A study on the solid holdup in a circulating fluidized bed riser using electrical capacitance volume tomography

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INTRODUCTION

Due to the high heat transfer and mixing efficiency of particles, fluidized bed technology was used for many thermochemical processes such as chemical, power generation, petroleum and thermal conversion processes. Because the performance of a fluidized bed is influenced by characteristics of fluidization, understanding the hydrodynamic characteristics of complex gas-solid flow in fluidized bed is significant research. These basics can provide the improvement of reactor design, scale-up and experimental condition. Hence various measurement methods have been applied to investigate gas-solid flow systems. Among these techniques, electrical capacitance volume tomography (ECVT) technique is a newly developed imaging technique. This imaging technique generates a whole volumetric three-dimensional image of the sensing area using the measured capacitance. In addition ECVT shows a real-time 3-D volume image. From the volumetric image in fluidized bed, the researchers understand the solid distribution and behavior in the fluidized bed intuitively. In this study, to investigate the particles behavior in a circulating fluidized bed (CFB) reactor, ECVT analysis was performed.

MATERIALS AND EXPERIMENTAL METHODS

Fig. 1 shows the experimental apparatus of this study. The experimental apparatus consist of riser, cyclone, down comer, loop seal and blower. Inner diameter and height of riser are 0.165 m and 5.1 m, respectively. Fig. 2 shows the ECVT system. For measurement of the solid hold-up of riser, ECVT sensor which has 24 sensing points was installed at the surface of CFB riser. And the capacitor sensor measured the capacitance between all inter-plate combinations in real time. The measuring data were reconstructed to provide an image of the phase concentration that is within the targeted volume. The capacitance data is collected and processed by a data acquisition system (DAS-2) which works as an intermediary between the ECVT sensor and host computer. The standard silica sand was used as fluidizing material.

Fig. 1 Experimental apparatus

Fig. 2 Electrical capacitance volume tomography

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The solid circulation rate (3.68, 11.75 and 15.66 kg/m²-s) and the measuring point (0.22-0.47, 1.08-1.33, 1.75-2.0, 3.12-3.37 and 4.85-5.1 m from the distributor) were used as an experimental variables. When the fluidization is stabilized, the measurement is started for 10 minutes.

RESULTS AND DISCUSSION

Fig. 3 and Fig.4 show time-averaged vertical and horizontal solid holdup distribution in riser, respectively. As shown in these figures, the 3-D image of measured volume is the strength of ECVT. From the Fig.3 and Fig.4, the solid holdup is highest at the bottom area and the lowest at the middle area. In the top area, solid holdup is a little higher than middle area because of the narrow cyclone entrance. The solid holdup distribution trends are very similar. But as solid circulation rate increases, annular flow is clearly observed.

CONCLUSION

In the present study, the particles behavior in a circulating fluidized bed riser is investigated using the ECVT. From the reconstructed 3-D image, distribution of sand particles with variation of riser height and solid circulation rate can be shown intuitively. Solid holdup of bottom area is the highest and that of middle area is the lowest. In the bottom area, annular flow is observed. At the high solid circulation rate, annular flow is clearly shown. From the results of this study, ECVT can help increase analytical accuracy of fluidization phenomenon in the CFB.

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