DEM Studies of Non-Spherical Particle and Flexible Fiber Flows: From Microscale Properties to Macroscale Behavior

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Abstract

The advanced Discrete Element Method (DEM) has been developed to simulate granular flows of non-spherical particles, such as rod-like particles and flat disks, and flexible fibers. Using the DEM simulations, we have investigated the correlation between microscale properties and macroscale mechanical behavior for these complex granular systems. The particle shape affects the micro-structure of a granular system: the largest dimension of a particle tends to align towards the material flow direction. Larger degree of alignment is obtained for the more elongated rods and flatter disks. The system coordination number and force chain network are also influenced by particle shape. As a result, the macroscale behavior, which is determined by the micro-structure, shows a strong dependence on the particle shape. Efforts have been made to develop models (of stress tensor and collisional dissipation rate) for the continuum description of non-spherical particle systems. Particle aspect ratio (particle length to diameter for cylindrical particles) and ordering number (quantifying the degree of particle alignment) are incorporated in the models to account for the effect of particle shape.

Flexible fibers introduce extra complexities that fiber bending deformation affects the system mechanical properties. Thus, fiber bending stiffness and fiber vibration damping coefficient, which uniquely characterize individual fiber response, should be included in the models that describe the flexible fiber systems. The effects of individual fiber properties on bulk flow pattern and system stresses have been explored. The results provide critical insights into the flow of flexible fibers.

References

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