Effect of Capillary and Viscous Forces on the Flow of Wet Granular Materials

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ABSTRACT

When a small amount of liquid is added to a pile of particles, pendular bridges form and the particles are attracted by capillary forces, creating complex structure and flow behaviour [1]. Using a combination of experimental study and discrete particle method simulations (DEM), we investigate the effects of capillary force, liquid viscosity and particle size on wet granular flows, and we establish a methodology that ensures the control of the bed flow motion in a rotating drum.

The velocity profile of the particles in the rotating drum is determined using particle tracking method and compared to the DEM simulation results. Capillary and viscous forces are included in the DEM model to describe the interactions between surface-wetted particles. A parametric study is used to investigate the effect of the liquid and particles properties on the bed flow and structure.

We show that the strength of capillary force between two adjacent particles can be altered through surface properties modification of the glass beads, thus, under the right conditions; we demonstrate that the bed flow motion can be controlled. Liquid viscosity effect on the bed flow motion is also investigated under low capillary forces. The capillary force between the particles is significantly reduced by making the glass beads hydrophobic via silanization. The simulation and experiment results were comparable in terms of the flow patterns and dynamic angle of repose. We find that liquid-induced cohesion increases the width of the flowing layer and the dynamic angle of repose. However, it decreases the particle flow velocity in the drum. We were able to obtain similar bed flow motion for different particle sizes, and the flow control methodology is found to be robust in the studied flowing regimes.

REFERENCES

[1] P. Tegzes, T. Vicsek, P. Schiffer, Phys. Rev. E 67, 051303 (2003).