231e Rheology and Structure Formation in Sheared Suspensions of Elastic Particles

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Large scale hydrodynamic simulations are presented for the rheology of sheared suspensions of elastic spheres. Suspensions dynamics are studied for two distinct sets of shear flow simulation - constant shear rate and constant stress. For dilute to moderately concentrated conditions up to volume fraction φ=.50, the particles remain disordered and suspension behavior resembles hard sphere suspensions. At higher volume fractions in the range $.50<\varphi<.60$, the suspensions may undergo a disorder-order transition with hexagonal packing patterns. Three dimensions probability distributions $g(x,y,z)$ are presented to characterize the suspension microstructure, while simulation videos are shown to illustrate the dynamics of structure evolution. The phase boundary is a function of the volume fraction, dimensionless elastic modulus and the strength of lubrication forces as characterized by a minimum effective separation gap $\delta_{min}$for hydrodynamic force calculation. Constant shear rate simulations show large fluctuations in instantaneous viscosity at high volume fractions, $\varphi>.50$. Constant shear simulations exhibit jamming phenomena at large φ. The jamming phenomenon is overcome and a liquid like state is re-established as the ratio of viscous shear/elastic modulus is increased. The deformation of the particles under high shear provides the free volume necessary to remobilize the particles. Elastic spheres present a useful model system for investigating the approach to jamming phenomena and transition to liquid like states. These systems represent an intermediate regime between rigid hard spheres and concentrated suspensions of deformable droplets.