

The Application and Analysis Method of Air-Condition System for Inner Zone

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Abstract: The article discusses the problem about how to effectually dispel the surplus heat of the inner zone with many ways. The inner zone is the least in the winter and is the most in the transitional season. The area between the least inner zone and the most is defined cushion zone. The second, discussing the reasonable setting of the cold source, the specialties of the typical inner air-conditioning system, and the limit of all the system. Three types of inner air conditioning systems have been analyzed emphatically in the article from the system design and the operation control. According to an actual project, we compare these three systems in the aspect of economy operation.

Keywords: Inner zone, Buffer, Open big room, Variable volume system

0. INTRODUCTION

There are two kinds of rooms in the public building: One is called outer zone, where rooms are near the envelope structure and the annual indoor temperature changed with outdoor weather, needing cooling in summer, heating in winter. The other is called inner zone, where rooms have no envelope structure or have large depth. Often personnel are intensive in these rooms, light and equipment load are heavy, and the load of these rooms becomes invariable in the whole year. Cooling load is needed all year round, free of weather condition basically.

The air conditioner system takes a big part of energy consumption in building. Large number of energy is consumed if cooling in inner zone all year, especially in high-rise public buildings. For example, John Burnet (Hong Kong comprehensive technology university) made a survey on 33 high-rise commercial buildings [3], the statistic data indicated that the power consumption of the air conditioner system accounts for 60% of the average power consumption. The annual cooling load simulation indicated that energy consumption in HVAC, 30% is used for reducing the heating value caused by illumination, 20% is used for eliminating the heat caused by sunlight kicked into by the window, 15% is used for reducing the heat value permeated from the roof, and 13% is used for eliminating the heat radiated from the facility in the building.

In recent years, a large number of high-rise public buildings have been built in our country. Only in Shanghai, skyscrapers completed and under construction has been already nearly 3000, most among them are the commercial office buildings and with intelligent facilities. The large energy consumption and maintenance cost of high-rise building need to pay close attention. It is one of effective way of energy saving to eliminate surplus heat using outdoor natural cold source in transitional season and winter,

considering the feature of inner zone of cooling all year. This paper analyses the establishment of the cold source in inner zone of air conditioner and rational regulation, ensuring good indoor thermal and humid environment and energy saving.

1. METHOD OF ZONE PARTITION

Modern office buildings always have features of large depth, complicated separation. In these buildings, staff in outer zone responses cold but staff in inner zone complains too hot in winter and transitional season, the temperature difference may reach up to 4 °C sometimes [5]. When ceiling separate inner zone and outer zone completely, the air in two zones is blocked and can't circulate with each other. In this case the range of inner zone and outer zone is very clear. To open large space, some American designers considered that zone dividing would be needed when building depth exceeded 8m, while designers in Europe, Japan and China said the zone influence should be considered when depth exceeded 5m [8]. In fact for open large space, air in two zones circulate and mix with each other, the zone partition is affected by a great deal of factors: for instance, outdoor weather condition, thermal characteristic of envelope structure, heating load caused by indoor person, lighting and equipment, etc. The theory analysis indicates that the range of inner zone and outer zone will be changed with fluctuation of weather condition.

According to above analysis, we select 1.8m apart from outer wall place as the zone limit in transitional season. Rooms inside this limit belong to inner zone, which temperature is hardly influenced by envelope structure but affected mainly by inner heat source. The range of inner zone changed with the fluctuation of weather condition, the minimum range appears in winter and the maximum scale appears in transitional season, shown in Fig.1.

