

Trend of the application research into air conditioning technology in large space building

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Abstract: by looking up a lot of correlative scientific literatures about the in large space building, get across the history, present situation and developmental direction of application research of this technique at home and abroad. And analyze the large space buildings' characters and thermal features, introduces the ways to evaluate the effect on air conditioning in large space building, put great emphasis to introduce principle and method of the model experiment. Aim at the efficient use of air conditioning energy of big space building, and bring forth some practical technological measures to save energy. Finally forecast the applied foreground of the air conditioning technology in large space building.

Keywords: large space building; air conditioning; save energy

1. Introduction

Along with the society advance and the raising of people living standard, what has appeared is that multitudinous merits completely and the first-class quality of large space public building for civil use, in order to supply people's leisure, amusement or carries on the style. In addition, accompanying the development of industry, some large-scale industry factory buildings that have specially merits also constantly emerges in large numbers. The control standard of indoor environment of this kind of large space building is higher, the energy consumption is huge, and it is dried up increasingly along with the sources of energy on the earth, synthesizing thinking over the effect of air conditioning system and the problem of economical save energy in the control of indoor environment of large space building also particularly is important. This text combined with the correlated documents of science and technology and some practice to applied engineering in which summarizes the air conditioning technology in large space building and at the same time, predicts the coming development of air conditioning technology in large space building.

2. The development general situation of large space building

The Ten Thousand Fanes of Rome whose height and diameter is all for 43.5m in the ancient Rome is the earliest large space building which the mankind society builds. The Tahoe Palace whose height is 26.92 m in

our country, which was built with wood structure in Ming Dynasty, is also one of the ancient large space buildings. The large space buildings in our country represented by the modern cinema began in the middle period of the 20s of the 20th century and at the initial stage of the 30s. Before the 80's of the 20th century, the building whose space height was more than 5m and volume was more than 10 thousand M³ was called the large space building. Chiefly indicates at the aspect of the for civil use public building: gymnasium, conference hall, theatre and concert hall etc, in addition, there are also a large number of large space factory buildings or workshops in the industry factory buildings.

After the 80s of the 20th century, because of the advance on the modern building technology, increasing of society productivity and raising of people living standard which make the mankind has much more leisure time and has higher requirement to spirit civilization living, the extent and sum of the public building has increased to some extent. Since that moment, people also have the further knowledge to the building in tall and large space when the building height has been enlarged to about 10m. In 1993, the dome shop was built up in Fudging in Japan and in 1994, "Huge Shop at Sea" was built up in Rock Qi where the various activities of seashore can be imitated in the indoor. The modern large space building has all kinds of patterns at the building form, diversity at the model and be required more agility at the merits. For example, there is a kind of building with membrane structure in the public building, built as the permanent

building and often as showing field shops, or else, sometimes which is removed just after the exhibition. In addition, the large space building sometimes is required "one kind of space and two kinds of effect, namely the open large space building. The "Sky Dome" in Canada is the super large-scale building which first has been realized the tentative plan, which is called "the third generation gymnasium" by people.

3. The Emergence and development of air conditioning technology in large space building

The mankind has not suffered from the cool in winter and the torridity in summer since the first air conditioning set sprang off in 1851. But the emergence of air conditioning has also brought a series of problems, for instance: greenhouse effect, atmosphere ozonosphere destruction and air conditioning disease etc. In the 70's of the 20th century, along with the emergence of crisis of sources of energy, the mankind began to be aware of the importance of save energy. And now in the advanced countries, the sources of energy of 20~30% are all used in the air conditioning system, thus the appeal for save energy is also more and more aloud. Henceforth, the save energy, especially the save energy consumption has become a new subject that the mankind must solve.

The emergence of large space building makes application of become a kind of objective requirement. Briefly, the practical air conditioning technology of large space building includes with spout, stratified air conditioning, sending the wind at bottom and displaced ventilating etc, among them, thinking over save energy, the stratified air conditioning is applied more

extensively.

