Direct numerical simulation of a bubble suspension in small amplitude oscillatory shear flow

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ABSTRACT

Bubble suspensions are often encountered in nature and in many industrial applications. When bubbles are added to a liquid, the magnitude of the viscosity changes and the behavior of the material is modified, giving it non-Newtonian properties. We use a 3D direct numerical simulation with the finite element method to investigate the effect on the rheology of bubble suspensions.

To describe the flow dynamics we assume that Brownian motion and inertia can be neglected and that the fluid is Newtonian and incompressible. The bubble interface is modeled as a sharp interface with surface tension. The resulting equations are discretized in space using the finite element method employing a mesh of quadratic tetrahedra (Taylor-Hood). For time discretization we use a second-order time integration scheme (BDF). The mesh is locally refined to accurately resolve thin layers between bubbles. A triperiodic mesh where the boundaries curve around the bubbles based on [1] is used. An implicit time-stepping scheme will be presented, where the velocities, pressures and positions of the bubble interfaces are solved in a single system. This approach greatly increases stability, and allows us to use large time steps. The suspension is subject to oscillatory strain while remaining in the linear regime.

The model is validated against the linearized Frankel and Acrivos model [2]. Results of ordered and random distribution of bubbles, of volume fractions up to 40%, will be presented. When the frequency is low, bubbles act as rigid fillers increasing viscosity. On the contrary, when frequency is high the strain is accommodated by the bubbles leading to viscosity decrease.

REFERENCES

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[2] Llewellin E. W., Mader H. M., Wilson S. D. R., The rheology of a bubbly liquid. *Proceedings of the Royal Society of London*, Vol **105**, pp. 987-1016, (2002).