Pressure-controlled secondary flows and mixing in sheared Platonic solid particles

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Abstract

Granular materials exhibit unique secondary flow behaviors upon shearing. We demonstrate, using particle dynamics simulations, that the secondary flow patterns are controlled by a pressure exerted on the particle bed. The threshold pressure, at which vortex flow transitions to disturbed or chaotic flow, depends on particle shape, that influences interparticle contacts and rheological performance. Our results show that the flow patterns are essentially determined by a dimensionless term combining the pressure and granular temperature for all the spherical and Platonic particles explored. Particle mixing is promoted by the vortex flow or the disturbed flow with strong diffusion. The highest mixing rate under a specified pressure is obtained for cubic particles, due to the remarkable microstructural ordering near the boundaries causing a high gradient of packing density. These findings may shed light on optimal control of granular secondary flows and mixing by tuning the applied pressure and particle shape.

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