Rheo-inertial transition to turbulence in pipe flow

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Résumé

The transition to turbulence in cylindrical pipes is still not fully understood despite extensive studies since the Reynolds experiment in the early 1880s [1], even more for non-Newtonian fluids, see recent reviews [2,3]. We focused here on the mechanism leading to the transition to turbulence in pipe for yield-stress shear-thinning fluids. This transition occurs for purely shear-dependant viscosity fluids (without elastic effects) due to their rheological behaviors, so called here *rheo-inertial transition to turbulence*. An experimental setup allowed us to identify flow regimes in a cylindrical pipe, by combining flow structures visualisations and pressure drops measurements. We observed a new regime in the rheo-inertial laminar-turbulent transition, triggered below the turbulent puffs onset. This pre-transition regime is characterised by a flow asymmetry [4,5,6] in which its position and degree evolve with the Reynolds number [7]. The origin for the rheo-inertial regime stability could be due to a favourable competition between the non-linear contributions of rheological behavior and flow inertia. Beyond this regime, we quantified the puff transit intermittence. It revealed the delay to turbulence caused by the yield stress. It also revealed for the first time a different rheo-inertial transitional behavior in the intermittency evolution versus Reynolds, with a smoother transition on a broader Reynolds hydrodynamical range. Finally the increasing delay to the onset of turbulent puffs with the yield stress is highlighted.

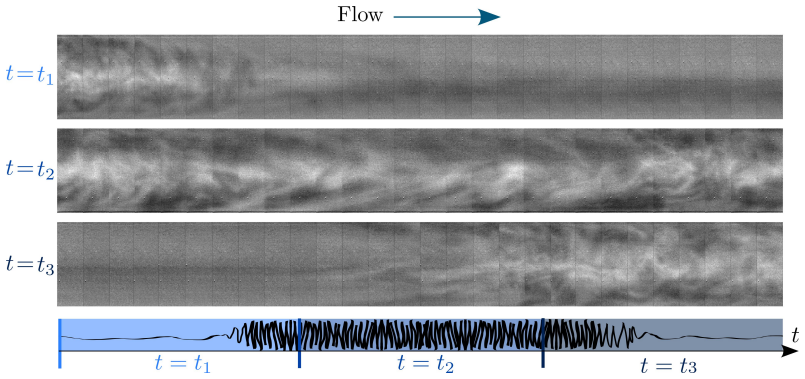

Figure 1. Flow visualisations on a yield-stress fluid at Re = 3 875.

Références

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