Analytical solution of the problem of dissolved gas segregation in melt by the plain crystallization front

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ANALYTICAL SOLUTION OF THE PROBLEM OF DISSOLVED GAS SEGREGATION IN MELT BY THE PLAIN CRYSTALLIZATION FRONT

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Abstract

Analytical solution of the segregation problem is found for the arbitrary crystal growth law using the quasi-steady-state approximation. The segregation in this case is caused by the displacement of dissolved gas by moving plane crystallization front. The effect of solidification shrinkage on the crystallization process was taken into account. The comparison made between obtained solution and existing exact solutions shows good agreement. It is shown that in the case of "equilibrium crystallization" (when the growth rate is inversely proportional to time) the solution of the problem becomes self-similar. In this case gas concentration at the crystallization front instantly increases to a certain value and than stays the same during the whole process. At the same time the diffusion layer thickness increases proportionally to time. The conditions for the inevitability of gaseous release leading to the formation of pores in solidified material is formulated for the general case.

Keywords: Segregation; Solidification; Diffusion; Mass transfer; Single crystal growth; Growth from melt

1. Introduction

It is a well known fact that the crystallization from melts is the most common method of modern materials production. Other than the powder metallurgy and some other technologies melting the batch mixture, homogenizing and subsequent transitioning to solid state is the mainstream method. Quality of the sample directly depends on its morphology so the ability to control it is the key to creating the materials with specific functional characteristics [1]. Here solidification shrinkage effects and gas porosity play the roles of no small importance. On the one hand, all technological processes of producing solid materials

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