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Fluid Dynamics and Transport Phenomena

CFD-PBE simulation of a bubble column in OpenFOAM*

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Abstract A general CFD-PBE (computational fluid dynamics-population balance equation) solver for gas-liquid poly-dispersed flows of both low and high gas volume fractions is developed in OpenFOAM (open-source field operation and manipulation) in this work. Implementation of this solver in OpenFOAM is illustrated in detail. The PBE is solved with the cell average technique. The coupling between pressure and velocity is dealt with the transient PIMPLE algorithm, which is a merged PISO-SIMPLE (pressure implicit split operator-semi-implicit method for pressure-linked equations) algorithm. Results show generally good agreement with the published experimental data, whereas the modeling precision could be improved further with more sophisticated closure models for interfacial forces, the models for the bubble-induced turbulence and those for bubble coalescence and breakage. The results also indicate that the PBE could be solved out the PIMPLE loop to save much computation time while still preserving the time information on variables. This is important for CFD-PBE modeling of many actual gas-liquid problems, which are commonly high-turbulent flows with intrinsic transient and 3D characteristics.

Keywords: population balance equation (PBE), multiphase, bubble column, OpenFOAM, computational fluid dynamics (CFD)

1. INTRODUCTION

Gas-liquid flows are often encountered in the cultivation of bacteria and mold fungi, production of cell proteins, treatment of sewage, liquid phase methanol synthesis, Fischer-Tropsch synthesis, *etc*. [1]. Bubbles may break and coalesce due to bubble-bubble and bubble-liquid interactions, which greatly complicate these processes. Thus, in the last decades, population balance equation (PBE) is being

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