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An operation strategy for using a ground heat exchanger system for industrial waste heat storage and extraction

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Research Article

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Abstract

A ground heat exchanger system is applied as a way to improve the heat recovery ratio in a project using industrial waste heat recovery for district heating. In order to meet the requirements of industrial processes, the outlet water temperature of the system should be strictly controlled within a range, but the heat transfer power varies with the warming or cooling of the soil. An operation strategy named "block by block" is implemented and a corresponding model is established. In this strategy, the total area of the system is divided into several blocks. The water flows by a specific combination of blocks at any given time, ensuring the outlet water temperature is relatively stable. By simulation, it is concluded that the strategy is fit for the practice of industrial waste heat storage and extraction.

Keywords

industrial processes,
waste heat storage,
district heating,
GHE system,
operation strategy and modeling

Article History

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1 Introduction

Large quantities of waste heat are discarded during industrial processes. To use the industrial waste heat during the winter, technologies, for example, absorption heat pumps (AHPs) and radiant floors, are used to recover the heat for district heating (Fang et al. 2011).

To make use of the waste heat in the summer, a ground heat exchanger (GHE) system is applied, as shown in Fig. 1. Industrial waste heat is totally or partially stored in the GHE system during the summer, and the stored heat is extracted by the low-temperature outlet water of AHPs in the substations during the winter.

Research involving GHE system focuses on the model-based simulation and validation of thermal performance of the system. A model including all the weather effects has been shaped to find three-dimensional temperature distributions in the soil, and the heat conduction equation has been solved numerically using alternating direction implicit finite difference formulation (Demir et al. 2009). A three-dimensional unstructured finite volume numerical model has been proposed, using Delaunay triangulation method to mesh the cross-section domain of the borefield, and dividing the soil into many layers in the vertical direction (Li and Zheng 2009). An explicit one-dimensional transient numerical model has also been built for fast simulation with a considerably accurate result (Su et al. 2011).

However, none of these studies claim that the GHE outlet water temperature should keep stable. On the contrary, many of them validate their models by comparing the temperature variation curve derived from the simulation with the measured one, or with another simulated result using an existing model. GHE is commonly associated with ground source heat pump systems (GSHPs), which is now popular in the HVAC industry. For a HVAC system, the fluctuation of GHE outlet water temperature exerts little impact on occupants' thermal comfort, as rooms have large thermal inertia and the human body has a large range of thermal comfort. However, for industrial processes, the temperature fluctuation, which is mainly caused by the heat transfer

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