A Quasi-Three Dimensional Transient Model for Thermal Calculation of Buried Pipe Heat Exchanger Systems

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Abstract: Geothermal energy, clean and renewable, has attracted more and more attention in this century challenged by energy crisis and climate change. Ground source heat pump (GSHP) technology, which has been widely applied in the field of heating, ventilating and air conditioning (HVAC), is one of the most important ways to utilize geothermal energy. The buried pipe heat exchanger system is the core of GSHP, sufficient investigations should be conducted prior to its design to clarify the relevant thermal and hydraulic characteristics. Numerical calculation is much more practical than experimental research for the buried pipe heat exchanger systems due to the expensive and time-consuming drilling and pipe locating. Since the thermal distribution of multi-pipe systems is asymmetric, the full model should be a 3D one describing the heat transfer within the solid and the flow and heat transfer of the fluid inside the pipe. Such a fully 3D model requires large computer source and is very time-consuming for computation. Therefore, this paper proposed a quasi-three dimensional thermal calculation of the buried pipe heat exchanger systems, which is essentially a 3D (heat transfer within soil) +1D (flow and heat transfer inside the pipe). Compared with the fully 3D model, the "3D+1D" model would save computation time significantly and make it economical and feasible to conduct numerical calculation for large-scale buried pipe system. For the test case studied in this paper, the deviation of the outlet temperature between the proposed model and the fully 3D model is smaller than 1.0℃. In addition, since Ansys Fluent does not provide a one-dimensional calculation module, this paper will illustrate the implementation of the proposed "3D+1D" model in Ansys Fluent, which provides convenience for engineering calculation using this model. This study will provide an efficient and convenient method for the numerical calculation and optimization design of buried pipe system.

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