Fully coupled simulations of monodisperse and bidisperse suspensions in a linear shear flow

M. Abbas[a] , E. Climent[a] and O. Simonin[b]

The dynamics of macroscopically homogenous sheared suspensions of neutrally buoyant, non-Brownian spheres is investigated in the limit of very small Reynolds and Stokes numbers using the Force Coupling Model (Lomholt & Maxey[1]). In this numerical approach, the velocity disturbance is obtained by a low order multipole expansion (particle forcing on the flow is represented by monopole and dipole terms spread on a finite volume envelop related to particle radius). Multi-body interactions are achieved by direct solution of Stokes flow equations coupled with the lagrangian tracking of particles in a fully periodic domain (typical size of the computational domain is 48 particle radius; 12% particulate concentration corresponds to 2400 particles). Short-range interactions between particles are modelled by a repulsion force that prevents non-physical overlapping of fluid volume occupied by particles.

The numerical model has been first validated on the analytic expressions of hydrodynamic interactions between two particles (Batchelor & Green[2]). The accuracy is very good when the distance between the two particle surfaces is larger than 25% of the particle radius. It means that our numerical simulations are limited to moderately concentrated suspensions typically less than 20% volumetric concentration.

Then, statistical quantities (translation and rotation velocity fluctuation tensors, particle self-diffusion tensor) were compared to the reference work of Drazer *et. al*[3]. Velocity fluctuation tensors (translation and rotation) grow linearly with the particle concentration and are highly anisotropic. Only one non diagonal term is found to be non zero. This is clearly related to trajectory symmetry breaking induced by the non-hydrodynamic repulsion force. Particle self-diffusion coefficients were both calculated from the long time behaviour of the particle displacement variance, and from lagrangian velocity autocorrelation functions. The self-diffusion tensor was found to be anisotropic. Determination of the self-diffusion coefficient in the flow direction is complicated by a combination of advection in the mean flow and diffusion in the direction of shear. The evolution of this coefficient has been rarely investigated in the literature. Probability density functions of velocity fluctuations showed a transition from exponential to Gaussian behaviour as particle concentration varies.

Similar analysis is carried out on bidisperse suspensions for various concentrations of both species. We also included inertia effect in the particulate phase that leads gradually (as Stokes number increases) to collision dominated regimes. These statistical data can be embedded in macroscopic modelling of solid-liquid suspensions based on kinetic theory of granular media.

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[a] Laboratoire de Génie Chimique, 5 rue Paulin Talabot, 31106 - Toulouse, France
[b] Institut de Mécanique des Fluides, Allée du Pr. Camille Soula 31400 - Toulouse France

[1] Lomholt & Maxey *J. Comp. Phys.* **184** , 381 (2003)
[2] Batchelor & Green, *J. Fluid Mech.* **56** 375 (1972)
[3] Drazer et al. , *J. Fluid Mech.* **511** 237 (2004)