Problem of Vain Energy Consumption in a VAV Air Conditioning System Shared By an Inner Zone and Exterior Zone

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Abstract: In northern China, there are a large number of space buildings divided in inner zone and exterior zone based on usage requirements. The exterior zone needs to be heated in winter and cooled in summer, while the inner zone needs to be cooled both in winter and summer. Taking a practical project as example, this paper analyzes the energy consumption of a VAV air conditioning system that is shared by inner zone and exterior zone. The paper also points out the serious problem of useless energy consumption for this kind of system.

Key words: inner and exterior zone, shared by, VAV air conditioning system

1. QUESTION PROPOSING

There are many new office buildings obviously can be districted in inner and exterior zone in Beijing. The approximately basically horizontal pattern of the standard floor is the core in the center, in the core there are elevator rooms, stair hall, power distribution room, toilet, air conditioning room and various pipeline shafts, and out of the core is the office districts with long depth of the building.

From the using function, an office area can not be used as one space, which normally is divided into several small rooms within the inner and exterior zone. For the air-condition system, inner zone is to be cooled all the year around and exterior zone is to be heated in winter and cooled in summer. This kind of building, generally is adopted primary air fan coil system or variable air volume air condition system, the latter one applied increasing in recent years. Primary air fan coil system mostly is made zoning two-pipe water systems in inner and exterior zone which inner zone is to be cooled all the year around and exterior zone is to be heated in winter and cooled in summer. When the variable air volume air conditioning system is to be adopted, theoretically it should be made system in different directions and inner and exterior zone. It ensues at any time supplying air volume effectively to satisfy with same VAV system for rooms. In practical project, it's very difficult to adopt putting four sets air condition towards exterior zone and one set air condition towards inner zone. Because machine room is too big with five sets air condition each floor.

Currently there are a number of projects with one set of VAV system in each floor established in Beijing, such as Industrial and Commercial Bank of China, Zhongguan Village financial center, Beijing B7 buildings and so on. To establish one set of VAV system in each floor has many advantages, such as saving air condition room space and easily air duct installation. But there are still a serious problem that huge energy counteraction quantity of inner and exterior zone

2. TYPICAL PROJECT ANALYSIS

Total construction area of a project is 220,000 m^2, four floors underground and 24 floors double-towers on the ground, including the 5-23th overground floor as a standard floor with 3.9m heigh. Single tower air conditioned area 1928 m^2 per standard floor, in which the inner zone is 1062 m^2, and the exterior 866 m^2. The total area of standard floor of inner zone is 40356 m^2, which of exterior zone is 32908 m^2.

One tower standard floor plane to shown like Fig 1. In this project one set of VAV system established each floor, serves both inner and exterior zone, and exterior zone establishes the radiator for heating. Now just analysis the winter conditions, that exterior zone be heated, while that of inner one be cooled.

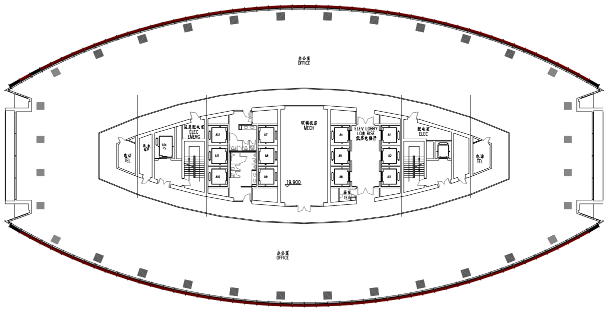

Fig 1 One tower standard floor plane

In the design conditions, the minimum supply air volume in winter. The air supply volume and fresh air volume of the system is constant values. After the computation, the air supply volume L＝29190 m^3/h and fresh air proportion m=39%. The indoor design conditions in winter is t_N=22□, Φ=40%; namely the enthalpy value of indoor air i_N=39.10 kJ/kg. The exterior zone is to be heated, while inner zone is to be cooled both in winter. One VAV air conditioning unit is shared by inner and exterior zone. The inner zone uses single duct variable air volume terminal, and the exterior one uses fan powered variable air volume terminal. In order to satisfy exterior zone heating needs in winter, used the radiator as auxiliary heating system.

