Experimental Study on Fluidization Characteristics of Cohesive Geldart Group B Particles (Postprint)

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Abstract

This study, for the first time, reconstructs the three-dimensional morphology of local bubbles during the fluidization of cohesive Group B particles based on multi-source X-ray tomography imaging technique and the Simultaneous Algebraic Reconstruction Technique (SART), and obtains abundant global fluidization information by combining pressure fluctuation analysis technique. Experimental results demonstrate that the increase in cohesive force enhances bubble coalescence, leading to increased bubble size and decreased frequency and velocity. When the bed temperature exceeds 35°C, the slugging regime is triggered and occurs alternately with the free fluidization state. Moreover, the greater the cohesive force, the longer the time proportion occupied by slugging in the fluidization process.

Full Text

Effects of Cohesive Force on Bubble Behavior in Gas-Solid Fluidized Beds

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Abstract
This study investigates the influence of cohesive interparticle forces on hydrodynamic behavior in gas-solid fluidized beds, particularly focusing on bubble characteristics and pressure fluctuation patterns under various operating conditions.

1. Introduction

Interparticle cohesive forces significantly affect fluidization quality and bubble dynamics in gas-solid systems. Previous research has demonstrated that liquid bridges, thermal effects, and chemical reactions can induce cohesive forces that alter fluidization behavior [?, ?, ?]. The presence of cohesive forces influences bubble size, shape, and rising velocity, which in turn affects heat and mass transfer efficiency [?, ?, ?]. Recent advances in non-invasive measurement techniques, such as X-ray tomography and pressure fluctuation analysis, have enabled detailed characterization of bubble properties in cohesive systems [?, ?]. This work systematically examines how cohesive forces modify bubble reconstruction, rising velocity, and pressure signal characteristics at different measurement frequencies and axial positions.

2. Experimental Methodology

Experiments were conducted in a gas-solid fluidized bed with Geldart B particles under controlled cohesive force conditions. The static bed height was maintained at 300 mm, and fluidization gas velocity was set at $2.5U_{mf}$ (minimum fluidization velocity). Pressure fluctuations were recorded at multiple axial positions using high-frequency transducers. Data acquisition was performed at four distinct sampling frequencies: 2500 Hz, 1250 Hz, 1 Hz, and 0.1 Hz to capture both rapid bubble dynamics and slow bed oscillations.

3. Results and Discussion

3.1 Bubble Reconstruction and Morphology Figure 5 [Figure 5: see original paper] illustrates the effects of cohesive force on bubbles reconstructed at 70 mm above the gas distributor. The results demonstrate that increasing cohesive force leads to larger, more irregular bubble shapes due to enhanced particle clustering. The static bed height of 300 mm and fluidization gas velocity of $2.5U_{mf}$ provided stable operating conditions for comparative analysis.

3.2 Bubble Rising Velocity The averaged rising velocity of bubbles was measured at different axial heights to quantify the influence of cohesive forces on bubble propagation. As shown in Figure 7 [Figure 7: see original paper], cohesive forces reduce bubble rising velocity, particularly in the lower dense region of the bed. The experimental parameters remained consistent with a static bed height of 300 mm and fluidization gas velocity of $2.5U_{mf}$.

3.3 Pressure Signal Frequency Analysis The average frequency of pressure fluctuations was analyzed as a function of cohesive force and measurement height (Figure 9 [Figure 9: see original paper]). At a fluidization gas velocity of $2U_{mf}$ and static bed height of 300 mm, cohesive forces were found to suppress high-frequency pressure oscillations associated with bubble splitting and coalescence, while promoting low-frequency bed oscillations.

4. Conclusions

Cohesive interparticle forces substantially modify fluidization hydrodynamics by altering bubble characteristics and pressure fluctuation patterns. The measurement frequency significantly affects the observed phenomena, with high-frequency acquisition capturing localized bubble dynamics and low-frequency recording revealing global bed behavior. These findings provide fundamental insights for designing and operating fluidized bed reactors under cohesive conditions.

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Note: The mathematical expressions and corrupted text segments have been cleaned. The experimental parameters such as $2.5U_{mf}$ and temperature $35^{\circ}C$ are preserved. The corrupted character sequences and misplaced alignment tabs have been removed to ensure LaTeX compatibility. Experimental Study on the Fluidization Dynamics of Cohesive Geldart B Particles MA Ji-Liang; LIU Dao-Yin; LIANG Cai; CHEN Xiao-Ping (Key Laboratory of Energy Thermal Conversion and Control of Ministry of Education, School of Energy and Environment, Southeast University, Nanjing 210096 China). This paper reconstructed three dimensional version of local bubbles in a fluidized bed processing cohesive Geldart B particles with a combination of X-ray tomography and Simultaneous Algebraic Reconstruction Technique (SART). Global fluidization dynamics were also obtained using in-bed pressure fluctuation analysis. The experimental results show that the presence of cohesive force facilitates bubble coalescence, thus increasing the bubble size and decreasing the bubble frequency and bubble rising velocity. When the bed temperature exceeds $35^{\circ}C$, slugging takes place alternatively with normal fluidization. Moreover, the duration of slugging sharply increases with the cohesive force. Key words: cohesive particles; X-ray tomography; pressure fluctuation analysis; fluidization.

Note: Figure translations are in progress. See original paper for figures.