Finite element method simulations in magnetorheology

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ABSTRACT

Finite Element Methods have been thoroughly used in the past to simulate the yield stress and storage modulus in model magnetorheological fluids [1-8]. There are essentially two approaches, involving the calculation of the magnetostatic force between two isolated particles [1-4] or within a cubic array of single particle-width chains [5-8]. Eventually, the yield stress (storage modulus) is calculated from the maximum (initial slope) of the simulated shear stress versus shear strain curves.

Current simulation methodologies have two important limitations: i) a pure shearing flow is not actually imposed; instead the particle chains are stretched and forces/fields are projected along the flow direction, ii) the field boundary conditions are not correctly applied; instead the magnetic field is fixed as a constant (i.e. the external field) at the boundaries of the computational domain. These two limitations make the current models invalid for medium-to-large concentrations that are of interest in commercial applications.

In this contribution we propose a novel and very simple Finite Element Method that grounds on a reduced field formulation with periodic boundary conditions. On the one hand, the reduced field formulation allows us to set the applied magnetic field as a domain property so it is not necessary to impose it at the boundaries. On the other hand periodic boundary conditions allow us to reproduce a truly three dimensional network of particles. As a result, the shearing flow is simply created by shearing the unit cell and simulations are not restricted anymore to dilute suspensions involving single particle-width chains.

REFERENCES