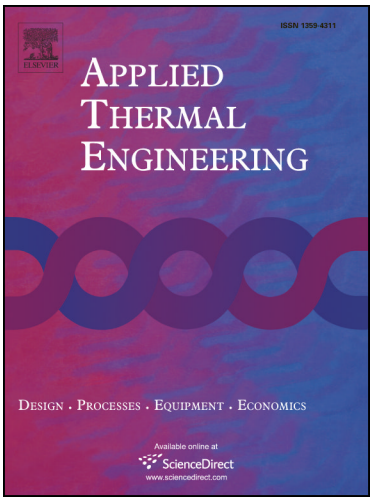

Research Paper

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Numerical Modeling of Energy Transfer in Underground Borehole Heat Exchanger within Unsaturated Soil

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Abstract

In the current study, the heat emission and heat extraction process is numerically studied for six u-shaped upright underground pipes during a 10 day period. The soil medium is considered to be unsaturated, which is the common case in most of the practical scenarios. For this purpose, the convective flows of dry air, water vapour, and surface water are simultaneously accounted for and the energy transfer amounts are estimated. Also, the radial distributions of temperature and moisture content are acquired for the 2^{nd}, 4^{th}, and 10^{th} days by minimizing the residual norm's value. The study mostly aims to obtain the results which yield a good insight into the efficiency of the system, which in case of further analysis could be used for the design purposes of heat pipe arrangement. It is shown that, for a constant 70 W/m^2 of heat emission and for the distances more than 1.5 m from the heat source, the amount of wasted energy remains approximately the same, independent of the measurement time period. Also, it is calculated that about 83.3% of the storable energy is stored in the medium by the end of the 6^{th} day; and 10% of the aggregated stored energy is wasted through convective heat flows, by the end of the 10^{th} day.

Keywords: Underground heat storage; emission phase; unsaturated soil; heat extraction; energy transfer.