399g Model of Wet Particle Collisions and Its Application to Dilute Wet Particulate Systems

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Collisions between particles wetted with liquid layers are common in several natural and industrial processes, such as avalanches, pollen capture, filtration, coagulation, agglomeration, fluidization and wet granular flow. Simulations of interactions occurring in wet multiparticle systems require models that capture the physics behind the wet collisions and yet are not too computationally intensive. In this work, we present an analysis of oblique collisions between two particles coated with thin liquid layers, using elastohydrodynamic theory. The theoretical predictions are compared with experimental data obtained by performing collisions of spheres using a pendulum set-up. For near head-on collisions, there is a critical velocity below which no rebound is seen, due to viscous losses. As the impact velocity increases above the critical value, the wet restitution coefficient increases and asymptotes towards the dry restitution coefficient. The normal restitution coefficient for oblique collisions can be completely described by the normal approach velocity, whenever the spheres do not stick to one another. Interestingly, oblique collisions occurring below the critical velocity lead to the formation of a doublet of particles, which are seen to rotate about each other and may eventually break apart. The theoretical and experimental data are then used to derive a model represented by closed-form expressions for the normal restitution coefficient, the tangential restitution coefficient, and the change in rotation due to impact. This model is employed to simulate a dilute system comprising many wet particles that are colliding with high inertia. The system has periodic boundary conditions in an infinite domain and is under uniform shear. The energy input to the system is varied by changing the shear rate. After the simulation is run for a sufficiently long time, the system reaches a state in which a substantial fraction of the particles are moving as doublets. However, as the shear rate is increased, the transition of the system from the non-clustered to clustered state is delayed or even prevented. The variation in this transition time as a function of shear rate is studied. Finally the solid stresses, which quantify the transfer of momentum between particles, in wet systems are compared to those from dry systems.