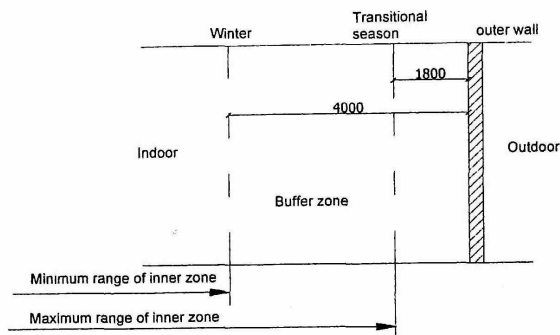


Fig.1 the annual changeable range of inner zone

The analysis of zone partition above indicated that outer zone needs heating in winter and cooling in summer, while inner zone needs cooling all year round to eliminate surplus heat. The range of inner zone is not fixed but changed along to fluctuation of annual weather. This paper calls the area between the minimum range and maximum range as buffer zone. The buffer zone needs cooling and heating simultaneously in transitional season and in winter, besides needing cooling in summer. That means consider buffer zone's load when setting up end units of air conditioning of inner zone and outer zone. According to the comparative result of the indoor and outdoor enthalpy value, the start-open and operation working state of end units of air conditioning is determined. Usually, the installation load of air condition units will not increase when considering factors of simultaneous use ratio and not large buffer

zone area.

Take a typical office building in financial street as example, there were VAV air conditioner systems set in every standard floor, and differential pressure transducer was used to control the frequency of return fan thus to control the air supply volume. Variable frequency discharge system was set up in every standard floor, controlling outdoor air and discharge volume by CO₂, IAQ density, as shown in Fig.2.

Among the system, VAVBOX in inner zone was independent-pressure blast volume controller, and VAVBOX in outer zone was attached reheat coils. The wind valley in outer zone was assigned close to outer walls, and wind valley in inner zone was assigned with the distance of 5m or more from outer walls. The load of buffer zone (3~5m away from envelope structure) was accumulated on VAVBOX in inner zone and outer zone, when selecting the VAV end units.

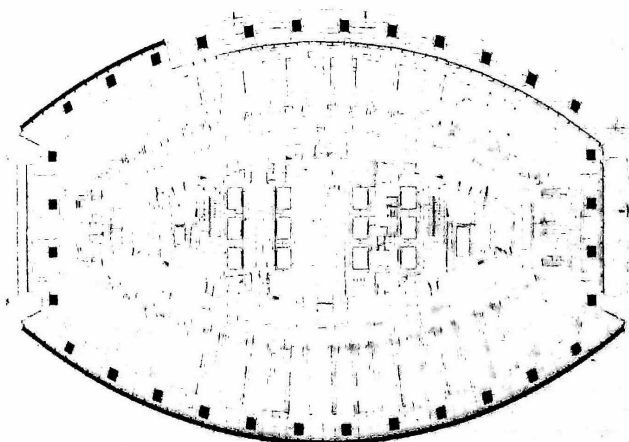


Fig.2 An air conditioning plan view in standard floor of a typical office building

2. FAN-COIL PLUS FRESH AIR SYSTEM (VARIABLE FRESH VOLUME)

This fan-coil plus fresh air system can be applied in open large space with large depth, and the fresh air system can be divided into two—inner fresh system and outer fresh system. The outer zone fresh air volume was confirmed according to personnel hygienic requirements and inner zone volume was calculated according to elimination amount of heat surplus in winter. The fan coils in outer zone supplied heat in winter and cold in summer, while fan coils in inner zone supplied cold in summer and stopped in winter and transitional season. The fresh air volume confirmed according to personnel hygienic requirements was smallest in summer, while the outer zone fresh air volume was invariable. In winter and transitional season, the fresh air volume increased confirmed according to elimination amount of heat surplus. The discharge fan set up in inner zone started, the controller control the supply air volume and discharge volume to satisfy the demand of temperature change in inner zone, according to the comparative result of the indoor and outdoor enthalpy value, after the indoor and outdoor temperature and humidity sensor transduced signals to controller. Automatic control system is an important part of this fan-coil plus fresh air system. Set up corresponding sensor and controller, and adjust systematic using state automatically according to the data determined by the sensor on system pipeline, to meet the demand of the indoor environment in different seasons.

3. VARIABLE AIR VOLUME (VAV) AIR CONDITIONING SYSTEM

In VAV (Variable Air Volume) system, the room temperature is controlled and adjusted by changing the supply air volume. Under proper outdoor climatic conditions, VAV system can utilize outdoor wind to dispel indoor load, not only save energy but also improve indoor air quality. After 1990s, VAV air conditioning system has been applied widely to domestic top-grade office buildings. As the increasingly development of building automatic control, the whole yearly air transform power of intelligent VAV system is only 40%-60% of the routine system [7].

