

# Gas Holdup in a Pressurized Slurry Bubble Column

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## Abstract

Gas holdup in a slurry bubble column was studied experimentally under the condition where the pressure was from 0.1 MPa to 1.1 MPa, and the superficial gas velocity was in the range from 1.0 cm/s to 15.0 cm/s.

Significant influence of pressure on gas holdup was observed when  $\text{CaCO}_3$  particles with diameter of  $16\text{ }\mu\text{m}$  or glass beads with diameter of  $17\text{ }\mu\text{m}$  were used as solid particles and the superficial gas velocity was larger than 4.0 cm/s.

## Introduction

The slurry bubble columns are often used as slurry reactors under pressurized condition. Gas holdup is required for a reliable design of a three-phase slurry reactor.

The effect of pressure on the gas holdup in the bubble columns was already studied by several authors<sup>3,4)</sup>, but the article on the effect of pressure on gas holdup in the slurry bubble column was presented only by Deckwer et al.<sup>2)</sup>. They found no significant effect of pressure on gas holdup in the slurry bubble column where the pressure was in the range lower than 1 MPa and the superficial gas velocity was less than  $4 \times 10^{-2}$  m/s.

We have studied the influence of pressure on the gas holdup and the bubble frequency in the relatively larger gas velocity than that of the previous work<sup>2)</sup>. A significant effect of pressure on gas holdup and bubble frequency was found in a certain range of experimental condition.

## 1. Experimental

The schematic diagram of the experimental apparatus is shown in Figure 1. The bubble column was a stainless steel tube having inner diameter of 45 mm. The height of the three phase contacting section was between 0.81 m and 1.38 m.

The gas was sparged into the column by metal sintered plate having a mean pore diameter of  $185\text{ }\mu\text{m}$  and by a single nozzle with inner diameter of 3 mm.

Air was used as the gas phase and its flow rate was measured by the orifice flow meters after reducing the pressure to a tomospheric pressure. As the solid phase three kinds of solid particles, glass beads with diameter between 0.105 mm and 0.125 mm, fine glass beads with mean diameter of  $17\text{ }\mu\text{m}$  and  $\text{CaCO}_3$  particles with mean diameter of  $16\text{ }\mu\text{m}$  were used.

The gas holdup was obtained from the expanded height of gas-liquid-solid system and



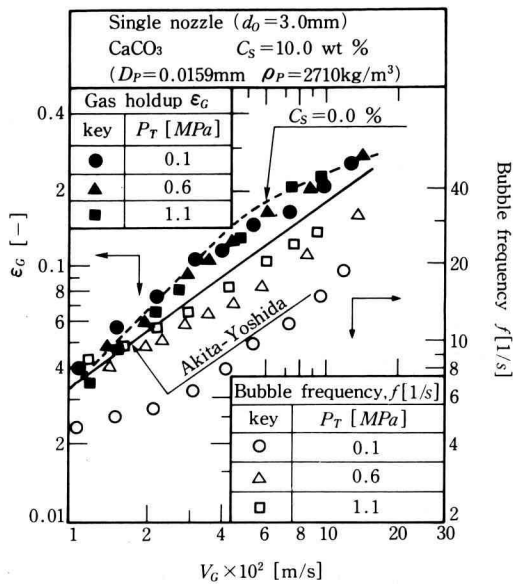


Fig. 2. Gas holdup and bubble frequency in the pressurized slurry bubble column equipped with a single nozzle as the gas distributor.

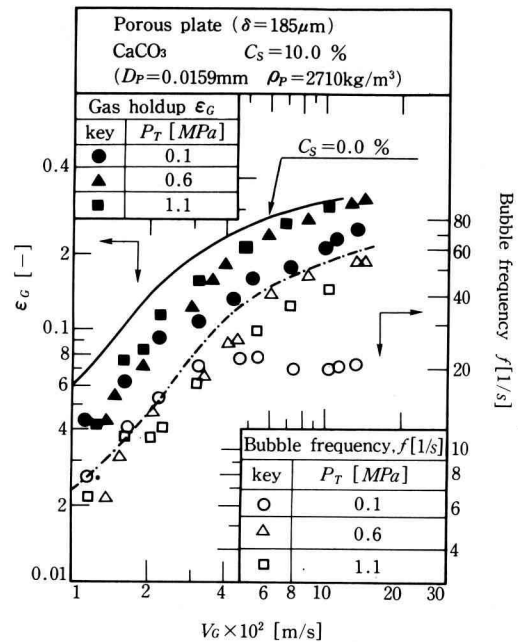


Fig. 3. Gas holdup and bubble frequency in the pressurized slurry bubble column equipped with a porous plate as the gas distributor.

