Geophysical Research Abstracts
Vol. 21, EGU2019-13512, 2019
EGU General Assembly 2019

Design and setup of a field test for high temperature borehole thermal energy storage in partially saturated sediments

Bo Wang, Paul Liedtke, Jens-Olaf Delfs, Christof Beyer, and Sebastian Bauer
University of Kiel, Institute of Geosciences, Geohydromodelling, Kiel, Germany (bo.wang@ifg.uni-kiel.de)

Geological heat storage is seen as one promising option to mitigate strong fluctuations in energy production from weather dependent sources, such as solar or wind power, as well as to increase the fraction of renewable energy in the heat sector. In urban areas, potential usable geological formations for the installation of near surface borehole thermal energy storage are often characterized by low permeability and partially saturated conditions. This study, therefore, aims at predicting and quantifying the induced thermal and hydraulic processes through highly controlled experiments on a scale close to the field application. This abstract will present the simulation-based design and setup of an experiment for high temperature borehole thermal energy storage under partially saturated conditions as well as the experimental data obtained from the first functionality test.

The experiment is set up at Kiel University, using a pit with dimensions of 5 m $\times$ 3 m $\times$ 2 m. This pit is filled with fine sand, characterized by a hydraulic conductivity of 1.52 $\times$ 10^{-6} m/s and a porosity of 0.33. The volumetric water content varies with depth from dry conditions to 4.8 % below 80 cm. Thermal conductivity varies from 0.29 W/m/K to 1.25 W/m/K, accordingly. A borehole heat exchanger is installed at the site. Accounting for the initial conditions and a potential drying-out zone around the borehole heat exchanger (BHE), a-priori numerical simulations were performed using a three-dimensional heat transport model for designing test durations, sensor positions and insulation thickness. Model results show that the first-phase of the experiment will last for at least 60 days applying a BHE inlet temperature of 70 ˚C. Using the simulated temperature distributions, two transects were designed for optimal positioning of the sensors to observe temperature and moisture changes, resulting in 143 Type-K thermocouples and 76 FDR moisture sensors. Three layers of isolation were placed at the top of the sand pit with a total thickness of about 30 cm.

The functionality test of the installed experimental system was conducted with a 25-min injection at a temperature of 40 ˚C set in the heat bath. The temperature at the inflow reached 39.5 ˚C after 25 min, and the observed temperature in the middle of the BHE grout was 30 ˚C. At a distance of 5 cm in the sand to the BHE, a maximum temperature change of 3.5 ˚C was observed after about 4 hours. The temperature change of larger than 1 ˚C can be observed at a distance of 20 cm to the BHE in the sand.