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Performance Evaluation and Operation Sustainability of Deep Borehole Heat Exchanger Coupled with Geothermal Heat Pump System

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To achieve a low-carbon and sustainable future, the utilization of geothermal energy gains more attention all around the world, due to its sustainability, continuity and low carbon emissions. Avoiding the disequilibrium of ground temperature and large area requirement from application of traditional borehole heat exchanger (BHE, around 150 m), deep borehole heat exchanger (DBHE, down to 2500 m), a state-of-the-art and feasible apparatus, could extract deep geothermal energy efficiently.
In this paper, a Finite Volume Method (FVM) based numerical model was constructed to simulate the heat transport process in multilayers of rock & soil. The model was developed by considering the ground temperature gradient in the axial direction and multilayer thermal properties of rock and soil.The model has been validated by the experimental data in a demonstration project.The heat extracting performance of DBHE under different types of run-stop ratio (including different working conditions for several building characteristics) are evaluated. In the intermittent operation for 10 years, the decreasing proportions of the outlet temperature under four different operation modes with the run-stop ratio (i.e. the ratio of the running time to the stopping time in a day) of 8:16, 12:12, 16:8 and 24:0, were no more than 3.57%. The rock temperature profiles in the heating mode of both commercial and residential buildings were presented and the annual decreasing proportions were less than 4.0%.
Under the continuous operation of 10 years, the outlet temperature of the DBHE gradually decreased with a decreasing proportion of less than 3%. The temperature variation of rock and soil surrounding the DBHE under the continuous operation of 10 years decreased with the increase of the distance away from the borehole. For 1 year's intermittent operation under different run-stop ratios, the outlet temperature of the DBHE decreased with the augment of the daily running time. The total heat extraction increased with grow of the daily running time. For 10 years'intermittent operation under two typical operation modes (commercial heating and residential heating), the decrease rates of the outlet fluid temperature were not more than 2.92% and 3.57% yearly, respectively. For 10 years'intermittent operation for the two typical operation modes, the annual decreasing proportions of the temperature of rock and soil at the reference points were less than 4%. After 10 years'operation, the decrease of the temperature of the rock and soil will be no more than 10%.
The findings obtained from this study could be used as a reference for sustainability research of DBHEs under different working conditions and operation modes. The study will also provide a reference for the application of DBHE coupled heat pump systems.

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