A drag force model formulation for polydisperse particle-fluid simulations using Discrete Element Method

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ABSTRACT

Particle-fluid systems in which the two-phase flow is governed by the interaction between the fluid and the particles are very common in both nature and industrial engineering. In practical applications, modelling and prediction of the flow is complicated by many non-ideal effects like non-spherically shaped, poly-disperse particulate materials or non-newtonian fluids. While Discrete Element Method numerical simulations have allowed overcoming temporal and spatial distribution issues of the flow characteristics within the solid phase, large-scale fluid-particle applications still require a coarse-grain discretization of the interphase momentum exchange phenomena, which are typically represented by some physical model.

In the present contribution, the problem of a physically consistent description of the particle-fluid momentum exchange in the presence of size polydispersion, with focus on the drag force on individual particles, is investigated. Differently from the monodisperse case, there is still no established relation that can express the force exerted by a fluid on one particle in a system with particle size distribution as a function of the fluid velocity and particle properties, voidage, size distribution and composition of the various size fractions.

Previous models (e.g. [1-4]) express the force on an individual particle as a function of the corresponding force in a monodisperse system at the same voidage and superficial velocity or as a function of the average force on a particle. For both cases, in the present contribution physical consistency issues are emphasized and a generally correct formalism for the coefficients of the expansion terms introduced. Within this framework, a compatible three-coefficient expression for the drag force is proposed.

A few fully-resolved Lattice-Boltzmann simulations of flow through particular randomly arranged polydisperse particle systems are presented to both highlight inconsistent effects that can arise and support the validity of the proposed drag model form.

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