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Research on Automatic Control of Central Fresh Air System

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Abstract: In the complex flow of people in large shopping malls and hospitals, in order to ensure the good quality of indoor air, it is very important to supply fresh air indoors. With the popularization of the application of central fresh air system, in order to strengthen the practicability of fresh air system, it is very important to manage the fresh air system through automatic control. This paper expounds the basic control theory of fresh air system and the principle of automatic control of central fresh air system.

Keywords: Central Air Conditioning; Fresh Air; Auto-Control

Introduction

With the continuous growth of China's economy this year and the continuous improvement of the quality of life of Chinese residents, people also put forward higher requirements for buildings and pay more and more attention to the air quality in buildings. In large public buildings such as hospitals and large-scale commerce and trade, the interior of the building has the characteristics of people flow and personnel density. The air quality has a great impact on the internal environment and the use feeling of the building. In the current fresh air system of central air conditioning, most of them adopt automatic control to ensure the effect of internal ventilation and internal air quality. With the acceleration of urbanization in China in recent years, large buildings are emerging, and the automatic control of fresh air system has also developed rapidly [1].

1. Indoor air quality and fresh air volume

1.1 Indoor air quality

In the closed environment of a building, the indoor air will be affected by all aspects of the building. Especially in the air-conditioned room, because the air is an internal circulation mode, it will cause a large number of low concentration pollutants in the indoor air. Affected by these pollutants, most people living in closed buildings will feel stimulated or uncomfortable. In relation to air quality, Danish scientists first put forward the definition of air quality in 1989. However, at this time, the research on air quality is subjective, and the definition of air quality is mostly people's subjective perception of whether the air quality is good. This method has no reference value. After that, in the study of air quality, people analyze the concentration of indoor pollutants and the content of different components in the air, so as to gradually realize the goal of quantifying air quality.

1.2 Standard for fresh air volume of building ventilation

With the development of architecture, in the 1970s, people gradually realized the impact of fresh air on the internal control quality of buildings, which is not only limited to the impact of people's feelings, but also has a negative impact on people's health. With the development of social construction, people are more and more resistant to the building mode at the expense of health and comfort. Under this background, indoor air quality standards have been formulated. Based on this, the European Union puts forward the calculation method of fresh air volume. China has also formulated clear requirements for

this. In the current design of central air conditioning, it is required to meet three basic conditions: first, central air conditioning can dilute the pollutants brought by people's activities. Secondly, the indoor exhaust air volume shall be supplemented to ensure that the indoor is in a positive pressure state. Finally, the indoor fresh air volume shall be greater than 10% of the air supply volume of the system. The specific marking requirements are shown in the table below:

Table 1-1. Indoor air quality standard

Serial number	Reference category	Parameter	Unit	Standard value	Note
1	Physical property	Temperature	℃	22–28	Summer air conditioning
2				16–24	Winter heating
3		Relative humidity	%	40–80	Summer air conditioning
4				30–60	Winter heating
5		Air velocity	m/s	0.3	Summer air conditioning
6				0.2	Winter heating
7	Chemical property	Fresh air volume	$m^3/(h \cdot p)$	30[a]	
8		Sulfur dioxide	mg/m^3	0.5	1h mean value
9		Nitric oxide	mg/m^3	0.24	1h mean value
10		Carbon monoxide	mg/m^3	10	1h mean value
11		Carbon dioxide	%	0.1	Daily mean value
12		Ammonia	mg/m^3	0.2	1h mean value
13		Ozone	mg/m^3	0.16	1h mean value
14		Formaldehyde	mg/m^3	0.1	1h mean value
15		Benzene	mg/m^3	0.11	1h mean value
16		Toluene	mg/m^3	0.2	1h mean value
17		Xylene	mg/m^3	0.2	1h mean value
18		Benzopyrene	ng/m^3	1	Daily mean value
19		Inhalable particulate matter	mg/m^3	0.15	Daily mean value
20		Volatile organic matter	mg/m^3	0.6	8h mean value
21	Biological property	Total colony	cfu/m^3	2500	According to the instrument