For the winter conditions, according to the cooling and moisture load calculates out the supply air parameter and air volume of inner zone. Because the cooling and moisture load of inner zone causes only by indoor heating gain (including heat from occupant, from lighting and from appliance and equipment), which has nothing to do with outdoor condition. Therefore, the load of inner zone cooling and moisture in winter and which in summer are the same. Thus, the supply air parameter and volume of inner zone in winter and which in summer are the same. After computation, for this project the enthalpy value of inner (exterior) zone supply air i_S =29.94 kJ/kg.

Enthalpy value of mixing air i_C

$i_C = m \times i_W + (1 - m) \times i_N$

i_C: enthalpy value of mixing air, kJ/kg

m: fresh air proportion in winter, in this project m=0.39

i_W: enthalpy value of outdoor air, kJ/kg; based on outdoor hourly annual value offered by China Meteorological Administration

i_N: enthalpy value of indoor air, kJ/kg; in this project i_N =39.10 kJ/kg

In order to in achieve the area supply air temperature air conditioning unit must process enthalpy difference

$\Delta i_{C\text{-}S} = i_C - i_S$

$\Delta i_{C\text{-}S}$: in order to in achieve the area supply air temperature air conditioning unit must process enthalpy difference

i_C: enthalpy value of mixing air, kJ/kg

i_S: enthalpy value of inner (exterior) zone supply air; in this project i_s =29.94 kJ/kg

When $\Delta i_{C\text{-}S} = 0$, mixing air can be supplied without heated or cooled, while exterior zone be heated by the radiator. When $\Delta i_{C\text{-}S}<0$, mixing air need be heated to inner zone supply air temperature t_s by air conditioning unit, while exterior zone be heated by the radiator. When $\Delta i_{C\text{-}S}>0$, mixing air needs to be cooled to inner zone supply air temperature t_s by air conditioning unit, while exterior zone needs to be heated by the radiator, in this condition, exists energy counteraction of inner and exterior zone.

When enthalpy value of outdoor air is lower than which of indoor air i_N(39.10 kJ/kg), is the winter conditions. At this time, inner zone must process the cold load, and exterior one must process the hot load. When outdoor condition enthalpy value i_W is higher than the room condition enthalpy value i_N (39.10 kJ/kg), is the summer operating mode, this time, both zone must process the cold load in, does not have, exterior zone cold, the thermal counterbalance question.

In summary, when enthalpy value of outdoor air i_W is less than which of indoor i_N, and enthalpy value of mixing air i_C is higher than which of inner(exterior) zone supply air temperature corresponding mixing air's enthalpy value, the system exists, under this conditions, energy counteraction of inner and exterior zone. In this project, the corresponding condition is enthalpy value of outdoor air 0.3 kJ/kg $<i_W<$39.10 kJ/kg.

energy counteraction quantity of inner and exterior zone Q

$Q = \Delta i_{C\text{-}S} \times L \times \rho \div 3600$

Annual energy counteraction quantity of inner and exterior zone in winter

$W = \Sigma Q \times h$

Q: energy counteraction quantity of inner and exterior zone in winter, kW

L: supply air quantity of exterior zone, m^3/h; in this project $L = 13130m^3/h$

ρ: the air density, takes the standard condition one ρ=1.2kg/m3

W: Annual energy counteraction quantity of inner and exterior zone in winter, kW

Because this project is an office building, VAV system runs only from 8 o'clock to 18 daily. Therefore calculates energy consumption in these times only.

The statistical computation results, energy counteraction quantity of inner and exterior zone per tower each floor in winter is 135332 kWh, converts into area 78 kWh each square meter.

3. CONCLUSION

We can get the conclusion from the analysis, exterior zone with air conditioning area 32908 m^2 loses 62t standard coal in one heating season (to count according to each 1t standard coal calorific capacity 7000kcal), and simultaneously loses the refrigeration electricity to consume 1250,000 kilowatt-hour (to count according to the COP value is 4), converts into 1,980,000 Yuan approximately. Which equals consumes the 1.9 kg standard coal, 38.8 kilowatt-hours electricity, each square meter.

China is a nation with great energy consumption. Now saving energy is emphasized in the whole world. Excavates the potential from improve protection structure and system optimization. But this kind of air-conditioning system wastes high quality energy. Some people may say China's heating policy is charging according to floor space. The consumer does not have the economic loss and natural cooling source can be used in winter. Has never realized, the waste thermal energy company also is Earth's resources, and the natural heat sink cannot solve the winter- supplying -heat problem completely. So we appeal here, VAV system should be separately established systems in inner and exterior zones in order to avoiding unnecessary waste.

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