Effect of Ce on Deformation Performance of ZK20 Magnesium Alloy

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Abstract. In this paper, Effect of different contents of Ce on the Mechanical Properties of ZK20 magnesium alloy and thermal deformation behavior, through the use of room temperature tensile and compression test thermal simulation, analysis Ce element is present in the form of ZK20 magnesium alloy and its alloys Mechanism the results show that: in the experimental range (0%~0.68%Ce (mass fraction)), with the addition of Ce addition amount of 0.7% of the best mechanical properties of alloy extrusion state, room-temperature tensile strength of 261MPa, yield strength 198MPa, elongation of 24.6%. 280℃×4h annealing process enables to improve strength and ductility of the extruded alloys, tensile strength reach 272MPa, yield strength of 209MPa, elongation of 26%. Cerium was added to make ZK20 alloy brittle fracture to the part of the dimple mixed fracture transition.

Introduction

Most magnesium alloys are close-packed hexagonal crystal structure, due to the slip coefficient less and plastic deformation of aluminum and steel, increasing the difficulty and cost of production of magnesium alloy prepared plastic processing, for research and development of new magnesium alloys in recent years, has begun importance in ensuring the strength while improving the thermal processing of plastic and deformation of magnesium alloys at room temperature, the way to resolve through the wrought magnesium alloy phase of design and adoption of new technology and other deformation mode. The rare earth magnesium alloy, in addition to refinement and strengthening the role of alloy phase, but also improve the thermal processing of plastic magnesium alloy to improve the thermal deformation rate, thus reducing the magnesium alloy hot deformation of the article processing costs. It is one of the most effective alloying elements, can enhance magnesium alloy recrystallization temperature and slow the recrystallization process, but also very stable precipitates dispersed particles, magnesium alloy greatly improved high temperature strength and creep dependent resistance. Effect of Rare Earth Ce studied different levels of microstructure and mechanical properties of ZK20 magnesium alloy, and thermal deformation characteristics, analyzes the presence of Ce in the form of ZK20 magnesium alloy and alloy microstructure and properties of mechanism of action, in order to optimize of Ce amount of ZK20 magnesium alloy to provide experimental basis[1-6].

Experimental

Water-cooled semi-continuous casting system with different concentrations of Ce casting ZK20 magnesium alloy semi-continuous slab containing the chemical composition of each alloy in Table 1.The resulting sample was cast in the wind circulation of 12KW box-type resistance furnace 420℃ ×10h homogenizing annealing treatment, ingot peeling, and extrusion tests in 500 tons horizontal extruder, in the blank mold holding furnace to 400℃×2~3h, the extruder barrel set temperature was 390℃, the extrusion speed is 3~5m/min. Sample on METTLERTGA DSC Ⅰ/1100LF type differential thermal analyzer measurement cast alloy phase transition temperature, heating rate of 15℃/min. Heat distortion resistance test conducted on Gleeble1500D, hot compression temperature of 400℃, heating rate 3℃/s, incubated 5min, compression rate $0.5s^{-1}$. In SANS CMT-5105 electron universal testing machine tensile testing carried out at room temperature, a tensile speed of 4mm/ min.

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

Alloy code	Si	Fe	Zn	Zr	Ce	Mg
ZK20	0.0063	0.0046	2.11	0.021	0.00	Bal
ZK20+0.1Ce	0.0062	0.0038	2.05	0.023	0.09	Bal
ZK20+0.3Ce	0.0061	0.0020	2.07	0.021	0.28	Bal
ZK20+0.5Ce	0.0065	0.0018	2.06	0.062	0.47	Bal
ZK20+0.7Ce	0.0058	0.0016	1.98	0.045	0.68	Bal

Results and Analysis

Mechanical properties of cast alloys are shown in Figure 1, we can see that when cerium and below 0.3% dosage, the tensile strength of cast alloys change little, elongation and yield strength slightly decreased; when cerium added in an amount of 0.5% or more, the yield strength of the alloy and little change, a significant reduction in tensile strength and elongation rate, tensile strength decreased to 192MPa from 186.7MPa, elongation of from 23.6% down to 16%.

