Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

Quantitative prediction of clustering instabilities in gas-solid homogeneous cooling systems CHRISTINE HRENYA, Univeristy of Colorado, PETER MITRANO, University of Colorado, XIAOQI LI, XIAOLONG YIN, Colorado School of Mines — Dynamic particle clusters are widely documented in gas-solid flow systems, including gasification units for coal or biomass, gravity-driven flow over an array of tubes, pneumatic transport lines, etc. Continuum descriptions based on kinetic theory have been known for over a decade to qualitatively predict the presence of such clustering instabilities. The quantitative ability of such continuum descriptions is relatively unexplored, however, and remains unclear given the low-Knudsen assumption upon which the descriptions are based. In particular, the concentration gradient is relatively large across the boundary between the cluster and the surrounding dilute region, which is counter to the small-gradient assumption inherent in the low-Knudsen-number expansion. In this work, we use direct numerical simulations (DNS) of a gas-solid homogeneous cooling system to determine the critical system size needed for the clustering instability to develop. We then compare the results to the same quantity predicted by a continuum description based on kinetic theory. The agreement is quite good over a wide range of parameters. This finding is reminiscent of molecular fluids, namely the ability of the Navier-Stokes equations to predict well outside the expected range of Knudsen numbers.

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Date submitted: 31 Jul 2014 Electronic form version 1.4