Effects of Nd on Extrusion Phase and Texture of ZM21 Magnesium Alloy

Quan Li
Chongqing Academy of Science and Technology, Chongqing 401123, China

Jian Peng
Chongqing Academy of Science and Technology, Chongqing 401123, China
College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China

Weibo Zhu
Chongqing Academy of Science and Technology, Chongqing 401123, China

Bin Zeng
Chongqing Academy of Science and Technology, Chongqing 401123, China
College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China

ABSTRACT: In this paper, by adding different amounts of rare earth Nd magnesium alloys in ZM21, ZM21 study of Nd on magnesium alloy thermal processing temperature ductility and plasticity effects and mechanism of the law. The results show that alloy appeared 1-3μm needle and granular three alloy phase T1 and T2, plastic alloys with increasing amounts of neodymium added significantly improved fracture mode, which ZM21+0.3Nd best overall properties of the alloy.
KEYWORD: Magnesium Alloy; Extrusion; Phase; Texture

1 INTRODUCTION

Adding rare earth magnesium alloy elements can significantly improve the alloy at room and high temperature mechanical properties. Of adding rare earth elements in magnesium alloys are mainly Y, Ce and Nd (Yu Kun et al, 2005) (Ravi Kumar N V et al, 2013) (J.S. Zhang et al, 2008), they began to form in magnesium alloy high temperature stability of the reinforcement of rare earth in the second phase, can significantly improve magnesium alloy at room temperature and high temperature strength, and obstacles in the process of thermal deformation of dynamic recrystallization grain growth, refining alloy grain, increase the strength and plasticity of alloy. Rare earth elements, Nd solid solubility in magnesium alloy is larger, 3.6wt.%, research on Nd increased the strength of magnesium alloy is more, less on the study of mechanism of the influence of the plasticity extremely (Li Wenxian, 2005) (Pan Fusheng et al, 2007) (Ding W J et al, 2012).

2 EXPERIMENTAL

Casting water-cooled semicontinuous casting system of ZM21 magnesium alloys with different mass fraction Nd semi-continuous casting, the chemical composition of the alloy are shown in table 1. Will cast the ingot in the 12kw wind circulation box type resistance furnace for 420℃x10h homogenization annealing treatment, air cooling after the ingot stripping, and extrusion production test in 500 tons of horizontal extrusion machine, extrusion, the blank in the mold at 400℃ heat preservation in heating furnace 2~3h, container set temperature is 390℃, the extrusion speed is 3.5~5.5m/min. The RigakuD/Max-1200 type X-ray alpha Cu target, K phase analysis. Using TESCAN VEGA company Ⅱ LMU variable vacuum SEM and EDS tissue morphology scan and compound composition analysis. In METTLERTGA DSC Ⅰ/1100 lf type differential thermal analyzer to determine the as-cast alloy phase change temperature and heating speed of 15℃/ min.

Table 1 Chemical compositions of experimental alloys (mass fraction, %)

Alloy code	Si	Fe	Zn	Mn	Nd	Mg
ZM21(1#)	0.0063	0.0046	2.11	0.86	0.00	Bal
ZM21+0.1Nd(2#)	0.0062	0.0038	2.05	0.88	0.09	Bal
ZM21+0.3Nd(3#)	0.0061	0.0020	2.07	0.87	0.28	Bal
ZM21+0.5Nd(4#)	0.0065	0.0018	2.06	0.87	0.47	Bal
ZM21+0.7Nd(5#)	0.0058	0.0016	1.98	0.88	0.68	Bal