2. Principle introduction of central fresh air system

2.1 Composition principle of fresh air system

In the whole fresh air unit, its components mainly include fresh air duct, air supply valve, air supply fan, etc. In the exhaust system, the main components are return air pipe, return air valve, exhaust fan, etc. There are two filter sections in the whole fresh air unit, namely, primary effect filter section and medium effect filter section. Besides the first time, there are hot spots at the fresh air and exhaust air. In the central air-conditioning system, the transmission mode of fresh air generally

adopts the form of replacement. After the external fresh air passes through the initial effect and medium effect, the filtered air is transmitted to the new air outlet, and the fresh air is transmitted to each room through the new air outlet. At the same time, there will also be sealing in each room, which corresponds to the new air outlet, so that the air in the whole room forms a cycle, takes away the indoor waste gas, and allows the indoor air to be replaced regularly to ensure the quality of indoor air. In the spatial layout, the fresh air outlet of the fresh air system is generally arranged at the ceiling, and the exhaust outlet is installed on the floor or lower position of the room to ensure that the indoor air can form a relatively stable flow state after the fresh air enters, so that the dirty air in a room can be discharged through the return air outlet. When cooling or heating the room in summer, the air will be cooled or heated in the fan coil at the exhaust outlet to adjust the indoor temperature. At the same time, in order to achieve the effect of energy saving, the general fresh air and exhaust system will be controlled by frequency conversion to ensure the ventilation effect in each room and reduce the power consumption of the whole system[2].

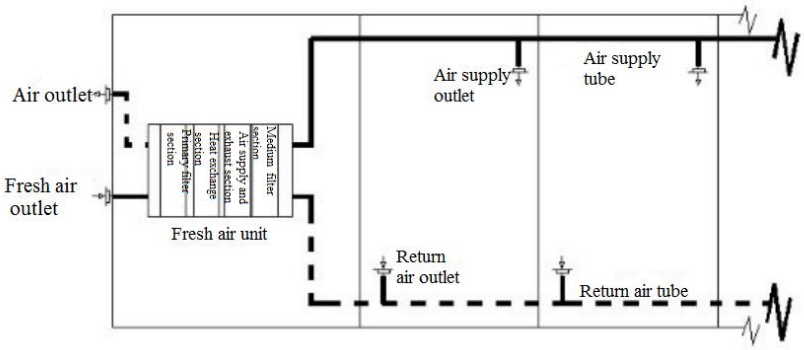

Figure 2-1. Structure diagram of fresh air system.

2.2 Automatic control theory of fresh air system

With the development of computer technology, automatic control system has played a great value in many fields. Under the background that the current building is developing towards intelligence, the control of central air conditioning is also developing towards intelligence. The operation mode of traditional buildings is replaced by intelligent systems, which greatly improves the regulation of office and living environment in buildings and the convenience of people's life. In the automatic control of central air conditioning system, there are many control modes, such as single chip microcomputer (PIC) control, PLC control, analog instrument control and direct digital control (DDC). In the current specific application, analog instrument control mode is less used. At the same time, using DDC and DCS for control also has the problem of excessive fraud. Most of the control through single chip microcomputer will integrate circuits, so there will be the problem of insufficient control function and difficult expansion. In the current air conditioning automatic control, PLC is the most commonly used control mode, and the stability of operation can also be guaranteed.

PLC has the advantage that the program can be written freely, and among the above control modes, this mode has the strongest anti-interference ability. But the problem with this is that the operation speed of PLC is also the slowest. The communication function of PLC is good, and it is very convenient to carry out or expand in the process of use. Therefore, the current automatic control of central air conditioning is the main control method. The specific control composition is shown in the figure below.

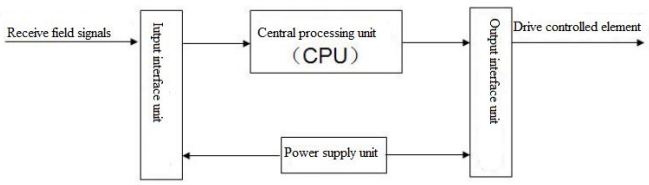

Figure 2-2. Basic composition of PLC.

However, nowadays, the building scale of Suihe building is increasing, and the complexity of the building is also increasing. In some special areas, higher requirements are put forward for air quality. For example, electronic workshop, operating room, etc. Therefore, it puts forward higher requirements for the technical level of automatic control. In order to meet the higher computational requirements of the current central air conditioning system, on the basis of the traditional PLC controller, it will also be combined with computer technology, communication technology and microelectronics technology.

