Effect of long-period stacking ordered phase on hot tearing susceptibility of Mg-Zn-xY alloys

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Introduction

Hot tearing, also known as hot crack, has been widely recognized as a major defect during solidification. It is a failure occurring in the mushy zone of a freezing alloy, i.e. at the solid fraction of $0.9 < fs < 0.99$. Mg-Zn-Y ternary alloys have been attracted much attention due to its high strength performance. The content of Zinc (Zn), yttrium (Y), and Zn/ Y (mass fraction) ratio were regarded as the two most influential factors of Mg-Zn-Y ternary alloys hot tearing. The type of precipitated phase was closely related to the and Zn/ Y ratio, when Zn/ Y ratio > 1, Zn/ Y ratio ≈ 1, Zn/ Y ratio < 1, the precipitated phase of the alloys are I phase (or I phase and W phase), W phase (or W phase and small amount of I phase), long-period stacking ordered (LOPS) phase (or small amount of W phase), respectively. Few studies have focused on hot tearing of LPSO phase influential. Therefore, effect of long-period stacking ordered phase on hot tearing susceptibility of Mg-Zn-xY alloys and the influence of m (Zn) / m (Y) ratio on Mg-Zn-Y system alloys were investigated in the present work.

Experimental Procedures

- **Material**

Mg-1Zn-xY (x=1, 2, 3);

Mg-2.5Zn-4Y, and Mg-4.5Zn-6Y

- **Text technology**

Hot tearing text system

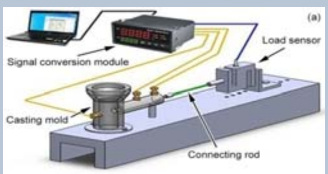

Fig. 1 Schematic of experimental setup

Thermal analysis system

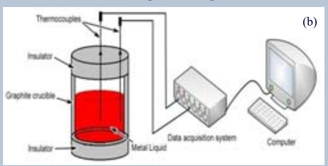

Fig. 2 Schematic diagram of thermal analysis setup

- **Microstructure observation**

XRD, SEM, EBSD

Conclusions

In the present study, The main conclusions can be summarized as follows:

(1) The LPSO phase could reduce the HTS of Mg-Zn-xY (x= 1, 2, 3) alloys.

(2) When m (Zn) / m (Y) < 1, LPSO phase formed, and the content of LPSO phase increased with increasing of Y element for Mg-Zn-xY (x= 1, 2, 3) alloys.

(3) LPSO phase benefited to the liquid flow with certain strength, and increased refilling traces at later stage of solidification.

(4) High m (Zn) / m (Y) exhibited low HTS for Mg-2.5Zn-4Y and Mg-4.5Zn-6Y alloys, and LPSO phase exists as a strengthening phase in Mg-Zn-Y alloys.

Results

Part 1. Mg-1ZnxY (x=1, 2, 3) alloys

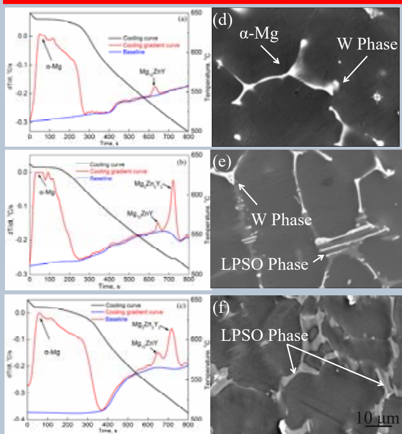

Fig. 3 Thermal analysis results of Mg-1Zn-xY alloys: (a) x=1, (b) x=2, (c) x=3; The corresponding microstructure of Mg-1Zn-xY alloys: (d) x=1, (e) x=2, (f) x=3, marked with W phase and LPSO phase.

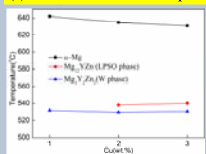

Fig. 4 The α-Mg, LPSO phase, and W phase reaction temperature of Mg-1Zn-xY alloys.

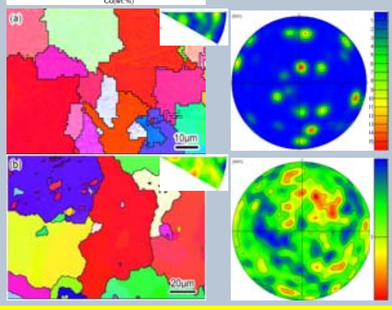

Fig. 5 EBSD maps of casting Mg-1Zn-1Y (a) and Mg-1Zn-2Y (b) alloys.

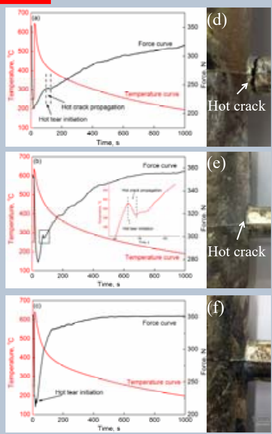

Fig. 6 The contraction force curves and microscopic samples of Mg-1Zn-xY alloys ((a) and (d) x=1, (b) and (e) x=2, (c) and (f) x=3).

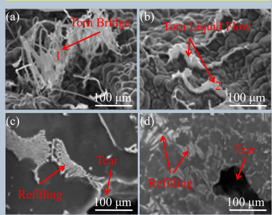

Fig. 7 Fracture surface of hot tearing and typical microstructure near hot crack region of Mg-1Zn-1Y alloys (a) and (c) and Mg-1Zn-2Y (b) and (d).

Table 1 The EDS results of point 1and 2 of Fig. 6 in atom percentage.

Point	Mg	Zn	Y
1	99.24	0.76	–
2	78.45	16.90	4.65

Part 2. Mg-2.5Zn-4Y and Mg-4.5Zn-6Y alloys (m(Zn)/m(Y) are 0.625 and 0.75, respectively)

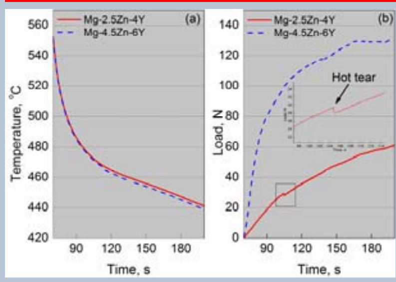

Fig. 8 The cooling and force curves of casting Mg-2.5Zn-4Y (a) and Mg-4.5Zn-6Y (b).

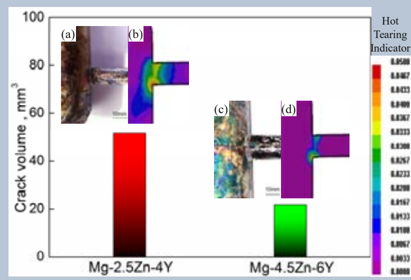

Fig. 9 The crack volumes, microscopic samples and corresponding numerical simulation results of Mg-2.5Zn-4Y (m (Zn) / m (Y) is 0.625) and Mg-4.5Zn-6Y (m (Zn) / m (Y) is 0.75) alloys.

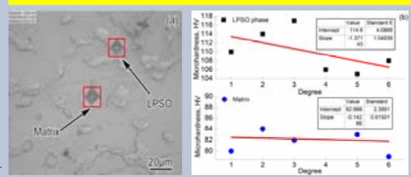

Fig. 10 Microhardness of Mg-4.5Zn-6Y alloy on matrix and LPSO phase.

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