Published in the Proceedings of the 16th International Aluminum Alloys Conference (ICAA16) 2018
ISBN: 978-1-926872-41-4
by the Canadian Institute of Mining, Metallurgy & Petroleum

MELT CONDITIONED DIRECT-CHILL CASTING OF ALUMINIUM ALLOYS

*Hu-Tian Li, Jayesh B. Patel, and Zhongyun Fan

BCAST, Brunel University London, Uxbridge, Middlesex, UB8 3PH, UK
*(*Corresponding author: Hu-Tian.Li@brunel.ac.uk)*

INTRODUCTION

Direct-chill (DC) castings of wrought Al alloys conventionally require the deliberate addition of a grain refiner (GR) to provide a fine equiaxed as-cast microstructure. However, grain refiner addition cannot ensure the achievement of high quality ingots/billets free of casting defects (e.g., porosity), coarse second phases, and uniform microstructures. Melt conditioned direct-chill (MC-DC) casting is an emerging technology to optimise the solidification process during DC casting. The MC-DC casting process combines conventional vertical DC casting with rotor-stator high shear mechanism directly in the sump to manipulate the solidification microstructure and defect formation. Intensive melt shearing in the sump has the following effects: (1) effective breakup, dispersion and uniform distribution of solid particles in the alloy melt (such as oxide films and other inclusions), which can act as nucleating sites and enhance heterogeneous nucleation during the solidification process; (2) intensive forced convection enhances mass transport and thus thermal exchange rate (thermal conditions) in such a way to shape the sump profile (Fan, et al., 2011). In this poster, refinement of grain size, porosity and the second phases by using MC-DC casting is reported. Characterisation of the second phases suggests the potential to shorten homogenisation process.

RESULTS

Grain Refinement without Grain Refiner Addition

Figure 1 shows the coarse grain structure in the DC cast billet of an A4xxx alloy of 650 mm diameter with 2 ppt of Al-5Ti-1B grain refiner addition (Figure 1a). One can see coarse dendritic grains close to the centre of the billet (Figure 1a), due to the lower cooling rate when the centre is approached, whilst grain refined uniform microstructure was achieved in MC-DC casting (Figure 1b).

Figure 1. a) Coarse grain structure of conventional DC billet of an A4xxx alloy of 650 mm diameter with 2 ppt AlTiB grain refiner and b) fine and uniform grains in MC-DC billet without grain refiner addition.

Refinement and Uniform Distribution of Secondary Phases

The main Fe-bearing intermetallics formed in MC-DC cast A6xxx is α-AlFe(Mn)Si phase with much finer size (Figures 2 and 3), which was almost no change after homogenisation (Figure 3), suggesting that the homogenisation process for MC-DC cast billet could be shortened.

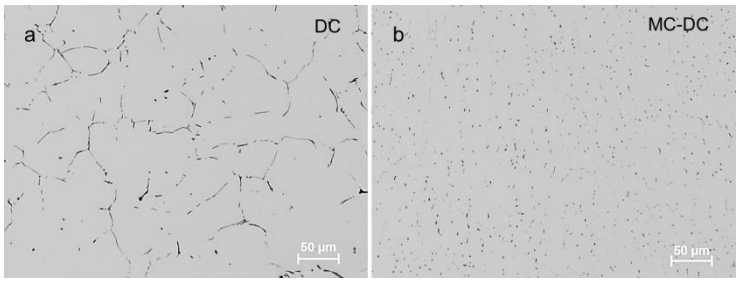

Figure 2. a) Coarse intermetallics in DC cast billet of an A6xxx alloy of 204 mm diameter with AlTiB grain refiner addition; and b) fine and uniform distribution of intermetallics in MC-DC casting without grain refiner.

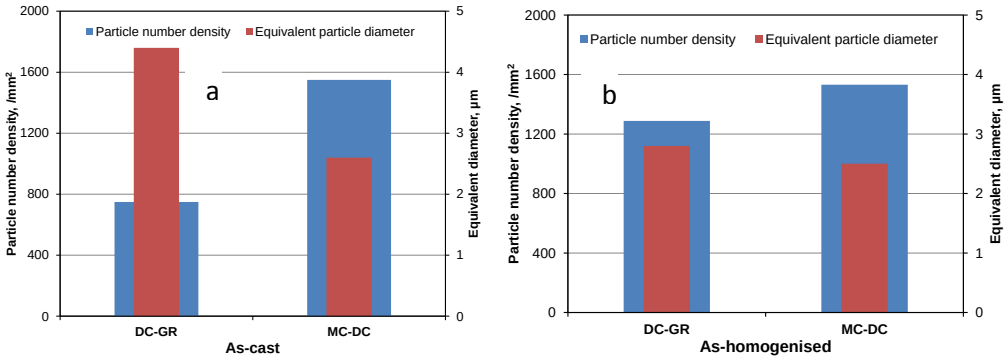

Figure 3. Characterisation of intermetallics in DC castings of an A6xxx alloy a) as-cast, b) as-homogenised.

Refinement and Reduced Porosity

Figure 4 shows refining of the porosity in MC-DC cast billet, and the reduction in the content (area fraction) of porosity, from 0.4% in conventional DC cast billet down to 0.15% in MC-DC cast billet.

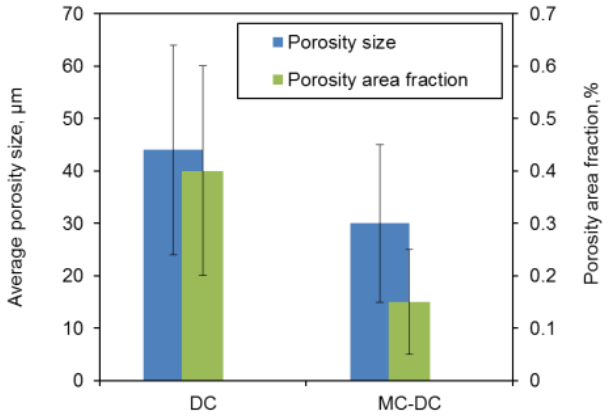

Figure 4. Refinement of porosity in DC and MC-DC cast billets of an A4xxx alloy of 650 mm diameter.

REFERENCES

Fan, Z., Zuo, Y., & Jiang, B. (2011). *Mater. Sci. Forum*, *690*, 141–144.