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Convergence-induced Stresses on Borehole Casing and Annulus Cementation due to Salt Cavern Operation with Respect to Assess Mechanical Integrity

Karl-Heinz Lux, Ralf Wolters, and Tianjie Pan
Clausthal University of Technology, Erzstraße 20, 38678 Clausthal-Zellerfeld, Germany

Abstract

During the operation of salt caverns that are used for storage of gas, oil or products or for brine production the installed last cemented casing will be stressed due to the convergence of the cavern, which results from the creep of the rock salt mass. These additional stresses may lead to a loss of mechanical integrity followed by leakage and unacceptable fluid migration.
Especially, at the casing shoe area of the last cemented casing, the combined system of casing, cementation and the contact interfaces between casing and cementation as well as between cementation and salt rock are of concern in order to withstand the impact from creep deformation of the years.
In order to check whether these stresses and strains induced by creep deformation may lead to a loss of integrity, monitoring methods controlled from surface are limited. However, numerical models will provide valuable support in order to check for the well integrity over time.
Against this background, the paper will demonstrate the basics for computational analysis of the stress state in the borehole elements (casing/cementation) and the surrounding rock mass as well as related interfaces as a result of a long-term natural gas storage operation. For this purpose, an exemplary numerical analysis for the determination of the temporal development of the borehole support load in the casing and the annulus cementation will be presented and discussed in terms of possible states of failure. First of all a 3D-cavern field is investigated consisting of large rock mass area as well as a large number of cavities with their typically large geometric dimensions and in contrast of filigree load-bearing construction elements regarding the wellbores. Secondly, the aforementioned borehole elements are physically modelled as individuals characterized by own material properties. Thirdly, evaluation criteria for the assessment of the deformation-induced stressing in the borehole elements as well as in the surrounding rock salt mass will be principally addressed. It will be shown that the simulation model can be successfully used to simulate the thermo-mechanically coupled behavior of a storage cavern, the surrounding rock mass and the borehole elements using the simulation tool FTK. In this regard, the simulation enables an improved knowledge of the effects of acting relevant physical processes and resulting additional stresses, which may lead to a loss of mechanical integrity over time with respect to borehole elements.

Key words: Rock Salt, Salt Cavities, Cavern Convergence, Cavern Well, Casing, Annulus Cementation, Well Integrity Analysis, Integrity of Last Cemented Casing, Integrity Evaluation, Interface Integrity, Well Integrity Management, TM-coupled Processes, Numerical Simulation, Simulation Tool FTK