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EFFECT OF HEAT TRANSFER THROUGH FREE SURFACE ON BUOYANT-THERMOCAPILLARY CONVECTION IN THIN LIQUID LAYERS

Abstract

In this paper, we focused on the convections driven by both buoyancy and thermocapillary forces (BTC) in thin liquid layers contained in an open rectangular cavity with differently heated sidewalls. Actually previous researchers have devoted much effort to this model mainly to study the instability of BTC, and the free surface was usually treated as an adiabatic boundary for simplicity in most theoretical and numerical researches. As a result, it is sometimes difficult to compare the ideal theoretical and numerical predictions with the practical experiments. In the present study, the significant effects of ambient air motion and heat transfer on BTC in liquid layers is the main purpose. To demonstrate the existence of the heat transfer through free surface and clarify its effects, at first one should be clear about what if the free surface is adiabatic. Among others, One of the consequences of the adiabatic assumption is that no matter how the temperature difference (T) is established, e.g. simultaneously raising the temperature of hot sidewall and lowering that of the cold by the same amount of T/2 from the ambient temperature (Te) (method 1) or keeping the cold sidewall at Te while raising the temperature of the hot untill the formation of the target T (method 2), the resultant flow will never change unless T is altered. Besides, MercierNormand claimed by asymptotic analysis that the recirculation eddies should exist near the hot wall for pure thermocapillary convection with Pr¿¿1. However, according to our PIV measurements for BTC in thin liquid layers of 50cSt and 100cSt silicone oils, the location of the recirculation eddies was different when T was established with the above two methods. The difference between our experiments and MercierNormand's theory was attributed to the effects of HTFS. In conclusion, HTFS due to natural convection has a significant effect on BTC in thin liquid layers especially for large Prandtl number fluids. A suggestion that the ambient temperature should be recorded as an important parameter during terrestrial experiments is given.