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Multiphase flow modeling: A tool to aid in scale up of processes

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Multiphase flows are ubiquitous in chemical processing industries. Traditional approach has been to ignore fluid dynamical effects by invoking simplifying assumptions of homogeneity, but pay the price during scale-up of processes. The question that I address is "Can Multiphase flow modeling come to our rescue in minimizing the need for pilot scale experiments?" On the fundamental side, we have developed algorithms for direct numerical simulation of multiphase flows. For dispersed rigid particles as in suspension flows, sedimentation etc, we couple the Navier-Stokes equations with the rigid body dynamics in a rigorous fashion to track the particle motion in a fluid. For deformable bubbles/droplets dispersed in another fluid, we also track their motion in an Eulerian grid. The two classes of algorithms show great promise in attempting direct simulation of multiphase flows, from which we can extract statistically meaningful average behavior of suspensions or bubbly flows. On the other hand, there is an immediate need to study flow of complex fluids of industrial importance. Such cases include polymer blending processes, erosion in pipelines and process vessels and mass transfer in packed beds. In such studies we use volume averaged equations as the basis of flow models coupled with experimental validation of such predictions in an effort to develop scale invariant closure models that are needed as part of the volume averaged flow models.