The Manifold Rheology of Agitated Granular Media Part II

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Agitated granular media have a rich rheology: they exhibit Newtonian behavior at low shear rate and density, develop a yield stress at high density, and cross over to Bagnoldian shear thickening when sheared rapidly--making them challenging to encompass in one theoretical framework. We measure the rheology of air-fluidized glass particles, spanning five orders of magnitude in shear rate. We show that all rheological regimes can be delineated by two dimensionless numbers: the Peclet number, Pe, and the ratio of shear-to-fluidization-power, Π. By comparing fluidization-induced to Brownian agitation, we propose a constitutive relation based on Mode Coupling Theory (MCT). The Granular Integration Through Transient (GITT) model qualitatively predicts the rheological regimes observed; when taking into account shear banding, GITT also quantitatively captures our results over seven orders of magnitude in shear rate, encompassing all flow behaviors in one unified framework.

References

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