3 RESULTS AND ANALYSIS

Alloy extrusion state of XRD diffraction pattern as shown in figure 1. Main alloy ZM21 squeezed state alloy is the alpha, Mn and Mg, when adding 0.1%Nd alloy newly created T_2 phase, adding 0.3%Nd and above, in addition to the T_2 phase in the alloy, also generates the T_3 phase. Due to squeeze the small size of the second phase particles in the alloy, by scanning electron microscope combined with energy spectrum can only qualitative determination of the second phase, and the possible elements cannot be quantitatively determine the composition and types of the second phase, so by transmission electron microscopy (tem) combined with energy spectrum analysis, and the second phase diffraction spot to determine the phase of the alloy extrusion state. ZM21+0.5Nd the second phase in the squeezed state alloy transmission diffraction and energy spectrum analysis is shown in figure 2. Through the STEM EDX analysis alloy at about 1~3 microns in size of needle and granular second phase for Mg-Zn-Nd ternary phase, such as A, B, C, D points. Needle point A and B granular phase of Zn, Nd content were significantly higher than the content of C and D points granular phase, by means of electron probe analysis of Mg-Zn-Nd ternary phase T_1, T_2, T_3, T_4 phase composition contrast, point A and B with T_3 phase composition, the composition of C and D and T_2 composition close to. By tem diffraction spot calibration, point A and B crystal structure is face-centered cubic structure, lattice constant is A=0.68 nm, C and D orthogonal structure, crystal structure for body heart A = 0.96nm, B =1.12nm, C=0.94 nm, crystal structure is consistent with T_3 and T_2, respectively, resulting from a Nd squeezed state alloy ZM21+0.5Nd size larger needle and part of the granular phase for T_3 phase ($(Mg, Zn)_3Nd$), and part of the large size of particle phase for T_2 phase($(Mg, Zn)_{11.5}Nd$) By scanning combined with spectrum analysis, ZM21+0.1Nd, ZM21+0.3Nd, ZM21+0.7Nd alloy ZM21 shape and composition and second phase in the alloy ZM21+0.5Nd similar, so add Nd alloy extrusion state the size larger needle and part of the granular phase for T_3 phase ($(Mg, Zn)_3Nd$), and part of the large size of particle phase for T_2 phase ($(Mg, Zn)_{11.5}Nd$).

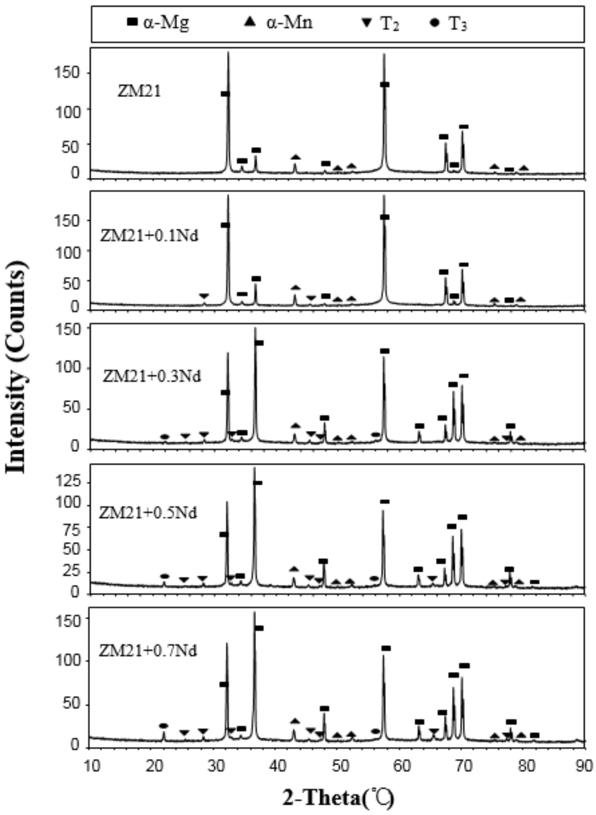
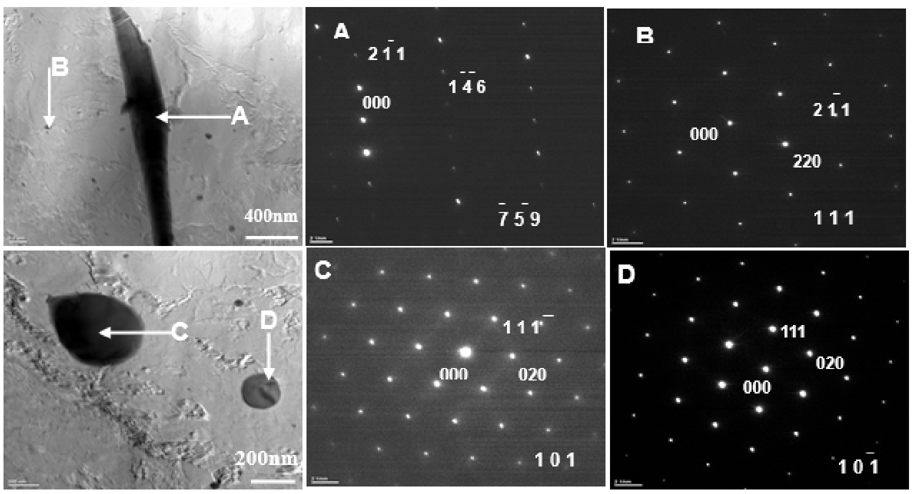


