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Operation Energy Saving of Fan-Coil Unit based on Auto-counting of People Number

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Abstract—In the current context of "peak carbon emissions and carbon neutral", today's society has put forward higher requirements for reducing building energy consumption. Therefore, to address the problems of high energy consumption and poor comfort of central air conditioning system in large public buildings, this paper proposes an energy-saving control method for fan coil unit based on auto-counting of people number to reduce the operating energy consumption of air conditioning system as much as possible while meeting the comfort of indoor personnel. It is concluded that the operation strategy can effectively reduce the operational energy consumption of the air conditioning system by 20%. It is applicable to the central air conditioning system of public buildings with large changes in the number of people, and has certain application prospects.

1 Introduction

China adds 2 billion square meters of new buildings every year, accounting for about 50% of the world's total[1]. Of the 46 billion square meters of existing buildings in China, 95% are non-energy-saving buildings, which waste resources and pollute the environment. At present, China's building energy consumption accounts for about 30% of the total energy consumption, and with the improvement of people's living standards, building energy consumption will increase to more than 30%[2]. The energy consumption of heating and air conditioning systems accounts for about 40%~50% of the total energy consumption of buildings[3]. Therefore, it is also crucial to reduce the energy consumption of air conditioning systems in buildings. In addition, with the rapid development of urbanization in China, people's living standard has also been greatly improved, and their requirements for buildings are also increasing[4]. In addition to the most basic functional needs, people are increasingly concerned about the comfort of the indoor environment.

For various reasons, the number of personnel in large public buildings such as teaching buildings, dormitory buildings, shopping malls, office buildings, etc. changes greatly. And their central air conditioning systems operate at full load for a long time will cause energy waste[5]; when the number of people in the room changes, the personnel cooling load changes, and there is a delay when this change is transmitted to the temperature sensor of the air conditioning system, so the air conditioning system cannot respond in time, resulting in the regulation of the air conditioning system delay and indoor personnel comfort is reduced[6].

To address the above problems and needs, this paper proposes an energy-saving control method for fan coil unit based on auto-counting of people number. By counting the number of people in the room, the air volume and water volume of the fan coil unit can be adjusted in time, so that the air conditioning system can respond to changes of indoor load in a timely manner.

2 Air conditioning load simulation and calculation

An existing university building is facing east-west, with a total area of 38520m^2, including an above-ground construction area of 33090m^2, 11 floors. Each floor is designed to accommodate a total of 400 people, and 2 underground floors, with a construction area of 5430m^2. The DeST model is established according to the building construction drawings, adding doors and windows and other components in turn, setting the ventilation rate, while checking the integrity of the model and screening out envelope structures which are fault to ensure the reasonableness of the model. Taking the standard floor of the building as an example, the architectural drawing and DeST model of the standard floor are shown in Figure 1 and Figure 2 respectively.

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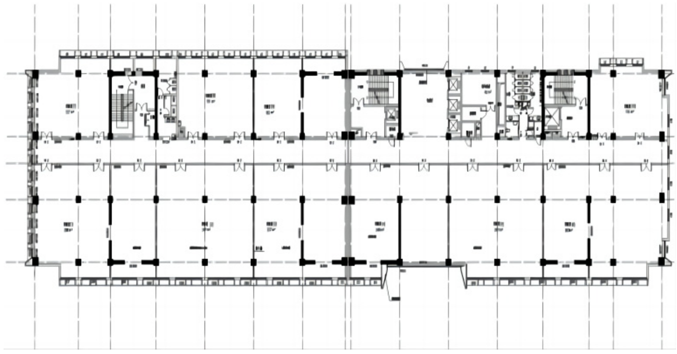

Figure 1. Architectural Drawing of the Standard Floor

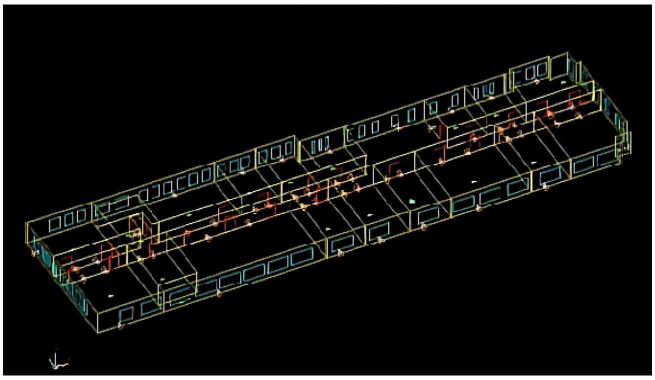

Figure 2. DeST Model of the Standard Floor

The whole building is reinforced concrete structure, the exterior wall material is 250 mm thick aerated concrete block wall, the west/south/north exterior windows are all made of 5+12+5mm double-layer intermediate blank glass, the east exterior windows are LOW-E glass, dark gray broken aluminum alloy electric spray frame, the roof is made of 3+3 SBS waterproofing membrane and 100 mm thick water-repellent rock wool board at the same time. The specific parameters of the thermal performance of the building envelope are shown in Table 1.

