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Steam jacket dynamics in in-situ combustion

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Abstract

In-situ combustion has the potential to increase the world-wide hydrocarbon reserves by utilization of deposits not economically mineable by conventional methods. In this context, underground coal gasification (UCG) involves combusting coal in-situ to produce a high-calorific synthesis gas, which can be applied for electricity generation or chemical feedstock production. Apart from high economic potentials, in-situ combustion may cause environmental impacts such as groundwater pollution by by-product leakage. In order to prevent or significantly mitigate these potential environmental concerns, UCG reactors are generally operated below hydrostatic pressure to limit the outflow of UCG process fluids into overburden aquifers. This pressure difference effects groundwater inflow into the reactor and prevents the escape of product gas. In the close reactor vicinity, fluid flow determined by the evolving high reactor temperatures, resulting in the build-up of a steam jacket.

Numerical modeling is one of the key components to study coupled processes in in-situ combustion. We employed a thermo-hydraulic numerical simulator to address the influence of reactor pressure dynamics as well as hydrogeological coal and caprock parameters on water inflow and steam jacket dynamics.

The US field trials Hanna and Hoe Creek (Wyoming) were applied for 3D model validation in terms of water inflow matching, whereby the good agreement between our modeling results and the field data indicates that our model reflects the hydrothermal physics of the process. In summary, our validated model allows a fast prediction of the steam jacket dynamics as well as water in- and outflows, required to avoid aquifer contamination during the entire life cycle of in-situ combustion operations.