Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 146 (2016) 586 – 593

Procedia Engineering

www.elsevier.com/locate/procedia

8th International Cold Climate HVAC 2015 Conference, CCHVAC 2015

Feasibility Study of a Novel Soil Thermal Recovery Method for HGSHP System

Pengyuan Shang, Chao Chen*, Kang Li, Jie Lin, Jinshun Wu

College of Architecture and Civil Engineering, Beijing University of Technology, Beijing 100124, China

Abstract

In order to solve the heat accumulation problem of GSHP system in cooling load dominated area with high humidity in summer, this paper presents a novel HGSHP system based on CT cool-storage in transition season. Then the performance evaluation model for HGSHP system is built on the base of the heat and moisture transfer principle of CT, the GHE multiple borehole finite line heat source model and TRNSYS software. At last, using the evaluation model, an actual project in Nanjing is used as an example to predict the thermal performance of this novel HGSHP system. The results show that using novel HGSHP system, the heat accumulation problem can be well solved.

Peer-review under responsibility of the organizing committee of CCHVAC 2015

Keywords: cooling load dominated area; ground-source heat pump; soil heat accumulation; cooling tower cool-storage; feasibility study

1. Introduction

The imbalance of heat extraction from the soil through the ground heat exchangers (GHE) in winter and its rejection into the soil in summer will lead to the “heat accumulation” problem of ground-source heat pump (GSHP) system for cooling load dominated areas [1].Currently, the main method to solve this problem is using hybrid ground-source heat pump (HGSHP), which the cooling tower (CT) is used as supplemental heat rejecter of GHE to undertake part of the condensing load in whole cooling season. For this system, Singh and Foster made a comparison about the technology and economy of two actual projects [2], and presented that the comprehensive technical and economic performance of HGSHP system is apparently higher than GSHP system. Yavuzturk and Spitler studied the

* Corresponding author. Tel.: +86 13601050837; fax: +86 10 67391608-201.
E-mail address: chenchao@bjut.edu.cn

Peer-review under responsibility of the organizing committee of CCHVAC 2015
doi:10.1016/j.proeng.2016.06.406

control method and gave out the control model of HGSHP system [3], the result showed that in HGSHP system, it is better to operate the CT when the difference between outlet water temperature of GSHP unit and ambient wet bulb temperature. Zhu Lidong simulated different operation modes of hybrid ground source heat pump system, aim at optimizing COP of the system and the annual change of soil temperature. The results show that: paralleling cooling tower and pipe is more conducive to the soil heat balance than in series, for parallel systems, the best control strategy is using 2℃ temperature difference to handle stop/ start of cooling tower with intermittent operation of ground heat exchanger every 2h. In addition, in order to solve soil heat accumulation in cold regions, Yang Tao proposed seasonal soil cool-storage system using natural cooling source. The system uses natural cooling source for cool-storage in winter, ground heat exchanger, intermediate heat exchanger and fan coil for indoor cooling in summer. Yang also predicted the operation effect of different cool-storage modes by simulation. Xie Li proposed a cool-storage mode of cooling tower-ground heat pump coupled in transition season and analyzed the influence of soil average temperature and wet bulb temperature on cool-storage using TRNSYS.

Actually, as an important heat and humidity exchange equipment for air conditioning system, the heat moisture exchange performance of cooling tower is affected by wet bulb temperature t_{S1}, inlet water temperature t_{W1} and water vapor ratio(μ=W/G) etc. These factors will affect or restrict the annual operation of cooling tower. Thus a novel hybrid ground-source heat pump system based on cooling tower cool-storage in transition season is proposed according to the dynamic change characteristic of air conditioning load in hot summer and cold winter area, based on the analysis method and results of the annual operation of cooling tower [4] that presented by our research team (ZL201210103729.2). That is, concerning the thermal performance of CT, during low cooling load period the CT works in parallel with GHE to share the condensing load, and in transition season the CT works in series with GHE to achieve cool-storage into the soil.

In order to validate the feasibility of this method, the performance evaluation model for HGSHP system is built on the base of ground heat exchanger (GHE) multiple borehole finite line heat source model and TRNSYS software. Using this evaluation model, an actual project in Nanjing is chosen to compare the thermal performance of novel HGSHP system and conventional GSHP system. These results can provide reference on high efficiency operation of GSHP system in cooling load dominated area.

2. The novel HGHSP system based on CT cool-storage

2.1. Basic description of the system

The schematic diagram of this new method HGSHP system is given in Fig.1. The basic operation principle is given below: in peak cooling load period (Jul., Aug.), the GHE undertake all the condensing load, and during low cooling load period (Jun., Sep.), the CT work in parallel with GHE to share the condensing load, and in transition season the heat pump system stop working, meanwhile, considering the effect of outside air parameter on the performance of CT, the CT work in series with GHE during this period to achieve the cool-storage into the soil.

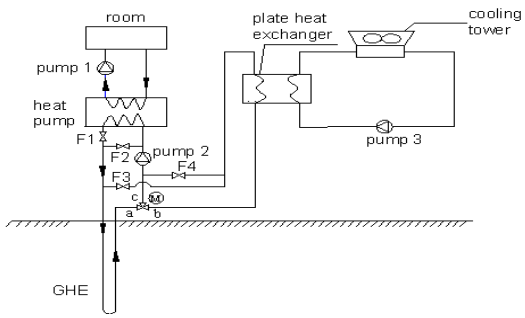

Fig.1. Schematic diagram of novel HGHSP system