OR2-7

低重力および地球上重力環境下密閉容器内での液体挙動 -ISS 軌道上実験に向けて-

Behaviors of Liquid Partially Filled in Sealed Vessels under Low and Normal Gravity Conditions - Toward On-orbit Experiment aboard the ISS –

千野祥瑚 [1], 村上岳 [1], 黒瀬築 [2], 鈴木和哉 [3], 坂本佑介 [3], 桜井誠人 [3], 上野一郎 [2]
Shogo CHINO[1], Gaku MURAKAMI[1], Kizuku KUROSE[2], Kazuya SUZUKI[3], Yusuke SAKAMOTO[3], Hiroki FURIHATA[3], Masato SAKURAI[3], Ichiro UENO[2]
1 東京理科大学大学院，Tokyo University of Science
2 東京理科大学，Tokyo University of Science
3 宇宙航空研究開発機構，Japan Aerospace Exploration Agency

Toward the development of Environmental Control and Life Support System (ECLSS) for the on-orbit and on-planet/satellite habitation facilities, it is essential and indispensable to understand and control the gas-liquid two-phase flow behaviors including the dynamic wetting under micro- and low-gravity conditions. Japan Aerospace Exploration Agency (JAXA) plans to conduct two types of fundamental experiments on the dynamics of fluids with free surface in closed vessels under low-gravity environment realized in the International Space Station (ISS) in 2022: (1) Sloshing test in a rectangular vessel and (2) Liquid migration test in between reservoirs (so called ‘half-hourglass’ vessel). We focus on the fluid behaviors accompanying with the movement of the solid-liquid-gas interface (contact line) and deformation of the liquid-gas interface (free surface) in each closed vessel inverted or swinged in time. In this study, prior to these on-orbit experiments, we carry out ground experiments and develop computational models to investigate the effect of the gravity level on the fluid motions.

Figure 1 shows the sealed rectangular vessel for the ground sloshing experiments. The vessel is swinged like a pendulum system around a single central point in the *x-y* plane. The ground experiments were conducted on two different systems by inverting the vessel: liquid fills on the side (a)without and (b)with the baffle to investigate the amplitude of the liquid level in the vessel swinged near resonant frequency[1,2] and the deformation of the gas-liquid interface when the liquid flows over the baffle, respectively. The test fluids were the air and the water for the gas and the liquid, respectively. Panels (a) and (b) in **Fig. 2** show the three-dimensional simulation models without and with the baffle, respectively, which was established to match the experimental system. We performed a series of the ground experiments and the simulations by varying the oscillation frequency and the swing angle of the vessel. The validity of the simulation model was checked by comparing the experimental results. Furthermore, the effects of gravity level and oscillation conditions on the liquid behavior were examined.

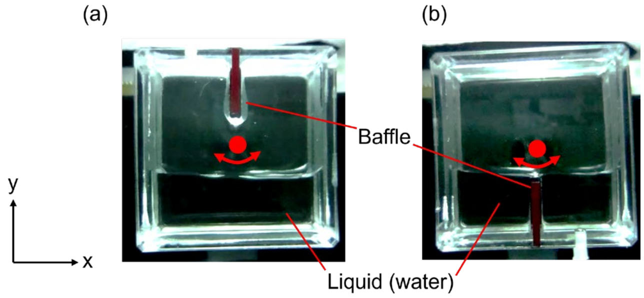

Figure 1. Rectangular vessels for sloshing experiment (a) without and (b) with baffle.

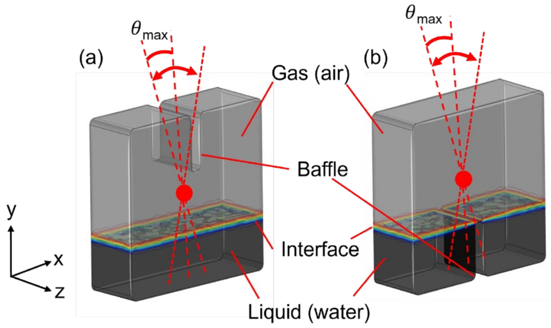

Figure 2. Simulation models for sloshing test (a) without and (b) with baffle.

Figure 3 shows the 'half-hourglass' vessel for the liquid migration test. The liquid transferred from the one reservoir to another through the narrow channel by flipping the vessel, that is, changing the direction of gravity. We examined two types of the test liquids: water and oils for low- and high-viscosity liquids. **Figure 4** shows the simulation model of the half-hourglass vessel. The effects of viscosity on falling behavior and liquid movement were investigated experimentally and numerically. We especially focus on liquid motion along the corner due to surface tension[3]. Additionally, the effects of gravity level on the fluid motion including the Rayleigh-Taylor instability were investigated.

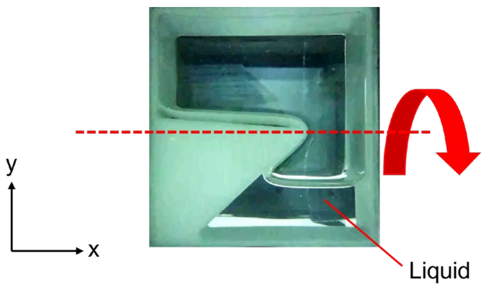

Figure 3. 'Half-hourglass' vessel for liquid migration experiment

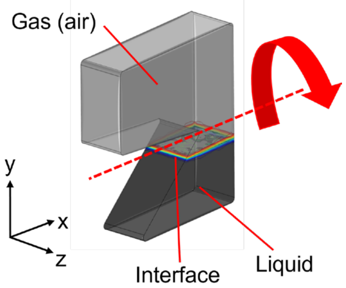

Figure 4. Simulation model for liquid migration test

2.4. References

1) H. Lamb: Hydrodynamics, Cambridge University Press (1932).

2) G.W. Housner: The Dynamic Behavior of Water Tank, Bulletin of The Seismological Society of America, **53** (1963) 381, DOI: 10.1785/BSSA0530020381.

3) M.M. Weislogel and R.M. Jenson: Passive no moving parts capillary solutions for spacecraft life support systems, International Conference on Environmental Systems **49** (2019) 203, URL: https://hdl.handle.net/2346/84433 (visited on the 28th Jul. 2022).