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Experimental study of viscoplastic fluid placement in a confined geometry with application in the plug and abandonment of oil and gas wells

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ABSTRACT

The plug and abandonment (P&A) of oil and gas wells is performed when a well reaches the end of its lifetime. Such P&A operations usually consist of placing several cement plugs in the wellbore to isolate the reservoir and avoid the contamination of fresh water resources, soil, and atmosphere. An economical method to place a cement plug in the wellbore is through the dump bailing method, in which a relatively small amount of cement slurry is placed inside the well on a barrier. In this method, a wide range of Newtonian or non-Newtonian fluids is used to displace and remove the in-place fluid (water) in the wellbore. We focus on an industrially interesting case where the placed fluid exhibits non-Newtonian behaviours, mainly with a significant yield stress. Motivated by the fluid mechanics of this process, we experimentally investigate the placement of a viscoplastic fluid in a vertical pipe to replace a lighter Newtonian fluid. The fluids of our interest are miscible. The concentration profiles are analyzed by image processing techniques to shed light on the mixing between the fluids in the flow domain. We investigate the effects of the viscosity ratio between the fluids, and the rheological parameters on the placement flow patterns. We successfully classify the different flow regimes that describe the flow dynamics versus the governing dimensionless numbers. We observe three distinct dynamical regimes: a break-up regime, a coiling regime, and a buckling regime. The results of this work can be used for improving the cement plug placement in P&A of the oil and gas wells.

Keywords: Plug and abandonment (P&A), Fluid placement, Viscoplastic fluids, Viscosity ratio.