DEFYING GRAVITY: THE FLUID MECHANICS OF OFF-BOTTOM PLUG PLACEMENT

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ABSTRACT

The abandonment protocols of oil and gas wells may vary among regions and countries. Most commonly, however, two or more cement plugs are placed along the well for this purpose. The plugs above the lowermost plug are often referred to as off-bottom. Balanced-plug is a common technique to place off-bottom plugs. The placement process involves: (i) identifying the plug location, (ii) placing the injector at the target position and pumping the cement slurry, and (iii) pulling the injector out of the well once the cement slurry is levelled in the injector and the annulus. In Western Canada, it is common to use the balanced-plug method to place off-bottom plugs without using a barrier; i.e., to inject the cement slurry directly in wellbores that are otherwise filled with water.[2] A successful placement is achieved when the injected cement slurry (a yield stress fluid) accumulates at the target position, over the lighter wellbore fluids.

While displacement flows in primary cementing have been studied extensively, the hydrodynamics of the balanced-plug method, in the absence of a barrier, remain largely unexplored. Considering the hydrodynamics of the placement process, four primary phases may be presumed: (i) *the onset of injection*, (ii) *the quasi-steady injection*, (iii) *pulling out of the hole*, and (iv) *the final steady-state*. Each flow development phase is a complex two-fluid problem that may reveal diverse flow dynamics and different modes of instability. We develop hydrodynamic models of the process in a representative two-dimensional domain and explore the effect of fluid properties and the flow domain. Our findings provide a mechanistic perspective of the processes that may prevent the buoyancy-driven failure of the placement process and the role of the rheology of the fluid.

References

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