Effect of drum shape on segregation

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Motivation

A common industrial problem, especially in the food and pharmaceutical industry is suppressing the natural tendency of mixed granular materials to segregate in order to generate a consistent blend. Generating high-quality homogeneous mixtures on an industrial scale is difficult and this fact is illustrated by the large number of different types of mixers available e.g. tumbling-, ribbon-blade-, rotating-, pneumatic-, and air-jet-mixers, each with numerous competing designs.

Controlling segregation is both a practical and a theoretical challenge and there are many big companies with strong interest in this field. Nestlé, Friesland Campina, Tata Steel and BASF are among the companies that have shown an active interest in this research.

Background

Recently, at the UT, it has been demonstrated how to control rotation-segregation by using convex and concave drum-shapes in combination. In particular, how to transform radial size-segregation (fast dynamics) into similarly rapid axial segregation. Our novel drum design leads to an order of magnitude increase in the axial segregation rate. This observation – and the new understanding that springs from its explanation – could lead to radical new designs for a vast set of particle processing applications.

The practical importance of this discovery can be far-reaching in industries ranging from pharmaceuticals to mining. We foresee several applications for our discovery, to name just two of them: rotating kilns, so to have differential residence times depending on the size of the particles; or, in milling devices whereby creating a sandwich of concave sections with a convex shape in the middle, big particles can be conducted into the middle of the mill, thus making the milling more effective by keeping the grinders and bigger particles in the mill while moving the fines to the ends, where they could be removed.

The Project

Previously, we have focused on the simplest possible regular concave drum, that is, the pentagram-drum. Different regimes are found for a fixed angular velocity depending on the filling fraction. Experiments, including optical, Reflective Index Matched Spectroscopy (RIMS) and Position Emission Particle Tracking (PEPT), and particle simulations have been useful to investigate this effect, see figure 1. For the experiments, we use drums made by stacking slices of 2 mm plywood, laser-cut to arbitrary shapes, allowing us to create any complex 3D drum we require. The particles simulations have been undertaken in our in-house open source code MercuryDPM.org.

So both simulation code and experiment setup already exist. The aim of this project would be to extend the research to new more complex designs using either the optical experiments or the simulation code.

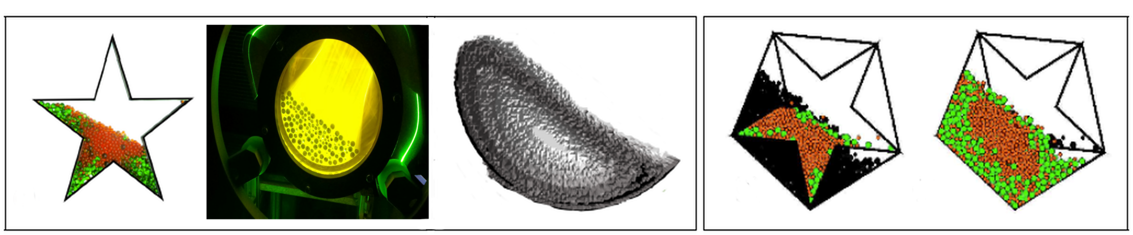

Figure 1: From the left:1) the pattern formed inside a rotating quasi-2D pentagon drums. 2) RIMS scan of a 3D drum. 3) PEPT data for the occupancy of large particles in a rotating circular drum. 4) Simulations for the axially inhomogeneous, layered drum after four revolutions, from the front i.e., the pentagram-shaped side, and from the back the pentagonal side. Particles are coloured by size with orange small and green big; black particles correspond to those particles that belong to the opposite side of the drum.