

Influence of gas properties on bubble behavior in a 3D fluidized catalyst bed

Yuto Fukami, Takami Kai, Tsutomu Nakazato

Abstract

Bubble size is one of the most important parameters in the fluidized bed reactor model. Therefore, many bubble size correlations have been also proposed¹⁾. However, almost all of these correlations are obtained by experiments using air as the fluidizing gas and Geldart B particles are used at room temperature. The gas properties are not considered in the correlations. However, in the case of particles classified as Geldart A particles, the expansion rate of the emulsion phase is affected by gas properties²⁾. The bubble size is also greatly influenced by the gas properties indirectly^{3, 4)}. We observed the bubble behavior with various types of gas in a two-dimensional fluidized bed using image analysis⁵⁾. It was confirmed that the voidage of the emulsion phase and bubble behavior was affected by the gas properties. In this study, we measured the frequency of bubbles rising in the bed to clarify the influence of the gas properties on the bubble size in a three-dimensional fluidized bed.

The fluidized bed used in this study is made of acrylic resin that have an inner diameter of 5 cm and a height of 100 cm. Porous silica having a particle diameter of 49 μm and a density of 754 kg/m^3 was used as the fluidized particles. The initial settled bed height was about 30 cm. Argon, carbon dioxide, hydrogen, nitrogen and neon are used as the fluidizing gas. An optical probe having an outer diameter of 1.2 mm was used. The probe was inserted horizontally into the bed, and the bubble frequency was measured by changing the position of the tip in the radial direction and the vertical direction. In order to calculate the bubble size from the bubble frequency measured by the optical probe, the following two assumptions were made: i) the bubble is spherical and has no bubble size distribution, ii) all bubbles passing through the horizontal plane with the tip of the optical probe were detected.

Fig. 1 shows the change in the bubble size based on the bubble frequency with $U_G - U_c$ at a height of 30 cm. The silica particles are fluidized with each gas in the 3D fluidized bed. When the bed was fluidized with hydrogen, the bubble size was the largest and decreased in the order of carbon dioxide, nitrogen, argon and neon. Since it has been reported that the expansion ratio of the emulsion phase is inversely proportional to the gas viscosity and density to the power of 0.12. The bubble size decreased with increasing the parameter. It is confirmed that the emulsion phase voidage was small and the bubble size was large when hydrogen was the fluidizing gas in a 2D fluidized bed. Thus, the gas properties affect the expansion ratio of the emulsion phase, and finally affect the bubble size. We directly observed⁶⁾ the bubble size in a 2D fluidized bed. Because the depth was very small, bubble growth was probably influenced by the friction by the walls. The bubble size in the 2D fluidized bed was much smaller than that in the 3D fluidized bed. In order to confirm the relationship between the gas properties and the bubble size, the result in the 3D fluidized bed was compared with that in the 2D fluidized bed in **Fig. 2**. The horizontal axis is the bubble size in the 2D fluidized bed, and the vertical axis is the bubble size in the 3D fluidized bed. The same particles were fluidized, and the bubble size were measured at 0.15 m height for both of them. Although the bubble size in the 3D fluidized bed was much larger than that in the 2D fluidized bed, it can be seen that the effect of the gas properties on the bubble size was almost the same for both the fluidized bed.

References

- 1) Karimipouret, S. *et al.*, *Powder Technol.*, **205**, 1–14 (2011).
- 2) Abrahamsen, A.R. *et al.*, *Powder Technol.*, **26**, 47–55 (1980).
- 3) Kai, T. *et al.*, *J. Chem. Eng. Japan*, **19**, 67–71 (1986).
- 4) Kai, T. *et al.*, *Powder Technol.*, **51**, 267–271 (1987).
- 5) Hiromori, Y. *et al.*, Preprint 24th SCEJ Symp. Fluidization & Particle Processing, Hachioji, Dec. 5-7, 97–100 (2018).

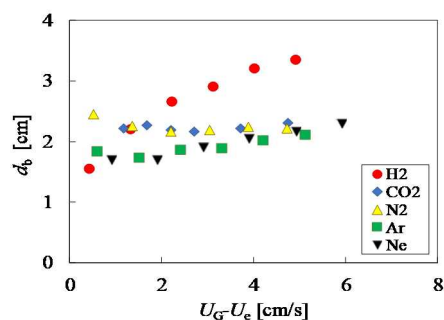


Fig. 1 Effect of gas type and gas velocity on bubble size; $L = 30$ cm.

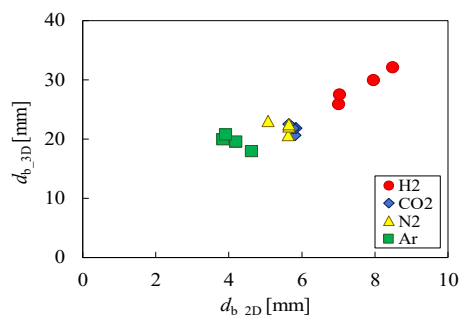


Fig. 2 Comparison of bubble size measured in a 2D-fluidized bed and in a 3D-fluidized bed.