RHEOLOGICAL MEASUREMENTS IN LIQUID-SOLID FLOWS

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The behavior of liquid-solid flows varies greatly depending on fluid viscosity, particle and liquid inertia, and collisions between particles. While particle collisions in inviscid fluids can be understood statistically, liquid-solid flows are complicated by the fluid viscosity and forces acting on the particles (e.g. lift, drag, added mass). These flows were first studied by Bagnold, whose investigation found two different flow regimes: a macro-viscous regime where the shear and pressure forces are proportional to the shear rate, and a grain-inertia regime defined by a dependance on the square of the shear rate [1, 2]. The scaling relations he developed have been used to model and understand natural phenomena since.

In an examination of Bagnold's work, Hunt *et al.* found that his experiments were in the range of a fluid transition. The two flow regimes described by Bagnold were actually the transition from a linear shear flow to a flow dominated by the boundary layer along the rotating end walls of his experimental apparatus and not a transition due to the effects of the particles [3]. It is with this fact in mind that some of Bagnold's experiments were repeated and preliminary results therefrom are presented. Previous research with few particles has shown that both normal and oblique collisions of particles are strongly influenced by the Stokes number, where no rebound of the particles occurs for $\mathrm{St} \lesssim 10$ and lubrication effects are negligible for $\mathrm{St} \gtrsim 2000$ [4, 5]. The pressure on the outer walls is composed of these direct collisions with the wall and collisions between particles near the wall, where the pressure is transmitted through the fluid. This pressure force has a strong dependence on the solid fraction [6].

Using a coaxial rheometer with a height to gap ratio (h/b) of 11.7 and gap to outer radius ratio (b/r_o) of 0.166, specially designed to minimize effects of secondary fluid motion, shear and pressure measurements were made of near suspensions. These experiments were made for a range of Stokes numbers and solid fractions, concentrating on the lower solid fractions and higher Stokes numbers where there is a dearth of reliable data. For these low solid fractions, the pressure and shear increased with solid fraction as well as Stokes number, but did not show the same sharp transition between flow regimes as in Bagnold's data.

References

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