Nonlinear dynamics of a nonisothermal thin liquid film on a horizontal cylinder subjected to axial vibration

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ABSTRACT

We recently investigated the nonlinear dynamics of an isothermal thin axisymmetric liquid film coating a horizontal cylindrical surface subjected to harmonic axial oscillation [1]. It was shown there that it is possible to arrest the long-time film rupture which occurs when the cylinder is static. This takes place if the cylinder is forced with a sufficiently high amplitude and/or frequency.

In this communication, we extend the study to the case of a nonisothermal liquid film placed on a cylindrical surface held at the uniform temperature different from that of the ambient gas phase. Due to the corrugation of the film interface the temperature along it becomes nonuniform and this in turn leads to the emergence of thermocapillary effect which affects the flow in the liquid.

Using the methods of the long-wave theory [2] we have derived a nonlinear evolution equation describing the spatiotemporal dynamics of an axisymmetric liquid film in the setting referred to above. We have shown that the critical forcing amplitude for prevention of rupture with thermocapillarity taken into account exists as in the isothermal case. It can be increased or decreased with respect to the latter [1] by applying the temperature difference ΔT, either positive or negative, between the cylinder surface and the ambient gas. The film rupture time also depends on ΔT.

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