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EFFECT OF HEAT TRANSFER ON GAS STORAGE CAVERN OPERATIONS

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Abstract

Heat transfer from the cavern wall to the gas, or vice versa, affects the amount of gas that can be injected or withdrawn from a cavern. A steady withdrawal rate of 200 MMSCFD (223.6 M-Nm^3/h) from a single cavern for 5 days, results in different end conditions compared to a steady withdrawal of 100 MMSCFD (111.8 M-Nm^3/h) for 10 days. Similar outcomes occur in the injection case. Although in long term daily operations heat transfer has little bearing on the available capacity of a cavern, it is during very high withdrawal or injection demand when its effects are most noticeable and should be considered. As the cavern nears its lower pressure gradient limit, if possible, it is important to flow the well at a rate which allows heat from the cavern wall to transfer into the gas. Similarly, during injection as the cavern reaches its upper pressure gradient limit, it is important to allow the cavern walls to absorb the heat from the gas.

A coupled thermodynamic - fluid flow and heat transfer model was developed using a commercial process simulation package to determine the pressure and temperature conditions inside a salt cavern used for natural gas storage during withdrawal, injection, and no flow conditions. The commercial simulator performs rigorous pressure drop and heat transfer calculations within the wellbore annulus in the upward and downward direction to determine the pressure and temperature condition at the casing shoe. A 1st Law approach is then used to determine the mid cavern pressure and temperature, such that the calculated density at the mid cavern pressure and temperature matches the calculated density using the creep adjusted cavern volume and measured flow out or into the cavern. The heat transfer, from the cavern wall into the gas, or from the gas into the cavern, is calculated using an empirical expression obtained using data from a temperature gauge inside a cavern over a period of 18 months when the cavern was not flowing.

Key words: Caverns for Gas Storage, Heat Transfer in Caverns, Computer Modeling, Creep, Thermodynamics, 1st Law of Thermodynamics, Commercial Process Simulator, Injection, Withdrawal, Equation of State.