Effect of the influence of slow rotation to stability of thermocapillary incompressible liquid flow in infinite layer in zero–gravity situation for small Prandtle number

- BIFD 2011 -

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ABSTRACT

The stability of thermocapillary flow arising in a rotating thin infinite liquid layer in zero–gravity situation is investigated. Both borders of a layer are free and also they are considered as plane, the thermocapillary tangent Marangoni force acts on them and a convective heat exchange on a Newton's law is present on the boundaries. The axis rotation is perpendicular to a liquid layer. The rotation is slow enough and allows neglecting centrifugal force [1].

Then the bound temperature is linear function of horizontal coordinates the considered thermocapillary flow is described by analytically, being the exact solution of Navier-Stokes equations [2]. There are two components of velocity: $u_0(z)$ and $v_0(z)$. The maximal values of velocity are reached on free borders of a layer, and temperature accepts extreme values near to these borders. The second component of velocity $v_0(z)$ accepts the largest value at the Taylor number $Ta = 6.5$.

According to the linear theory of stability the neutral curves depict the dependence of a critical Marangoni number on a wave number at different values of Taylor number. On the basis of the accounts which have been carried out in an interval of small Taylor numbers $0 \le Ta \le 30$ and $0 < Bi \le 1$, the influence of rotation on stability of thermocapillary flow of a fluid is appreciated at small Prandtl number *Pr=0.1* for normal perturbations as periodic in x in the form of rollers with the axis, perpendicular direction of a gradient of temperature on borders of a layer (hydrodynamic mode). The calculations by using the technique of small perturbation [3] showed the monotonous character of instability. With growth of Ta a slow rotation unstable the flow before some critical Taylor number, which value depends on Biot number. After that, with growth of Taylor number the rotation begins stabilize the thermocapillary advective flow.

The behavior of perturbation of finite amplitude in the supercritical region for Marangoni numbers (Mn) large than critical ones was investigated by a grid method on the bases of nonlinear system. Perturbations of temperature represent system alternating warm and cold spots, located along a direction of a gradient of temperature on borders of a layer. With growth of Mn a cold and warm spots serially change the site on borders of a layer. Near to minima of neutral curves perturbations of movement represent a pair of stationary spatial vortices, their place, quantity and size varies with growth of Marangoni number.

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