Instability of 2-D flow structure of non-isothermal liquid film

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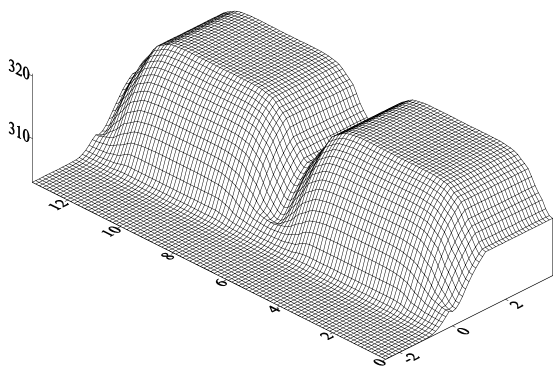
ABSTRACT

The present work is devoted to theoretical study and numerical modeling of processes in film flow of fluid on inclined surface with local heat source. Experimental researches carried out at the Institute of Thermophysics SB RAS [1] show that the effect of thermocapillarity under certain conditions can significantly influence the regime of film flow. Forming of "roller" of fluid is observed in the experiments in the area with high gradient of film surface temperature. If the temperature (or surface tension σ) gradient exceeds certain critical level then 2-D flow regime becomes unstable and periodical 3-D flow structure appears. The main quantity of fluid is gathered in periodical rivulets. Between them the thickness of film decreases significantly. The author's previous theoretical results described 2-D regime of locally heated film flow in long-wave approximation [2]. Those results allow us to state the following hypothesis: 2-D flow structure becomes unstable and 3-D perturbations grow as the local arrest of liquid is achieved due to thermocapillary effect. The results of linear stability analysis and numerical modelling are presented.

The obtained expression for the wavelength of the most unstable perturbation:

$$\Lambda = 2\pi\left[250\left(\sigma h_{\max}/3\right)^3 \rho\nu^2\right]^{1/8} \left|d\sigma/dx\right|_{\max}^{-1/2},$$

here h is the film thickness, ρ is the density and ν is the kinematic viscosity of the liquid. The period predicted by linear analysis is close to the experimental data.



The temperature at the free surface, K.

The obtained solution of linear problem is used for numerical modeling of periodical film surface and also temperature and velocity distributions. The evolution equation taking into account the non-linear kinematical effects has been solved by spectral method with periodic boundary conditions (see figure).

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REFERENCES

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[2] O.V. Sharypov and P.A. Kuibin "2D Flow Structure in a Thin Liquid Layer under Thermal Wave Propagation", *Microgravity Sci. Technol.*, Vol. **21**, pp. S321-S324, (2009).