Continuum modelling of granular flows?

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Continuum modelling of granular flows is rapidly becoming a reality, with a number of groups throughout the world developing continuum theories to simulate dry/wet and or cohesive grains in industrially relevant settings. Continuum models are potentially much more efficient than Discrete-Element-Method/Discrete-Particle-Model (DEM/DPM) simulations, but they are not necessarily a universal panacea. They come with their own problems and computational challenges, and new skills will need to be acquired by industry in order to use them. Unlike fluids, where the Navier-Stokes equations have long been established, the underlying equations for granular flow are still a subject of intense research. Considerable progress has been achieved over the past two decades, with the development of the $\mu(I)$-rheology. This links the local friction μ to the inertial number I (which may be thought of as a shear-rate that is non-dimensionalized by the local pressure and the particle size). The $\mu(I)$-rheology has been very successful at explaining a wide range of experimental observations of liquid-like granular flows. Models for the solid-like granular flows were developed by geotechnical engineers back in the 1960s, but these become mathematically ill-posed in the liquid-like regime. Researchers are now unifying the two descriptions, to solve problems of practical interest, such as in chutes, silos and rotating drums. Most theories assume the granular material is monodisperse, but new models are also being developed for polydisperse granular flows, which are able to calculate the bulk motion as well as the particle segregation that occurs within them. I will give a brief overview of what different groups are doing, and try to stimulate some discussion.