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Experimental investigation and optimization of a ground source heat pump system under different indoor set temperatures

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HIGHLIGHTS

- The GSHP system was optimized based upon two aspects.
- The heat recovery technology was designed to alleviate the imbalance of earth energy.
- The indoor set temperature was optimized to further reducing the imbalance of earth energy during system operation.

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ABSTRACT

A constant temperature and humidity air-conditioning system driven by a ground source heat pump (GSHP) was designed and constructed in an archives building. The imbalance of earth energy caused by the difference of load between heating mode and cooling mode affects soil temperature, which may result in poor efficiency of the GSHP system. Therefore, the system was optimized based upon two aspects. Firstly, the heat recovery technology was used to reheat the air inside the air handling unit (AHU), which aimed at alleviating the imbalance of earth energy. The experimental results showed that the imbalance of earth energy for the system during the whole year was 16.3%, discharging about 33.7% less heat to the soil compared with the system without heat recovery technology. Secondly, the set value of indoor temperature was optimized for the purpose of further reducing the imbalance of earth energy during the system operation. It was shown that the heat transfer between the ground heat exchanger and soil was distinctly affected by the indoor set temperature. Considering the long-term stability of soil temperature and energy conservation of the system, higher value of indoor temperature was suggested to be set on condition that the indoor environment could be met. Both the design method of heat recovery and the optimization of indoor set temperature are meaningful for the suitable utilization of GSHP systems in cooling-dominated buildings.

1. Introduction

It was estimated that heating, ventilation and air-conditioning (HVAC) systems accounted for about 65% of the energy consumption in the buildings of China [1]. Therefore, it is strongly necessary to reduce the energy consumption in HVAC systems. Recently, both professionals and policymakers have been making great efforts in this aspect [2]. It seems that the most effective approach is to improve the utilizations of energy conservation techniques and renewable energy.

GSHP is a highly efficient, renewable energy technology for space heating and cooling. This technology relies on the fact that, at depth, the Earth has a relatively constant temperature, warmer than the air in winter and cooler than the air in summer. A GSHP can transfer heat stored in the Earth into a building during the winter, and transfer heat out of the building during the summer. GSHP technology is receiving increasing interest because of their potential to reduce primary energy consumption and thus reduce emissions of greenhouse gases [3].

It is reported that GSHP technology was well established with over 550,000 units installed worldwide and with more than 66,000 units installed annually. About 80% of the units installed worldwide are domestic [4]. GSHP systems have become attractive choices for both residential and commercial buildings because of their higher energy efficiency compared with conventional air source heat pump (ASHP) systems. Elisabeth Kjellsson et al. [5] reported that the use of GSHP systems for heating and domestic hot water in dwellings was common in Sweden. Yasuhiro Hamada et al. [6] described a GSHP system using friction piles as heat exchangers

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