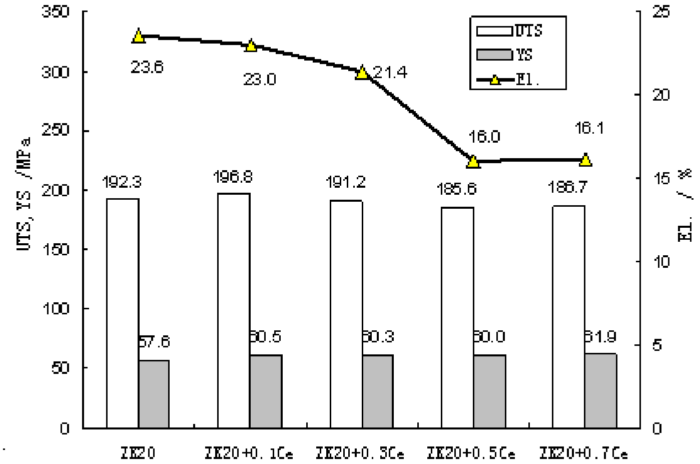


Figure 1. Mechanical properties of as-cast alloys

Figure 2 is a state of the mechanical properties of extruded alloy, by extrusion, the mechanical properties of the alloy are been effectively improved, cerium dosage and below, the tensile strength of the alloy increases the amount of cerium added 0.5% when a weak increase. When cerium dosage 0.7%, the tensile strength has been obviously improved, reaching 261MPa. With the increase of the added amount of cerium alloy yield strength after the first and then decreased, while cerium dosage 0.7%, the yield strength of 198MPa. After the addition of cerium, plastic alloys have increased greatly, so that 0.1% cerium elongation increased from 14.9% to 21.5%, followed with increasing Ce amount of plastic has a slight increase in the amount of cerium when 0.7% maximum 24.6%, compared with ZK20 alloy increased by 44%, from the foregoing, the cerium can effectively improve the strength and ductility of the extruded alloys, adding 0.7% cerium in ZK20 alloy Alleged the effect of improving the mechanical properties of the alloy.

In order to study the annealing process on extruded alloys properties and deformation capacity, we will extruded ZK20+0.7Ce alloys at 280℃, 320℃, 360℃, 400℃, 440℃ incubated for 4 hours, cooled baked after room temperature tensile test. Effect of annealing process on pressing state ZK20+0.7Ce alloys shown in Figure 3, the figure shows, 280℃×4h annealing process enables extrusion state ZK20+0.7Ce alloy strength and ductility are increased, its resistance tensile strength of 272MPa, yield strength of 209MPa, elongation of 26%. Then as the annealing temperature, the strength and ductility of the alloy are slightly lower annealing above 400℃, tensile strength and elongation whims alloy are deteriorated. ZK20+0.7Ce alloy extruded at a low temperature annealing can be aging strengthening, but this effect is enhanced with the increase of annealing temperature decreased. When the annealing temperature exceeds 400 ℃, not only aging strengthening effect disappeared, because this time the grain growth, resulting in tensile strength and elongation whims alloys decreased significantly. Having a finer grain structure of the cerium-containing extruded alloys, although limited by the grain growth, the effective annealing temperature of the alloy narrow, but low-temperature annealing to improve the strength and ductility of the alloy still play a better role.

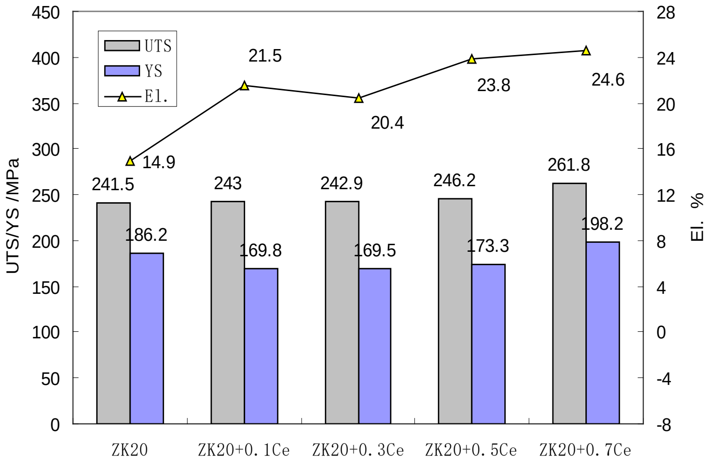
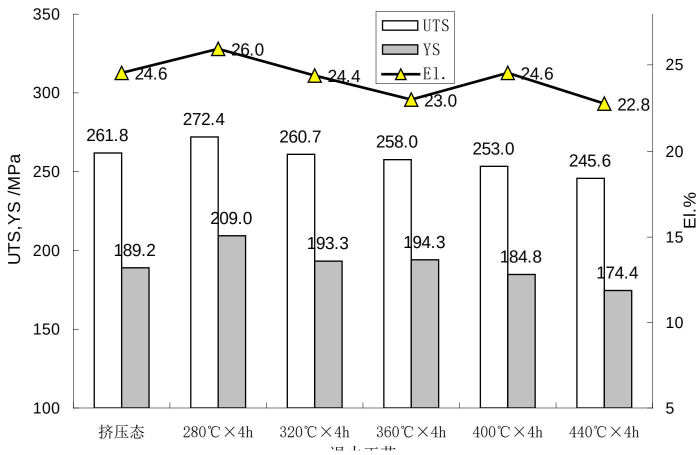


Figure 2. Mechanical properties of as-extruded alloys



Extrusion

Figure 3. Relationship between properties of as-extruded ZK20+0.7Ce alloy and annealing temperature.

