

ABSTRACT

Shishodia, Nagendra, M.S.E., Purdue University, December, 2001. Segregation due to Particle Induced Buoyant Forces in Granular Systems. Major Professor: Dr. Carl R. Wassgren, School of Mechanical Engineering.

A new granular material segregation mechanism based on particle-induced “buoyant” forces is proposed in this thesis. An analytic model is developed whereby the weight of an impurity particle is balanced by the net pressure force acting on the impurity due to the surrounding particles. Model predictions of an impurity’s equilibrium position in a flow of otherwise homogeneous particles compare well with results from two-dimensional discrete element computer simulations for a vibro-fluidized bed, a chute flow, and flow in a vertical bin.

Computer simulations demonstrate that a large impurity moves to an equilibrium height in a vibro-fluidized bed of otherwise homogeneous particles. This equilibrium height increases with increasing vibration velocity amplitude and decreases with the impurity-to-surrounding-particle density ratio. Increasing the density ratio beyond a critical value results in the impurity bouncing on the base of the oscillating container with the surrounding particles acting to dampen the impurity’s motion. The effect of varying the impurity diameter ratio and coefficient of restitution on the impurity motion are also studied.

Segregation also occurs in inclined chute flows of a particle bed containing a larger impurity. The impurity segregates to a well-defined position depending on the impurity density ratio, with a denser impurity sinking deeper into the flowing bed. Increasing the slope of the chute increases the height of the bed and the equilibrium height of the impurity. For the special case of a vertical chute contained between two walls, the large impurity shows no preferred location in the flow.

Previous studies have shown that a large impurity migrates to the free surface of a

deep, tapped bed regardless of the impurity's density ratio. Simulation measurements of the particle pressure force during the in-flight period of the particle bed indicate that buoyant forces are too small to induce significant impurity movement.

Previous studies have not considered particle-induced buoyant forces as a segregation mechanism. The results from this thesis indicate that buoyant forces do indeed play a significant role in the segregation of impurities in vibro-fluidized beds and chute flows.