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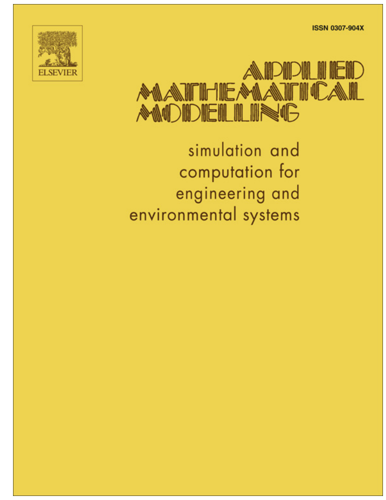

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Efficient simulation of gas-liquid pipe flows with the generalized population balance equation coupled with the algebraic slip model

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Abstract

The inhomogeneous generalized population balance equation, discretized with the Direct Quadrature Method of Moment (DQMOM), is solved to predict the bubble size distribution (BSD) in a vertical pipe flow. The proposed model is compared against a more classical approach, in which bubbles are characterized by a constant mean size. The turbulent two-phase flow field, modeled with a Reynolds-Averaged Navier-Stokes equation approach, is assumed to be in local equilibrium, so that the relative gas and liquid (slip) velocities can be calculated with the algebraic slip model, accounting for the drag, lift and lubrication forces. The complex relationship between the bubble size distribution and the resulting forces is accurately described through DQMOM. Each quadrature node and weight represent a class of bubbles with characteristic size and number density dynamically changing in time and space to preserve the first moments of the bubble size distribution. The obtained predictions are validated against experiments from the literature, demonstrating the advantages of the approach for large-scale systems and suggesting a future extension to long piping systems and to more complex geometries.

Keywords: Population balance equation, Gas-Liquid flow, Algebraic Slip Model, Direct Quadrature Method of Moments

1. Introduction

Turbulent multiphase flows are present in a number of important industrial applications, in particular in the oil, process and chemical industry. With the recent development of high performance computers Direct Numerical Simulation (DNS) of problems involving turbulence and interphases is now applicable to small-scale systems. However, a full description of these systems is still impracticable for large-scale systems and there is an increasing need of predictive (yet affordable) simplified computational models. This is relevant,

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