Routine VAV air conditioning system has two kinds of zone dividing ways: is it set up VAV concentrated and zoned. In concentrated VAV system, load both in inner zone and outer zone are supplied by one system (inner zone and outer zone use a system together), which means the same supply air temperature in both zones all year round. While the supply air volume in different zone can be adjusted independently by setting VAVBOX respectively. In winter, set the inner zone supply air temperature to the extent that can eliminate inner zone surplus heat, and set reheat system (reheat coils or radiators) in outer zone to meet the needs of room temperature.

Zoned VAV system means two systems (inner zone system and outer zone system), in which the supply air temperature and volume in two zones can

be controlled and adjusted dependently and respectively. If the indoor design parameter in inner zone is invariable basically in summer and winter, the supply state point is steady in the whole year. In transitional season and in winter, outdoor natural cold sources and surplus heat in return air can be used fully by adjusting the ratio of fresh air, return air and discharge air. Humidifying the mixed air to the supply state point, and to control the ratio of fresh air, return air and discharge air via the enthalpy value of supply air. Control the supply air volume of VAVBOX via indoor temperature sensor, and control the rotate speed of supply fan and return fan via the pressure sensor set in main and branch pipes.

4. COOLING TOWER INNER ZONE COOLING SYSTEM

When utilize cooling tower to supply cooling, add some pipelines and equipment on routine air conditioning water system, close refrigeration units and supply cooling to air conditioning system directly or indirectly using circled cooling water and meet the demand of cold load, while outdoor wet ball temperature is low under a certain value [8]. As we all know, the energy consumption of the refrigeration units takes an extremely high proportion in the air conditioner system. If replace refrigeration units with the cooling tower under the proper weather condition, it will save considerable operation expenses [9]. It is one of the common and effective ways to cooling tower to eliminate inner zone surplus heat. The aim of this system is to shorten the running time of the refrigeration units to the maximum extent, make cooling tower replace the refrigeration units under proper climate environment and building load conditions, becoming the cold source that does not cost money.

Because the region of China is wide and the meteorological parameter in different areas differs significantly, the difference of available refrigeration time and operation efficiency in different areas should be considered when design the water system of cooling tower refrigeration system. In a word, in northern district, outdoor temperature is lower in transitional season and winter, which is good for heat exchange between cooling tower and outdoor air, offering low temperature cold water for inner zone to use. On the other hand, in design of cooling tower refrigeration air conditioning system, choose the end units rationally and make the sum of first investment and operating expenses reaching for the lowest, getting the highest ratio of cost and performance.

5. CONCLUSION AND PROSPECT

With the fast development of China's economy, the energy pressure of China increases year by year. Substitute carbon energy with renewable energy and realize comprehensive utilization of energy is the long-term strategy of energy and development trend of world revolutionary of energy [10]. Using natural cold sources in inner zone air conditioning system just accord with this trend, with the features of clean,

environmental protection and energy saving. On the other hand, with the improvement of the urban living, increasingly higher requisition for indoor air quality and thermal comfort becomes, the rationality of setting inner zone air conditioning system is paid attention to progressively.

There are two mainly ways to eliminate the surplus heat in inner zone air conditioning system: one way is to set up air conditioning wind system, that is to change the fresh air volume based on the change of room load and supply into room after filtering, humidifying and heating (ensure a certain supply temperature difference), utilizing outdoor air fully; Another way is to set up the zoned air conditioning water system. The inner zone water system is supplied cooling all year round, utilizing the heat exchange between cooling tower and outdoor air in transitional season and in winter to offer chilled water.

With the constant development of science and technology, some traditional technologies are reconfigured, improved and innovating, becoming new concept and technology. The technological progresses are being applied to the inner zone air conditioning system progressively. The overheated problems of inner zone in domestic public buildings are outstanding at present in transitional season and in winter. There are kinds of air conditioning ways to solve these problems. According to the request of building function, choose the appropriate air conditioning ways, use the new technology rationally, and utilize natural sources effectively, to create healthy and comfortable indoor environment for people. Studies showed that suitable thermal environment can boost productivity up to 18%, so air conditioning trade is not only the consume trade, it is also the trade of creating wealth indirectly.

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