3. Correlation control between indoor pollutants and fresh air volume

In the traditional ventilation control, CO_2 concentration is generally used as the control reference standard. That is, in the calculation of ventilation volume, it will be adjusted and calculated according to CO_2 concentration. When the sensor detects that the CO_2 concentration in the air exceeds the standard, the system will control the fresh air valve and adjust the fresh air fan at the same time, so as to change the input of indoor fresh air. In the initial design, the main reason for taking this as an index is that in people's activities, the most significant index is the CO_2 concentration in the air, so it is regarded as the only standard for air quality identification in the central air conditioning system. However, the concentration of CO_2 in the air cannot be used as the only standard. In the whole building, not only the changes of air quality brought by human activities, but also furniture and decorative materials will bring various air pollutants, which will affect the air quality. The concentration of these organics exceeds the standard, even greater than that of CO_2, and greater harm to human body. Therefore, it is unscientific to take CO_2 concentration as the only standard in control. However, there are many reasons for indoor air pollution, and the concentration of some pollutants is very low. The complex problem of air components makes it impossible to detect all components. After all, which one do you choose? Therefore, in the quality control measurement, air pollutants will be measured according to different scenarios. By combining the grey clustering analysis of different buildings, taking the representative pollutants in different types of buildings as the key reference standard, the correlation control between air pollutants and fresh air volume is established. There are mainly the following different site types [3].

3.1 Underground shopping mall

The underground supermarket has the characteristics of high personnel density and strong mobility. When people pass through underground shopping malls, it will not only increase the concentration of carbon dioxide, but also aggravate the concentration of dust in the air. Underground supermarket shops need to be decorated, so there will be a large number of organic pollutants such as formaldehyde brought by decoration materials. However, with the improvement of the level of urban architecture, it has brought more and more serious space problems, resulting in the continuous improvement of the number and scale of underground shopping malls. Underground shopping malls have the characteristics of high closeness. They can't open windows for ventilation like aboveground buildings. If they don't change air in time, it will inevitably lead to a sharp decline in air quality. However, if the mechanical air supply and exhaust system is adopted, it will bring more energy consumption problems. In order to calculate the grey correlation degree of pollutants affecting air quality in the air, classifying and detecting the pollutants, and correlating the fresh air system are very key. In the relevant gray correlation statistical research, carbon monoxide, carbon dioxide and radon can be classified into one category in the air pollutants of underground shopping malls. Inhalable particulate matter and TVOC can be classified into one category, and organic matter such as formaldehyde can be classified into one category.

3.2 Teaching buildings

In the attention to air quality, teaching buildings and office buildings are the key objects. In order to ensure the practical effect of air conditioning, the early classroom design will adopt a closed design method. Therefore, it will lead to bad smell and poor air quality in the classroom in summer or winter. Classroom is the main activity place for students. Air quality has a great impact on students' study, life and health. According to relevant statistics, students spend more than half of their time in the classroom. Improving classroom air quality is of great practical significance to students' study and life. In the study of gray correlation statistics related to teaching buildings, carbon dioxide, formaldehyde and radon can be classified as one of the air pollutants in classrooms. There is no necessary correlation between carbon monoxide, inhalable particulate

matter and TVOC.

3.3 Office building

The study of indoor pollutants in office buildings is the earliest. The office building has the characteristics of stable personnel and high density. At the same time, there are a large number of electronic equipment and office furniture in the office building, which will have a certain impact on air quality. Combined with the carbon dioxide brought by personnel breathing, the air composition in the office is complex. In the gray correlation statistical study of office buildings, carbon monoxide, formaldehyde and inhalable particulate matter can be classified into one category. Carbon dioxide, microorganisms and sulfur dioxide can be classified into one category. Nitrogen dioxide is classified separately.

4. Conclusion

In the automatic control of the central fresh air system, the detection of the inhalable pollutants in each room, and then the adjustment of fresh air volume after computer calculation are the key to the automatic control of the fresh air system. The key point is to monitor the concentration of pollutants in the air. However, air has the characteristics of complex components. This paper expounds the correlation degree of air pollutants based on different public scenes, and analyzes and studies the whole central fresh air system in combination with the controllable principle of fresh air system, in order to provide reference value for relevant technicians.

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