TABLE 1 SPECIFIC THERMAL PERFORMANCE PARAMETERS OF THE ENCLOSURE STRUCTURE

Enclosures	Materials	Heat transfer coefficient (W/ m²·°C)
Exterior Parapets	250 mm thick aerated concrete block wall	0.6
Internal partition wall	200 mm thick aerated concrete block wall	0.6
West/south/north exterior windows	5+12+5 mm double-layered glass in blank	2.7
East exterior window	LOW-E glass, dark gray broken aluminum alloy electric spray frame	2.3
Roofing	Waterproof layer adopts 3+3 SBS waterproof membrane, insulation layer adopts 100 mm thick water-repellent rock wool board	0.5

DeST software was used to calculate the hourly air conditioning load of the building, and the annual hourly air conditioning load was obtained as shown in Figure 3. It can be seen that the total annual heat load is slightly larger than the total cooling load, in which the heat load is mainly concentrated from November to March each year, and the annual time-by-time heat load is mostly concentrated around 1500 kW, with the maximum heat load of 3488.48 kW occurring on February 19, corresponding to the maximum heat load index of 110.24 W/m^2 ; while the cooling load is mainly concentrated from June to July, with the maximum cooling load of 3016.73 kW occurring on July 6, corresponding to the maximum cold load index of 96.74 W/m^2 ; and the cooling load is mainly concentrated from June to July, with the maximum cooling load of 3016.73 kW occurred on July 6, corresponding to a maximum cold load index of 96.74 W/m^2.

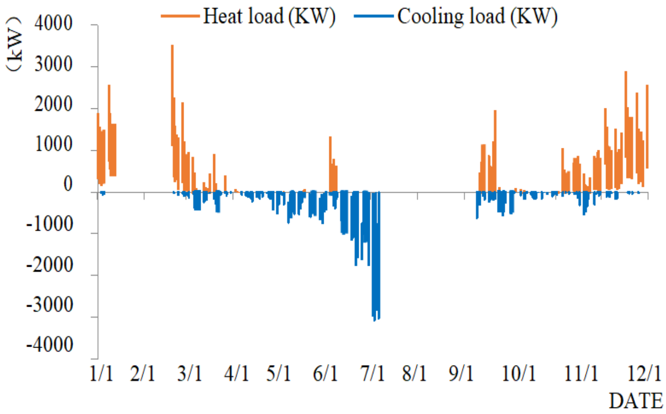

Figure 3. The Annual Hourly Air Conditioning Load

By classifying the simulation results of the building's hourly load , the load results can be divided into four parts: indoor sensible heat load, indoor dehumidification load, sensible heat load of fresh air, and dehumidification load of fresh air , and the load distribution diagrams in summer and winter are shown in Figure 4 and Figure 5, respectively.

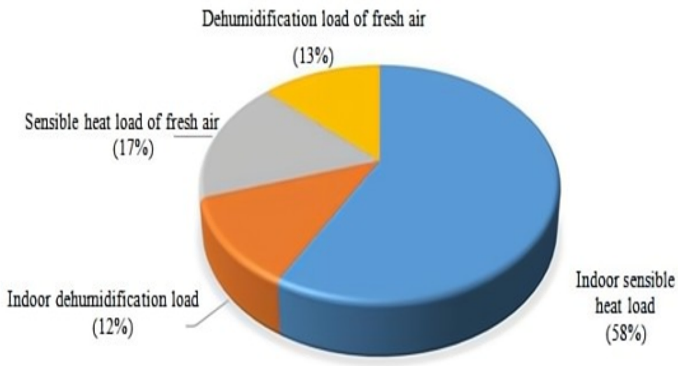

Figure 4. The Composition of Cooling Load in Summer

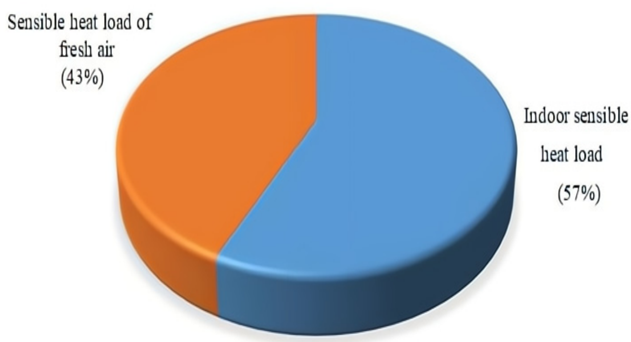

Figure 5. The Composition of Heating Load in Winter

The simulation results show that the indoor cooling load accounts for 58% in summer and the indoor heat load accounts for 57% in winter. The load of fresh air is relatively large in winter and summer. But the air conditioning system controlled by conventional methods will generate a larger energy consumption, so it is necessary to optimize the operation of the air conditioning system.