Early in the 60s of the 20th century, the United States began to use the stratified air conditioning, in which it was firstly used in the equal ion laboratory of a casting factory in Philadelphia. Japan began to apply the stratified air conditioning from the 70s of the 20th century and carried on many experiment researches of air current distribution in large space building. In 1974, Xiao Lin Man and other else contrasted the model experiment to the practical survey of the stratified air conditioning in the large-scale precise machining assembly workshop in Shans. And the cold load was economical by 38%. For the first time our country mainly the stratified air conditioning technology in some theatres and gymnasium match field, and recently for more than 20 years application of the stratified air conditioning technology has been gradually enlarged to some large iron tools workshop or hydroelectric power stations etc. Briefly, the forms of air current organization suitable to the stratified air conditioning in large space building mainly includes four kinds as follows (seeing pictures 1)[1], among them: (1) the stratified air conditioning of spurting wind from two sides and sending wind at bottom with air curtain; (2) the stratified air conditioning of spurting wind from two sides and getting rid of wind at top and bottom; (3) the stratified air conditioning of spurting wind from two sides, getting rid of wind at top and bottom and spurting return air at middle; (4) the stratified air conditioning of spurting wind from two sides, getting rid of wind at top and bottom and spurting fresh wind at middle.

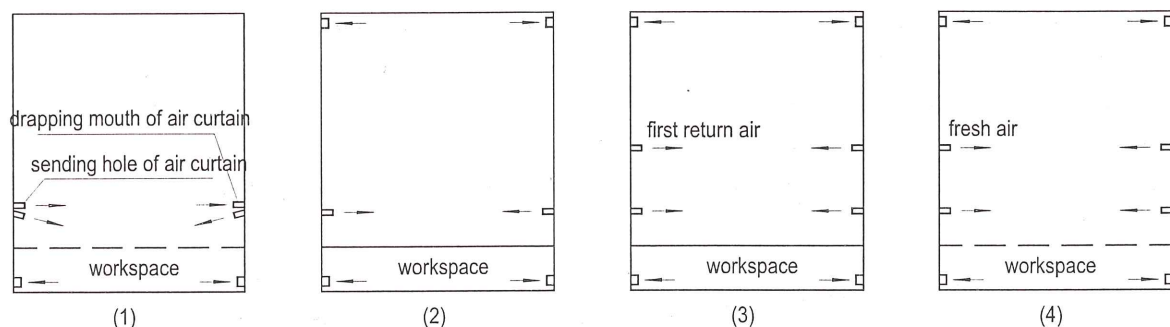


Fig. 1 The four forms of air current organization of the stratified air conditioning in large space building

The basic principle of air conditioning technology application large space building is: (1) When supplied, the cold air is only delivered to the workspace, and in addition to use outdoor air or return air in order to form

the non- air-condition space of top or to be used fire fighting to get rid of smoke. (2) When supplying heat, temperature gradient of sending wind should be small, and just should be delivered to the workspace. When

having the condition, it should be combined with the heat radiation. Adopting these measures, the air conditioning load can reduce by 30%~40%.

Jing ShangyuShi, a Japanese professor, according to public building of different quality and person

condition, thought over as a whole the forms of sending air conditioning wind in large space building as the below table. And the concrete measure should be dealt with respectively according to various kind of building (see Table 1).

Table 1 The selection of sending wind method in the large space

Classification	Example	Ceiling spout	Ceiling air device	Horizontal spout	Horizontal air device	Sending wind upwards
Occasion of stopping in long time and high comfortable requirement	Theatre; spectator hall; religion hall; Cathedral	○	△	□	△	○
Occasion of stopping in long time and not too high comfortable requirement	Gymnasium; indoor baseball field; The large workshop	○	☆	○	△	□
Occasion of stopping in short time	Port hall; entrance hall	○	☆	○	□	☆

The notes: ○ No matter scope is large or small is; △ Only small scope is suitable; □ To be decided according to using quality of real occasions; ☆ To be unsuitable. [1]

4. The building characteristic and hot load characteristic of modern large space building

4.1 The building characteristic of modern large space building

1)As the term suggests, the large space is that the height is high that is the major cause that forms the temperature gradient;

(2)The ratio of the outer wall area of large space to its floor area is greatly, and this makes the influence of natural convection from the external interface to the space of indoor great and easily creates the lower air current around in winter.