the height of gas free suspension. These heights were measured by the level sensing device, which is a stainless steel pipe (4 mm in diameter) having 40 point-electrodes with an interval between 1.0 cm and 2.0 cm.

The bubble frequency at the center of the bubble column was measured by the void meter (KANOMAX 7931).

The range of the experimental conditions is summarized in Table 1.

## 2. Experimental results

### 2.1 Gas holdup and bubble frequency in the slurry bubble column equipped with the single nozzle.

Gas holdup and bubble frequency in the bubble column equipped with the single nozzle using  $\text{CaCO}_3$  particles as the solid phase are plotted in Fig. 2 against the superficial gas velocity based on the pressure and the temperature in the slurry bubble column.

The dotted line in Fig. 2 is the representative line for the present data of the gas holdup in the bubble column containing no solid particles. The solid line represents the empirical equation of Akita et al.<sup>1)</sup> As shown in this figure, the effect of pressure on gas holdup was not observed, but the bubble frequency increased slightly with the pressure. Even in the case where the other kind of solid particles was used, the same tendency as in Fig. 2 was observed

in the bubble column equipped with the single nozzle.

## 2.2 Gas holdup and bubble frequency in the slurry bubble column equipped with the porous plate.

Experimental results in the bubble column containing  $\text{CaCO}_3$  particles of 10% in solid concentration are shown in Fig. 3. As shown in this figure, in the region where the superficial gas velocity is beyond about  $4 \times 10^{-2}$  m/s, gas holdup on the pressurized conditions becomes larger about 40% than those on the atmospheric condition and shows the tendency approaching to gas holdup in the bubble column with no solid particles.

The solid line in Fig. 3 represents the gas holdup in the bubble column containing no solid particles. The bubble frequency data on the pressurized condition shows the larger values than those on the atmospheric condition in the superficial gas velocity above  $4 \times 10^{-2}$  m/s. The dashed line in this figure is the representative line of the bubble frequency data in the bubble column containing no solid particles.

With increase of solid concentration of  $\text{CaCO}_3$  particles beyond 10%, the effect of pressure on gas holdup and bubble frequency was decreased.

Same tendency as in the slurry bubble column containing  $\text{CaCO}_3$  particles was observed in the slurry bubble column containing fine glass beads (mean diameter  $17 \mu\text{m}$ ). On the other hand, when the glass beads of diameter between 0.105 and 0.125 mm were used as solid phase in the slurry bubble column equipped with the porous plate, no effect of the pressure on gas holdup and bubble frequency was observed.

## Conclusion

The effect of pressure in the range from 0.1 to 1.1 MPa on the gas holdup and bubble frequency was experimentally examined in the slurry bubble column.

It was found that the effect of pressure on gas holdup appeared most significantly in the bubble column equipped with porous plate under the condition that superficial gas velocity was beyond 4.0 cm/s and the solid concentration of  $17 \mu\text{m}$ -glass beads or  $16 \mu\text{m}$ - $\text{CaCO}_3$  particles was 10%.

## Nomenclature

$C_s$ : solid concentration in gas free slurry in weight percent	[%]
$D_p$ : diameter of solid particles	[mm]
$d_o$ : diameter of single nozzle	[mm]
$f$ : frequency of bubble at the center of the slurry bubble column	[s <sup>-1</sup> ]
$P_T$ : pressure in the slurry bubble column	[MPa]
$V_G$ : superficial gas velocity based on the condition in the slurry bubble column	[m/s]
$\rho_P$ : specific density of solid particles	[kg/m <sup>3</sup> ]
$\epsilon_G$ : gas holdup	[—]

**Literature cited**

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