Influence of Heat Treatment Process on Microstructure and Properties of Indirect Squeeze Casting ZM5 Magnesium Alloy baffle

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Abstract: This work is based on the self-developed ZBYT500 multifunctional liquid molding equipment to prepare ZM5 magnesium alloy baffle by squeeze casting process. The effects of two different heat treatment processes, T4 (solution treatment) and T6 (solution treatment + artificial ageing), on the mechanical properties of castings were investigated. The average tensile strength of the castings after solid solution treatment was 228.37 MPa, the average yield strength was 91.49 MPa and the average elongation was 7.3%. The average tensile strength of the best mechanical properties after aging treatment is 242.49 MPa, the average yield strength is 120.8 MPa, and the average elongation is 3.9%. Considering the comprehensive properties, T4 treated ZM5 magnesium alloy baffle will be more suitable for the application.

Keywords: Squeeze casting; Magnesium alloy; Solution treatment; Aging treatment; Mechanical properties.

1 Introduction

Magnesium alloys as the lightest structural metal materials in current engineering applications, are mainly used in large-scale and complex structural components [1]. However, the absolute strength of magnesium alloys molded by the traditional casting process is relatively low due to the presence of harmful phases. In Mg-Al alloys, β-$Mg_{17}Al_{12}$ dissociated eutectic organizations are usually in the form of coarse network or lamellar distribution, which is prone to stress concentration and fracture, thus reducing the mechanical properties of the alloys and restricting their further development in engineering applications [2,3]. In this study, ZM5 baffles were produced based on ZBYT500 multifunctional liquid molding equipment using indirect squeeze casting process. And the heat treatment research on magnesium alloy baffle castings were expected to provide reference for the promotion and application of heat treatment process technology of squeeze casting magnesium alloy castings.

2 Experimental procedure

The baffle castings were produced through the processes of material preparation, melting, pouring under protective gas and indirect squeeze casting. Baffle casting refers to HB5462-1990 standard for heat treatment process. ZM5 magnesium alloy heat treatment process parameters is shown in Table 1.

Table 1. Heat treatment process parameters

Solid solution temperature/℃	Solid solution time/h	Quenching medium
410	20	Water
Ageing temperature/℃	Ageing time/h	Cooling medium
200	8	Air

3 Result and discussion

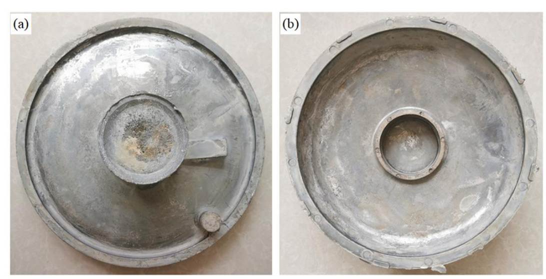

Fig. 1 Photographs showing the macroscopic morphology of ZM5 magnesium alloy baffle.

The ZM5 magnesium alloy baffle prepared by indirect squeeze casting process are shown in Fig. 1(a)(b). It can be found that the casting filling is complete; the surface of the casting is free from defects.

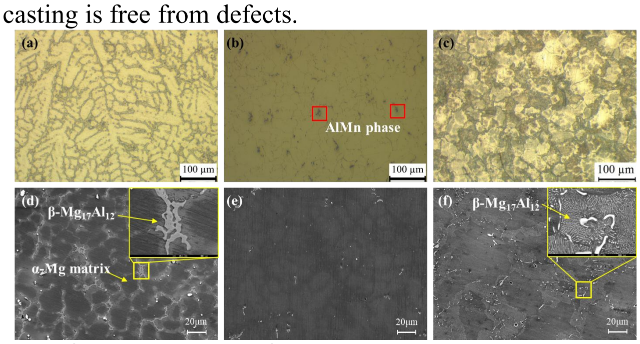

Fig. 2 Optical microscopy (OM) images showing (a) as-cast, (b) T4-treated, and (c) T6-treated ZM5 baffle. Scanning electron microscope (SEM) images showing the microscopic morphology of castings under different heat treatment processes: (a) as-cast, (b) T4-treated, and (c) T6-treated.

The microstructure of the baffle in different heat treatment states is shown in Figs. 2(a)-(f). The coarse eutectic phase $Mg_{17}Al_{12}$ of the as-cast castings is distributed on the grain boundaries in a network structure. After solid solution treatment, the second phase $Mg_{17}Al_{12}$ at the grain boundaries and inside the grains was basically dissolved into the matrix, forming α-Mg oversaturated solid solution. The lattice distortion occurred in the solid solution treated grains, and the grain size increased compared with the as-cast state. In Fig. 2(b), the red box shows the incompletely dissolved AlMn phase inside the α-Mg grains. Figs. 2(c) and (f) are the microstructure of castings after T6 treatment, and it can be found that the castings after aging treatment precipitate the second phase inside the grains in the form of continuous precipitation, and precipitate at the grain boundaries in the form of discontinuous precipitation.

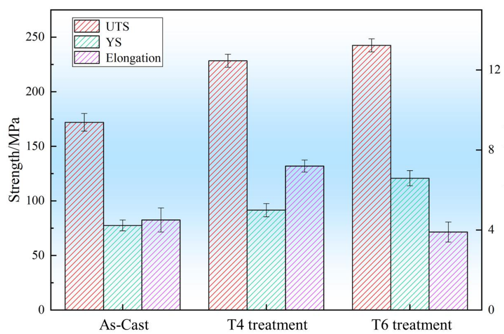

Fig. 3 Mechanical properties of castings under different heat treatment processes.

The test results of mechanical properties of castings under different heat treatment processes are shown in Fig. 3. It can be found that the mechanical properties of the castings in the T4 heat treatment state are improved compared with the as-cast state. While the tensile strength and yield strength of castings after T6 treatment are slightly improved, the elongation decreases and is even lower than the as-cast state. The lattice distortion caused by the solid solution treatment after the dissolution of the coarse second phase into the matrix and the undissolved AlMn particle plays a synergistic effect to enhance the mechanical properties of the castings, while the second phase particles re-precipitated after artificial aging become an effective nailing point to hinder the dislocation slippage, which further improves the mechanical properties, but a large number of brittle second-phase precipitation also reduces the ductility of the castings.

4 Conclusion

ZM5 magnesium alloy baffle plate was successfully prepared by indirect squeeze casting technology, and the casting is complete with no obvious defects on the surface. In terms of comprehensive strength and elongation, the baffle casting after solid solution treatment at 410℃×20h is more suitable for actual industrial production.

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