3 Fan Coil Unit energy saving operation methods

3.1 Introduction

In summer, for example, in the composition of air-conditioning cooling load, heat loss of human body and

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fresh air are the main sources of indoor cooling load[7]. When the number of people changes, the heat loss of human body and fresh air demand will change. When the personnel decreases, the indoor load will also decrease, and the conventional air conditioning system cannot sense and reduce the cooling supply in time for energy-saving operation.

In response to these shortcoming, a new control method is proposed. As shown in Figure 6, the fan coil + fresh air system generally includes wall thermostats, fan coil unit, fresh air pipes, electric valves of fresh air, etc[8]. This control method enables the controller to control the valve of fan coil unit and electric fresh air valve by counting the number of people entering the meeting room.So it can avoid the delay in the adjustment of the indoor air conditioning system, the deterioration of the indoor environment, and the discomfort of indoor personnel before the air conditioning system reacts.

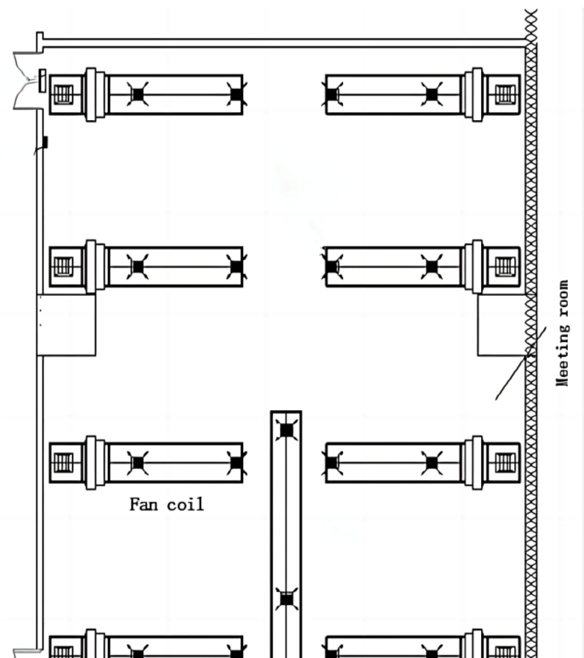

Figure 6. Air Conditioning System in a Meeting Room

3.2 Control principle

Since the conventional air conditioning system cannot sense and reduce the supply cooling quantity in time[9], the method proposed in this paper is to add the control condition of dynamic change of people number on the basis of controlling the temperature. It can reduce the running energy consumption of central air-conditioning as much as possible while ensuring the comfort.

The principle of the system is: by counting the number of people, sending the electric signal to the programmable logic controller for processing, and issuing instructions to control the fresh air volume and water volume of the fan coil unit and the fresh air valve in the fresh air ducts to realize the automatic adjustment of the fan coil unit.When the number of people in the room decreases, the electric valve of fresh air will be controlled to reduce the fresh air volume, reduce the water volume of the coil, and reduce the fan speed to achieve energy saving. The control point diagram are shown in Figure 7.

Also, the number of people can be counted by adding photoelectric sensor switches at the door, and in times of epidemics, the door temperature measurement system can also be used to count the number of people, etc.

