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Fluid and Particle Coarsening of Drag Force for Discrete-Parcel Approach

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Abstract

Fine-grid Euler-Lagrange simulations of gas-fluidization of uniformly sized particles have been performed in three-dimensional periodic domains. Snapshots obtained from these simulations have been systematically coarse-grained to extract filter size dependent corrections to the drag law that should be employed in coarse Euler-Euler (EE) simulations. Correction to the drag law that should be employed in Coarse Multi-Phase Particle-in-Cell (MP-PIC) model simulations is examined through a two-step process: separating the coarsening of the fluid and particle phases. It is found that the drag correction is almost entirely due to the coarsening of the fluid cells, with particle coarsening having only a weak effect. It is shown that drag correction for coarse EE and MP-PIC simulations are comparable. As a result, coarse drag models developed for EE simulations can serve as a good estimate for corrections in MP-PIC simulations, and vice versa.

Keywords: MP-PIC, parcel approach, fluid coarsening, particle coarsening, drag force, filtered two-fluid model

1. Introduction

Industrial-scale gas-particle flow systems exhibit flow structures which span a wide range of spatial and temporal scales; bubble-like voids of varying sizes rising at different velocities form in dense beds, while dynamic clusters of different shapes and sizes are found in dilute flows. These meso-scale structures affect the macro-scale flow patterns, which impacts the performance of fluidized bed chemical reactors. This multi-scale nature of flow complicates analysis and scale-up of these devices. Coarse simulation methods that can reproduce reliably the macro-scale flow structures in these devices have been a topic of much research (Agrawal et al., 2001; Wang and Li, 2007; Igci and Sundaresan, 2011a; Parmentier et al., 2012; Ozel et al., 2013; Milioli et al., 2013; Schneiderbauer and Pirker, 2014).

Industrial-scale fluidized bed simulations can be classified into two groups: (1) Eulerian-Eulerian simulations based on two-fluid model (TFM) approach (Gidaspow, 1994; Syamlal et al., 1993; Balzer et al., 1998) and (2) Eulerian-Lagrangian simulations based on multiphase particle-in-cell method (MP-PIC) (Snider, 2001; Snider and Banerjee, 2010; Snider et al., 2011).

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