Figure 1 XRD spectrums of as-extruded alloys



Position	Mg(at.%)	Zn(at.%)	Nd(at.%)	Mn(at.%)	Phase
A	46.53	33.53	19.95	—	T_3
B	31.34	43.16	25.5	—	T_3
C	67.79	23.84	8.37	—	T_2
D	66.77	24.67	8.56	—	T_2

Figure 2 STEM patterns and EDX of as-extruded ZM21+0.5Nd alloy by TEM

Table 2 lists the squeezed state of alpha Mg alloy substrate absolute strength of each crystal plane diffraction peak. Can be seen from table 2, ZM21 alloy cylinder diffraction peak intensity is large, base of diffraction peak intensity is small, but in the five alloy is one of the biggest, cone of diffraction peak intensity than the lower cylinder; After adding 0.1%Nd, alloy cylinder diffraction peak intensity increases slightly, base the diffraction peak intensity is reduced, in (10-11) and (11-22) cone of the diffraction peak intensity increases, but the diffraction peak intensity in other cone are reduced. When Nd content reached 0.3%, alloy cylinder diffraction peak intensity drops sharply, the base surface diffraction peak strength continue to reduce, cone diffraction peak intensity increases, are higher than Nd alloy ZM21 and ZM21+0.1Nd cone diffraction peak intensity, and cone in alloy ZM21+0.1Nd the diffraction peak intensity is higher than that of cylinder; Nd levels continue to increase to 0.5%, alloy cylinder diffraction peak strength continue to reduce, base the diffraction peak intensity increases slightly, compared to the alloy ZM21+0.3Nd, (10-11), (11-22) and (20-21) cone diffraction peak intensity is slightly lower, other cone diffraction peak intensity is increased slightly; ZM21+0.7Nd alloy cylinder diffraction peak intensity increases, higher than ZM21+0.3Nd alloy cylinder diffraction peak intensity, base the diffraction peak intensity drops, cone diffraction peak intensity increases, higher than ZM21 and ZM21+0.5Nd alloy cone diffraction peak intensity. Squeezed state alloy cylinder and cone of diffraction peak intensity is stronger, base the diffraction peak intensity is weak. This is squeezed state alloy cross-section in the direction perpendicular to the extrusion diffraction pattern, from the observed on the cross section parallel extrusion cylinder is equal to the direction of base level of longitudinal section, cross section of the base level is equal to the longitudinal section of the cylinder, the resulting in alloy extrusion state have formed a strong parallel to the extrusion direction of surface texture, but along with the increase of the content of Nd texture changed.

