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Do we have to consider temperature-dependent material properties in large-scale environmental impact assessments of underground coal gasification?

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Underground coal gasification (UCG) can increase the world-wide coal reserves by utilization of coal deposits not mineable by conventional methods. The UCG process 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 its high economic potentials, UCG may induce environmental impacts such as ground subsidence associated with groundwater pollution due to generation of hydraulic connectivities between the UCG reactor and adjacent aquifers. These changes overburden conductivity may introduce potential migration pathways for UCG contaminants such as organic (phenols, benzene, PAHs and heterocyclics) and inorganic (ammonia, sulphates, cyanides, and heavy metals) pollutants. Mitigation of potential environmental UCG impacts can be achieved by improving the understanding of coupled thermo-hydro-mechanical processes in the rocks surrounding the UCG reactor. In the present study, a coupled thermo-mechanical model has been developed to carry out a parameter sensitivity analysis and assess permeability changes derived from volumetric strain increments in the UCG reactor overburden. Our simulation results demonstrate that thermo-mechanical rock behavior is mainly influenced by the thermal expansion coefficient, tensile strength and elastic modulus of the surrounding rock. A comparison of temperature-dependent and temperature-independent simulation results indicates high variations in the distribution of total displacements in the UCG reactor vicinity related to thermal stress, but only negligible differences in permeability changes. Hence, temperature-dependent thermo-mechanical parameters have to be considered in the assessment of near-field UCG impacts, while far-field models can achieve a higher computational efficiency by using temperature-independent thermo-mechanical parameters. Considering the findings of the present study in the large-scale assessment of potential environmental impacts of underground coal gasification, representative coupled simulations based on complex 3D large-scale models become feasible.