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Range of particle properties affecting the defluidization caused by gas switching

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Abstract

Gas-solid fluidized beds are used in various fields such as catalytic reaction, combustion, gasification and granulation. Fluidizing gas is not usually switched in the steady state operation. However, this operation is performed to change reactant gases with an inert gas when starting up or shutting down operation. Rietema and Hoebink[1] reported that the defluidization occurred when the lower density gas was switched to the higher density gas. Kai and Takahashi[2] investigated the influence of gas properties in detail. As the result, they found that the intensity of the defluidization depends on the difference in the reciprocal route of the molecular weight of the two gases. They considered the non-equimolar counter diffusion and the bulk flow due to the pressure difference to describe this phenomenon and proposed a model based on this idea. It has been reported that simulation of non-equimolar diffusion phenomenon in an isobaric system called Graham's law can be performed and the experimental results by other researchers can be explained well[3]. The purpose of this study is to clarify the influence of particle properties on the defluidization. In addition, the methods to mitigate the influence of defluidization is proposed.

An acrylic resin tube was used for the construction of fluidized bed. The inner diameter and height were 52 mm and 1500 mm, respectively. The combination of gases was H_2/N_2, H_2/Ar, He/N_2 and He/Ar. Porous silica particles were fluidized. In the experiments, the first gas was supplied and the stable fluidization was confirmed. Then the data sampling by a pressure sensor was started. The fluidizing gas was changed to the second gas after 10 s. This procedure was repeated five times to determine the average value of the pressure change.

Based on the experimental results obtained by changing particle size and density for H_2/Ar system, the values of the three parameters in the correlation were determined. **Fig. 1** shows the relationship between particle diameter and particle density that bring η = 0.01 and η = 0.05. The difference between the particle properties when η = 0.01 and η = 0.05 was small. By assuming that defluidization does not occur when η is less than 0.01, the region is beyond the curve for η = 0.01. On the other hand, defluidization will possibly occur in the region below the curve. In addition, the intensity of defluidization increase the particle properties is far from the curve. Fig. 2 also shows the particle properties that are used for fluidized catalyst beds as region AA [4]. This figure clearly indicates that defluidiztion highly likely occur in fluidized catalyst beds.

In this study, a gradual change of gases is evaluated to avoid defluidization. A wind box was installed on the gas feed line just before the fluidized bed. The first gas and the second gas were mixed in the box and the mixture was supplied to the fluidized bed. The gas replacement time was varied by varying the volume of the wind box. The change in gas composition with time was measured by gas chromatography. The replacement time increased with increasing the box volume. **Fig. 2** shows the pressure change when gas is gradually switched from He to Ar. The induction time of defluidization increased with the replacement time, t_S. In addition, the intensity of defluidization decreased with increasing t_S. When t_S was 310 s, channeling did not occur and a good fluidization could be maintained. It was found that temporary defluidization due to non-equimolar diffusion can be prevented by the gradual gas switching.

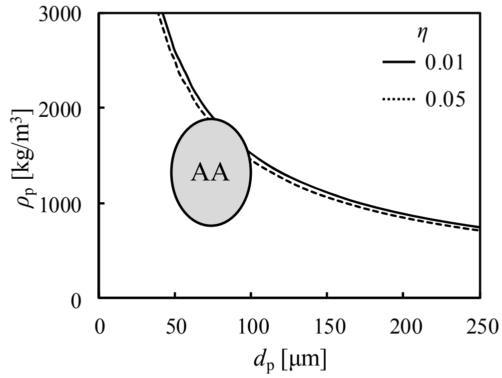

Fig. 1 Range of particle properties having possibility of defluidization by the gas switching.

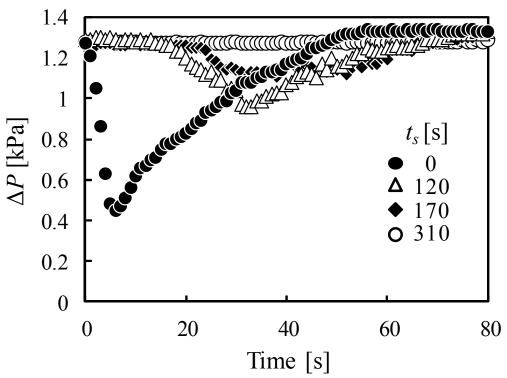

Fig. 2 Effect of the time required for substitution of fluidizing gas from He to Ar.

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