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Analysis the Applicability of the THIC System in the Humid and Hot Area

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Abstract: In this paper, it is used the DEST to analysis energy consumption of the temperature and humidity independent control system of the office building in Zhuzhou city, Hunan province, provided references for the system in the humid and hot area. Take the Airpak to analysis the comfort in the building which is one of the special software in the HVAC. And state that the dry fan coil system is worthy of popularizing.

Keywords: Temperature and humidity independent control system, comfort, the dry fan coil system

I. INTRODUCTION

As the rapid development of the social and the economic, the human has a higher requirement for the working and living environment. The temperature and humidity independent control air-conditioning system can satisfy the demands of the human. It makes the temperature of the chilled water of air- conditioning system raised up to 14-19℃. It is greatly improved the heat transfer capacity of the air-conditioning system, and provided a chance to use the natural source, because the higher temperature of the chilled water will reduce the energy consumption and the working cost.

In the temperature and humidity independent control system, the dry fan-coil units only to deal with the sensible heat load, and the fresh air dehumidification system conducts the latent heat load and the rest. In general, the fresh air dehumidification system can deal with 30%-50% load of the total quantity of the system, this part is an effective way to save the air-conditioning system energy.

II. CONSTRUCTION PROFILES

A. Building Introduction

This office building is located in Yunlong Avenue, Yunlong demonstration area, Zhuzhou, the total area is 49085.08 m^2, the height is 46.5 m, the main structure form of the underground part used the reinforced concrete structure, and the ground part adopts the steel structure. The whole building on the ground is 12 storeys, it's mainly for offices and conferences, and the underground part has two storeyes, mainly for the garage. The cold and hot source of the air-conditioning system used the ground source heat pump, and the terminal of the air-conditioning is the dry fan-coil units and the fresh air dehumidification system. The building air-conditioning system is also equipped with an indoor air quality monitoring system to collect and analysis the indoor air pollutant concentration, the main function is to alarm the content real-time, to monitor the density of the carbon dioxide and the pollutants. By associating the indoor air pollution detection system, it can realize the automatic ventilation [1].

Zhuzhou is located at the middle south of China, in summer, it is very hot and sultry. The temperature of the chilled water of the general air conditioning system is 7/12℃, the refrigerating should consistent with the heat load, so this system can't reduce the energy consumption. However, the refrigerating of the temperature and humidity independent control system just to handle part of the sensible heat load, it will save much energy on the heat-exchange. If it adopted the series connection system, the energy consumption will be more less [2].

B. Load Analysis

This article used the DeST to analysis the load of the office building. DeST is developed by the Department of Architectural Science of Tsinghua University, which is mainly used for the air-conditioning system of the building, it can analysis the environment and energy efficiency evaluation of

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the building. It used the graphical operation section and common platform for calculation.

According to the characteristic of the climate in Zhuzhou, the air-conditioning runs from May 1 to September 30 during the cooling period, and the heating period is from November 15 to March 15 the next year. To simulate the load of the air-conditioning system of the office building, the general situation should keep pace with building envelope [3]. This office building adopted reinforced concrete structure, the underground is used as the garage and parking lot, so the underground places are not within the air-conditioning area. It is only considered the 12 layers on the ground when establish the building model.

As a typical zone of the hot and humid climate, the cooling load of the air-conditioning reaches a maximum value, the humidity value can reach 24 g/kg. If the air conditioning system adopted the all-air system, it will be difficult to achieve the goal of the energy-saving, and the comfort level is also difficult to meet the requirements, so it will be better to adopt the temperature and humidity independent control system in this area. In this system, the fresh air system deals with the latent heat load and some others, the terminal systems only to bear the sensible heat load, so the temperature of the chilled water will raise up to 19/14 ℃. In the transition season, it just to turn on the fresh air system can meet with the requirements of the comfort level. It will not only improve the efficiency of the system, but also can reduce the energy consumption [4].

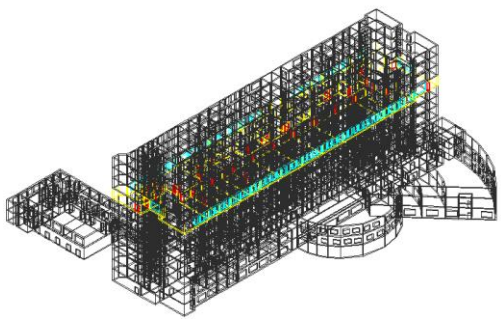

Figure1. 3D model of the building by DeST.

