Electronic Supplementary Material (ESI) for Soft Matter

Supplementary figures to “Yielding dynamics of a Herschel-Bulkley fluid: a critical-like fluidization behaviour”

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1 Supplementary Figure 1

The total slip velocity v_s was computed as the sum of slip velocities at the rotor and at the stator recorded once steady state is reached and averaged over at least 150 s. Supplementary Figure 1 shows v_s relative to the rotor velocity v_0 for various gap widths and applied shear rates. v_s/v_0 is much larger for small gap widths than for larger gaps. For $e = 0.45$ mm, the amount of wall slip is about 30 %, independent of or weakly decreasing with $\dot{\gamma}$. The same trend is observed for $e = 1.5$ mm yet wall slip is smaller and of the order of 15 %. For $e = 3$ mm however, the relative slip sharply decreases with $\dot{\gamma}$ from about 20 % at the lowest shear rate down to negligible values of the order of our uncertainty of about 2 %.

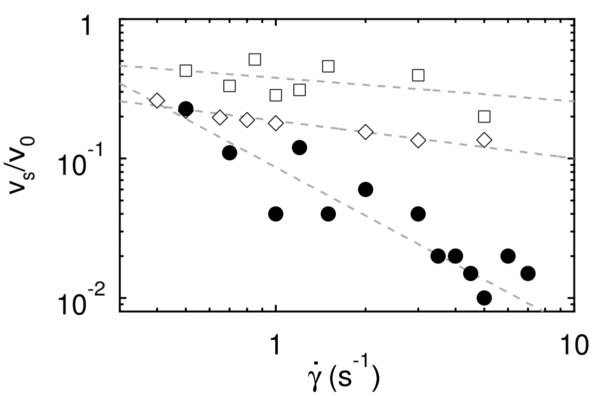

Fig. 1 Steady-state total slip velocity v_s relative to the rotor velocity v_0 as a function of the applied shear rate $\dot{\gamma}$ for smooth Couette geometries of gap width $e = 0.45$ mm (□), $e = 1.5$ mm (◇), and $e = 3$ mm (•). Dotted lines are power laws drawn to guide the eye. Experiments performed on different batches of 1 % w/w carbopol microgels.

2 Supplementary Figure 2

Supplementary Figure 2 shows the spatiotemporal diagrams of $v(x,t)$ recorded in the three different Couette cells for similar shear rates $\dot{\gamma} \simeq 0.8$ s^{-1} together with the corresponding stress responses. Transient shear banding is observed for $t < \tau_f$ as indicated by white dotted lines (see also the movies in the supplementary material†).

The results for $e = 0.45$ mm are qualitatively similar to those found previously for $e = 1$ mm and $\dot{\gamma} < \dot{\gamma}^\star$ [see e.g. $\dot{\gamma} = 1.5$ s^{-1} in Fig. 9(a)], i.e. the transient regime presents a quasi-stationary phase followed by strong fluctuations and abrupt full fluidization. Here, it is interesting to note that the quasi-stationary phase ($t \lesssim 10^3$ s) involves a pluglike flow at about half the rotor velocity whose velocity slowly decreases and that precedes the nucleation of a fluctuating shear band (see also the movie in the supplementary material†). This initial plug flow is only seen in smooth geometries and was already evidenced in a previous study devoted to the stress overshoot phenomenon at short times.[1]

On the other hand, the spatiotemporal diagrams for $e = 1.5$ mm and $e = 3$ mm resemble that of Fig. 9(c). Indeed, as the gap width is increased, the characteristic kink in $\sigma(t)$ disappears as well as the fluctuations of the flow field, and the shear banding regime becomes more progressive and continuous.