Can get from this, after adding 0.3% Nd, squeezed state alloy cylinder diffraction peak intensity drops sharply, ZM21+0.5Nd alloy cylinder diffraction peak intensity of the minimum, cone diffraction peak strength greatly increased, ZM21+0.1Nd, ZM21+0.3Nd, ZM21+0.7Nd alloy cone diffraction peak intensity is relatively close to. Squeezed state in the alloy base of diffraction peak intensity is weak, and reduce with the increase of Nd content. After adding 0.3%Nd, squeezed state alloy grain arrangement oriented decreases, and make the alloy in parallel to the direction of the extrusion base texture significantly diminished, ZM21+0.5Nd the strength of the alloy base surface texture is minimal.

Table 2 Absolute intensities of Mg diffraction peaks of as-extruded alloys (area)

crystal face	ZM21	ZM21+ 0.1Nd	ZM21+ 0.3Nd	ZM21+ 0.5Nd	ZM21+ 0.7Nd
(100)	275900	309414	120030	90644	122475
(110)	234563	257021	115263	65736	87505
(200)	19392	23876	5840	4951	8885
(002)	3301	2117	1962	2083	1583
(101)	9674	15952	202502	190094	222871
(102)	1291	963	10145	13840	14874
(103)	—	—	4812	5125	5539
(112)	369	1292	35657	25344	33403
(201)	35799	34057	44521	39171	47835
(202)	315	208	3503	5038	4127
(104)	—	—	—	658	752

By XRD tested ZM21 and ZM21+0.5Nd alloy extrusion state parallel to the extrusion direction longitudinal cross section figure, as shown in figure 3. ED is vertical parallel to the extrusion direction, TD is horizontal direction perpendicular to the extrusion. From {0002} basal pole figure can be seen that ZM21 and alloy ZM21+0.5Nd squeezing states were formed in parallel to the direction of the extrusion base texture, but compared with ZM21 alloy, alloy ZM21+0.5 Nd base texture intensity decreased significantly. ZM21 alloy base surface texture intensity in a maximum of 4.325, ZM21+0.5Nd alloy base texture intensity maximum reduce to 2.375. Through the results more intuitive reaction in the test, after adding Nd alloy extrusion state parallel to the direction of extrusion texture changes, consistent with the result of the XRD diffraction pattern analysis.

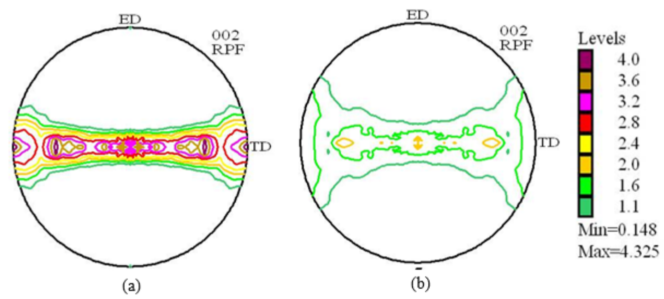


Figure 3 {0002} pole figures of as-extruded alloys (a) ZM21, (b) ZM21+0.5Nd

4 CONCLUSION

The main phase of ZM21 magnesium alloy composition is Mg, Mn and Mg-Zn. When adding amount is more than 0.3% neodymium, a ternary alloy phase in the alloy T_1 and T_2, the size is 1~3 microns acicular and granule, the alloy phase number increases with the increase of adding amount of neodymium.

ZM21 magnesium alloy extrusion state strength and plasticity of the alloy grain size, along with the change of content of Nd solid solution atoms, the second phase and the influence of texture, which has obvious effects of texture. After adding Nd weakening base texture and grain refining alloy plasticity increase; With the increase of Nd content, grain refinement can make the strength of the alloy increase, but the decrease of the base surface texture intensity and Zn solid solution strengthening effect is abate, the strength of the alloy in overall downward trend.

ZM21 squeezed state alloy base texture a maximum intensity of 4.325, after adding 0.3%Nd, squeezed state alloy base level obviously texture, 0.5%Nd alloy base texture of minimum intensity, the maximum value of 2.375.

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