Hydrodynamics in bubble column with internals: experiments and simulations

Xiaoping Guan[1]*, Ning Yang[1]

1 State Key Laboratory of Mesoscience and Engineering, Institute of Process Engineering, Chinese Academy of Sciences, Beijing 100190, PR China

**Corresponding author: xpguan@ipe.ac.cn*

Highlights

- The presence of internals reduces the bubble size in bubble columns
- The first peak in the BSDs at high superficial gas velocity becomes more prominent in the presence of internals
- The effects of internals is scale-dependent and makes scale-up of bubble columns more challenging

1. Introduction

The heat exchanging tubes are important internals for controlling the temperature in the slurry bubble column reactors, but the mechanism of the influence of the internals on the flow-transfer-reaction is still not clear. This study will focus on the regulation of multi-scale flows in bubble columns by internal components, using experimental measurements and numerical simulation methods to reveal the physical mechanism of the effects of internals and understand the scale-up of bubble column containing tube internals. Furthermore, new internals technology is developed to achieve quantitative control of the flow structure. This study deepens the scientific understanding of gas-liquid-solid multiphase reactors and provides scientific guidance for the development of internals technology and reactor scale-up.

2. Methods

The experiments were performed in a Plexiglas column with an inner diameter of 0.15 m and a height of 1.6 m. 16 or 32 Plexiglas rods of 0.012 m in diameter, arranged in triangular distribution, were installed in the bubble column. A dual-tip conductivity probe was used to measure the bubble properties. The measurements were performed at 9 radial positions (r/R=0, ±0.2, ±0.4, ±0.6, ±0.8). Superficial gas velocity (SVG) was in the range of 0.01-0.23 m/s. CFD-PBM Simulations were performed to model the hydrodynamics in bubble columns with internals using breakage kernel of Luo and Svendson (1996) and Coalescence kernel of Prince and Blanch (1990). Other kernel models are also evaluated.

3. Results and discussion

Figure 1 compares the measured and the predicted CSA-averaged BSD at Z=0.75 m. Both the simulations and experiments show the marginal effect of 10% internals. However, the simulations give wider and right-shift BSD at high SGV when the percentage of internals increases to 20%, which is opposite to the experimental observations. Furthermore, at the SGVs 0.05-0.23 m/s, the simulations predict more evident peak of small bubbles than the experiments in the empty column or the column with 10% internals. The BSD for 20% internals is relatively well estimated by the combination of Luo-Svendsen breakage model and Prince-Blanch coalescence model. The comparison between simulations and experiments suggest that bubble coalescence rate may be underestimated or the breakage rate over-predicted in the column with 0% or 10% internals.

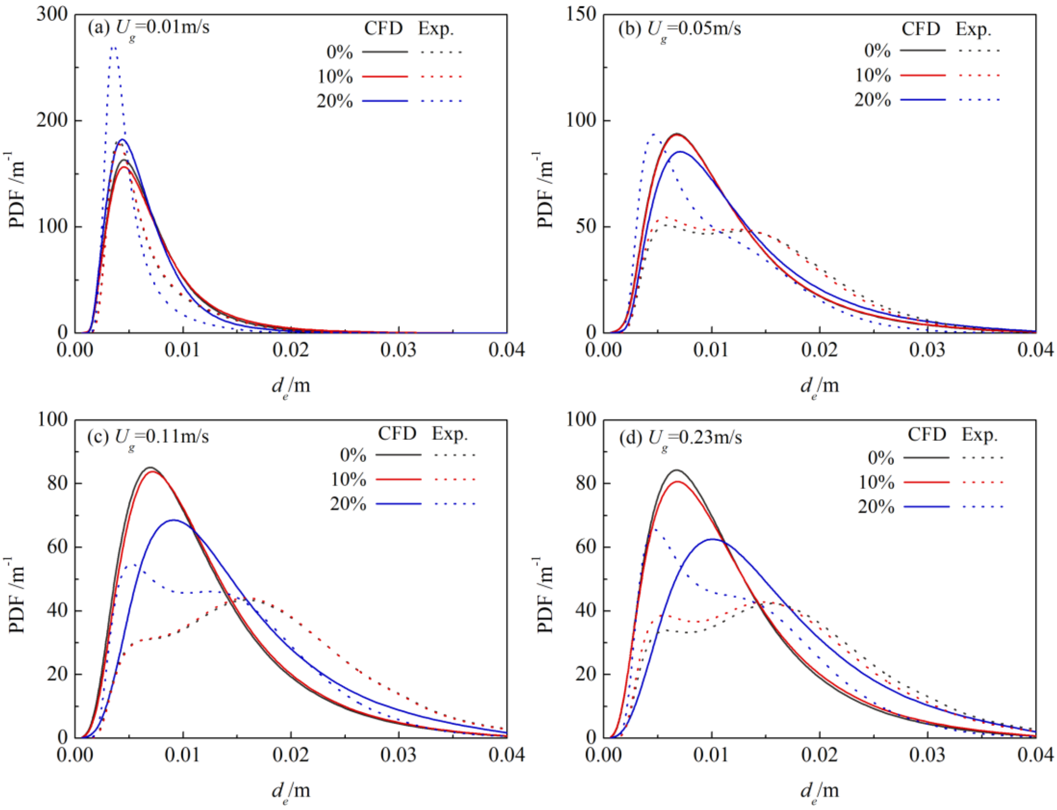

Figure 1. Measured and predicted CSA-averaged BSD at *Z*=0.75 m

4. Conclusions

Experiments and CFD-PBM simulations were performed to investigate BSD in the BCRs with internals. With the increase of SGV, BSD changes from the unimodal to the bimodal distribution, and the second peak becomes prominent. The effect of 10% internals on BSD is marginal, whereas 20% internals increase the small-bubbles fraction, and the first peak of BSD becomes more evident. The BSD for 20% internals is relatively well estimated, but the effect of internals on BSD or the Bimodal distribution is not captured by the applied combination of Prince-Blanch coalescence and Luo-Svendsen breakage models.

References

[1] Prince M J, Blanch H W. Bubble Coalescence and Break-up in Air-Sparged Bubble-Columns. Aiche Journal. 1990; 36: 1485-1499.

[2] Luo H, Svendsen H F. Theoretical model for drop and bubble breakup in turbulent dispersions. Aiche Journal. 1996; 42: 1225-1233.

Keywords

Internals; CFD-PBM simulation; bubble properties; bubble column