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Internship : Complex flows of granular materials made of cohesive particles

Place : Université Gustave Eiffel, IFSTTAR, Campus de Nantes, laboratoire MAST/GPEM, Allée des Ponts et Chaussées, 44344 Bouguenais

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Duration : 6 months

Context : Granular materials (powders, grains) are ubiquitous in industrial processes but often problematic to handle as they easily agglomerate and jam : this yields excessive energy and resource demands. The processes associated to flows of these materials (as feed or product) often involve phenomena like agglomeration and particle breakage.

Recent studies prove that shear localization can be explained by long-range correlations in the framework of non-local modeling. However, a general non-local mathematical description that may be used to simulate processes of industrial interest is still lacking. In particular, existing models are often limited to cohesionless systems and lack of micromechanical insights (studies on the rheology of cohesive grains have up to now been limited to simple flow configurations, far from being comparable to industrial ones).

This internship is carried out in the framework of the ANR PRCI project « MoNoCoCo : Nonlocal Models for Complex, Cohesive granular flows » (2021-2024), which is an international collaboration with the group of Prof. F. Yang at the National Taiwan University (NTU), in Taipei, Taiwan. The intern will receive a compensation of the order of 500 €/ month. Application to programs such as Erasmus+ for Traineeship is possible.

Topic : The objective of the internship is to provide experimental data for complex flows of cohesive particles, where the cohesion is not strong enough to form large agglomerates. Different materials will be tested, from fine powders to wet grains, to sticky particles obtained by coating (Gans et al., 2020).

Two experimental setups will be used. The first is an annular shear cell (Artoni et al. (2018)) in which the grains are sheared by the rotation of the bottom wall and are compressed by a load on the top wall; the setup generates interesting localization patterns (Artoni et al. 2015, Artoni et al 2018). In this cell, flow profiles will be computed by Particle Image Velocimetry on videos recorded by a high-speed camera. The cell will also be equipped by torque sensors and multi-axis wall force sensors.

The second setup is a powder rheometer (Freeman FT4), which will allow to characterize the material with two tools, a helicoidal blade and a shear cell. Besides the characterization procedures proposed by the machine (flow energy, yield locus), the effect of cohesion on the rheology and shear localization in the cell will be characterized by particle image velocimetry at the outer wall.

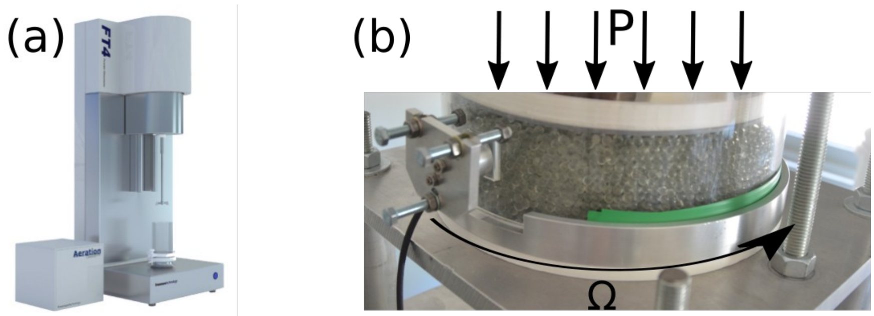

Figure: Experimental tools: (a) Freeman FT4 Powder Rheometer, (b) annular shear cell.

Profile : M2 en physics, mechanics, civil or chemical engineering.

References :

Artoni, R., & Richard, P. (2015). Effective wall friction in wall-bounded 3D dense granular flows. Physical review letters, 115(15), 158001.
Artoni, R., Soligo, A., Paul, J. M., & Richard, P. (2018). Shear localization and wall friction in confined dense granular flows. Journal of Fluid Mechanics, 849, 395-418.
Gans, A., Pouliquen, O., & Nicolas, M. (2020). Cohesion-controlled granular material. Physical Review E, 101(3), 032904.