It simulates the air-conditioning loads by DeST, and the 3D model is shown in Figure 1, the result of the hourly sensible and latent heat load of the building will be shown in Figures 2 and 3, it can be seen that the latent heat load of the air-conditioning system is almost 50% of the total heat load.

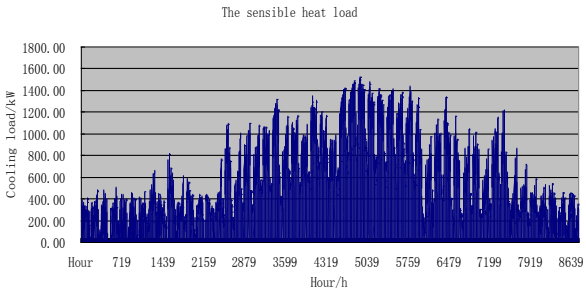

Figure 2. Sensible heat load.

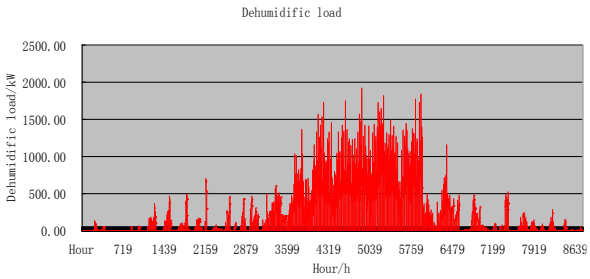

Figure 3. Latent heat load

III. Analysis the Air Conditioning System

The temperature of chilled water of the traditional air conditioning system is 7℃/12℃, the temperature of the supply and return water of the water chiller is 5℃. The fresh air system and fan coil system is in series. The working process of the series system is that the cold water of the chiller handled the fresh air system first, then to conduct the fan coil system. the air-conditioning system schematic diagram is shown in Figure 4.

The outdoor air is conducted by the fresh air dehumidification system, and treated the air as a supercooled or saturated state, the dry fan-coil units processing the indoor return air, then put the two hybrid air into the room. It improved the supply air temperature and avoided reheating the air. To ensure the indoor wet bulb temperature, the dehumidification capacity of the fresh air volume is adjusted by the rate of the water flow and the water temperature. The fresh air volume is decided by the number of people and the largest fresh air volume per capita. The chilled water came out from the fresh air unit for one heat transfer, and then put into the dry fan coil system to deal with the return air of the room [5].

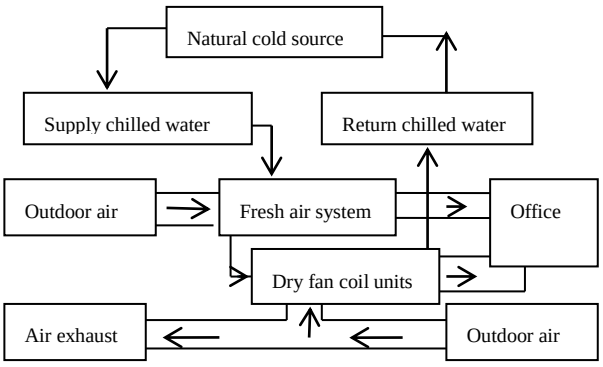

Figure 4. The schematic diagram.

The air in the room is supplied by the dry fan-coil and fresh air units in the temperature and humidity independent control air-conditioning system. Referred to the relevant domestic research of dry fan-coil units and the conventional fan-coil units, there are some different parameters of them, it is shown in the Table 1 [6]. It can be seen that the amount of cooling capacity of the dry condition is only 30-40% of the wet conditions.

Table 1. Parameters of Dry Fan Coil and the Traditional Fan Coil.

	Dry Condition *(Chill1ed water 7/21 ℃)*		**Wet Condition** *(Chilled water7/12 ℃)*	
Type	FP-5	FP-10	FP-5	FP-10
Rated air flow（m^3/h）	679	1058	619	1058
Room parameter	***Dry-bulb Temperature***：*26 ℃*，***RH***：*50%*			
Supply air temperature（℃）	20.7	20.6	14.2	14.0
Supply air RH（%）	69	69	95	95
Cooling capacity（W）	1102	1914	2976	5312

IV. ANALYSIS THE COMFORT OF THE THIC SYSTEM

A. The Geometric Model

This paper used the Airpak software to analysis the comfort level of the room, which is one of the most famous professional software of HVAC. This simulation model selected a small office of the building, the geometric dimension is 6800×4200×3000, it is shown in Figure 5. Simulate the indoor air temperature and humidity of this office.

