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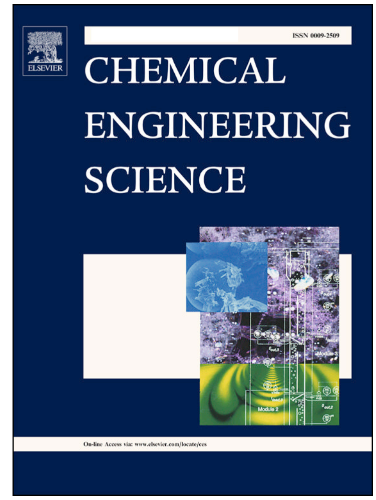

Development of a drag force correlation for assemblies of cubic particles: The effect of solid volume fraction and Reynolds number

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Development of a drag force correlation for assemblies of cubic particles: The effect of solid volume fraction and Reynolds number

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Abstract

The accurate prediction of the drag force exerted by a fluid on assemblies of particles is critical to simulate key characteristics of gas-solid systems such as the bed expansion in fluidized beds. To this end, a lattice Boltzmann method has been applied to compute the drag force acting on assemblies of cubes for a wide range of Reynolds numbers, $\mathrm{Re}_V = 0-200$, and solid volume fractions, $\phi = 0.1-0.45$. The numerical data was used to propose a new drag force correlation for assemblies of cubes as a function of the Reynolds number and solid volume fraction. The new drag force correlation is expected to improve the accuracy of Euler-Euler and Euler-Lagrangian simulations of cubic particles.

Keywords: Drag force; Super-quadric cubes; Lattice Boltzmann method; non-spherical particles assemblies

1. Introduction

The numerical simulation of gas-solid systems, e.g. fluidized beds, relies critically on the accurate formulation of the drag force exerted by a fluid on the particulate phase. For example, Li et al. (2003) reported that the bed expansion in a gas fluidized bed is very sensitive to the dependence of the drag force on the void fraction. The most commonly used drag force correlations, i.e. the correlations by Ergun (1952) and Wen & Yu (1966) were derived experimentally by measuring the pressure drop in packings and the sedimentation velocity, respectively. However, it is under debate whether these correlations can be used for the wide range of solid volume fractions typically encountered in fluidized beds (Gidaspow, 1994). Due to the difficulty to perform highly resolved (both temporally and spatially) experiments in gas-solid systems (Müller et al., 2006; Holland et al., 2008; Müller et al., 2011).

Recently, direct numerical simulations (DNS) have been employed to improve the accuracy (and parameter space) of drag force correlations. In direct numerical simulations the fluid flow around the particles is fully resolved and the drag force acting on the individual particles can be calculated accurately. Hill et al. (2001b) were the first to derive a drag force correlation for assemblies of spheres using a lattice Boltzmann method as a DNS technique. Beetstra et al. (2007) extended the work of Hill et al. (2001b) and proposed new drag force correlations for mono- and bi-disperse assemblies of spheres. Recent works dedicated to improve the accuracy of predictions of the drag force acting on assemblies of spheres for a wide range of Reynolds number have focused on two aspects: (1) developing highly accurate solid-fluid boundary conditions (Tenneti et