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TRANSIENT HEAT TRANSFER ANALYSIS AND TEMPERATURE MODELING FOR SOLUTION MINING CAVERNS

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Abstract:

An elevated temperature solvent is used in most solution mining operations to improve cavern performance. Employing heated injection solvent during solution mining increases the dissolution rates and allows for a more concentrated production brine, thereby improving mining efficiency and lowering processing costs. On the other hand, higher injection temperatures increase costs, and by heating the rock mass surrounding the cavern, accelerate creep deformation. To optimize solution mining design, the heat transfer and temperature profile along the wells and cavern walls should be studied in detail. Heat transfer in the solution mining process includes heat transfer from solvent/brine to the formation rock through the well casing, heat transfer from cavern brine to the formation rock, heat loss/gain due to dissolution of minerals, and heat exchange between solvent and brine for coaxial injection-recovery design. For this paper, a mathematical model was developed to simulate the heat transfer processes and temperature distribution for three types of solution-mined caverns. Model predictions were compared to detailed temperature measurements obtained from actual solution mining operations. The model accurately predicted the heat transfer from injection at the surface, through the cavern, and recovery of the brine at the surface. A parametric performance study was then carried out for the coaxial injection-recovery cavern design (utilizing horizontal wells) with different flow rates and casing properties. The results clearly show a significant increase in cavern temperature by increasing flow rate and through the use of insulated tubulars in configurations where the injection solvent is pumped through the injection tubular, which is surrounded by production brine. An overall performance table for coaxial injection-recovery cavern design with various flow rates, injection temperatures, tubing materials, and dissolution heats is presented.

Key Words: transient heat transfer, semi-analytical approach, dissolution, computer modeling