Fluidization of Wet Particles: Flow, Heat and Mass Transfer

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Highlights

- An two-stage evolution of bubble characteristics with increasing liquid content.
- The shape of cloudy zone is like a horseshoe shape.

1. Introduction

Gas-solid fluidization with liquid injection is often referred to as "wet fluidization". Compared with the fluidization of dry particles, wet fluidization presents more complex hydrodynamics, and uneven mass heat transfer behaviours. For example, the agglomeration of wet particles would decrease the fluidization stability in the "cloudy zone" of the fluidized bed for gas-phase ethylene polymerization[1].

2. Methods

By applying digital image analysis on the bubble characteristics in a 2D wet-particle fluidized-bed, we study the evolution of bubble characteristics with increasing liquid content. Furthermore, the cloudy area in a fluidized bed for gas-phase ethylene polymerization process was simulated by CFD-DEM method. We then established a heat and mass transfer model of liquid injection, film coating and evaporation process to quantitate the droplets and wet particles, characterize the gas-liquid-solid cloudy zone.

3. Results and discussion

We report an two-stage evolution of bubble characteristics with increasing liquid content in a 2D wet-particle fluidized-bed. In the first stage, bubble number and uniformity of bubble fraction increase, while bubble average diameter and aspect ratio decrease. In the second stage, these characteristics shift towards an opposite direction. This two-stage evolution of bubble characteristics are analogous to that of reducing particle size in dry-particle fluidization, and the fluidizing properties of particles shifts from Geldart group B to group A and then to group C. The CFD-DEM simulation results shows that the shape of cloudy zone is like a horseshoe shape. The area of cloudy zone increases gradually with the liquid ejection rate.

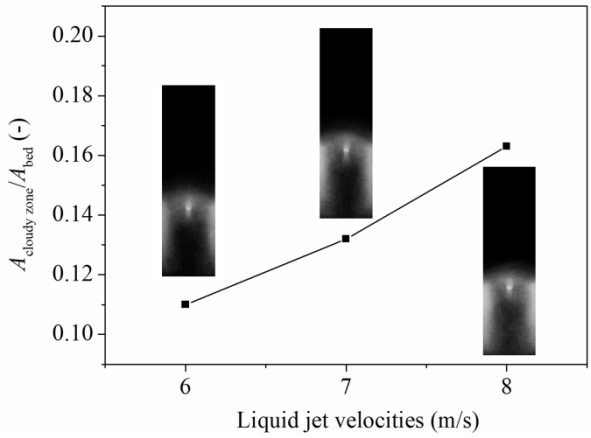

Figure 1. Cloudy zone at different liquid jet velocities.

4. Conclusions

In general, the flow, heat and mass transfer characteristics of wet particles in the fluidization process are measured and characterized through experiments and simulations.The research results provide a theoretical basis and reference for deepening the understanding of wet particle fluidization and preventing reactor blockage.

References

[1] Q. Xu, X. Guan, R. Ocone, N. Yang. AICHE Journal, 69(2023), 11, e18207

Keywords

Wet particle, fluidization, heat and mass transfer.