Effect of Mold Wall Thickness on the Defect Band of AlSi10MgMn in High-Pressure Die Casting Technology

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Abstract: In order to investigate the defect band within the casting, the design of a stepped mold with a thickness gradient of 1mm (the thickness of its five stepped areas were 5mm, 4mm, 3mm, 2mm and 1mm), the selection of AlSi10MgMn alloys to carry out high pressure die casting experiments. Statistical analysis reveals that the band thicknesses of 2mm、3mm and 4mm die castings were measured to be in the range 7 - 18 mean grains wide, which is substantial evidence on that defect bands form due to strain localization in partially solidified alloys during HPDC. In addition, the defect band of 1mm, 2mm and 5mm areas are relatively indistinct. For 1mm and 2mm area, the filling and solidification process of castings plays a deterministic role. But for 5mm area, the distribution of ESCs in band is the key reason. At the same, the distribution of ESCs also makes the defect bands in the 3mm and 4mm regions well defined. Finally, no additional porosity occurs in the AlSi10MgMn alloys, which display defect bands of positive macrosegregation.

Keywords: AlSi10MgMn; High Pressure Die Casting; Defect Band; Externally Solidified Crystals; Porosity

1 Introduction

At present, the ultra-large integrated die casting technology equipped with large and complex metal molds is the first choice for achieving efficient near-net forming of complex lightweight aluminum alloy structural parts. Logically, the ultra-large integrated die is inevitably composed different wall thicknesses. This study focused on the microstructure and defects of different wall thickness areas of stepped castings under the same die casting process, and to analyze the influence of ESCs on defect bands. In addition, 3D characterization was conducted on different wall thickness areas within the stepped casting, and their porosity was statistically analyzed. The reasons for the abnormal porosity in the 1mm, 2mm, and 5mm wall thickness areas were explained.

2 Experimental procedure

The stepped sample with dimensions of 5mm, 4mm, 3mm, 2mm and 1mm was prepared by cold chamber HPDC TOYO-BD-350V5. The die casting molten metal liquid temperature is 695°C and the mold preheating temperature is 150°C.

3 Result and discussion

The defect band width (*w)* and the grain size (d_{sb}) inside of defect band were extracted and their ratio w/d_{sb} was plotted in Fig.1. The w/d_{sb} for the defect bands in the steps of 2mm, 3mm and 4mm were in the range of 7-18. This result is consistent with that for dilatant shear bands in both classical granular materials and from controlled rheology experiments on partially solid alloys[2]. This provides substantial evidence that defect bands in HPDCs are dilatant shear bands. However, the w/d_{sb} in the step of 5mm is about 24.47, which is beyond the range of 7-18.

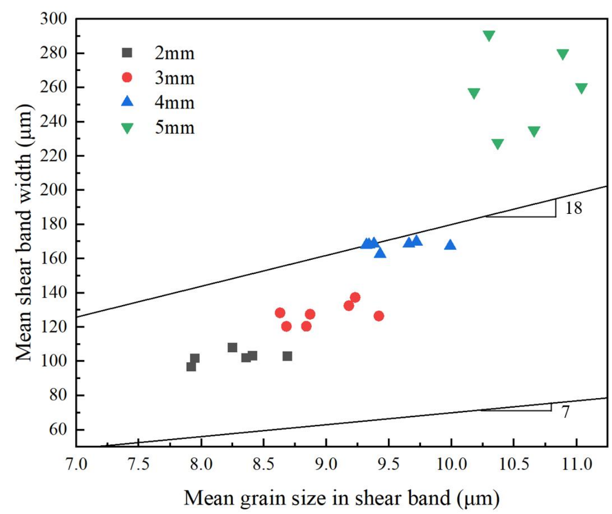

Fig. 1 The relationship between band thickness and average grain size in the defect band (w/d_{sb}) for different wall thickness area

The f_s^{coh} marks the point of impingement of the dendrites and where strength development begins, and the f_s^{pk} corresponds to the maximum packing solid fraction. When the solid fraction is higher than f_s^{pk}, the shear strength of the grain network increases rapidly[2]. The value of f_s^{coh} and f_s^{pk} is closely related to the grain size and morphology, as shown in Fig. 2. So, the distribution of ESCs in the defect band will have a serious impact on them.

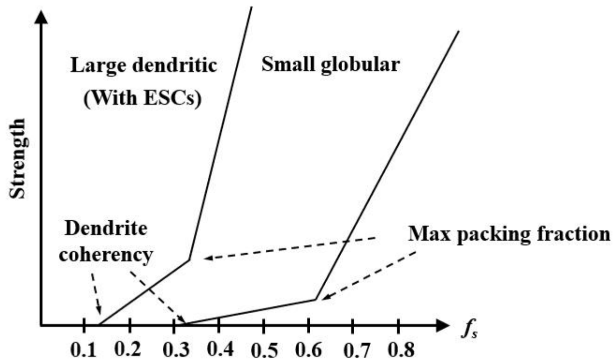

Fig. 2 General behavior of the increase of shear strength vs solid fraction in the mushy zone for two extremes in microstructures: large dendritic grains and small globular grains [2]

4 Conclusion

In order to investigated the influence of wall thickness on the defect band, AlSi10MgMn alloy was casted by HPDC equipped with one stepped die containing different thicknesses (1mm, 2mm, 3mm, 4mm and 5mm). This study has revealed the following.

The w/d_{sb} of defect bands in the steps of 2mm-4mm are in the range of 7-18. This supports the hypothesis that partially solid HPDC microstructures deform as granular materials and that strain localizes into dilatants shear bands during processing. However, the w/d_{sb} in the step of 5mm is beyond the range of 7-18. The abnormal ESCs distribution of defect bands and the lowest shear rate in the step of 5mm were considered to be the key factors.

By statistically analyzing the ESCs distribution of different wall thickness areas with different locations, filling and solidification processes, the influence of ESCs and shear rate on defect band formation was elucidated. The extensive distribution of ESCs within the defect band is not conducive to the formation of the defect band; excessive or insufficient filling speed is detrimental to the formation of defect bands.

References

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