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Leakage Detection in a Casing String of a Brine Production Well by Means of Simultaneous Fiber Optic DTS / DAS Measurements

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Abstract

As part of a well integrity assessment, distributed fiber optic temperature measurements (DTS) and distributed fiber optic acoustic measurements (DAS) were performed simultaneously to detect possible leakages, especially very small ones in the cemented 13⅜“ casing of a brine production well.

For this purpose, the borehole was temporarily pressurized with nitrogen and then relieved again. By injecting nitrogen into the borehole, the nitrogen-brine level was positioned below the 13⅜“ casing shoe. As a result, nitrogen passed through a leakage path into the cementation and a nitrogen reservoir formed in the cementation over a period of approximately 16 hours. During the subsequent nitrogen relief, the rise of the nitrogen-brine-level was much faster than the emptying of the nitrogen reservoir formed in the cementation. As a result, in the nitrogen relief phase, the pressure of the nitrogen in the cementation was significantly higher than the sum of the hydrostatic brine pressure and the gas pressure of the remaining nitrogen blanket. Due to the resulting pressure gradient, nitrogen escaped into the rising brine from the cementation at the leakage in form of bubbles. This leakage of the nitrogen bubbles is associated with both the generation of noise and a temperature change which can be detected by applying DAS and DTS techniques.

The use of a fiber optic sensor cable containing multiple fibers allows a simultaneous measurement of the temperature and noise depth distribution in the borehole. By coupling the two independent methods, the validity of the measurement results is significantly increased, e.g. non-leakage temperature anomalies can be excluded as the cause of a leakage.

In order to understand the measurements and perform a comprehensible interpretation, an FEM-simulation model of a coupled solid and pressure acoustic measurement was set up to simulate the noise propagation in the borehole. The simulation result shows the fundamental pattern of sound propagation in the borehole in high similarity to the result of the distributed fiber optic acoustic measurement. Thus, the application of the FEM simulation model contributes to the interpretation of the measurement results and to the detection/verification of the leakage position.

The method of simultaneously distributed fiber optic measurement of temperature and acoustics was used for the first time and proved successful in the investigation of the borehole integrity. A casing connector was identified as the cause of the leakage.

Key words: brine production, geophysics, instrumentation and monitoring, leak, monitoring,modeling, solution mining, well casing.