Fluid Phase Change in Thin Gap

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Laminated steel plates are widely used as metal cores in various types of electric transformers. These cores are often immersed in insulating mineral oils, and it requires time and cost to wash the oil away when disposed. Recently a method of vapor washing with organic solvents has been proposed; it is experimentally confirmed that, under sufficiently high temperature (typically 100~200℃, depending on the solvents) and low pressure conditions, the mineral oil between the core plates is gradually replaced by the solvent vapor and completely washed away. To understand the washing mechanism and optimize the process, it is essential to investigate the phase change dynamics in such narrow gaps in more details.

We have experimentally investigated evaporation dynamics of liquid confined between solid plates under reduced pressure [1, 2]. As the test liquid, we use deionized water and several organic compounds. To visualize the fluid motion in the thin gaps, we adopt glass plates. When a test liquid is sandwiched between a float glass plate and a sand-blasted one, vertically incident light passes through the plates without much scattering; once the liquid starts to evaporate, dried rough surface of the ground glass scatters the light and we can monitor the flow pattern; typical examples are shown in Fig. 1.

Based on the transmitted light intensity, the whole plate area is categorized into three regions; completely wet, completely dry, and semi-dry one; the last one is supposed to be the state that thin liquid film spreads on the plate. In the case of water, many tiny spots of semi-dry region appear and expand at the initial stage, which is probably cavitation of dissolved gas. In organic liquid cases, evaporation seems to start from the edges of the plates. At a later stage, the semi-dry region expands with complicated branching patterns. In all cases, occasional rapid motions of liquid were observed, which correspond to two dimensional flash boiling. We also investigated the influence of the control pressure, the surface roughness, and the plate deformation.

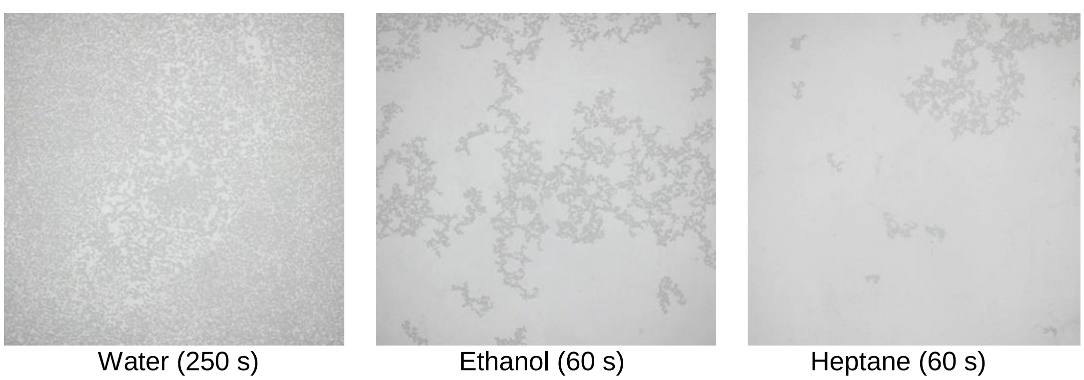

Fig. 1: Example of observed patterns during evaporation.

[1] K. Ogawa et al., "Quasi two-dimensional evaporation and boiling under reduced pressure," *Int. J. Air-Conditioning and Refrigeration*, **25**, 1750003 (2017).

[2] M. Matsumoto et al., "Evaporation and boiling in narrow gap," *Appl. Therm. Eng.*, in press.