

Thermal-Economic Modeling and Optimization of Vertical Ground Coupled Heat Pump

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Abstract

The optimal design process of a ground source heat pump includes thermal modeling of the system and selection of optimal design parameters which affect the system performance as well as initial and operational costs. In this paper, the modeling and optimizing processes of a Ground Coupled Heat Pump (GCHP) with closed Vertical Ground Heat eXchanger (VGHX) are presented.

To verify the modeling procedure of heat pump and VGHX systems, the simulation outputs were compared with the corresponding values reported in the literature and acceptable accuracy was obtained. Then an objective function (the sum of annual operating and investment costs of the system) was defined and minimized, exposed to the specified constraints to estimate the optimum design parameters (decision variables). Two Nelder-Mead and Genetic Algorithm optimization techniques were applied to guarantee the validity of the optimization results.

For the given heating/cooling loads and various climatic conditions, the optimum values of heat pump design parameters (saturated temperature/pressure of condenser and evaporator) as well as VGHX design parameters (inlet and outlet temperatures of the ground water source, pipe diameter, depth and number of boreholes) were predicted.

Furthermore, the sensitivity analysis of change in the total annual cost of the system and optimum design parameters with the climatic conditions, cooling/heating capacity, soil type, and number of boreholes were discussed. Finally, the sensitivity analysis of change in optimum design parameters with increase in the investment and electricity costs was performed.

Keywords: "Thermal-economic modeling", "optimization", "Ground coupled heat pump", "Vertical ground loop"

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