Sloshing instability driven by bubble plume

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Some molten glass furnaces are stirred by gas flames in the volume, leading to surface instabilities that can have important industrial consequences. We design and built an analog experiment with water and air as working fluids. A sparger is immersed in a water tank and injects air vertically at a constant air flow rate. An air plume is then created : air bubbles rise up towards the water surface. Above a certain flow rate, a sloshing mode grows at the water surface, due to a complex interaction with the air plume, as previously observed in a similar geometry by Aoki *et al.* [1].

In this study, we aim at identifying when and why the surface destabilizes. Our main control parameters are the air flow rate and the tank aspect ratio, $R = \frac{h_0}{L}$, where h_0 is the static water height and L the tank width. To measure the bubble trajectories and the free surface position, we use shadowgraphy techniques.

Figure 1. Planar view of the bubble plume with self-induced sloshing

We characterize the instability by measuring the critical air flow rate as a function of tank aspect ratio, and the oscillating frequency. To identify the instability mechanism, we performed a spectral analysis in time of both the jet and the surface. We show that the sloshing frequency is incompatible with low frequency oscillations of bubble wakes, which occurs in mixing bubble columns used in chemical engineering for example [2]. We eventually propose a phenomenological model of coupled oscillators to explain what motors this instability.

Références

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2. L. Liu, H. Yan, T. Ziegenhein, H. Hessenkemper, Q. Li & D. Lucas, A systematic experimental study and dimensionless analysis of bubble plume oscillations in rectangular bubble columns, *Chem. Eng. J.*, **372**, 352–362 (2019).