

On the phase interface shape at crystallization of diluted binary melt

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Within the frame of classical model of binary melt solidification extended on bidimensional case, the condition jointness problem at the crystallization front (CF) has been studied. The solution of this problem is shown to result in solution of the CF shape problem.

В рамках классической модели затвердевания бинарного расплава, распространенной на двумерный случай, исследована проблема совместности условий на фронте кристаллизации (ФК). Показано, что решение этой проблемы приводит к решению задачи о форме ФК.

The integral functional method with unknown integration region was first used to study the problem of cellular crystal growth in [1]. Small deviations from the flat crystallization front (CF) shape relating directly to its stability theory were taken as examples to illustrate the high efficiency of the method. The variation problem arising from its application, however, seems to be overdefined at a first glance. So, at a preset temperature distribution in the crystal-melt (CM) system and the preset disturbance form, one of conditions on CF can be excessive [1]. This work is aimed at the problem of the condition jointness at the CF.

As in [1], let the classic model of binary melt solidification [2] be used with its extension on bidimensional case and the unchanged crystallization direction along Ox axis. The impurity concentration in the melt, $C(x,y)$, will be measured in $C_0(1-k)/k$ units from the C_0 level, C_0 being the concentration at an infinite distance from the CF and k, the impurity distribution coefficient. The x and y coordinates as well as the cellular structure half-period l will be measured in D/v units, D being the impurity diffusion coefficient in the melt and v, the crystallization speed.

Then the impurity diffusion problem in a melt crystallizing at a constant speed can be formulated as follows:

$$C_{xx} + C_{yy} + C_x = 0, \qquad (1)$$

$$C_x(\varphi(y)) - \varphi_y C_y(\varphi(y)) + (1-k)C(\varphi(y)) + k = 0, \qquad (2)$$

$$C = 1 - B\varphi(y), \qquad (3)$$

$$C(\infty,y) = C_\infty, \quad C_y(x,0) = C_y(x,l) = 0. \qquad (4)$$

Here the indices are used to denote the partial derivatives of C with respect to x and y as well as the derivative function $\varphi(y)$ with respect to y; $x = \varphi(y)$ is the CF line equation;

$$B = \frac{kGD}{(k-1)mvC_0}, \qquad (5)$$

G, temperature gradient; m, the liquidus line slope. Eq.(2) is the impurity conservation condition at the CF. The condition (3) reflects the fact that the impurity concen-