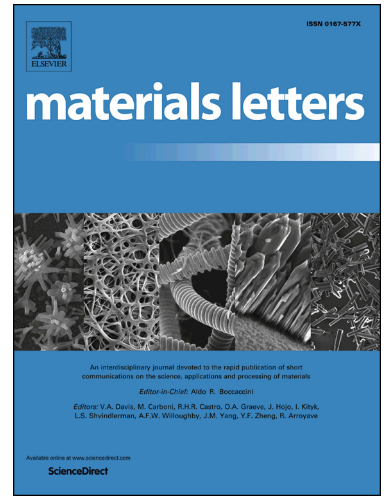
Accepted Manuscript



Considerations on the effect of solutal on the grain size of castings from superheated melts

Leandro Bolzoni, Nadendla Hari Babu

PII: S0167-577X(17)30669-9
DOI: http://dx.doi.org/10.1016/j.matlet.2017.04.117
Reference: MLBLUE 22538

To appear in: *Materials Letters*

Received Date: 23 March 2017
Accepted Date: 23 April 2017

Please cite this article as: L. Bolzoni, N.H. Babu, Considerations on the effect of solutal on the grain size of castings from superheated melts, *Materials Letters* (2017), doi: http://dx.doi.org/10.1016/j.matlet.2017.04.117

Considerations on the effect of solutal on the grain size of castings from superheated melts

Leandro Bolzoni[1,2]*, Nadendla Hari Babu[2]
[1]The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand
[2]BCAST, Brunel University London, Kingston Lane, Uxbridge, Middlesex, UB8 3PH, U.K.

Abstract

The amount of solutal present in an alloy affects the grain size of the cast metal as solute is rejected at the solidification front. This is normally quantified using the so called growth restriction factor *Q*. This work presents some considerations about the effect of solutal on the final cast structure with a focus on the nature of the alloy system, the effect of non-equilibrium solidification conditions and the effect of superheating of the molten metal.

Keywords: Casting, solidification, grain refining, phase diagram, metal and alloys

1. Introduction

The achievement of fine equiaxed grains is desirable in metals casting, independently of wrought or shape-casting alloys. Both grades benefit from better feeding of the molten metal in the mushy zone resulting in more homogeneously distributed porosity and reduced hot tearing susceptibility [1]. Apart increasing the soundness of the castings (i.e. lower rejection rate), other benefits of a fine structure are higher mechanical performances, and easier and more homogeneous subsequent mechanical working for wrought-grade alloys [2]. In every solidification process, metals casting involves nucleation of a new phase and consequent growth of the solid phase. Easton and StJohn reported that nucleation will not occur in the bulk of a metal without adequate solute being present [3]. The concept of *growth restriction factor* (*Q*) was first introduced by Maxwell and Hellawell [4] as an independent parameter relevant to the refinement of cast structure, in particular for binary Al alloys. *Q* is an extension of the early work of Tarshis et al. [5] who proposed that the solute present in the solidification front accounts for the degree of growth restriction, a parameter that was called *constitutional supercooling parameter* (*P*). *Q* and *P* are related via the equilibrium partition coefficient *k* [6]:

$$Q = m_L(k\text{-}1)C_0 = kP \tag{1}$$

where m_L is the liquid slope, and C_0 is the solute content in the alloy.

The scientific community focusing on solidification of molten metals has widely adopted the use of *Q* to relate it to the grain size (*d*) of the casting [3, 7] because otherwise complex thermodynamic models have to be implemented to study grain growth restriction [8, 9]: