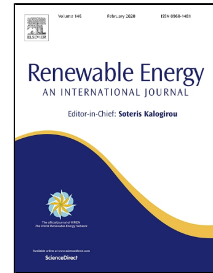


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An Experimental and Numerical Investigation on Temperature Profile of Underground Soil in the Process of Heat Storage

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Abstract: A detailed understanding of soil temperature in underground energy engineering is a major concern in designing a high-efficient and less cost-operated underground soil energy system (e.g. ground source heat pump (GSHP) and ground energy pile system). In this paper, similitude theory is introduced as a methodology to design a small-scale thermal energy storage experiment setup for studying the heat transfer behavior in underground soil. Based on heat transfer governing equations and similitude analysis, the scaling laws and similarity conditions are derived, and a laboratory scaled-down thermal energy storage experiment model is designed and constructed. The proposed experiment can be used to study the heat transfer behavior of ground energy storage by reducing the time consumption substantially. A transient 3-D numerical model is proposed and validated with sandbox data set. The numerical model is applied to calculate the temperature variation of ground heat exchanger in full scale and used to estimate the accuracy using the p -linear distribution approximation to represent the vertical profile of fluid temperature. The comparison between the experiment model results (after scaling to prototype) and numerical results are given, and the coincidence between them is good, particularly at the late-time period. For implementing a design and optimization of the field-scale engineering underground energy storage system, by using the scaling factor, the results could be used to predict the temperature distribution of the full-scale underground energy storage system with different types of underground soil in different controlled working conditions. This work would provide more accurate reference data and foundation with less time-consuming for engineering application of underground energy storage system, such as GSHP, ground energy pile and etc..

Keywords: underground soil; borehole heat exchanger; similitude experiment; energy storage; numerical simulation; geothermal energy

1. Introduction

Using renewable energy such as solar energy, waste or low-carbon heat sources, instead of fossil fuels, for district heating, heat pumps or heat storages would greatly reduce CO₂ emissions and environmental loads. For many places in the world, the ground source heat pump (GSHP) is recommended as an efficient supplementary system to be combined with

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