Outflow and clogging of shape-anisotropic grains in hoppers with small apertures

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Abstract

Outflow of granular material through a small orifice is a fundamental process in many industrial fields,
for example in silo discharge, and in everydayôs life. Most experimental studies of the dynamics have
been performed so far with monodisperse disks in two-dimensional (2D) hoppers or spherical grains in
3D. We investigate this process for shape-anisotropic grains in 3D hoppers and discuss the role of size
and shape parameters on avalanche statistics, clogging states, and mean flow velocities. It is shown that
an increasing aspect ratio of the grains leads to lower flow rates and higher clogging probabilities
compared to spherical grains. On the other hand, the number of grains forming the clog is larger for
elongated grains of comparable volumes, and the long axis of these blocking grains is preferentially
aligned towards the center of the orifice. We find a qualitative transition in the hopper discharge
behavior for aspect ratios larger than E6. At still higher aspect ratios 48ï12, the outflowing material
leaves long vertical holes in the hopper that penetrate the complete granular bed. This changes the discharge
characteristics qualitatively.

Soft Matter 2017, January