Evolution of gas – solid binary fluidized bed reactor and investigate the flow dynamics behavior using radioactive particle tracer methods

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1. Introduction

In this study, the focus is on enhancing the understanding of binary fluidized beds dynamics, crucial for optimizing their performance in various industrial applications.

The experiment was conducted on a laboratory-scale gas-solid fluidized bed reactor with an inner diameter of 0.15 m. Glass bead particles of Geldart 'B' class, with a particle density of 2500 kg/m³ and varying sizes (100-200 µm and 400-600 µm) for fine and coarser particles, respectively, were used as a binary mixture of solids. The fine particle composition ranged from 0-8 Wt.%, and compressed air served as the gas phase, with controlled gas flow rates using an air rotameter. Superficial gas velocities ranging from 0.3 to 0.54 m/s were employed to study the flow dynamics behaviour of gas –solid binary fluidised bed reactor solid distribution using advanced radioactive particle tracer methods.

2. Methods

The gamma-ray densitometry technique, a non-invasive radiation-based method, used to find the solid volume fraction in fluidised bed reactor using a scintillation detector (NaI(Tl)) and a gamma source (137Cs) placed at 180° in the plane. The study investigated the impact of binary mixture composition and superficial gas velocity on chordal average solid fraction distribution at three axial heights (Z/H = 0.25, 0.5, and 0.75). The resulting solid fraction distribution map illustrated an increase from the centre to the wall region.

Radioactive particle tracking (RPT) is a non-invasive technique to measure the velocity field. In RPT, motion of a single radioactive particle, that is marker of the phase, is tracked by using a series of NaI(Tl) scintillation detectors arranged strategically around the column. A radioactive particle Sc-46 doped in glass bead is used to track the solid phase in which the size, shape and density of the radioactive particle kept same as of the other solid present in the bed.

3. Results and discussion

Densitometry measurements give an estimate of phase holdup based on the variance in inverting medium diameter. In the present case, as the primary interest pertains to ascertaining the variation of particle

under different operating condition, averaged solids holdup as obtained from the experimental measurements was compared to that predicted by CFD simulation. As the densitometry measurements were obtained as discrete locations along a locations along a plane. It was noted that in solid fraction showed that bed cross section had a non uniform solids distribution of solids. It was found that the solid composition grew with radial direction for different compositions at different planes of column, while the void fraction at every plane increased with velocity
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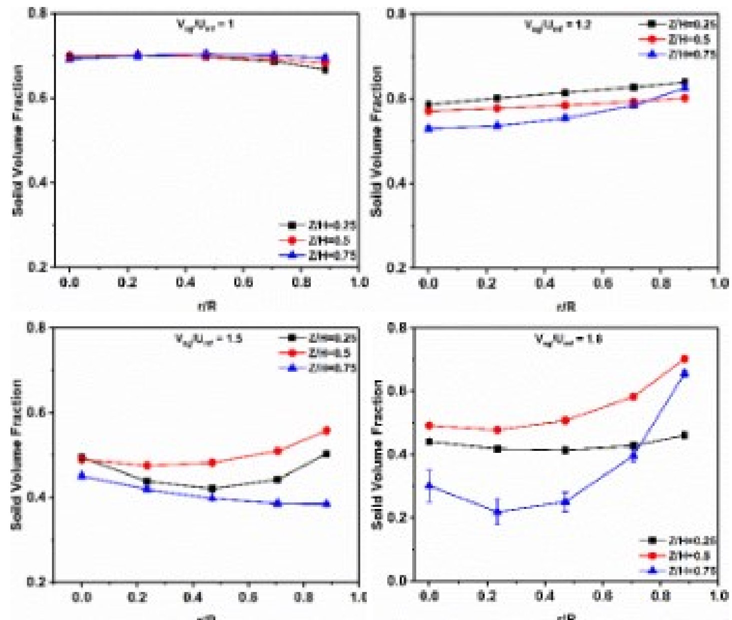

Figure : Result of densitometry with 0% of fine particle respectively A,B,C,D @VSG//UMF =1 ,1.2, 1.5 & 1.8

4. Conclusions

This research contributes valuable insights into the dynamics of binary fluidized beds, emphasizing the significant impact of superficial gas velocity on solid flow dynamics. The combination of experimental and CFD data, along with advanced techniques like gamma-ray densitometry and RPT, provides a robust foundation for the precise design and optimization of fluidized bed reactors in industrial applications.

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Keywords

Fluidized bed reactor, Multiphase flow reactors, Gamma ray densitometry, Radioactive particle tracking.