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Effectiveness of the Thermal Stimulation for Deep Geothermal Reservoirs

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Geothermal is a clean and renewable source of energy and in its most abundant manifestation it exists in the form of Hot Dry Rocks (HDR) almost everywhere at depth. In order to economically exploit such sources, however, appropriate stimulation strategies are required, the result of which is otherwise known as Enhanced Geothermal Systems (EGS). There exist a wide range of stimulation approaches, amongst which, thermal stimulation is of particular interest due to its effectiveness. Thermal stimulation in the context of reservoir engineering is applied by sudden introduction of cold fluid to the hot intact rock which can causes localized stress (strain) concentration and rock damage and therefore permeability improvement. Such an improvement can be theoretically predicted providing that an accurate rock characterization is available. In case of the application of thermal stimulation to geothermal reservoirs, however, the wellbore plays an intermediary role between the injected cold fluid at the well surface and the subsurface hot reservoir rock. Depending on the heat exchange between the fluid and the surrounding rock along the wellbore trajectory, the effectiveness of the thermal stimulation may dramatically differ at the target reservoir location.

In this study, a damage mechanic model is built to monitor/quantify the level of thermal stimulation of the reservoir rock based on the rock permeability changes in a Thermo-Hydro-Mechanical (THM) framework. The developed model is coupled with the full wellbore hydro-thermal model so as to take into account the heat exchange between the fluid column and the surrounding rock along the wellbore path. The developed model can also predict the evolution of the fluid temperature—which is delivered at the reservoir depth—during the stimulation operation. For the sake of clarity, only near wellbore effects are considered in this study. Also Comsol Multiphysics is used as the numerical finite element solver.

The results of this study show that—for a fixed injection temperature at the well top, there exists a minimum flow rate below which thermal stimulation does not result in an optimum improvement in the injectivity of the reservoir. Such an analysis helps us to design the best thermal stimulation strategy for a given reservoir with certain temperature/depth.