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Experiments on a confined shear flow of elongated particles : shear localization, particle orientations and rotations

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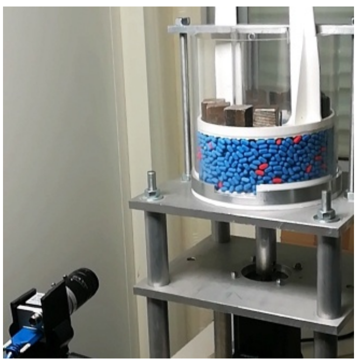
Most granular materials are composed of non-spherical particles, and, in particular, anisotropic particles are common to several applications. The rheological behavior of systems of elongated particles depends on their aspect ratio. For example, there is evidence in the literature [1,2] that anisotropic particles display inhomogeneous orientation distributions in shear flow which depend on the particle aspect ratio. In a previous work [3], in relation to coarse graining of variables related to particle rotations, Artoni and Richard studied the relation between the micro-inertia balance and the average orientation of particles, and highlighted that the orientation distribution of the particles is correlated to angular velocity fluctuations. In this work, we present experimental results on the flow of elongated particles in a confined shear cell. Experiments were performed in an annular shear cell (Fig 1) in which the bottom bumpy wall rotates at fixed velocity, while a pressure is applied at the top bumpy wall. The coaxial cylinders delimiting the flow are flat, frictional and transparent allowing visualization of the particle flowing close to the walls. Spherocylinders (minor axis 6 mm, aspect ratio ranging from 2 to 4) were made in PLA by 3d printing. Some tracer particles were printed with a differently colored material and their displacements and rotations were tracked.

Kinematic profiles were obtained for different aspect ratio of the grains and different loads applied at the top wall. Velocity profiles are heterogeneous and exponential. The corresponding characteristic length depends on the applied load and on the particle aspect ratio. The orientation distribution of the particles against the transparent wall shows a preferential orientation, and the average rotational velocity of the particles deviates from the theoretical value for spheres (i.e. half of the shear rate), which is a symptom of the frustrated motion of the bodies.

[1] Nagy, D.B., Claudin, P., Börzsönyi, T., Somfai, E. (2017). Phys. Rev. E 96(6), 062903.
[2] Campbell, C.S. (2011). Phys. Fluids 23(1), 013306.
[3] Artoni, R., Richard, P. (2019). Acta Mechanica, 230(9), 3055-3069.
[4] Artoni, R., Soligo, A., Paul, J. M., & Richard, P. (2018). Journal of Fluid Mechanics, 849, 395-418.


(a)

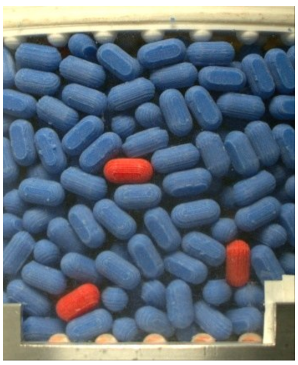

(b)

Figure 1 : (a) View of the experimental setup and (b) Example of an input raw image for the particle tracking analysis.