Solid Phase Flow Dynamics in Circulating Fluidized Bed Riser at Two Scales Using Radiotracer Technique

Trilokpati Tribedi[1,2], Pankaj Tiwari[1], Harish Jagat Pant[3], Rajesh Kumar Upadhyay[2]*

[1] *Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam 781039, India; Department*

[2] *Department of Chemical Engineering and Technology, Indian Institute of Technology (BHU) Varanasi, Varanasi, Uttar Pradesh 221005, India*

[3] *Isotope and Radiation Application Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400085, India*

**Corresponding author: rku.che@iitbhu.ac.in*

Highlights

- With the increase in internal diameter solid circulation increases resulting more parabolic profile.
- At a smaller internal diameter downward motion is less velocity compared to a higher diameter riser.
- Higher internal circulations at higher riser diameters result in higher rms velocity.

1. Introduction

Though circulating fluidized bed (CFB) has been used since last year for four to five decades in industry, and lots of work has been done by several researchers, the solid flow behavior is not fully understood and difficult to predict. Moreover, most of the research data available in literature are for Geldart's group A particle. There are limited solid flow field data available for Geldart's Group B particles. In current work, we aim to fill this gap by conducting experiments and collecting solid flow field data for Geldart's Group B particles at two different scales using the non-invasive radioactive particle tracking (RPT) technique. Various flow parameters, including mean axial and radial velocities, root-mean-square velocities, granular temperature, and turbulent intensities, are systematically computed for both scales.

2. Methods

The laboratory scale CFB riser has an internal diameter of 0.05 m and 3 m, and the pilot scale CFB has an internal diameter of 0.1 m and 6.5 m. Glass beds (density of 2500 kg/m^3 and particulate diameter of 500 µm) are used as solid phases. Most of the data available in the literature for CFB uses indirective techniques. The RPT technique is one of the non-invasive techniques that can provide a complete velocity flow field for a fluidized bed reactor. In PRT, a solid tracer (high-energy gamma ray emitter) of similar diameter and density is used to map the motion of the solid phase. A single radioactive tracer is tracked for a long time. In RPT, first the scintillation detectors are strategically placed (Roy) at the zone of interest. The tracer particles are placed at different locations in the zone of interest, and count data is recorded for the same. The count versus position data is utilized to construct a comprehensive count vs position data table across the entire cross-section of the system. In the experimental setup, the tracer particle freely follows the movement of the solid phase, simulating its flow, and the detectors record count data. By comparing the recorded count data with the comprehensive count vs position data, the instantaneous position of the tracer is determined. Time series position then convered in to time series lagrangian velocity using time derivate of instantaneous position. Subsequently, these time series lagrangian velocity is converted [1,2] to Eulerian flow filed data.

3. Results and discussion

Experiments are performed at similar solid flux and similar gas velocity at the pilot scale and laboratory scale riser to decipher the effect of scale. Figure 1(a) Figure 1(b) shows the velocity vector of the pilot and laboratory scale. Irrespective of the inlet gas velocity, sold flux and scale mean velocity is high at the center and decrease towers the wall. However, solid velocity is always lower than the gas velocity. Some researchers [3] reported higher solid velocity than the inlet gas velocity at the center for Geldart's grip A particles. This is not true for the current operating condition with Geldarts's group B particles. Due to no slip boundary condition gas velocity is always lower near the wall region which is why mean velocity is lower near the wall region. The probability distribution function (PDF) diagram of instantaneous velocity, shows no downward motion near the center of the column at both laboratory and pilot scale CFB. However, near the wall section significant downword motion is observed at pilot plant scale system though the mean axial velocity at wall is in upward direction. On contrary at laboratory scale system, even near the wall negative instantaneous velocity is not observed. In a typical CFB riser solid holdup is higher near the wall which creates more hindrance in the solid motion resulting in higher velocity fluctuation near the wall. However downward velocity is less visible in the laboratory scale riser irrespective of radial location. In a lower diameter riser, the solid holdup is comparatively flat due to reduce radial motion. Similarly, experimental data for different gas inlet velocity and solid flux will be presented in the final contribution.

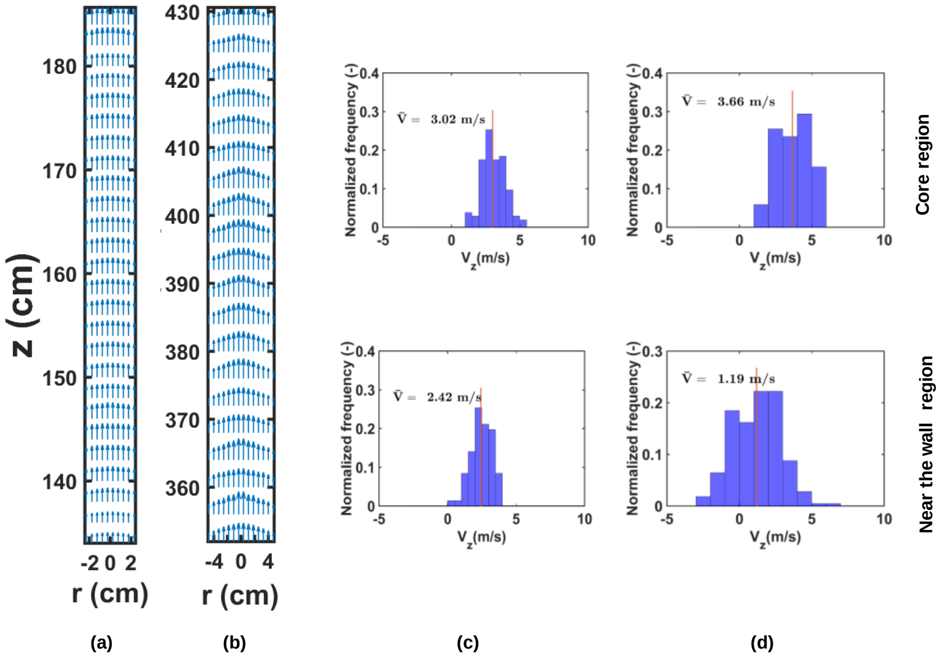

Figure 1. Velocity vector of laboratory scale (a) pilot scale(b) riser; PSF diagram of instantaneous velocity diagram at core region and near the wall region for laboratory scale (c) pilot scale(d) riser at U_g – 8 m/s and G_s – 150 kg/m^{2}s

4. Conclusions

With an increase in riser diameter solid fluctuation and as well as chances for the formation of meta-stable structure increases. Results also indicate the solid internal circulation increases with an increase in riser diameter.

References

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Keywords

Circulating Fluidized Bed, Radioactive Particle Tracking, Velocity flow filed, Solid Phase Hydrodynamics