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Superlubricity and energy saving in granular shear flows under external vibrations

We investigate the use of external vibrations to reduce macroscopic friction in pressure-imposed, granular flows sheared between bumpy planes, in the absence of gravity, using the discrete element method. We observe that the system becomes superlubric, i.e., the macroscopic friction is less than 0.01, if one of the bumpy plane oscillates with a sufficiently large velocity amplitude.
We compare the reduction in the energy dissipated by the system through the work of the shear stress induced by the reduction in the macroscopic friction and the external energy required to make the bumpy plane oscillate, for different combinations of amplitude and frequency of oscillation, and imposed pressure. It turns out that up to 70% of the energy can be saved by means of external vibrations. We propose a phase-diagram and criteria, in terms of imposed pressure and velocity amplitude of oscillations, to predict the energy performance of the flows and their resistance to shear. Our results demonstrate the existence of a confined region in parameter space where the flow becomes superlubric and energetically favorable.