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Predicting the heat depletion characteristics of hydrothermal doublet systems under varying reservoir and operational conditions

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Geothermal power output and the associated heat depletion in hydrothermal doublet systems depend largely on the existing reservoir and operational conditions. In this study, we use CMG-STARS Simulator to numerically simulate the temperature depletion of a homogeneous, horizontal hydrothermal reservoir in Western Saudi Arabia due to geothermal exploitation by a well doublet. We vary the reservoir, operational, and boundary conditions to account for uncertainty or natural variability in the model and to calculate the corresponding variations in thermal power generation over time. For a given reservoir depth, thickness, pressure-and-temperature-related parameters, permeability, flow rate, and well configuration, it is imperative to determine the optimal well spacing to achieve the largest thermal energy generation over the lifetime of the hydrothermal reservoir. To determine the optimal doublet spacing would require hundreds, if not thousands, of permutations of the different uncertain or naturally variable reservoir and operational parameters for any specific hydrothermal system. In this study, we develop a novel generalized non-dimensional expression of power generation over production time. The dimensionless power is calculated as the ratio of the enthalpy difference between the geofluid at the production wellhead and at the injection wellhead to the enthalpy difference between the geofluid at the initial reservoir condition and at the injection wellhead. A dimensionless time is also calculated as a function of circulation flow rate, fluid density, porosity, doublet spacing, reservoir thickness, and time. We conducted simulations varying these parameters. The results tend to collapse onto a single curve in this non-dimensional phase diagram. Hence, this graphical representation can be used to predict the evolution of power over time for various combinations of the parameters without running new simulations. From this dimensionless power-time plot, the thermal power output can be calculated at four critical dimensionless times, which include the power output at (i) $\tau_d=0$ (start of production), (ii) $\tau_{d,max}$ signifying the dimensionless time at maximum thermal power output, (iii) the dimensionless thermal breakthrough time, $\tau_{d,TB}$. With this value, the thermal breakthrough time of a doublet for the hydrothermal system considered in this study can be determined without carrying out computationally expensive simulations. Lastly, (iv) dimensionless time after the thermal breakthrough has occurred, $\tau_d>\tau_{d,TB}$. The heat depletion at this stage can be expressed mathematically as an exponential decay.
Hence, for any combination of the reservoir and operational parameters, the optimal well spacing that provides the largest thermal power output over the reservoir lifetime and what combination of the parameters depletes the reservoir heat the fastest can be provided easily with the dimensionless power-time plot.

Participation

In-Person

References

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