Drag force applied to an intruder during its extraction from an ensiled granular medium: experiments and 2D DEM simulations

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Abstract.

In many powder technologies such as kneading, mixing or raking, an intruder is used to shear the granular material and to induce particle mobilities. For such processes, it is important to better control the energy transfert from the reactor to the particle scale.

In this work we investigate, by means of experiments and Discrete Element Method (DEM) simulations, the drag force acting on an intruder vertically pulled up from an ensiled granular medium. In the experiments, the intruder is first positioned at the bottom of a cell filled with glass beads and then moved upward at constant velocity. The fluctuations of the drag force acting on the moving intruder is monitored by a force sensor while the particle flow around it is captured using a high-speed camera. The images are then processed using a Particle Image Velocimetry (PIV) code. The force profiles and the flow of particles around the intruder are characterized as a function of the intruder velocity. A 2D DEM code was developed in order to simulate this problem with similar boundary conditions. With this code, it is possible to better analyzed the perturbation of the granular network in the vicinity of the intruder. The simulated particle flows and the drag force show a good agreement with the experimental results. Three flow regimes can be distinguished depending on the depth of the intruder: quasistatic, frictional and collisional. These regimes depend to the velocity of the intruder scaled by the characteristic particle speed ($\sqrt{gd}$) of the particles.

Keywords. Drag force, Particle flow, Intruder, Discrete Element Method, Rheophysic of granular medium