Because the indoors physical volume is far bigger than the normal building, the volume of per person is big, and it is good to see from the hygiene angle, and can adopt small times of air changing.

Many of modern large space building have request of many functions, so need be loaded provisional equipments. Therefore, not only lead to request of various environments to air conditioning, but also these equipments affect the establishing of air conditioning system. In addition, the control of air conditioning system request to have more flexibility, which make to consider the allotment of load of air conditioning system and installing cool and hot source.

4.2 The hot load characteristic

The hot load of large space building chiefly includes several aspects as follows: (1)The heat transfer load between the indoor and outer air because of difference

in temperature; (2)The heat load because of Solar radiation;(3)The heat load because of air from door and window seam etc; (4)The heat load because of the opening door.

Owing to the fact that the height of large space building is high, if air conditioning in entire room is thought over the energy consumption and early investment are will large, and from the save energy angle, the stratified air conditioning applied should be fallen into upper non-air-condition area and lower air-condition area. Therefore the heat counted according to upper and lower two areas, namely the hot load of ventilation in the non-air-condition area, the air-conditioning load should be calculated in the air-condition area. In view of that, the stratified air conditioning should be thought over the exchanging heat of convection between upper lower areas and shifting the cold load because of exchanging heat of radiation besides general air conditioning in entire room. After using the stratified air conditioning, the calculated temperature of two areas indoor is not identical, and must be defined. The indoor calculation temperature in air conditioning area can be decided according to the requirements of production technique or personal standard of the comfortable degree, and have not the strict requirement to the temperature of non- air-condition area. But for calculating the hot load of the non-air-condition area must be firstly decided the indoor calculation temperature of that.

5 .The evaluation of effect on air conditioning

in big space building

The evaluation of effect on air conditioning in large space building has model experiment and sum imitations two methods. It can verify the request of the design preparing thinking, and apply the observational experiment on the current of air to be the direct identifying means at the same time. The other adopts sum imitations for current of air[3]. Because of computer's big capacity and fast speed besides development of calculation fluid mechanism, make use of the basic equation K-ε of disordered current and ways of difference to analyze num of three system, and to complicated distribution of current air in large space building can get distribution of wind velocity and distribution of velocity which has directions and amount [3]. Below primarily introduce the model to experiment the method. Chiefly introduces the model experiment method below.

5.1 The similarity norm of model experiment

Firstly the suitable similarity norm will be decided before the design of the model is carried on.

In applied engineering, because in summer the wind temperature of air conditioning is lower than the air temperature inside factory building, the efflux of sending wind serves as the non- equal temperature efflux. The gravity that the efflux is received is more than the buoyancy; the difference between the gravity and the buoyancy is called as effectively gravity. The winding level of the efflux depends on the effective gravity, so we should use the model law of Froudz. Because the quantity of gravity and buoyancy that the efflux is received can be compared; while the effective gravity affects flow, therefore, we should multiply by $\Delta\rho / \rho$. Among them, $\Delta\rho$ is the difference of density between the sending wind and the surrounding air and ρ is density of the sending wind. Introducing by the state equation:

$$\frac{\Delta\rho}{\rho} = \frac{\Delta T_0}{T_0} \quad (1)$$

where ΔT_0 is the temperature difference between the sending wind and the surrounding air and T_0 is the absolute temperature of the sending wind. The deformation of the norm number of Froude -- Ar:

$$Ar = \frac{g l \Delta T}{v_0^2 T_n} \quad (2)$$

In the tall and large factory building, the air

temperature distributes fairly complicatedly and really not even, in addition, the temperature field itself inside the factory building is one of research object of model experiment, which is to be decided. Therefore, temperature of ventilating wind or return air will be decided to be representative for the temperature of air around, more properly from the ventilating thermal $q = c_p v_0 F_0 \rho \Delta T$ --which is to:

$$\Delta T_0 = \frac{q}{C_p \rho v_0 F_0} \quad (3)$$

To the round wind gap, total area of sending wind is $F = \frac{1}{4} \pi d_0^2$. By simplifying, putting in order and removing the constant $\frac{1}{4} \pi$, it is collated[3]

$$Arq = \frac{gq}{c_p \rho v_0^3 T_0 d_0 n} \quad (4)$$

where q is ventilating thermal; C_p is Specific heat of sending atmosphere flows; ρ is Density of sending atmosphere flows; v_0 is Sending air velocity, m/s; d_0 is Vent diameter; n is The number of wind gap.

