Prediction of vegetal cohesive powder Flow

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ABSTRACT

The vast majority of consumer products are powders or made from them. Many examples of such products may be pharmaceutical or food products, cosmetics, bio-sourced composites and bio-fuels. However, in comparison with liquids and gases, our knowledge of the powder properties, or generally the materials composed of particles, remains limited in more ways than one. Any progress in understanding their behaviour and especially in their use in processes can have considerable impact on industrial applications.

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Project leader : NEZAMABADI Saeid
Project leader's institution : UM
Project leader's RU : IATE

Budget allocated : 13608 €
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Funding : Labex

GOAL

The objective of this project is to investigate the flow behaviour of vegetal powders using numerical modelling. Vegetal powders are composed of deformable particles with cohesive interactions from multiple physicochemical origins. These powders have never been mechanistically modelled at the particle scale. In order to simulate the vegetal powders behaviour, our numerical approach is based on the Material Point Method (MPM) to account the deformability of the particles and the Contact Dynamics (CD) method for the treatment of (cohesive, frictional...) interactions between the particles [1].
This project indeed is a milestone of a strategic and general plan involving collaboration with INRA (UMR IATE) specialising in bioprocesses and the University of Leeds (School of Chemical and Process Engineering), which is an expert in powder technology. It will help to better understand important phenomena in a broad range of industrial applications and several disciplinary sectors (bioengineering, pharmacy, agri-food systems...).

RESULTS

This study will be carried out in three steps that define the main steps of the project: 1) optimisation of the numerical procedure, 2) isotropic compaction and 3) shear flow. The first step will be devoted to optimising particle discretisation and defining the number of particles for our parallelised code. The samples will be prepared starting from a gas of grains and by applying isotropic compression until the desired packing fraction is reached. Each compaction simulation will be performed with several independent initial configurations in order to be able to evaluate the statistical variability of the samples and mechanical and microstructural properties. We analyse the evolution of packing fraction as a function of the confining pressure with focus on states above the jamming state. The microstructure will be characterised at different levels of pressure in terms of various descriptors such as the particle shapes

and their contact surfaces, connectivity and force distributions. The effect of system parameters, and more specially that of material behaviour, will be considered for each value of the confining pressure. In the third step, we consider shear simulations that will be started from the isotropic states corresponding to several values of the confining pressure. This pressure sets the particle shape change state of the packing. The key issue is to understand the influence of the confining pressure on the strain-strain relationships, dilatancy and steady shear state. Since the deformability and shape change of particles depend on their characteristic stress (i.e. their material behaviours), the shear strength does not scale with the confining pressure and therefore, it is not possible to characterise the steady shear state by a simple coefficient of friction as in hard-particle packings.
In the context of this project, we plan to organise one workshop at Montpelier in June 2019.