PREDICTICTING THE RATE OF CEMENT PLUG FAILURE

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ABSTRACT

Plugging is an essential part of decommissioning wells. Often cement plugs are set at various depths to isolate critical zones of interest. These zones can include production zones, aquifers and surfaces, ensuring the wellbore is isolated correctly. The cement slurry is either pumped on top of a mechanical support (retainer, bridge plug), or is placed directly over the wellbore fluid. The cement plug should hydrate and form an impenetrable barrier between the subsurface and the surface. Since the cement slurry (with a yield stress) is typically denser than the fluid below, there is a tendency to destabilize mechanically. Proper selection of cement properties, namely the yield stress, is therefore essential to the success of the abandonment process. If the cement does not set correctly, the well integrity is compromised and another cement plug will need to be placed.

The success of the cement placement is governed by the interface between the cement and lighter (usually Newtonian) fluid. Over the initial setting time, the interface can become unstable allowing light fluid to propagate upwards into the denser fluid. Experimental studies conducted with water under a denser yield stress fluid show that the interface usually takes the form of a long finger moving centrally upwards. If this finger can reach a critical height in the cement plug before it sets sufficiently, the plug will lose its integrity and fail. Therefore, being able to predict the velocity of the finger is of critical importance. Here the viscous finger is modelled using a lubrication approximation of the momentum equations. We can then derive an analytical expression for the flow rate and mean velocity of both the viscous finger and the dense fluid flowing down. Experiments show that the model accurately predicts the velocity of the finger for a range of rheological properties and densities. The speed of the finger is governed by the yield stress, the density contrast between the two fluids and the ratio of effective viscosities.