Prediction of powder segregation in mass and funnel flow silos

Every process involving the handling of particulate materials with different physical properties (e.g. particle size, density, shape or surface roughness) can lead to a spatially non-uniform state of the bulk. This phenomenon is called segregation. The British Materials Handling Board asserts that “segregation is the most influential common factor that adversely affects the uniformity of bulk materials”; segregation, in several case, creates granular products out of specification. Broad size distributions seem to be the major factor determining the segregation of granular materials. Typically during bulk deformation, the smaller particles fall down into the voids existing between the larger ones with the result that some regions are enriched of fines while other of coarse material. This specific mechanism of segregation is called percolation.
The prediction of segregation in order to control and minimize the phenomenon is an important industrial challenge. APTLab has developed and implemented a numerical model for prediction of segregation in binary mixtures of granular materials differing in size. Bulk composition variations due to percolation can be predicted for example during the discharge of silos operating in different flow regimes: mass [Fig.1] and funnel [Fig.2] flow regime. This model is sensitive to the local mixture composition and to the local shear rate. The flow of granular material is simulated through an ad hoc rheology and numerically coupled with the segregation model. Numerical simulations have been compared with published experimental data to validate the model. The model correctly predicts three different stages during the discharge both the flow regimes (mass and funnel flow in [Fig.3] and [Fig.4] respectively): 1) an initial transient, with an enrichment of fines at the outlet; 2) a pseudo-steady state in which no segregation is observed and 3) a final transient characterized by a large segregation of fines, particularly in the funnel flow regime.

Fig. 1

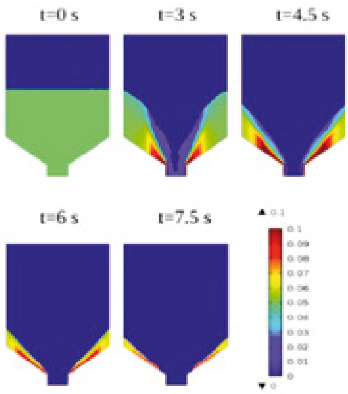


Fig. 2

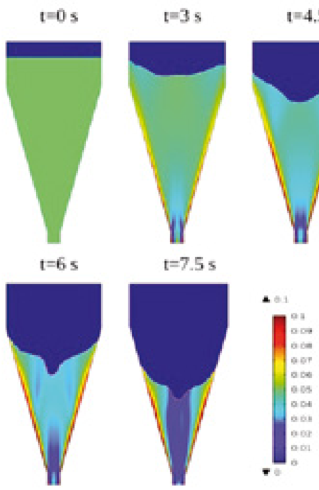


Fig. 3

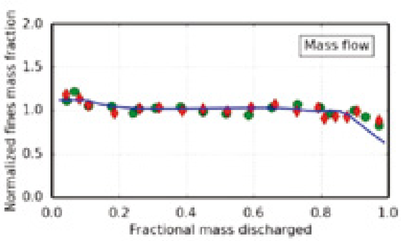
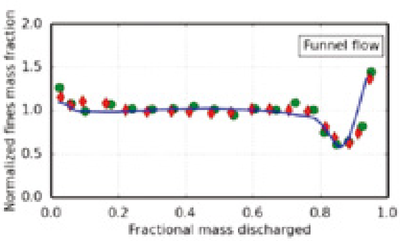


Fig. 4



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Main research topics:

- Mechanics of particulate materials
- Multiphase flows (gas-solid flows, wet granular materials)
- Mixing and segregation of powders
- High shear wet granulation
- Powder wettability and flowability
- FEM and DEM modelling of powder behavior