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ANALYSIS OF DRAG MODELS FOR EULER-LAGRANGE SIMULATIONS OF BI-DISPERSE SUSPENSION FLOW

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It is well known that simulations of dense fluid-particle systems are extremely challenging and often inaccurate in case a too coarse computational grid, or an inappropriate fluid-particle drag force model is used. A key challenge is to model the effect of particle clustering on the effect fluid-particle interaction force. Euler-Lagrange (EL) simulations of bi-disperse suspension flow constitute are a promising tool to face this challenge.

We have implemented a novel drag model [1] into Matlab® (one-dimensional force balancing) and compared it with fully three-dimensional simulations, the Euler-Lagrange solver "CFDEM" [2] to study clustering phenomena. Various simulations in an unbounded domain, as well as in a bubbling fluidized bed have been carried out. Specifically, the "Beetstra monodisperse" drag model (i.e., the standard implementation in CFDEM), the "Beetstra polydisperse" drag model, and the "Holloway" drag model, which includes a fluid-mediated drag contribution, were analyzed. Results obtained with these drag models were then compared in order to assess the fidelity of each model. A comparison with experimental data allowed us to study the effect of important simulation parameters on the segregation process in a bubbling bed. The results of the Matlab® model helped us to understand the importance of the contribution due to drag and inter-particle collisional forces.

We show that the model for collisional particle-particle interaction forces is more important for predicting segregation phenomena in gas-particle suspension compared to the fluid-mediated drag force. However, we find that the density ratio and the Reynolds number play a critical role for the relative importance of these two forces. Via detailed EL simulations we then simulate particle clustering in bi-disperse systems in an unbounded domain. We show that this clustering has a severe effect on the segregation rate depending on the flow regime. Specifically, we show that clustering can increase (at low particle volume fractions) or decrease (at higher particle volume fractions) the rate of segregation (see Figure 1). Finally, our study of axial segregation in a bubbling fluidized bed shows that the newly implemented drag model does not improve the predictive quality of the simulation. We relate this to the fact that this is due to the treatment of the near wall region, which still needs future research.

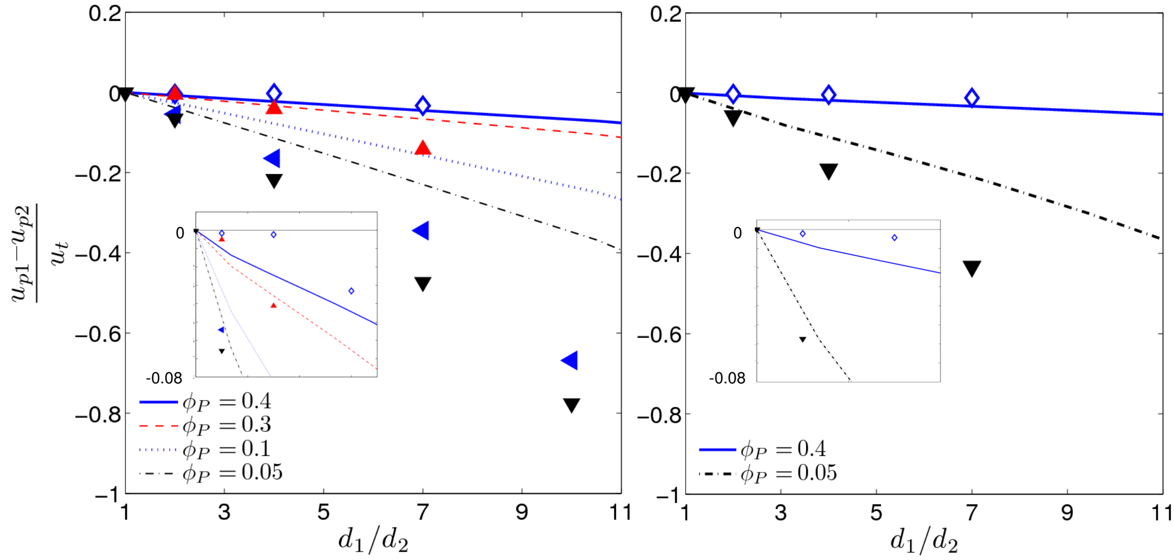

Figure 1: Comparison of CFD-DEM results with reference results based on the sedimentation of a homogeneous suspension (lines: Matlab calculation; symbols: CFD-DEM simulations; (Left panel: "Beetstra monodisperse" drag model; Right panel: Holloway drag model).

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