Application of Screen Channel Liquid Acquisition Devices for Phase Separation in Microgravity

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Phase separation is critical for the supply of gas-free liquid propellant from the tank outlet to the engine of a spacecraft. In a microgravity environment, surface tension and contact angle become the governing mechanism for phase separation and dictate the position of the liquid-gas interface. Liquids with zero-degree contact angle tend to adhere to the tank wall, and gas stays in the center [1]. Therefore, to maintain a constant supply of liquid to the outlet of the tank, a liquid acquisition device (LAD) is essential. Screen channel liquid acquisition devices (SC-LAD) are a type of LAD that work on the principles of capillary action. Liquid enters into the channel through a porous screen but the entry of gas is blocked as long as the pressure difference across the screen is below its bubble point.

In this project, the experiment is designed to test the phase separation in a microgravity environment with the help of a screen channel liquid acquisition device SC-LAD. For this purpose, a supply tank has been designed with a SC-LAD inside it. The screen used in the SC-LAD is DTW 200x1400. The liquid is removed from the supply tank with the help of a gear pump and a combination of valves in the liquid pipeline. A total of 22 drop tower tests are performed with 9.1 seconds of microgravity each. The analysis of the sensor data and the images obtained by the high-speed cameras shows a successful separation of phases through the SC-LAD in subcritical conditions and ingestion of bubbles at the critical condition. A combination of various complex phenomena and their effects on one another could be also observed visually during the experiments. The phenomena observed are reorientation of the free surface under microgravity, capillary rise of liquids between parallel plates, flow through screen pressure loss due to applied removal flow rate and bubble point breakthrough of the screen.

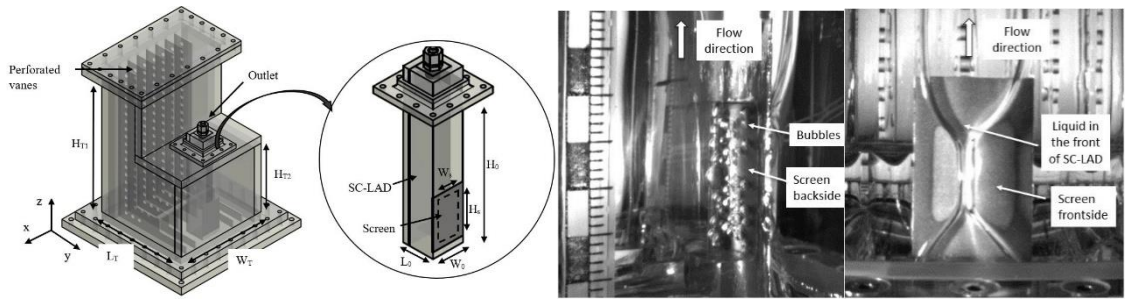

Figure 1: Experiment tank CAD model and sample drop test results showing ingested bubbles after the bubble point breakthrough.

References

[1] Kamal S. Bisht, Michael E. Dreyer, Phase separation in porous media integrated capillary channels, Microgravity Sci. Technol., 32:1001–1018, (2020).