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Start-up flow in a model yield-stress fluid

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We have investigated the start-up flow and yielding transition of Carbopol 940 in a vertical pipe. Carbopol is a soft solid when the applied shear stress is lower than its yield stress, but flows for higher stresses. Carbopol in a vertical pipe was displaced by an immiscible Newtonian fluid injected at a constant rate at the bottom of the pipe. Measurements of the wall shear stress and the velocity field in the Carbopol indicate that the flow undergoes a complex transient as the material yields, with the flow profile being parabolic at early times before approaching the expected plug-like flow at sufficiently long times. For rough boundary conditions, yielding took place when the wall stress was equal to the yield stress. For smooth boundaries, flow occurred at lower stresses due to slip at the walls. I will discuss our results in the context of our understanding of the yielding transition and the viscoelastic properties of the material.

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