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Transport, Storage and Forming of Industrially Relevant Granular Materials: Interreg Project "PowderReg" http://powderreg.com/en/home-3/

CHALLENGES AND OBJECTIVES

Experimental and numerical study of powder behavior during the whole process of storage, transportation and product formulation.

Development of an experimental setup including different process steps and description of powder behavior by a numerical toolbox with regards to the following aspects:

- characterization of different methods for feeding, conveying, and shaping for different industrially relevant powders

• measurement and modelling of micromechanical properties of particles as well as their influence on the rheology and transportation behaviour of powders

simulation and prediction of powder flow behavior

UNIVERSITY OF KAISERSLAUTERN – FEEDING & SUPPLY

- Measurement of contact properties for fine particles by nanoindentation, triboindentation & adhesion tests
- Development of contact models for relevant particles
- Simulation of flow behaviour of cohesive powders in silos

DEM simulations of conical hopper outflow velocities for different particle cohesions





SAARLAND UNIVERSITY – TRANSPORT

- Rheological measurements of powders of interest in a given industrial configuration
- Characterization of flow properties in geometries and scale close to those encountered in industry devices (e.g. pneumatic and vibrating conveyors)



Mystery Of How The Egyptians Moved Pyramid Stones Solved May 5, 2014 by Janet Fang



A. Fall, ..., J. Fiscina, C. Wagner, and D. Bonn. Phys. Rev. Lett. **112**, 175502 (2014)

Tube Rheometer



When building the pyramids, the Egyptians wetted the sand with water if they wanted heavy constructions to slide over it, as is shown explicitly in a wall painting of 1880 BC, suggesting that the dry sand, although perhaps more easily deformed, does not quite behave as a ballbearing type system that facilitates the sliding. When confined (as it was in the case of the Egyptians), wet sand in fact flows more easily than its dry counterpart, showing that the Egyptians were right in wetting the sand.

UNIVERSITY OF LIÈGE – COMPACTION DYNAMICS

Powder characterization with recently developed instruments:

- Improved 'tap-tap test' to measure the compaction precisely
- Rotating drum to measure flowability.
- Powder tribo-electrometer to measure powder electrostatic properties.

measurement of cohesion by a rotating drum





density measurement by the tap-tap test

Small beads proportion

measurement of electrostatic charge by the tribo-electrometer

UNIVERSITÉ DU LUXEMBOURG – SEGREGATION & UPSCALING

- Upscaling through derivation of constitutive law
- Prediction of engineering relevant scenarios of powder flow with a discrete approach
- Analysis of predicted results through statistical methods such as averaging and homogenization
- Derivation of appropriate constitutive laws applicable to continuum mechanics numerical methods

Vertical size segregation on a forward acting grate due to bat motion and gravity

Pattern formation visualized as a network of various strength between neighboring particles

Residence time distribution of differently sized particles on a forward acting grate due to segregation

UNIVERSITY OF LORRAINE - RHEOLOGY

INDUSTRIAL PARTNERS

- Experimental measurements of local properties for vibrated suspensions by refractive-index matching technique.
- Rearrangement of the grains at the local scale: link with the macroscopic rheological properties (e.g. viscosity).

Bulk and local rheology – dependency of the viscosity and rearrangement time with the vibration parameter $\sigma_v \propto (Af)^2$

Experimental setup – Couette geometry borosilicate beads (d=1 mm) into glycerol

