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Experimental study of the sealing properties of cement plug during the early age

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In sequestered CO2 underground wells or in permanently abandoned wells, a cement plug is typically used as a well barrier material to ensure long-term zonal isolation of the well [1]. Proper plugging should prevent any flow of fluids from the well to the surrounding environment and the surface. It is assumed that the ability of the cement plug to fulfil its barrier function over the long term depends on its behaviour from the early age to the hardened state [2]. A good knowledge of this initial stage might allow prediction of potential crack (microannuli) formation between the cement and casing. In this study we investigate the impact of curing time during the early age of the cement plug, on its sealing properties in a scaled-down configuration but under relevant downhole conditions.

In the first stage we use an Ultrasonic Cement Analyzer (UCA) to monitor the evolution of cement strength over time, under appropriate downhole conditions. From this test, we mainly detect 3 phases: before the setting time (zero and no cement strength), a second phase where we have a strong increase of cement strength (transient state) and a third phase where the cement strength increase is negligible (steady). This allows us to select times we use as curing times before performing a plug integrity test in the transient and steady states.

In the second stage, we use a custom-built set-up [3] with which we simulate and evaluate the integrity of the plug by inducing several differential pressures and monitoring the resulting flow rates. The cement slurry is always identically mixed and placed but cured for different durations. The slope of the curve of flow rate as a function of differential pressure, namely the effective permeability of the cement-casing system falls in two distinct regions.
For curing time in the steady state, the neat Portland G cement exhibits a rapid gas breakthrough and relatively high flow rates compared to the time in the transient state. However, for curing time in the transient state, the pressure breakthrough of the gas is delayed, and the flow rates are very low or almost not observed. This suggests a degradation of the bondings and thus
of the sealing properties of cement with time despite the significant increase in cement strength.

Participation

In-Person

References

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