A NUMERICAL STUDY FOR THE EFFECT OF BUBBLE SIZE DISTRIBUTION ON THE FLOW BEHAVIOUR IN BUBBLE COLUMN REACTORS

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ABSTRACT

Computational fluid dynamics (CFD) simulations of bubble columns have received recently much attention and several multiphase models have been developed, tested, and validated through comparison with experimental data. In this paper, we present numerical techniques for two-way coupling of CFD and Population Balance Equations (PBEs) in the framework of bubble columns, based on the incompressible flow solver FeatFlow which is extended with a) k turbulence model, b) breakage kernel model of Lehr et al., c) coalescence kernel model of Lehr et al.. To solve the momentum equations of gas-liquid dispersed phase system a mixture model is employed and the velocity of the gas phase is recovered by using algebraic slip relation. Moreover, bubble-induced buoyancy is incorporated into Featflow by using an analog of the Boussinesq approximation. The inter-phase forces (drag, lift and virtual mass) are discussed in detail to obtain an accurate and widely applicable model without free parameters which has to be adjusted according to experimental results. Different closure terms for inter-phase forces are used and coupled with method of classes (CM) for population balance in order to predict the bubbles size distribution and to show the effect of bubble size on the drag force and slip velocity. This inevitable coupling between turbulent fluid dynamics and PBEs results in a great system of nonlinear partial differential equations which can lead to irrational computational cost and many difficulties in numerics unless the problem is tackled properly. A robust solution strategy based on nested iterations is proposed for the numerical treatment of the resulting PDE system. The incompressible Navier-Stokes equations are solved by a discrete projection scheme from the family of Pressure Schur Complement methods. High-resolution finite element schemes based on algebraic flux correction are employed for the discretization of convective terms. The aim of this study is to propose a comprehensive mathematical model with the assumptions which neglects the relations having insignificant effect on the results, and an implementation strategy with efficient algorithms for the solution of system of PDEs as a result of coupling CFD and PBEs in the frame work of bubble columns.

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