Influence of blockiness and bumpiness on modelling dense granular flows of non-spherical particles

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ABSTRACT

The influence of various particle-scale properties on flow dynamics of granular assemblies has been extensively studied using the Discrete Element Method (DEM). Among these properties, it has been reported that shape parameters can highly affect the dynamics of the flow [1]. In this respect, to account for the shape complexity of the real particles, different shape representation techniques have been developed. The most common approach is using multi-spheres, where each DEM particle is composed of several overlapped spheres [2]. Another shape description, recently implemented in the DEM package LIGGGHTS, is the superquadric [3] that is an extension of spheres and ellipsoids. Looking in the literature, there is lack of a comprehensive study, which focuses deeply on the flow characteristics of the two approaches. Accordingly, a systematic study is planned, clarifying the influence of each method on packing and discharge processes.

Varying the aspect ratio is one way of describing the non-sphericity for shape representation [1]. However, this might not sufficient to model particles with sharp corners or those with non-smooth surfaces. Meanwhile, both superquadrics and multi-spheres have options for adjusting the geometry of the particles to address the shape complexities: a) for clumped spheres, controlling the number of sub-spheres leads to surface bumpiness; b) for superquadrics, changing the edge sharpness (or blockiness) can regulate the angularity of the particles.

The current study investigates the effect of surface bumpiness and edge sharpness on the kinematics of dense granular flows. A set of cylindrical particles is simulated and the discharge of these particles from a flat bottom silo is monitored. The dependency of the particle-level DEM data on edge sharpness and surface bumpiness is assessed by determining the mode of motion, either rotational or sliding, and by evaluating the contact forces by mapping of the mobilized friction in the system. Using a coarse-graining technique [4], which applies spatial and temporal averages to the DEM results, the influence of shape characteristics on the continuum-scale parameters (e.g. stress and density) is also identified. In this way, the differences arising from the influence of each shape representation method on the silo flow in both the micro and macro scales is addressed.

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