Predicting Granular Segregation: A Continuum Model Using Parameters From GPU-Based DEM Simulations

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ABSTRACT

Modelling size and density segregation of granular materials has important applications in many industrial processes and geophysical situations. We have developed a continuum model for granular segregation that uses parameters based on kinematic details measured from discrete element method (DEM) simulations. Because many simulations involving $O(10^6)$ particles were necessary to obtain parameters characteristic of the flow and segregation, we developed a CUDA-based parallelized DEM code so simulations could be performed on low-cost commercial NVIDIA Graphics Processing Units (GPUs). This approach reduces the simulation time by an order of magnitude, making possible parametric studies of flow and segregation phenomena via DEM simulations.

The segregation length scale and collisional diffusion coefficient are found as functions of the flow rate, particle diameters, and shear rate based on a large number of DEM simulations. These relations along with appropriate kinematic conditions such as the velocity profile and flowing layer depth are used in an advection-diffusion model that is modified to include a segregation term with parameters obtained from DEM simulations.[1-3] The theory has been tested for size bi-disperse particles for several quasi-2D granular flows including heaps, chutes, and rotating tumblers. In addition, the theory has been extended to model tri-disperse quasi-2D heap flow and log-normally distributed polydisperse quasi-2D chute flow. The theoretical segregation patterns and particle size distributions match results from full-scale DEM simulations and experiments.

Ongoing work is focused on further extending the theory to polydisperse size segregation in other geometries, simultaneous density and size segregation, and shape segregation in quasi-2D configurations as well as Couette flow and fully 3D granular flows.

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REFERENCES

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