Short-Term Behavior and Steady-State Value of BHE Thermal Resistance

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Abstract

Introduction: In order to study the thermal behavior of Borehole Heat Exchangers (BHEs), the most employed model is that based on two thermal resistances, namely the BHE thermal resistance and the ground resistance [1-4]. Usually, the first one is assumed to be uniform along the whole BHE and constant in time. However, when considering the short-term behavior of the BHE, this assumption is quite rough and can lead to relevant discrepancies with respect to the real BHE performance. Indeed, the heat capacity of the grout cannot be neglected in hourly simulations. In Ref.[5], the Authors proposed a new method for the hourly simulation of BHE fields, where the internal structure of the BHE is also taken into account. The present paper complements Ref.[5] being a transient parametrical study of the grout thermal resistance of the BHE, i.e., the resistance between the tubes and the ground. This resistance is provided in a dimensionless form by considering both single and double U-tube configurations with different values of the shank-spacing among the tubes. The considered geometrical configurations are based on commercially available geothermal probes [6].

Use of COMSOL Multiphysics® software: A 2D transient study on the dimensionless cross-section of BHE and surrounding ground is performed by means of COMSOL Multiphysics®. A given dimensionless heat flux is imposed at the external surface of the tubes, whereas an adiabatic boundary condition is imposed at the external surface of the ground.
A preliminary extensive analysis of the independence of the results on both computational mesh and domain size is performed.

Results: Two geometrical configurations are considered for double U-tube BHEs, which differ for BHE and tube diameter, and shank-spacing. Moreover, single U-tube BHEs are taken into account, by considering three values of the tubes shank-spacing [7]. Finally, three values of the ratio between ground and grout thermal conductivities are considered, as well as three values of the ratio between ground and grout heat capacities, for a total of 45 cases.

Conclusion: The first obtained results show that the pipe spacing and the heat capacity ratio play an important role in the transient behavior of the BHE internal resistance, whereas the pipe spacing and the conductivity ratio play an important role in the steady value of the BHE resistance.

Reference

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