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Utilization of a GSHP System in a DHC Network

Modeling and Optimization

Anjan Rao Puttige

Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt försvar i Triple Helix, Samverkanshuset
Tisdag den 19 oktober, kl. 13:00.
Avhandlingen kommer att försvaras på engelska.

Fakultetsopponent: Docent, Saqib Javed,
Avdelning för installations-och klimatiseringslära, Lunds Universitet, Lund, Sverige.

Department of Applied Physics and Electronics

Organization
Umeå University
Department of Applied
Physics and Electronics

Document type
Doctoral thesis

Date of publication
28 September 2021

Author
Anjan Rao Puttige

Title
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Abstract

The ground source heat pumps (GSHPs) of customers connected to the district heating and cooling (DHC) network can benefit both the customer and the energy company. However, operating the GSHP to minimize the cost of providing heating and cooling to the customer while ensuring the long-term stability of the ground temperature is a challenge. This thesis addresses the challenge by developing accurate models of GSHP and optimizing the operation of the GSHP system using these models.

The models presented in this thesis use field measurements to develop accurate models with low computational time. The main components of a GSHP system are the heat pump and the borehole heat exchanger (BHE). This thesis presents two approaches to use measured data to improve the accuracy of analytical models for BHE. The first approach is the calibration of the model parameters using this measured data. The second approach combines the analytical model with an artificial neural network model resulting in a hybrid model. The calibration approach reduced the relative RMSE of the analytical model from 21.9% to 13.9% in the testing period. The relative RMSE of the hybrid model for the testing period was 6.3%.

We compared different data-driven models for heat pumps and determined that artificial neural network models have an advantage over traditional regression models when field measurements are available. The artificial neural network model was refined to better utilize the measured data. The refined models of heat pumps had a relative RMSE of less than 5%.

The hybrid BHE model and an artificial neural network model for the heat pumps were used to model the GSHP system. The model was validated using four years of field measurements. The relative MAE for the compressor power and BHE power were 7.3% and 19.1% respectively.

The validated model was used to optimize the operation of the GSHP system. In optimal operation, the cost of providing heating and cooling to the area was minimized from the perspective of the energy company while maintaining a stable temperature in the ground. In optimal operation, the annual cost of operation was shown to reduce by 64 t€ and the annual CO_2 emission was shown to reduce by 92 tons.

Keywords
Ground source heat pump, district heating and cooling, optimization, borehole heat exchanger, artificial neural network, hybrid model, field measurements, calibration, heat pumps. prosumer

Language
English

ISBN
print: 978-91-7855-648-9
PDF: 978-91-7855-649-6

Number of pages
60 + 4 papers