Particle Segregation in the Shearbox

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Delivery of final report: January 2025

Background

Segregation is an important phenomenon in granular flows, where particles separate based on their properties like density, size, and shape. This de-mixing phenomenon causes problems in pharmaceutical, agricultural, mining, and food industries since countless particles are processed globally every year [1]. Recently, this interesting phenomenon has received a lot of attention from the academic community.

Different particle properties highly influence the segregation phenomenon [2]. In granular flows with different particle sizes (Fig.1), small particles tend to percolate downwards while large particles tend to be squeezed upwards [3]; In granular flows with different particle densities, heavy particles tend to percolate downwards while light particles are squeezed upwards [4].

To date, most studies focus on the influence of particle size ratio on segregation, less is studied on the influence of particle density ratio. **It would be very inserting and promising to see the coupling effect of size ratio and density ratio on segregation.**

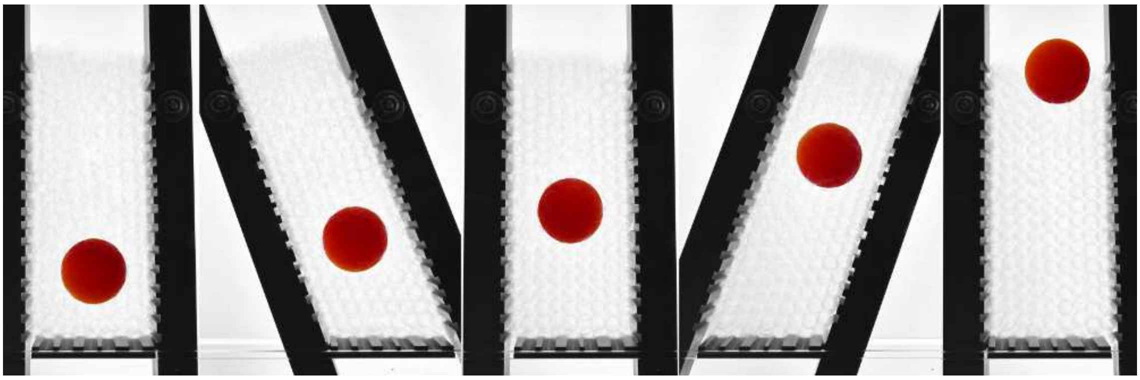

Figure 1: Demonstration of the experiments. From left to right, the red large particle is gradually squeezed upwards [5].

Purpose

This project aims to measure segregation paths with different particle density ratios and size ratios. We use high-speed cameras to capture images of granular flows, and then **obtain segregation path using image analysis.**

Methods

The facility used is the shearbox in the lab (Fig.2), which is easy to use. Four steps for achieving the purpose are summarized here:

- Set the experiential parameters of the shearbox,
- Set the high-speed camera for the best optical measurement,

- Start the experiments and capture particle motions using the camera,
- Analyze segregation paths with image analysis.

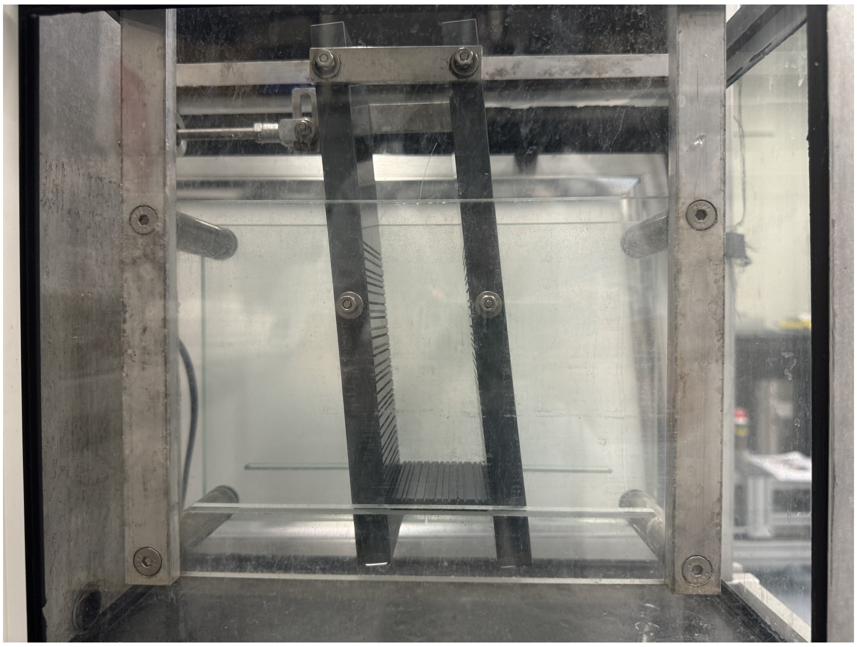

Figure 2: The shearbox used for the experiments.

What You Will Learn

- Conduct simple experiments on granular flows,
- Understand the segregation mechanism,
- Improve the ability in image analysis.

Final Report

The student should submit a report that includes: (1) a summary of the experiments done by the student, (2) the methodology of image analysis used, and (3) the qualitative description of segregation phenomenon.

References

1. Gray, J. M. N. T. Particle segregation in dense granular flows. *Annual Review of Fluid Mechanics* **50,** 407–433. doi:10.1146/annurev-fluid-122316-045201 (2018).
2. Trewhela, T. & Ancey, C. A conveyor belt experimental setup to study the internal dynamics of granular avalanches. *Experiments in Fluids* **62,** 207. doi:10.1007/s00348-021-03299-0 (2021).
3. Gray, J. M. N. T. & Ancey, C. Particle-size and -density segregation in granular free-surface flows. *Journal of Fluid Mechanics* **779,** 622–668. doi:10.1017/jfm.2015.438 (2015).
4. Xiao, H., Umbanhowar, P. B., Ottino, J. M. & Lueptow, R. M. Modelling density segregation in flowing bidisperse granular materials. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* **472,** 20150856. doi:10.1098/rspa.2015.0856 (2016).
5. Trewhela, T., Ancey, C. & Gray, J. M. An experimental scaling law for particle-size segregation in dense granular flows. *Journal of Fluid Mechanics* **916,** A55. doi:10.1017/jfm.2021.227 (2021).