PRIMARY CEMENTING OF HORIZONTAL WELLS: LAMINAR DISPLACEMENT FLOWS IN OBSTRUCTED ECCENTRIC ANNULI

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ABSTRACT

Primary cementing is an operation performed during the construction of an oil well. The aim is to displace the drilling mud with a cement slurry along the gap between the rock formation and the steel casing. Difficulty arises because the gap is small, because the in-situ fluids (drilling muds) have a yield stress, and because the steel casing is rarely concentric in horizontal wells. Additional difficulties to the displacement include the presence of other geometrical irregularities along the length of the well such as the presence of washouts, keyseats and breakouts (see Renteria *et al.*[1] for more details) and also left over rock cuttings from drilling.

The motivation of this work is the study of displacement flows in a partially obstructed, eccentric annular space, which may be caused by a consolidated cuttings bed in the narrow side of the annulus. Recently, Mitishita *et al.*[2] experimentally investigated turbulent displacements of a Carbopol solution (yield stress fluid) in both an unobstucted and obstructed annulus, with the eccentricity $e = 0.5$ and 0.7. The addition of the obstruction was mostly detrimental at low eccentricities, with a significant amount of Carbopol left behind downstream of the obstruction. Furthermore, lowering the Reynolds number (while still in the turbulent flow regime) generally resulted in lower displacement efficiencies. However, other investigations resulted in less conclusive findings about efficiency of turbulent *vs* laminar displacements[2,3], without taking well irregularities into account.

We expand the previous experiments of Mitishita *et al.*[4] by focusing on laminar displacement flows in obstructed, eccentric annuli. These types of flows have only been studied briefly by 3D simulations[5], but not in experiments. To address this gap, we perform displacement flow experiments with Carbopol solutions as a displaced fluid. To achieve laminar Reynolds numbers in our large scale flow loop, xanthan gum solutions at high concentrations are used as displacing fluids. The rheology of the fluids is characterized with a Malvern Kinexus Ultra+ rheometer. Experimental measurements include pressure drop, flow rate and direct visualization of the displacement flows with high-resolution cameras. Our results serve as a comparison to the results of Mitishita *et al.*[4], while provinding an initial benchmark for numerical simulations of such flows.

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