Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 205 (2017) 95–100

Procedia Engineering

www.elsevier.com/locate/procedia

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

Numerical Simulation of Airflow Around Cooling Towers in Semi-closed Space

Zhu Yanhe[1], Deng Yahong[2], Li Chang[2], Zeng Junyong[1], Wu Xuezhi[2], Zhong Jian[2], Jiang Changwei[1,*]

[1]*College of Energy and Power Engineering, Changsha University of Science and Technology, Changsha 410004, China;*

[2]*Second Construction Engineering Co. LTD, Bureau 3 of CSCEC Wuhan 430074,China*

Abstract

As an important part of the air conditioning system, the operating performance of the cooling tower has a direct impact on heating and refrigeration of the air conditioning system. Now the cooling towers are placed in the room in many high-end buildings, which results in poor ventilation of the cooling towers. In order to improve the efficiency of the cooling towers, the organized air exhaust scheme of cooling towers should be adopted to reduce or prevent the back-mixing of humid air around the cooling towers. A design method of tower group operation performance in semi-closed space was proposed and the air distribution around the cooling towers in semi-closed space under the organized air exhaust scheme was simulated numerically in this paper. The object of this study is a super high-rise building with 10 layers podium and 164 layers main building. The cooling tower room is 67.3m long, 65m wide and 21.6m high, 13 sets of cooling towers are installed in the cooling tower room. The complicated actually physical structure is simplified and the areas of inlet and outlet are established according to the actual area of 50% in the process of numerical simulation. The airflow distribution and flow resistance characteristics around the cooling towers were obtained through the numerical simulation of air-flow organization around cooling towers. The numerical results show that the exhaust air of cooling towers can be expelled from the semi-closed space smoothly with the organization of air exhaust and the airflow in cooling tower machine room is relatively stable, the inlet air volume of cooling towers can reach rated air flow rate and the cooling towers can run efficiently under the rated condition.

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

Keywords: Cooling tower; Air distribution; Numerical simulatio

*Corresponding author: Jiang Changwei; Tel.: 13786107308;
E-mail address: cw_jiang@163.com

1877-7058 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.09.939

1. Introduction

In recent years, with the improvement of people's survival and development, the large-scale public buildings such as theaters, shopping malls, stadiums, exhibition halls and so on are built in many countries, and people demand more and more comfortable for the working environment of public buildings. The air conditioning system plays an important role in ensuring comfort in the public building, but as an important part of the air conditioning system, the performance of cooling towers has direct impact on the air conditioning system. In order to improve the operating efficiency of cooling towers, the back-mixing of hot and humid air in cooling towers should be reduced and prevented, so the cooling towers are usually placed on the top of the building or on the ground. But now, in order to ensure the overall appearance of the building and reduce the effect of noise at run time on the surrounding environment, the cooling tower are placed in the room at many high-end buildings. This leads to poor working conditions and affects the heat transfer performance of cooling towers.

At present, many scholars had carried out study of the influence of environment wind on the performance of cooling towers. A mathematical simulation of the heat and mass transfer processes in the indirect evaporative air cooling tower had been investigated by Sergey Anisimov et al. [1]. They found that the proposed exchanger obtains lower outlet air temperatures and higher cooling capacity than the typical regenerative unit. However, for higher parallel air flow rated it may achieve lower COP. Gu et al. simulated the heat transfer performance of a 1000MW IDAC tower power stations with four different wind-break structures (cross walls, wind-break walls, cross line-screen, and louvers) using computational fluid dynamics method(CFD) [2]. They found that the face velocity for the windward sectors of the cooling tower increases with increasing the ambient wind velocity. But the gradient of the heat transfer rate decreases with increasing face velocity. The thermal performance of a natural draft wet-type cooling tower with counter flow arrangement has been investigated by Mondal et al. [3]. They found that the temperature drop of circulating water and the effectiveness of cooling tower increase with increasing inlet water temperature for any particular water flow rate in the windless condition. Hooman [4] presented a simple theoretical model to predict the effects of crosswind on the performance of natural draft dry cooling towers. Their prediction results will be useful for future work on the development of air cooling condensers, especially for geothermal and solar thermal power plants. Lu et al. [5] numerically and experimentally investigated the effect of crosswind on the small natural draft dry cooling towers in the wind tunnel experiment, and found that the total heat transfer rate of natural draft dry cooling towers was proposed to be a combination of a natural convective heat transfer term and a forced convective one. Klimanek, etc. [6] developed a complete CFD model to predict natural draft wet-cooling tower performance under various operating conditions. The recirculation phenomenon and operating performance of two groups cooling tower were investigated by Dang et al. [7]. They considered the effects of crosswind velocities and distance between acoustic barriers and inlet of cooling towers and found that the recirculation and operating performance are strongly affected by crosswind velocity. Lu et al. [8] studied the influence of crosswind speed on the heat transfer performance of a small NDDCT (natural draft dry cooling tower) and found that the overall heat rate of towers enhances when the velicity ratio of air is over 10.

Above studies focus on the impact of environmental crosswind on cooling performance of the cooling towers. The circulating water cooling can make full use of natural wind for the cooling tower placed in the outdoor. While the influence of environment wind on the cooling performance of cooling tower significantly reduced for the cooling tower placed in the indoor. So, in order to improve the efficiency of cooling tower, the organized air exhaust scheme of cooling tower should be adopted to reduce or prevent the back-mixed of humid air around the cooling tower. Therefore, a design method of tower group operation performance in semi-closed space was proposed and the air distribution around the cooling towers in semi-closed space under the organized air exhaust scheme was simulated numerically in this paper.

2. Methods

2.1. Physical model

The object of this study is a super high-rise building with 10 layers podium building and 164 layers main building. The cooling tower room is 67.3m long, 65m wide and 21.6m high, 13 sets of cooling towers are installed in the