature	Tensile Strength [MPa]	Elongation [%]
20 °C	219	1.89
200°C	253	2.55
250°C	283	3.15
300°C	264	3.35

Conclusions

- 1) The strengthening phases precipitated from the Mg-12Gd-2Y-1Sm-0.5Zr alloy are mainly Mg_5Gd and $Mg_{24}Y_5$.
- 2) The tensile strength of Mg-12Gd-2Y-1Sm-0.5Zr alloy increases at first and then decreases as the temperature increasing, while the peak appears at 250°C.

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