364b Segregation during Hopper Discharge: a DEM and Experimental Study

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Granular materials typically consist of particles with a distribution of sizes, shapes, and densities, which, upon handling, may induce segregation of the material. This segregation of granular materials is undesirable for many solids handling processes as the product quality is often contingent on maintaining blend homogeneity. Therefore, it is of interest to examine the causes and extent of segregation in various systems. The system of interest in the present work is flow from a hopper.

This work uses the discrete element method (DEM) to investigate the effects of various hopper geometries and particle properties on the segregation of a spherical, bidisperse granular material during hopper discharge. Particle contacts are modeled using a soft-particle model consisting of a hysteretic spring system and sliding friction. The hopper variables of interest here include the hopper wall angle, diameter of hopper opening, the fill height, and the initial fill conditions of the particles within the hopper, such as a random or ordered state. Particle properties of interest include the diameter ratio and the overall fines mass fraction.

These computational results are compared to those from a small experimental system with the same basic hopper dimensions and particle properties. The use of this small scale system permits a comparison with the DEM model on a one-to-one basis. The experiments utilize bidisperse glass spheres in a small, Plexiglas cylindrical hopper that is used in the ASTM standard test for sifting segregation. Particles are discharged from either a ‘mass flow' or ‘funnel flow' hopper design and collected transiently in equal volumes until these hoppers are empty. Analysis of the weight fractions of fine and coarse particles are conducted by sieving. A comparison of the computational and experimental results provides an indication of the model's success at predicting segregation during hopper discharge and the applicability of the DEM model to other granular flow systems.