Segregation in sheared granular media: Effects of intrinsic particle properties such as size, density and shape

Gerald G. Pereira* and Paul W. Cleary[†]

[*] Computational Modelling, Commonwealth Scientific Industrial Research Organisation (CSIRO)
Clayton, 3169, Australia
e-mail: Gerald.Pereira@csiro.au, web page: http://www.csiro.au/

[†] Data61, Commonwealth Scientific Industrial Research Organisation (CSIRO)
Clayton, 3169, Australia
e-mail: Paul.Cleary@csiro.au, web page: http://www.csiro.au/

ABSTRACT

When granular media which have different size, density, shape or even frictional properties flow they will tend to segregate. This is of fundamental scientific interest but also has significance in a variety of industries such as mining, pharmaceuticals, food processing as well as for natural phenomena such as landslides. Here we consider segregation that occurs when a granular mixture is sheared, such as when it flows down along an inclined surface. A cylindrical tumbler is approximately half filled with the granular mixture and is slowly rotated (around 1 revolution per minute) about its axis (which is perpendicular to gravity) is a popular test-bed to examine sheared granular segregation. Here we consider simulation (Discrete Element Method, DEM), experiment and continuum theories to understand the segregation that occurs.

Using DEM simulations we can clearly determine the underlying causes of segregation which intimately depend on intrinsic particles properties such as their size, density, shape and frictional properties. We compare these DEM simulations with both experiments and continuum theories, for a number of these properties, and find very good agreement. It will be shown that the segregation that occurs due to differences in particle size is the strongest, with stable asymptotic states being reached after only one or two cylinder rotations. Density segregation is the next strongest followed by segregation due to particle shape. The underlying physical mechanism leading to segregation is different in each of these cases. We compare and contrast these mechanisms in detail.

We also consider granular mixtures where particles differ in two or more intrinsic properties at once (i.e. particles where their size, density and shape differ simultaneously) and show in certain situations that novel segregation patterns can arise, such as a sun-pattern or streak-pattern. Again using DEM simulation we will determine the underlying physical mechanisms which give rise to these novel streak patterns.

REFERENCES

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