JASMAC
Conference of the Japan Society of Microgravity Appllication
JASMA

P24

自由液膜内温度差マランゴニ駆動基本対流場に対するアスペクト比の影響

Effect of aspect ratio on basic-flow pattern induced by thermocapillary effect in free liquid films

本間貴大 [1], 和田亮平 [1], 川津晃貴 [1], 塚原隆裕 [2], 上野一郎 [2]
Takahiro HOMMA [1], Ryohei WADA [1], Koki KAWAZU [1], Takahiro TSUKAHARA [2], Ichiro UENO [2]
1 東理大院, Tokyo Univ. Science
2 東理大, Tokyo Univ. Science

Thermocapillary-driven flow in a free rectangular liquid film (i.e., liquid film with two gas-liquid interfaces in a rectangular hole) under a temperature gradient parallel to the free surfaces is investigated experimentally. Dr. Donald Roy Pettit, a NASA astronaut, demonstrated a series of experiments in the International Space Station in 2003 [1]. In this experiment, he formed a thin free liquid film of water in a metallic ring and placed a heated iron close to one side of the ring. From this experiment, he found that the fluid was driven from a colder region to a hotter region even though the fluid has a negative temperature coefficient of surface tension. After such unique demonstrations, Ueno and Torii [2] indicated there exist two major basic flows in a free liquid film; double-layered flow and single-layered flow. Flow structures in the single-layered flow are indicated as functions of the shapes of liquid film; the aspect ratio $\Gamma_{zx}(\equiv L_z/L_x)$ and the volume ratio $V/V_0 < 1$, where V is the liquid volume and V_0 is the volume of the hole region $(= L_x L_z d)$. Fei et al. [3] indicated the flow direction induced by the thermocapillary effect is dominated by the volume ratio of the film and visualized the cross-sectional flow structure of the single-layered flow as well as the double-layered flow. Such effect was discussed via numerical simulations as well.[4-6]

In the present study, we focus on a multicellular flow structures in the single-layered flows by changing Γ_{zx}. In our experiments, a liquid film of 6-cSt silicone oil (Pr = 83.25) is formed in a rectangular hole in the aluminum plate. Target geometry is shown in **Fig. 1**. The variation of the cell numbers in a single-layered flow against of the liquid film is illustrated through a series of experiments (see **Fig. 2**). We will discuss the formation of the multicellular structures by making comparisons with numerical results.

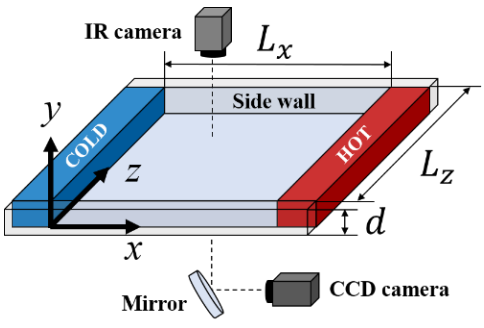

Fig. 1 Schematic of experimental apparatus

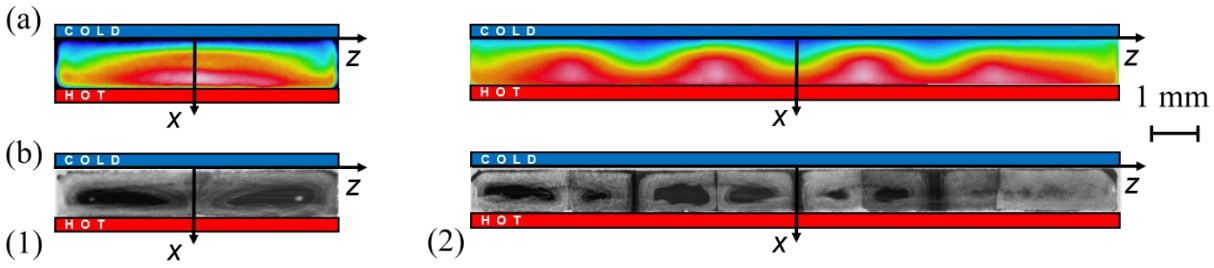

Fig. 2 (a) Temperature distributions on top free surface measured by IR camera and (b) path lines of suspended particles of 15 μm in diameter accumulated for 1 s taken by CCD camera under (1) $\boldsymbol{\Gamma_{zx} = 6}$ and $\boldsymbol{\Delta T = 3.6}$ K and (2) $\boldsymbol{\Gamma_{zx} = 15}$ and $\boldsymbol{\Delta T = 5.5}$ K.

References

1) https://spaceflight.nasa.gov/station/crew/exp6/spacechronicles_videos.html (checked: the 14th Sept. 2020).
2) I. Ueno and T. Torii, Acta Astronautica, **66** (2010) 1017.
3) L. Fei, K. Ikebukuro, T. Katsuta, T. Kaneko, I. Ueno and D.R. Pettit, Effect of static deformation on basic flow patterns in thermocapillary-driven free liquid film, Microgravity Sci. Technol. **29** (2017) 29.
4) T. Yamamoto, Y. Takagi, Y. Okano and S. Dost, Numerical investigation for the effect of the liquid film volume on thermocapillary flow direction in a thin circular liquid film, Phys. Fluids, **25** (2013) 082108.
5) T. Yamamoto, Y. Takagi, Y. Okano and S. Dost, A three-dimensional simulation of thermocapillary flow in a circular thin liquid film under zero gravity, Trans. JSASS Aerospace Tech. Japan, **12** (2014), No. ists29, Pe19.
6) T. Yamamoto, Y. Takagi, Y. Okano and S. Dost, Numerical investigation of the effect of free surface shape on the direction of thermocapillary flow in a thin circular pool, Journal of Chemical Engineering of Japan, **48** (2015), No. 6, 407.