Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 205 (2017) 167–174

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

Experimental Evaluation of the Ground Source Heat Pump System with a New Control Strategy - A Case Study in Tianjin

Tianhao Yuan[a,*], Neng Zhu[a], and Kun Yang[a]

[a]*School of Environmental Science and Engineering, Tianjin University, Tianjin 300072, China*

Abstract

In order to improve the cooling performance of the ground source heat pump (GSHP) system, save the operating cost and reduce the heat discharged into the ground soil, a new free cooling control strategy is proposed in this paper, with which the circulating water in the ground heat exchanger is used to cool the building directly. Firstly, an office building located in Tianjin is selected. Then, the measurement of the GSHP system is conducted during the cooling season. Finally, the experimental evaluation of the new strategy is performed. The results show that the free cooling strategy can meet the cooling demand of the case building at the beginning of the cooling season, there is no dewing phenomenon on the floor surface during the floor radiation free cooling period and the average system energy efficiency ratio (*EER*) (with the value of 49.29) of the free cooling mode is 16.6 times that of active cooling mode. The electricity consumption and operation cost have a great saving potential. The total heat discharged into the ground soil is reduced largely. This will slow the performance deterioration of the GSPH system.

Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.

Keywords: Ground source heat pump; Free cooling strategy; Floor radiation cooling; Experimental evaluation

1. Introduction

Building energy consumption increases rapidly with the development of society in the recent years. According to International Energy Agency (IEA), building sector energy consumption accounts for 31% of the total primary energy use in China [1]. As addressed by U.S. Energy Information Administration (UEI Administration), building sector energy consumption is about 40% of the total primary energy use in the United States [2]. Another literature reveals that building energy consumption of European uses approximately 40% of the total energy demand [3].

* Corresponding author. Tel.: +86 18698168721.
E-mail address: y.tianhao@163.com

1877-7058
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.09.949

Energy use of cooling and heating system generally accounts for 40-60% of total building energy consumption. Therefore, the reasonable selection of cooling and heating system has a great energy saving potential.

Underground soil temperature is more stable than ambient temperature. Therefore, GSHP is now a renewable perspective technology which uses ground as a heat source or thermal sink. This system is widely used in the building cooling and heating system because of its high energy efficiency. Moreover, there is no waste heat released to environment. The operation energy saving of GSHP is about 25-50% compared with conventional central air conditioning system [4]. However, the energy performance of GSHP will deteriorate year after year when annual heat extracted from and rejected into the soil is imbalanced [5]. The reason is that the underground soil temperature is far from the initial state.

To improve the soil thermal balance, hybrid ground source pump (HGSHP) integrated with some auxiliary facilities, such as solar heating device, boiler, cooling tower and so on, are researched more and more in the recent years. Capozza et al. [6] used the simulation software CaRM to investigate the GSHP thermal performances of two office buildings in Italy, and the result shows that increasing the number of boreholes does not significantly affect the thermal drift. Qi et al. [7] gave an overview of the status and development of different types of HGSHP systems. Zhu et al. [8] designed a GSHP system coupled with solar seasonal storage for a new building of a campus in Tianjin. This system is dominantly used for heating and supplying hot water. After a long test period, the results show that the soil temperature increases by 0.21℃, the COP of the system and the heat pump unit increase by 3.4% and 2.4%, respectively, compared with the operation data without solar seasonal storage process during last year. Liu et al. [9] analyzed the application of a practical GSHP system coupled with gas boilers. The results show that the initial cost of the system decreases. However, the economy, performance and reliability of the system are improved. Cui et al. [10] used TRNSYS 16 to analyze the GSHP system coupled with a cooling tower. Both parallel and serial HGSHP systems were studied. Moreover, the design and operation parameters of the systems were optimized at last.

HGSHP system can solve the thermal imbalance in some degree as mention in the previous studies. However, the auxiliary facilities will increase the initial investment or still release waste heat to the environment. In addition, the complicated system brings challenges for the stable operation of itself. A GSHP system coupled with borehole free cooling is proposed in this paper. With this control strategy, the circulating water in the ground heat exchanger is used to cool the building directly. The aims are to make the best use of the cold water exchanged by the outside pipes buried in the ground soil, reduce the run-time of the GSHP unit and the amount of waste heat released into the soil. Firstly, an office building located in Tianjin is selected. Then, the measurement of the GSHP system is conducted during the cooling season. Finally, the experimental evaluation of the new strategy is performed.

2. Methods

2.1. Description of the building and the cooling system

The studied building is a six-story retrofitted office building with the total floor area of 5700m^2 located in Tianjin, China. The air conditioning area is about 4735m^2. The south wall and the north wall are equipped with the electric sun visors. The east, west, south and north window wall ratio are 0.4, 0.3, 0.46 and 0.33, respectively. The ground floor is built for exhibition area, duty room and GSHP plant. The sixth floor is built for elevator machine room, fresh air plant, pump room and activity room. The rest floors are built for office spaces. The appearance of the office building is shown in Fig. 1.