FORMATION DYNAMICS OF TRANSIENT SHEAR BANDS IN A SIMPLE YIELD STRESS FLUID

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Yield stress fluids (YSF) encompass a large amount of everyday-life and industrial complex fluids ranging from hair gels, cosmetic creams, and toothpastes to many food products. They respond elastically below a certain stress threshold σc, known as the yield stress, whereas they flow as liquids above σc. The behaviour of YSF still raises many fundamental issues, in particular, in the vicinity of this solid-to-fluid transition [1]. Recently, it has been shown [2], that a carbopol gel which is a simple yield stress fluid presenting no aging nor thixotropy, exhibits transient shear banding before reaching a steady state characterized by a homogeneous, linear velocity profile. The duration of the transient regime decreases as a power law with the applied shear rate.

In this study, we also perform shear-rate controlled experiment on carbopol gels but we concentrate on the beginning of the experiment, i.e., the formation of the transient band. Using ultrasonic speckle velocimetry simultaneously to standard rheological measurements, we follow the temporal evolutions of the velocity profiles into the gap and the global stress. As shown on the figure below, the formation of the band follows three different steps: (a) an elastic deformation, (b) & (c) failure at the rotor and elastic recoil, and (d) shear band growth.

These different steps can also be identified in the stress evolution: the elastic deformation of the gel corresponds to the increase of the stress, the maximum of the stress corresponds to the fluid breaking and to the elastic recoil, and the final stress relaxation corresponds to the growth of the shear band.

We also study the influence of the shear rate on the stress evolution with time, in particular on the value of the stress maximum and on the corresponding time. We show that the maximum of stress is obtained for a strain of about 100% and that the value of the stress maximum increases as a power law of the shear rate. We interpret these results in light of recent theoretical models.

[1] E. Weeks, in Statistical Physics of Complex Fluids, (Tohoku University Press, 2007)
[2] T. Divoux *et al*., Phys. Rev. Lett. 104, 208301 (2010).