Scaling the Percolation Velocity for Quantitative Prediction of Segregation Due to Size/Density Difference in Flowing Granular Mixtures

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ABSTRACT

Segregation of granular materials due to size difference is studied through discrete element simulations. First, binary mixture of two different size spherical particles flowing over an inclined plane is studied for different angles and size ratios. Starting from a completely segregated state in the beginning, the granular mixture is evolved to steady state. We focus on the percolation velocity of both large and small particles as the flow becomes steady and explore various ways of scaling the percolation velocity. Our results indicate that the shear rate based scaling of the percolation velocity, which has been commonly used by researchers [1-3], is not appropriate for chute flows. Specifically, in the case of shear rate scaled percolation velocity, the proportionality constant is found to be strongly dependent upon the inclination angle. Square root of the shear rate based scaling is found to be appropriate for flows for all the inclination angles considered in the study. Next, we explore if such a scaling is also appropriate for describing segregation of grains that differ only in density. We find that the shear rate based scaling of percolation velocity is not appropriate for density segregation in chute flow case as well since the constant of proportionality depends upon the inclination angle in this case. The square root of the shear rate based scaling, however, is found to be appropriate for density segregation as well for the chute flow over a range of inclination angles. These findings show that both density and size segregation can be described using similar scaling and indicate that the effect of both size and density can be considered simultaneously using this approach.

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