Mechanism of influence of gas properties on bubble behavior in a fluidized catalyst bed

The 31st International Symposium on Chemical Engineering, November 30 - December 2, 2018, Chiang Mai, Thailand

Mechanism of influence of gas properties on bubble behavior in a fluidized catalyst bed

Yuta Hiromori, Takami Kai, Tsutomu Nakazato

Abstract

In order to apply fluidized catalyst beds to many reactions while utilizing the advantage of fluidized beds, many reactor models for determining the conversion have been proposed[1)]. Bubble size is one of the important parameters. Therefore, many correlations for bubble size have been also proposed previously[2)]. However, to obtain these correlations, air was used as the fluidizing gas at room temperature, and the properties of the fluidizing gas were not considered. The expansion ratio of the emulsion phase is influenced by gas properties such as gas viscosity and gas density for Geldart's A particles[3)], and bubble size is also greatly affected by these properties[4)]. When the catalyst particles were fluidized, the bubble size was strongly influenced by the properties of the fluidizing gas[5)]. Therefore, it is important to clarify the influence of gas properties on bubble size to accurately estimate the conversions in industrial reactors using various types of gases at high reaction temperature. The purpose of this study is to clarify the influence of gas properties on bubble size in fluidized catalyst beds.

Two-dimensional fluidized beds made of glass was used to prevent particle adhesion to the wall due to static electrostatic force and to observe inside the wall. The height of the column was 0.8 m and the width 0.15 m. Porous silica was used as fluidizing particles. Five types of gases were used as the fluidizing gas. The bed was illuminated from the back side using an LED light panel, and the fluidization behavior was photographed by a video camera from the front side. The photographed images were captured by a computer, and they were processed. The difference in the voidage of the emulsion phase was expressed by color gradation. Gray-scale images were obtained via backlight transmitted through the emulsion phase in a two-dimensional fluidized bed. The gray-scale images were converted to color images using a color gradation based on digital image conversion.

Fig. 1 shows the state of fluidization when Si-1 particles were fluidized with each gas at $U_G - U_e$ = 6.0 cm/s. It is clearly shown that bubble size was affected by the gas type. The emulsion phase voidage was also affected by the type of gases. The voidage when the bed was fluidized by hydrogen was small and almost equal to that of the fixed bed. On the other hand, when fluidized by argon, the emulsion phase expanded and the voidage was large. These results indicate that the emulsion phase expansion and bubble size are affected by the gas properties. Since the expansion ratio was affected by the gas properties[6)], it is considered that bubble size is influenced by the voidage of the emulsion phase. Gas properties would not directly affect the bubble size, but directly affect the expansion ratio and voidage of the emulsion phase. Therefore, the bubble size was correlated using the concept of apparent viscosity of the emulsion phase. Apparent viscosity is correlated by particle size, particle density and emulsion phase voidage[7)].

Fig. 2 shows the relationship between bubble size and the apparent viscosity. The bubble size increased with the apparent viscosity. For the same particle system, the bubble size increased with the apparent viscosity due to the influence of the emulsion phase expansion ratio. In addition, the bubble size increased with increasing the particle size when the bed was fluidized by the same type of gas. However, the smaller the particle size, the greater the influence of the emulsion phase expansion ratio on the bubble size. Even though the change in apparent viscosity is small, the change in bubble size is very large in Si-1. This is because the bubble size was restricted by the size of experimental equipment and the bubble size in this figure would not necessarily reach the equilibrium bubble size (especially in the case of large and heavy particles).

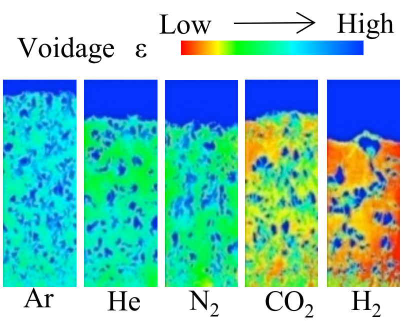

Fig. 1 Effects of gas type on the fluidization behaviors (Si-1).

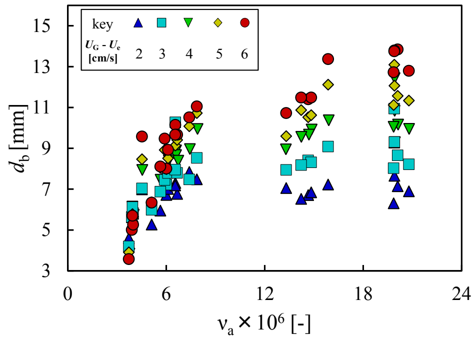

Fig. 2 Relationship between apparent viscosity and bubble diameter.

References

1) Philippsen, C. G. *et al.*, *J. Mater. Res. Technol.*, **4**, 208–216 (2015).
2) Karimipouret, S. *et al.*, *Powder Technol.*, **205**, 1–14 (2011).
3) Abrahamsen, A.R. *et al.*, *Powder Technol.*, 26, 47–55 (1980).
4) Kai, T. *et al.*, *J. Chem. Eng. Japan*, **19**, 67–71 (1986).
5) Kai, T. *et al.*, *Powder Technol.*, **51**, 267–271 (1987).
6) Kai, T. *et al.*, *J. Chem. Eng. Japan*, **20**, 282–286 (1987).
7) Kai, T. *et al.*, *J. Chem. Eng. Japan.*, **24**, 494–500 (1991).

Department of Chemical Engineering, Kagoshima University, Kagoshima 890-0065, Japan