ABSTRACT

Sarkar, Avik Ph.D., Purdue University, December 2011. Modeling a Continuous Granular Mixer Using Discrete Element Method Periodic Sub-Models . Major Professor: Carl R. Wassgren, School of Mechanical Engineering.

Continuous granular mixing provides an alternative to traditional batch blending operations employed by pharmaceutical, food, mining, and construction industries. For large throughput operations, continuous mixing is more economical as labor costs associated with loading, unloading, and cleaning can be reduced. Moreover, issues pertaining to process scale-up can be avoided as continuous mixers can be operated for longer durations to obtain a larger quantity of blended material. Characterization of the influence of operating conditions and material properties is necessary if the performance of a continuous mixer is to be optimized. Such parametric and optimization studies can be performed in a computational framework using modeling tools such as the discrete element method (DEM).

Since DEM is a computationally expensive method, large scale parametric studies using the full continuous blender geometry is not feasible. A more efficient modeling approach is to use periodic slice sub-models representing sections of the full blender. Even though inlet and outlet effects are not captured accurately using periodic slice sub-models, comparisons of flow microdynamics show that the periodic slice approach reproduces the flow inside a full blender reasonably well.

Using periodic slice sub-models, parametric studies investigating the influence of impeller speed, fill level, particle cohesion, and particle size in a continuous mixer are performed. The optimal mixing strategy for blending non-cohesive and cohesive particles is found to be similar, even though mixing rates for cohesive materials are generally smaller. A large impeller speed at a small fill level (small inlet feed rate) leads to fluidization of granular bed, which results in best mixing performance. Vary-

ing the size of particles has a weak influence on advective flow but strongly affects mixing rates. Mixing rates measured from periodic slice simulations are also used in the advection-diffusion equation in an attempt to develop an hybridized DEM-continuum mixing model.

The periodic slice approach significantly reduces simulation time when used instead of a full continuous blender DEM model. Useful information regarding flow patterns and mixing mechanisms inside a continuous mixer is obtained from periodic slice simulations at a fraction of the computation cost. Periodic slice sub-models of the continuous blender can be used to further study other parameters of interest not discussed in this work, such as mixer design and material properties of particles. The periodic slice approach described in this work may also be applicable for modeling other continuous granular operations such as continuous granulation and continuous coating.