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SQUEEZE CEMENTING WITH MULTIPLE PERFORATIONS: FAST COMPUTATIONS

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ABSTRACT

CO_2 and CH_4 leakage from re-purposed reservoirs and existing wells significantly contributes to industrial greenhouse gas emissions. In British Columbia (BC), approximately 28% of the wells drilled between 2010 and 2018 experienced leakage problems. Squeeze cementing, which involves injection of cement slurry through perforated casings to seal leakage pathways (i.e., micro-annuli formed during and after primary cementing), is the standard remediation technique. However, optimizing this process is challenging due to uncertainties in the micro-annulus geometry and limited downhole measurements. In the literature, a stochastic modeling approach has been adopted, simulating numerous possible geometries to predict outcomes. However, even a single simulation of squeeze cementing around one perforation can take 2-8 hours on a single compute core, making large-scale modeling computationally prohibitive. This constraint limits the use of time-dependent physical simulations for optimizing squeeze cementing operations, highlighting the need for a more efficient approach. Therefore, in this work, we attempt to develop such efficient methods. At a fixed injection pressure, cement slurry penetrates a certain distance before stopping due to the balance between the pressure gradient and the slurry's yield stress. Neglecting particle jamming, the penetration front at the stoppage time follows a contour defined by the critical pressure, which varies based on the micro-annulus gap and cement properties. Since this penetration occurs rapidly, the key question is whether we can directly compute the maximum penetration location without simulating transient dynamics. By framing this as a geodesic problem, we develop a computationally efficient method to determine the critical pressure gradient contours around multiple perforations. These contour maps provide a practical tool for estimating the volume of micro-annuli filled at a given injection pressure and assessing residual leakage rates post-squeeze. Additionally, they help determine the pressure differential required to ensure cement fully seals between perforations, which is an essential factor in job design. The developed method presents a fast, reliable approach for improving squeeze cementing strategies, reducing computational demands while enhancing leakage prevention effectiveness.