Large-scale grain distribution simulations with rotating machinery using efficient discrete element models

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ABSTRACT

A modular discrete element method (DEM) framework for the simulation of grain-handling using rotating machinery is presented. Typically such applications involve a contact-dominant regime for the particles on the machinery, and a sparsely-interacting regime for particle flight dynamics. This is used to partition the particle dynamics computations. A contact and collision driven DEM is used to model the movement of grains close to the rotating parts, where high collision frequencies are expected. A fully decoupled computation of the ballistic flight of grains after they launch off the rotating parts is solved in parallel thereafter. This substantially decreases the overall computational cost and allows for simulations of large volumes of grains. Unlike previous studies [1, 4], a triangulation-based mesh is used to discretize the surface of the machinery parts. This approach is versatile, but we demonstrate that it introduces an artificial surface texture that requires mesh-convergence considerations for numerical model development.

A simple Hertzian-type spring-dashpot contact model [3] is used for modelling both the inter-particle and the particle-surface contacts. This contact model can be characterized solely by the linear elastic parameters of the material and a normal restitution coefficient, which can be shown to be independent of the incident normal velocity for this model. In conjunction with it, a modified form of the Maxey-Riley equation [2] is solved for modelling the in-flight dynamics of the particles as they launch off of the rotating surface. Qualitative as well as quantitative comparisons of obtained results with available experimental data are preformed. Excellent quantitative agreement is observed in the prediction of the particle distribution dynamics from the on-disk simulations of the system near the machinery. The final distribution patterns post-flight show good qualitative agreement. Quantitative benchmarking with existing data requires additional systematic testing. The developed framework, and the insights obtained from our experiments, will therefore enable us to design process simulations for industrially relevant grain-handling systems.

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