CFD simulation of gas-liquid-solid flow in slurry bubble columns with EMMS drag model

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CFD simulation of gas-liquid-solid flow in slurry bubble columns with EMMS drag model

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Abstract

The drag models reflecting the complex phase interactions are of critical importance in the CFD simulation of gas-liquid or gas-liquid-solid flows. In this study, we demonstrate that the Dual-Bubble-Size (DBS) drag model based on the Energy-Minimization Multi-Scale (EMMS) concept, is capable of effectively predicting the distribution of gas holdup in slurry bubble columns. For solid-free or low solid loading systems, a thorough comparison of the DBS-Global and other drag models indicates that, without any fitting parameters, the DBS-Global drag model prediction on the radial distribution of gas holdup and solid hydrodynamics is in conformity with experiments over a wide range of superficial gas velocities. The three-fluid and two-fluid models are also compared in this work, indicating that the three-fluid model in combination with the DBS-Global drag model gives the best prediction. Previous experiments show that the effects of solid presence on hydrodynamics become pronounced at high solid loading conditions. The prediction of the original DBS-Global drag model deviates from the experiments at high solid loading conditions, and the solid effects need to be taken into account. This work then proposes a modified drag model for simulating three-phase systems at high solid concentration. The new model is capable of accurately predicting the local gas holdup for the systems of solid loading of 25% or 40%. Further fundamental study of the solid effect on the change of flow structure and dominant mechanisms in gas-liquid flow is required.

Keywords: Multiphase flow; CFD; Slurry bubble columns; EMMS; Drag; Meso-scale.