Dense, dry, granular flows driven by a turbulent gas

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We study the flow of grains, against gravity, driven by a turbulent gas through an axisymmetric pipe. We focus on steady and fully developed flows and analyze cases in which the grains are dilute and dense. We employ kinetic theory for the grains and a simple turbulent fluid model for the gas.
We first test the results in a dilute flow with the experimental observations from the literature. We then analyze a dense flow and discuss the solutions obtained at different average solid volume fractions and total volume flow rates. Featureless frictional and bumpy wall boundary conditions are applied, and we observe and discuss the changes that occur in the flow behavior. Featureless frictional walls promote a uniform particle distribution, whereas bumpy walls enhance particle fluctuations near the boundary.