

Relation between free surface shape and local vertical stress in the relaxation of granular materials poured into a container

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During the filling of a container by a dry granular material (ex. storage in a silo, mixer container, packaging), the powder flow interacts with the side walls and the bottom of the bowl, and leads to the creation of a semi-confined free surface in the “feeding zone” and of particle jamming under the free surface. The “feeding zone” corresponds to a zone of strong energy dissipation induced by shocks and frictions between the grain bed formed, the particles in movement and walls of the bowl. The resultant free surface takes the shape of a heap and the surface rises upward the bowl with the powder filling. Once "buried" within the heap, particles are immobilized under the free surface. Particle jamming can be postponed according to the possible local mobility. The stabilization of the intergranular force network inside the heap leads to the establishment of a local stress field. The intensity and the distribution of these stresses can be very different according to the elastic and frictional properties of the particles and also according to the powder filling conditions (size of the bowl, mechanical properties of the walls, flowing properties of the particles, initial velocity of the particles, etc.). The knowledge of the local stress field is important for a mechanical stability of storages or a grain re-mobilization grains under the influence of a shear stress (mixing, flowing) or a compression stress (packing, tapping, compaction).

This work concerns the experimental identification of the static mechanical state within an ensiled granular material by measuring the force applied on a sensor immersed inside the heap. The experimental analysis of the powder filling and of the stabilized bed formation is realized with granular materials of contrasted properties (durum wheat semolinas, agglomerates), which are poured according to a calibrated protocol in a cell in order to follow the evolution of the free surface by recording successive pictures.

The results allow to characterize the formation of a heap with repose rest angle more or less important. This structure, which results from local granular arrangements, suggests the expression of two main modes of layout: the one by "layering" with a lateral homogeneity of the local stresses (at least until a certain distance of the side walls), the other one in "dune", (sloping heap) with a lateral heterogeneity of the local stresses. The joint analysis of the local vertical stresses in the granular bed, reveals a direct relation between the structure of the free surface and the distribution of the local stresses. Several modes of stress distribution could be distinguished and could be classified according to a parameter of uniformity and their gap from an ideal hydrostaticity.