

Tunable discontinuous shear thickening with MR suspensions

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Introduction

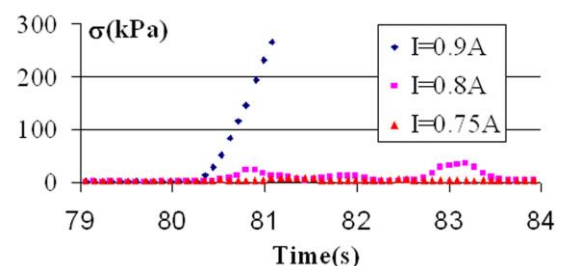
Discontinuous shear thickening is usually observed in very dense suspensions of particles and manifests by a jump of shear stress at a given shear rate that we call the critical shear rate or by a decrease of the shear rate during a ramp of stress. This transition is believed to be created by the sudden formation of a percolating network with frictional contacts between the particles and happens when the shear forces dominate the repulsive forces which keep the particles apart. These repulsive forces can be due to ionic or to polymer layers adsorbed on the surfaces of the particles. Our aim here was to be able to control this transition thanks to the application of a magnetic field.

Materials and methods

We have used iron carbonyl particles in water with a coating by a superplasticizer molecule used in cement industry. The volume fraction of particles was 61%. The rheometer was specially designed for high torque measurements with a limit of 10N.m. The cell consisted of an helicoidal tool of diameter 24mm rotating inside a cylindrical cavity with a gap between the helix and the outer cylinder of 1mm. A coil is surrounding the cell giving a magnetic field parallel to the axis of rotation (the field is parallel to the vorticity axis).

Results

The main result is presented in the figure below. The shear rate was constant and equal to 12.5s^{-1} . After a given time we suddenly apply a current and follow the torque evolution. For a current $I=0.75\text{A}$ nothing happen (red curve). For $I=0.8\text{A}$ large fluctuations of the stress begin to appear (purple squares) and for $I=0.9\text{A}$ we obtain the jamming transition with a stress which triggers the mechanical security above 9N.m (blue diamond).



The stress corresponding to this limiting torque is 270kPa and was obtained for a field $H=4.3\text{kA/m}$ (54Oe). It should be compared with the usual value of 60kPa obtained with the commercial MR fluids at field values of at least 5000Oe. It clearly opens the way to new applications of MR fluids. We shall present the evolution of the critical field with the shear rate and also other results obtained at different volume fractions. A first explanation of the phenomenon will be proposed.

Acknowledgment

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