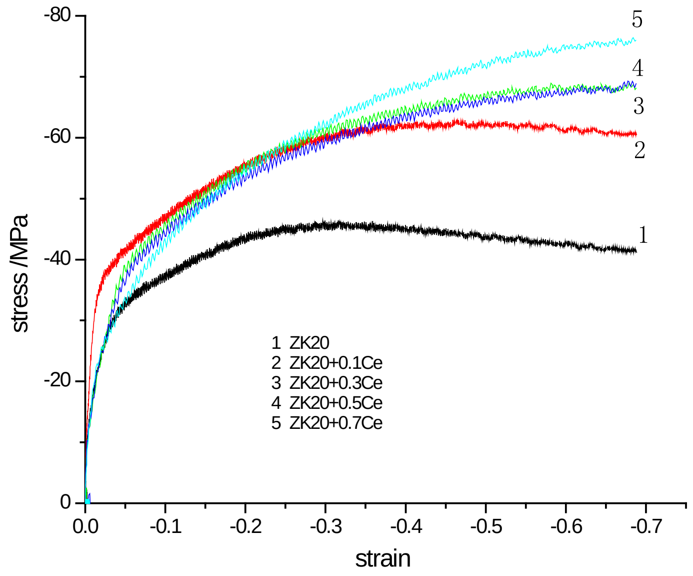


Figure 4. The Compression Curves and peak stress of as-cast alloys

Alloy	Stress / MPa	Strain
ZK20	45.7	0.264
ZK20+0.1Ce	62.6	0.465
ZK20+0.3Ce	68.2	0.700
ZK20+0.5Ce	68.8	0.700
ZK20+0.7Ce	76.1	0.700

Cast alloy compression true stress-strain curve and peak stress shown in Figure 4, the figure shows, with increasing deformation, ZK20 alloy and ZK20+0.1Ce alloy stress has reached the highest value, followed by a slow decline really began to stress, He entered a softening stage, when Ce is greater than 0.1%, before the true strain of 0.7, stress has been true alloys with the strain growth, alloy hardening phase in the alloy flow stress with increasing the maximum amount of Ce increases . Cerium added can greatly contribute to the hardening phase alloys, both the peak stress increase, but also to make the corresponding strain increases. From the perspective of hardening, with the alloying elements increase the work hardening coefficient alloys continued to grow.

Conclusion

Within the scope of the study, the addition of cerium can not cast alloy increases the strength of the plastic. With the increase of the added amount of cerium, grain refinement so that tensile strength and elongation of the alloy improve the mechanical properties of cerium added in an amount of 0.7 per cent-extruded alloy best, room-temperature tensile strength of 261MPa, yield strength 198MPa, elongation of 24.6%. Annealing 280℃×4h enables strength and ductility of extruded alloys have higher tensile strength reaches 272MPa, yield strength of 209MPa, elongation of 26%. Then as the annealing temperature increases, the strength and ductility of the alloy are slightly reduced.

Acknowledgements

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References

[1] Li Wenxian. Magnesium and magnesium alloys[M]. Changsha:Central South University Press, 2005.6.

[2] Pan Fusheng, Han Enhou. High-Performance Wrought Magnesium Alloy and Their Processing Technigues[M]. Beijing: Science Press, 2007.18.

[3] ZHONG Hao，CHEN Qi，YAN Yunqi，et al. Analysis of microstructures and mechanical properties of hot extruded AZ31 magnesium alloy [J]. Light Metals, 2007, (3): 52-55.

[4] GEIGER M, MERKLEIN M. Sheet metal forming-a new kind of forge for the future [J].Key Eng Mater，2007，344:39-46.

[5] ZENG Xiaoqin, DING Wenjiang, YAO Zhengyu, et al. The microstructure and mechanical properties of Mg-Zn-Al alloys[J]. Journal of Shanghai Jiaotong University, 2005, 39 (1): 46-51.

[6] SCHUMANN S. The paths and strategies for increased magnesium applications in vehicles[J].Materials Science Forum,2005,488/489:1-8.