ABSTRACT

Sanga Reddy Peerreddy, MSME, Purdue University, May, 2002. Modeling Particle-Laden Viscous Flows using an Eulerian-Lagrangian Approach. Major Professor: Prof. Carl R. Wassgren, School of Mechanical Engineering.

This thesis describes the methodology and results from computer simulations of two-dimensional, laminar, particle-laden viscous flow in Couette and lid-driven cavity geometries. The computer simulations utilize the Eulerian-Lagrangian modeling approach where particle states are modeled using the discrete element method (a Lagrangian technique) and the fluid state is determined by solving the Navier-Stokes equations using a control volume approach (an Eulerian technique). Coupling between the solid and fluid components occurs through momentum exchange and volume fraction effects.

Measurements of the wall shear stresses and velocity and solid fraction profiles are made for a range of flow parameters in the Couette flow simulations. The wall shear stress trends observed in the simulations are similar to the experimental results reported by Bagnold (1954). The simulations indicate that the transition from the macro-viscous to the grain-inertia regime occurs primarily a result of an increase in the particle wall stresses and not due to the particle influence on the fluid phase. Velocity gradients in both the fluid and solid phases at the channel center increase and particles are more uniformly distributed with decreasing Bagnold number. Contrary to Bagnold's observations, the simulations showed that at a given Bagnold number, the dimensionless wall shear stress is dependent on the channel wall velocity, channel gap width, the solid volume fraction, and the particle-particle and particle-wall friction coefficients.

The particle velocities in the lid-driven cavity simulations are compared to experimental measurements performed at the same operating conditions. The simulated

velocity field agreed well with the experimental results in dilute regions of the flow and when the lid velocity is small. The largest discrepancies between the experimental and simulated solid velocities occurred near the cavity walls. The particles in the simulations closely followed the fluid streamlines everywhere except near the downstream and far walls.

In general, the Eulerian-Lagrangian computational approach implemented here appears to successfully model particle motion in dilute, low velocity gradient regions. Possible improvements to the model include improvements to the particle contact force models and empirical fluid drag models.