On the Theory of Two-Phase Zone Incipience due to the Effect of Constitutional Supercooling

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Abstract:

Directional crystallization of binary melts is one of the ways of obtaining solid materials, the quality of which is completely determined by the physical and regime parameters of the solidification process. It is well known that, under certain conditions, the solid-liquid interface becomes morphologically unstable [1] and the constitutional supercooling occurs ahead of the planar solidification front [2], which leads to the appearance of a metastable region. In this supercooled region, crystals can grow in the form of dendrites, grow on impurity inclusions, etc. As this zone is transitional between the already formed crystal and the melt, it is called a two-phase zone.

In this paper, we present the results of numerical experiments carried out in accordance with the model taking into account the formation of a two-phase zone. In particular, qualitative and quantitative patterns of the time dependence of the formation of a two-phase zone in the Fe-Ni melt are obtained under two different regimes of active and passive cooling. Based on the results of calculations, it can also be concluded that, in both cases, there are such values of the cooling parameters, under which a two-phase zone is formed very close to the right boundary of the sample, i.e. practically the whole sample remains homogeneous. Choosing the appropriate cooling mode and its parameters makes it possible to optimize the metallurgical process both in the quality of the obtained alloys and in the speed of their production.

Keywords: Moving boundary problem, partial differential equations, Stefan problem

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