Transport in sheared granular suspensions

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Although in nature granular materials are usually immersed in a fluid phase (like the air, for instance), the influence of the latter on the dynamics properties of solid particles is generally neglected in most theoretical and computational studies. However, in many situations of practical interest the impact of the gas phase on grains cannot be ignored. At a kinetic theory level, the description of such multiphase flows is quite intricate since the system involves two different phases. However, most of the models proposed in the literature consider a Boltzmann kinetic equation for the solid particles where the influence of the gas phase is accounted for via a viscous drag force proportional to the peculiar velocity of the particles [1]. In addition, the solid particles are modeled as a gas of inelastic hard spheres with constant coefficient of normal restitution.

The aim of this contribution is to analyze momentum and heat transport of a granular suspension under uniform shear flow (USF). This flow is defined by constant density and temperature and a constant shear rate. The rheological properties of the granular supension under USF has been recently [2] obtained analytically from Grads method and by means of Monte Carlo simulations. A said before, our objective here is to study transport around USF. Thus, we assume that the reference base state (USF) is perturbed by small spatial gradients. This will give rise to new contributions to the momentum and heat fluxes that can be characterized by generalized transport coefficients. Since the system is strongly sheared, the corresponding transport coefficients are highly nonlinear functions of both the shear rate and the coefficient of restitution. As in previous works [3,4], the Boltzmann equation is solved by means of a Chapman-Enskog-like expansion around the reference USF distribution. To first order in the expansion, the momentum transport is characterized by a viscosity tensor of rank 4 while the heat flux is expressed in terms of a thermal conductivity tensor and a Dufour-like tensor. These tensors are given in terms of the solutions of a set of coupled linear integral equations, which are approximately solved by employing a BGK-like kinetic model. Explicit expressions for the set of generalized transport coefficients are obtained and illustrated for conditions of practical interest. The results show that the functional forms of these tensors differ clearly from their elastic forms.

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