Nonstationary Growth of Spherical Particles in a Supercooled Melt

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Abstract:

The processes of industrial production of many materials are frequently accompanied by phase transformations of the liquid-solid type. Such phase transitions often occur in the presence of a supercooled region - a two-phase zone. This zone is filled with crystals of solid phase, evolving in a metastable liquid. Depending on the supercooling, the crystals can be either microscopic aggregates or dendritic-like structures [1].

The evolution of an ensemble of microscopic particles in a supercooled melt is usually described using the kinetic equation for the particle-size distribution function and the balance equation for the temperature or supercooling of the liquid. The mathematical formulation of the problem depends on the law for the rate of growth of individual particles evolving in a supercooled medium. Traditionally, the steady-state approximation is used for this velocity, which follows from the solution of the stationary Stefan thermal problem for a spherical particle [2]. However, the release of heat on the surfaces of growing crystals significantly changes the temperature field around them and leads to the need to consider the non-stationary process of their growth. In this paper, the main nonstationary corrections to the steady-state law for the growth rate of spherical crystals in a supercooled metastable liquid are determined.

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

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