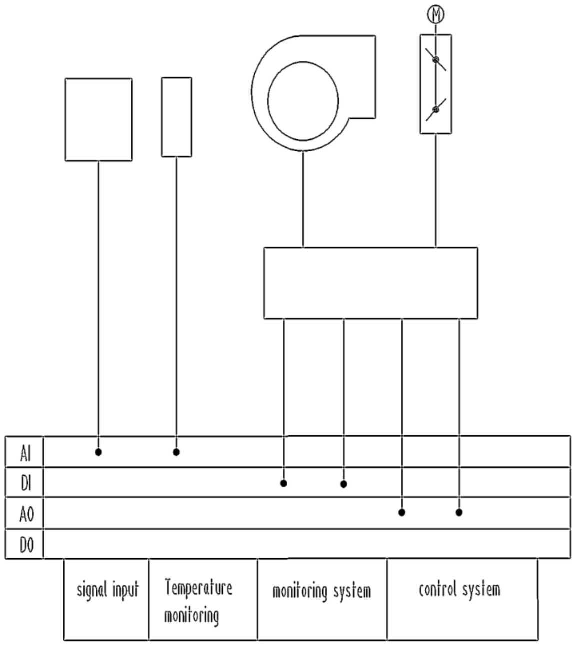

Figure 7. Fan Coil Unit Automatic Control System

3.3 Control strategy

The control method mentioned in this paper is based on the conventional temperature controller, adding the condition of auto-counting of people number,taking the above meeting room as an example, the control operation strategy is as follows.

(1) According to the measured data signal of the number of people, the indoor temperature regulation is realized by adjusting the water valve and fan speed.

(2) At the first 5 minutes, if there are many people entering the meeting room, the signal of people number control priority, after 5 minutes, when the indoor temperature decreases, the system control will be controlled by temperature controller. The number control is triggered when a large number of people leave, and the speed is reduced until the fan coil is closed.

(3) The number of people in the room precisely controls the fresh air volume to improve the comfort of indoor personnel and save energy.

(4) When the wall temperature controller is operated by personnel, the operation of the wall temperature controller be out of action.

4 Summary

In the current context of low carbon emission reduction, reducing building energy consumption is an important part of achieving the goal of peak carbon emission and carbon neutrality[10], so energy-saving operation of air conditioning system becomes especially important[11]. In this paper, simulation calculations are conducted for a school building building, and it is found that the air conditioning load accounts for a relatively high proportion,and the energy wasted by running overload for a long time. Therefore, a new energy-saving operation method for fan coil unit is proposed, which can automatically control the system based on auto-counting of people number. It can reduce the operation energy consumption of the air conditioning system while satisfying the indoor personnel comfort. And it is applicable to the central air conditioning system of public buildings with large changes in the number of people, and has certain application prospects.

In this paper, the method of counting the number of people is not described in detail. In future research, different methods can be proposed to calculate the real-time number of people in the room, so as to regulate the fan-coil system more accurately and make its operation more energy-saving.

References

[1] Yue Zifeng. Research on energy-saving optimal control strategy of air conditioning units [C]. Beijing Forestry University, 2013.

[2] Guo Qianqin. Modeling and control simulation of variable air volume air conditioning system [C]. Qingdao University of Technology,2014.

[3] Deng, J.W.; He, S.; Hao, Z.G.; Wei, Q.P.; Zhang, F.. Research on the operational adaptation method of air conditioning system in public buildings(5):all-air variable air volume system[J]. HVAC,2020,50(377):71-78.

[4] Liu Pengfei. Application of HVAC system automation in a terminal building project [J]. Electromechanical Information,2019(585):57-58.

[5] Li Chengmeng. Research on the control strategy of variable air volume air conditioning system based on intelligent algorithm [C]. Beijing University of Architecture,2018.

[6] Wang LJ; Liu YF; Liu GaP. Experimental study on the effect of wind speed on the heat dissipation characteristics of human body[J]. Journal of Xi'an Engineering University,2015, 29(135):49-54.

[7] Tezhigele; Zhao Tianyi; Liu Zhongjie; Zhang Jili. A continuous experimental method for air conditioning unit airflow suitable for online application[J]. Building Energy Efficiency,2020,48(349):10-14.

[8] Xu Yingying. Coordinated operation of HVAC and automatic control in design and operation [J]. Building Materials and Decoration,2019(562):229-230.

[9] Li Jingqi. Simulation study on optimal control of indoor temperature and humidity in air handling units [C]. Shenyang University of Architecture,2019.

[10] Wang Lixia;Kang Bing. Influence of HVAC systems on the environment inside buildings [J]. Journal of Shandong Agricultural University (Natural Science Edition),2021,52(1):1-3.

[11] Zhang L. W. Research on the current situation of air conditioning operation and energy-saving operation control in public buildings in Chongqing [C]. Chongqing University, 2009.

[12] Yi Peng. Building Energy Saving and New Energy Utilization in Building Design [J]. International Journal of Higher Education Teaching Theory,2021,2(3).

[13] Yi Peng. Discussion on Energy Saving Transformation Methods of Modern Buildings [J]. International Journal of Higher Education Teaching Theory,2020,1(2).

[14] Liu Yang,Wang Xian-jia,Zhou Shan,Chen Hongyu. Enhancing public building energy efficiency using the response surface method: an optimal design approach[J]. Environmental Impact Assessment Review,2021,87.