References

1 T. Divoux, C. Barentin and S. Manneville, Soft Matter, 2011, **7**, 9335–9349.

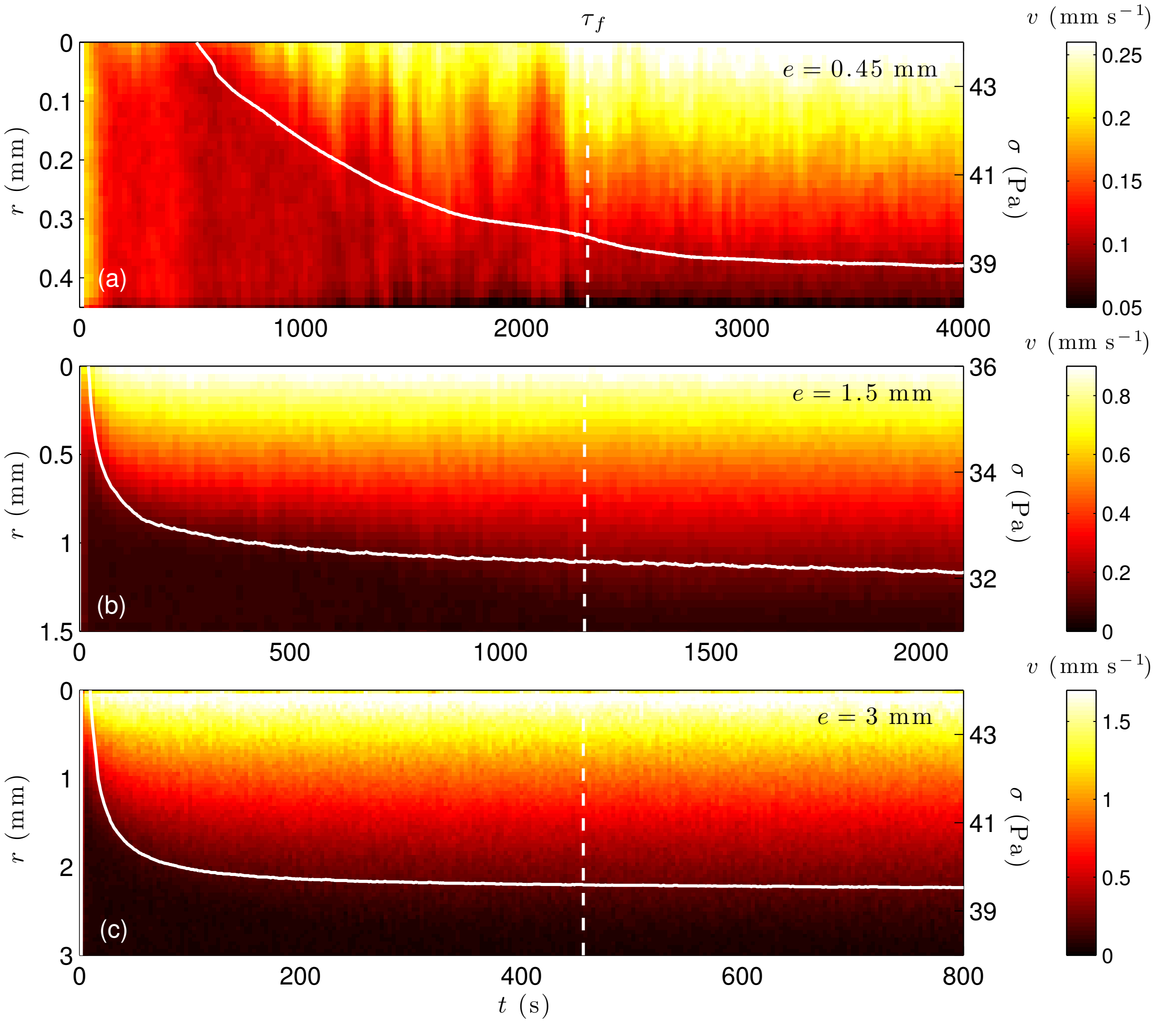

Fig. 2 Spatiotemporal diagrams of the velocity data $v(r,t)$ in smooth Couette cells of different gap widths e and under similar shear rates. (a) $e = 0.45$ mm and $\dot{\gamma} = 0.85$ s^{-1}. (b) $e = 1.5$ mm and $\dot{\gamma} = 0.8$ s^{-1}. (c) $e = 3$ mm and $\dot{\gamma} = 0.7$ s^{-1}. White lines are the corresponding stress responses $\sigma(t)$ (right vertical axis). The vertical dashed lines indicate the fluidization times τ_f. The time interval between two velocity profiles is 21 s, 17 s, and 4 s in (a), (b), and (c) respectively.