Master 2 internship proposal
(6 months, University of Lorraine, Nancy, France)

Experimental and numerical study of the rheology of vibrated granular dispersions

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Description

Context.

This study is a part of the European Project Interreg VA "PowderReg" coordinated by the University of Lorraine, in order to propose a demonstrator for the transport, the storage and the forming of industrial powders.

In this internship, we would like to study granular dispersions. In practice, these media are widely encountered in industrial and geophysical issues (flour or medicines transport, soil liquefaction, mudslides…) [1]. These kind of materials can sometimes be completely jammed (silo for instance) due to the emergence of consolidated contact networks at the grain scale. This can happen when friction between grains controls the mechanical behavior of the system. These phenomena are responsible for occasional dynamics or jamming of the flows.

If these systems are submitted to external vibrations, a modification of the available free volume can occur and induce a decrease of the cohesion forces leading to the unjamming of the flow. Understand the mechanisms that cause the jamming of these systems would allow us to limit it. This is of great interest as part of the optimization of the transport of granular dispersions.

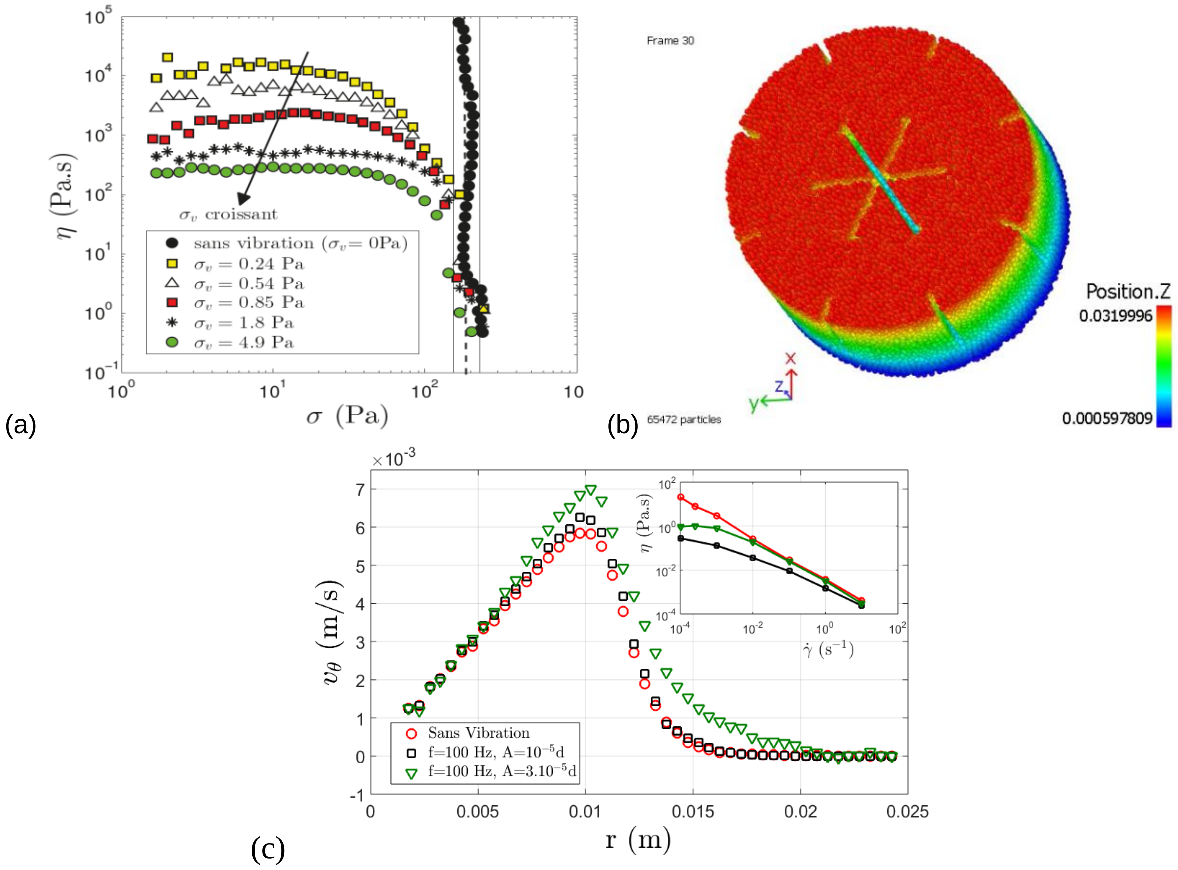
In this context, we here propose a study to characterize the effect of mechanical vibrations on the flowing properties of granular dispersions.

Proposed work.

We propose to study various model granular dispersions, made of spherical beads (glass or borosilicate beads) with various diameter greater than 100 microns. These systems are submitted to external vibrations that we can choose the supplying energy (frequency and amplitude).

To characterize the effect of the vibrations on granular dispersions flows, we propose a study through two ways:

- An *experimental approach* to characterize the macroscopic behavior of granular dispersions with a classical rheometer and a "powder cell" connected to a vibration shaker. This gives access to the global properties of the dispersion, with and without vibrations. The first results show a typical yield stress fluid behavior when no vibrations are applied. However, a "Newtonian plateau" appears under vibrations whose the amplitude depends on the injected energy (Fig. a) [2].
- A *numerical approach* to characterize the microscopic behavior in DEM (discrete element method) simulation. This allows us to simulate a "numerical rheometer" (Fig. b) which gives access to information at the grain scale. Velocity profile and stress field in the sample allow us to extract a local rheology (Fig. c). For this part, we also propose a collaboration with the University of Luxembourg.



Figures: (a) Flow curves of granular dispersions, with and without vibrations, obtained with classical rheometry, (b) "Numerical rheometer" (DEM simulation) and (c) Example of velocity profiles obtained in DEM for various vibration energies.

We propose to link these two approaches to understand what are the **mechanisms at the local scale** (local rheology with DEM simulations) leading to the **macroscopic behavior of the granular dispersion** (global rheology extracted from experiments). We propose to study how these mechanisms evolve for various granular dispersions (diameter, materials…) when they are submitted to external vibrations.

[1] P. Coussot, Rheometry of Pastes, Suspensions and Granular Materials: Applications in Industry and Environment, Wiley ed. (2005).
[2] C. Hanotin, S. Kiesgen de Richter, P. Marchal, L. J. Michot, and C. Baravian, Physical Review Letters 108 (2012), 10.1103/PhysRevLett.108.198301.