Large-Eddy Simulation of a Flat Bubble Column

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Bubble columns are widely used in the chemical and pharmaceutical industry to produce a variety of products. It has been known that these devices are characterized by a high degree of unsteadiness and complexity[1]. Thus a detailed understanding of the liquid-phase flow field and the bubble dispersion pattern is crucial in the design and scale-up of bubble columns.

Using computational fluid dynamics (CFD) modelling, insight of flow and mixing in multiphase systems could be obtained. Albeit significant efforts invested by researchers, challenges still remain. For instance, three dimensional modelling of commercial-scale bubble columns are prohibitively expensive for conventional CFD models. Recently, parallel computation technology allows us to perform simulations of commercial-scale equipment with reasonable expenses. Therefore, we focus on developing a reliable computational tool with high efficiency in parallel computation.

In this work we studied dilute gas-liquid flow in a laboratory-scale bubble column (the so-celled Becker case[2]) by means of Large-Eddy Simulation (LES) approach combined with Lagrangian particle tracking model with two-way coupling. This approach is known as the Eulerian-Lagrangian method. In order to solve the Navier-Stokes equations, we chose the lattice-Boltzmann (LB) scheme because of its outstanding computational efficiency especially on parallel computer platforms[3]. The standard Smagorinsky subgrid model is incorporated into the LB scheme to include the energy dissipation induced by the interaction between resolved and unresolved scales[4]. Furthermore, the modified forcing term is used to guarantee the consistent of LB scheme with the Navier-Stokes equations[5]. Our work also includes a “particle-source-in-ball” (PSI-ball)[1] concept for the efficient coupling between phases. Excellent agreement with experimental data[2] for the mean velocity field as well as the transient bubble dispersion patterns is obtained.

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