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Size segregation in dense, dry, inclined flows of binary granular mixtures

Michele Larcher (1) and James T. Jenkins (2)

(1) University of Trento, Trento, Italy (michele.larcher@unitn.it), (2) Cornell University, Ithaca (NY) (jim.jenkins@cornell.edu)

Despite the importance of particle segregation in dense, collisional particle flows, the theoretical framework for its description is still incomplete. Phenomenological theories exist, such as those described by Gray and Ancey [1] that produce plausible predictions of species' concentrations and mixture velocity for appropriate choices of parameters. However, our goal here is to make such predictions in the context of a more fundamental theory that is based on the inter-particle interactions and that incorporates a measure of the energy of the particle velocity fluctuations.
We phrase and solve a problem of particle segregation in a dry flow of two sizes of spheres down an inclined, rigid, bumpy bed in the absence of sidewalls. The flow is assumed to be steady and fully-developed, collisions between particles are dissipative, and the sizes and masses of the particles are not too different.
For the mixture, we employ the kinetic theory for identical, inelastic spheres developed by Garzo & Dufty [2], modifying their expression for energy dissipation to take in to account the formation of particle clusters [3]. We incorporate friction in the particle interactions through the introduction of an effective coefficient restitution in the translational energy equation [4]; this accounts for energy lost to the fluctuations in translation velocity due both to their conversion to rotational velocity fluctuations and their dissipation due to sliding friction. We employ a theory for segregation in a binary mixture of spheres by Arnarson and Jenkins [5] that is appropriate for particles with relatively small differences in size and mass. We compare the predictions of species' concentration, mixture concentration and mixture velocity to the results of numerical simulations carried out by Tripathi and Khakhar [6]. We employ the particle sizes, masses and interaction parameters of their simulation in the theory; however, because the measures of size and mass difference employed in the simulation are not so small, we expect qualitative, rather than quantitative, agreement. A more complicated segregation theory is expected to provide improved results, but at the cost of the loss of transparency the present theory provides.

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