This norm number is called as "Thermal Ahjemed Number", which is a more practical similarity norm of model experiment. The flow similarity of model and original is realized as long as the law of Ahjemed is followed. [3]

6. The effective utilization of sources of air conditioning energy in the large space building

6.1 The new idea about the problem of saving energy

In 1980s, the problems of saving energy about large space buildings mainly were focused on saving energy and comfortable nature. Since 1990s, besides the above thoughts, the influence has been being thought over more than before which the building in air conditioning to the earth environment, which is involved in the problem that quantity of hothouse gas is given off represented by the carbon. Showing concern for the influence of building to environmental, we do best to reduce pollution of building to environment in building design and facility design.

The traditional means of the effective utilization sources of energy still are suitable to the large space buildings. The measures of saving energy include reducing the design load at the aspect of the air conditioning (design of building cooperating), using

the air conditioning at resided area, reasonably deciding the amount of sending wind and the amount of new wind, reducing the transport energy consumption of air and water, utilizing new wind to supply cold, organizing reasonable sources of energy, choosing high efficient refrigeration equipment and air end equipment, applying cool stored technology and utilizing technology the low order heat source etc, which are all important measures.[1]

6.2 Other methods of saving energy

6.2.1 Buildings used with overturn soil covered into it

The large space building will be built into sunken form namely undergroundization, whose vicinity overturns with soil layer, that is very advantageous in insulate against sound, heat preservation and aspect of raising the building stability. For example, BeiXi gymnasium in Paris is used with overturning the soil skill to have covered almost the standing face. And the central gymnasium in Japanese Osaka almost is covered completely into the underground because of the landscape to protect the original park.

6.2.2 The utilization of natural ventilation and natural energy resources

To the large space building without interference of ambient noise, it is most reasonable to utmost utilize the natural ventilation to improve the indoor environment and save energy consumption of building. Meanwhile, still can use straight sunlight to plant the lawn cultivated and pot culture inside the scene, and make indoor environment green.

When using the natural ventilation, we can decide the open window area according to wind pressure and effect pressure that the hot pressing creates, and forecast indoor air current and temperature distribution with computer imitation technology.

The application of natural ventilation technology mainly can save cost for air conditioning operating and energy consumption, though it has difficulty in controlling temperature and humidity, expenses can be cut down and has the better air character.

In addition, owing to the fact that the area of the large space building covers a great area, we can be better to take advantage of deeply well water and soil heat whose great uncovered area tad good advantage of solar energy, too.

space building

Along with the society advance and the raising increasingly of mankind's science and technology, computer's big capacity and fast speed besides development of calculation fluid mechanic, make use of the basic equation $K-\epsilon$ of disordered current and ways of difference to analyze num of three system, and to complicated distribution of current air in large space building can get distribution of wind velocity and distribution of velocity which has directions and amount. In addition, by comprehensively analyzing indoors air and heat flow, still can imitate temperature in large space building and distribution of PMV in space. At the same time, on the basic of physics model experiment, CFD[4] emulaton technology which take advantage of emulaton software of flow field to imitate temperature field and velocity field make the technology that the computer simulation and the model experiment are combined will be applied extensively on the research of air conditioning technology about the large space building, meanwhile, the air conditioning in the large space building will have a very vast foreground because the research about the air conditioning in the large space building is riper along time.

The air conditioning in the large space building in future will be based on the foundation of new idea about save energy; the air conditioning system that will be effective, comfortable, consume less energy and fully uses the various sources of energy will realize automation control. At the same time, the stratified air conditioning will be very important in the air conditioning in the large space building.

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