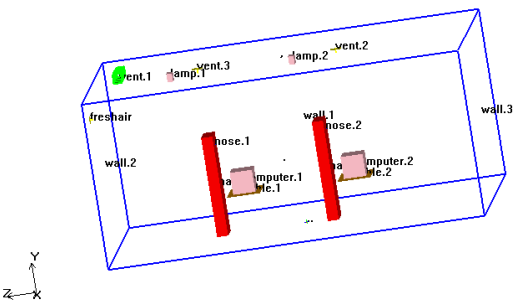

Figure 5. The geometric model.

The simulation simplified some boundary conditions, the three internal walls treated as the adiabatic side. It's set that there are two office workers in the office, and the radiating equipment is the computers and the lamps, it is shown in the Figure 5. The heat of human body, the computers and the lamps is set as 75 W, 173 W, 34 W, respectively. In summer, the temperature and humidity of the dry fan-coil units is set as the Table 1, the air supply temperature is 20.7℃, and the relative humidity is 69%. The temperature of fresh air is 24.3℃ and the relative humidity is 54% (the moisture content is 9.8 g/kg) [6] according to the Temperature and Humidity Independent Control Air-conditioning System, which is written by Liu Xiaohua and Jiang Yi.

B. Analysis the Indoor Relative Humidity Simulation

In the latest ASHRAE STANDARD 62-2001, it put forward a stricter requirement for the control of the temperature and humidity of the air-conditioning area, the relative humidity of the air conditioning room should be controlled in 30%-60%. Because when relative humidity of the air is below 30%, it will cause discomfort for the human, when the indoor humidity is higher than 65% or more, it will provide a good breeding place for the bacteria, mold, and some other microbial [7], it will have a great impact on the indoor air quality. It will damage the structure and interior equipment. It will be more serious [8, 9].

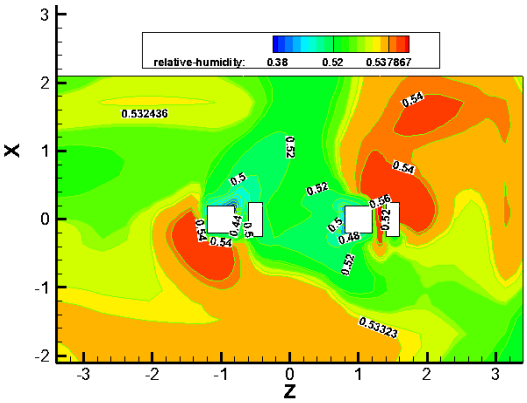

Figure 6. The RH of the room.

From the diagram of Figure 6, the indoor humidity control is within 44% to 55%. It completely meets with the ASHRAE STANDARD 62-2001 and the comfort requirements of the human.

C. *Analysis the Concentration Simulation of CO_2*

According to some results from the questionnaire survey, it is the concentration of the carbon dioxide reflects the quality of the indoor air. The carbon dioxide concentration in the volume fraction is 0.04% (400 PPMV), it is set in the external environment of the model. The concentration of CO_2 of supply air of the vent is set higher than the outdoor because of the influence of the return air, it's set as 450 PPMV [10].

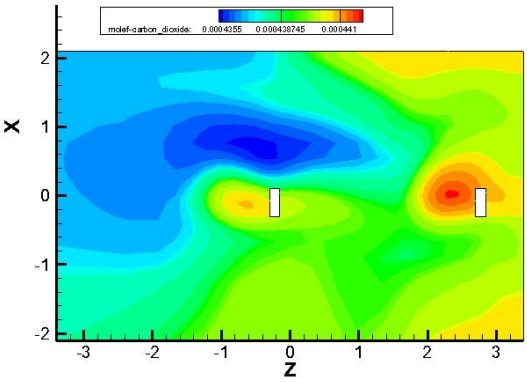

Figure 7. The concentration of CO_2 of the room.

The result of the simulation is shown in Figure 7. The main factors affect the quality of indoor air is the carbon dioxide, it is made by the human body's breathe, and there are only two people in the room, so the concentration of CO_2 is close to the air of the outdoor. The air environment of in the office is very comfortable for the human.

V. Conclusion

The dry fan-coil units and fresh air system can deal with the latent load and sensible heat load separately, it is worth popularizing, especially in the south region of China. To use the fresh air system to deal with the latent heat can greatly reduce the energy consumption, improve the COP value of the refrigeration units, and at the same time, it will ensure the quality of indoor air.

Acknowledgment

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