The development of automated energy-saving HVAC systems

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Abstract: The building energy consumption is one of the major concern by all countries in the world. In the intelligent building systems, the consumption of the HVAC systems is more than 35 percent of the total building consumption. So it is important to study the strategies of energy-saving for air-conditioning systems. This paper investigates the efficiency of some energy-saving HVAC systems, such as ice-storage air-conditioning system and under floor air-conditioning system. It presents the strategies to achieve energy-saving by using materials of energy-saving for enclosure structure and control systems. Some problems on the conservation of design and the difficulties in practical operation of energy-saving air-conditioning systems are discussed.

Keywords: Building energy consumption; energy-saving; equipment management; system integration

1. Introduction

Central air-conditioning system has got extensive use along with society's development and the exaltation of living level. The energy consume of air-conditioning system is so high that nearly reaches 40% of the whole building energy consume. So the first thing we need to do is that to develop an energy conservative system and intelligent equipment management to make sure the long-term low cost, energy saving and regular operation of the whole system. There are many subsystems inside a building. Especially in recent years, the construction scale is enlarged day by day, building system become more and more complicated, traditional ways of maintenance can not work at all, so intelligent equipment management is the very way to solve this problem.

Building energy conservation is one of the heated questions got widely attention, now we face the challenge that the overall average energy consume level and energy efficiency are low, the average energy utilization ratio is only 30% in our country. So if we want to save the energy, to know how to enhance energy utilization level is the first thing we need to do. In China, building energy consume ratio is 11.7% of national energy consume, and the energy consume of the air-conditioning systems is 35% of building energy consume, so to research in the energy conservation of air-condition systems has significant meaning both for economic and social benefit. Integrating information of technology with control systems, gives an all-direction solution to the building energy conservation.

Hardly any large-size building can build without cooling tower, ventilation air-conditioning, backup generator, water pump house and other equipments. Operation staff cannot afford the management of so many equipments neither for time nor for physical labor. It would be easier for monitoring if based on a network of building automation system. Integrated management brings great convenience to operation and maintains. It can improve the energy efficiency, such as simplizing HVAC equipment maintaining, self-balance and self-restart etc. The new mode of management with network integration greatly improves the performance of the whole system. The reality of building integration solves the problem of equipment operation and maintenance. The key point to a multi-building network is the so called integrated digital network.

For the old management mode, either the reliability or speed, or even the quality of the equipment management, cannot meet the demand of modern equipment management. An increasing demand of equipment management and information integration becomes so urgent. Modern equipment management now is heading for centralized monitoring, intelligence and combining with network. The integration of computer, control and communication technology provides the technical support of intelligent management for subsystems distributed inside buildings. Of course, the advanced management technology itself makes the equipment management easier and more efficient. To develop automatic building equipment management system has great meaning both for economy and for technology.

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Equipment management becomes more and more important in modern intelligent buildings.

2. High-efficiency energy conservation HVAC system

2.1 Heat, electricity, cold cogeneration system

For statistic figure in 1997, in China the efficiency of thermoelectric power plant is 83.68 %; the total energy transfer efficiency is 38.07 %. But after using the heat, electricity and cold cogeneration system and gas burning heat pump, for the waste heat is used, the total energy utilization ratio reaches 80 % to 85 %, also called total energy system. The efficiency of total energy system without gas energy heat pump can reach 65 % to 80 % if it can supply heat, electricity, and cold.

2.2 Ice storage air-conditioning system

An ice storage air-conditioning system make use of the electricity price difference between hill and dale load of electric power system, which remove the hill load to fill the dale load. If large amount of ice is made and saved during night at low electricity price, then the air-condition system could be assisted by the stored ice, so in the day time when the electricity price is high, we can shut down the plant unit or use a part of the plant only. From the viewpoint of basic science theory or the aspect of a single user, the ice storage air-condition system itself does not earn energy saving, but from the aspect of whole society the ice storage technology has great economic value and meaning on environment protection. The electricity capital investment for taking away 1 kW of electricity from the hill load with ice storage Air-condition is 1200 RMB, while set up of a 300 000 kW heat power plant will have an above 2 billion capital cost, or costs 6.67 RMB per watt, it is 5 times the cost of ice storage air-condition. This technology has great meaning to environmental protection and society, while it releases less CO_2 and other greenhouse gas than set up more heat power plants.

2.3 Vast space stratified air-conditioning system for high-rise space

Suppose for a space has a height more than ten meters, in the traditional air-conditioning system we have to handle the none-working zone at the top of the space, it is not only unnecessary but also an energy wasting job. For a stratified air-conditioning system, we just need to handle the cool load of the air-conditioning zone and the interference of none air-conditioning zone, no need for whole vast space cold load. Comparing with the traditional air-conditioning system, it is more efficient.

For example, the equipment room of Three Gorges Dam hydroplant has a length of 39.0 m width of 38.3 m, and height of 38.7 m, designed with a stratified air-conditioning system. Because this design only got air treatment of staff zone, for the none air-conditioning zone at the top, a side air supply with axial-flow fan is adopted, to take away part of indoor cool load at none Air-conditioning zone, weaken the heat transfer to air-conditioning zone by radiation, and to ensure the uniformity of temperature and velocity distribution. So energy can be saved.

2.4 Heating by floor radiation

In the traditional ways of indoor heating, in general, radiators are adopted, they are installed under the windows of external walls, and this configuration has two major defects. First, the wall next to the back of the radiator could be overheated and some vain energy will be lost by conduction through the external wall; second, warm air ascending leads to the vertical temperature difference, this causes a stagnant stratum of warm air up in the room. It is obvious; this portion of energy is wastefully lost. These two kinds of energy loss can be avoided by using floor radiation heating. In order to avoid the energy loss from overheating, we can lower the temperature by 2 degrees when the floor radiation heating is used. Because the decrease of the Indoor temperature, the energy can be saved by 11.4 %.

2.5 Vapor crystal system(VCS)

The highlight feature of VCS is to use the density difference of refrigerant as its motivation force, so there is no need to install any compressor as a motivation power, then correspondingly no electricity input and no efficiency transform, so, it is possible to achieve a high efficient energy conservative performance. As Table 1 shows, VCS has obvious advantages of energy conservation over normal air-conditioning system.

Table 1. Comparison of energy saving running between vapor crystal system and traditional systems

	Installed capacity Cold and source/%	Electricity forconsume hotcapacity/%	Running cost/%
Centralized air-condition system			
Distributive air-condition system			
Vapor crystal system			

Note: Data are calculated for an office building of 10 000 m^2

2.6 Building enclosure

"Structure energy-saving ninth five-year development plan and 2010 plan" set the target making building energy saving by 50 %. But it would be very difficult to achieve the aim by only improving HVAC equipments and adopting favorable air-conditioning systems. One of the necessary solutions is to utilize advanced building enclosure and supers or materials to reduce the cool load.

2.7 Energy efficient wall

We can reduce the cool load of the building enclosure by using non conductive and high conservative materials. They have a small co-efficiency of heat transfer and a large co-efficiency of heat storage. Usually we use energy-saying wall instead of normal wall.

2.8 High performance window material

The heat gain of external windows acts as the main part of cool load from solar radiation. By using high performance material, not only can reduce indoor cool load but also can provide a larger space to designer and equipment engineer of cooperation. Besides, external shading of sunlight can effectively ensure energy saving. For example, in southern China, fixed external shadings to reduce the sunlight radiation from outside; in Changjiang drainage area, movable external shadings may appropriate, they can resist radiation in summer and make use of sunlight in winter ;on the contrary, in northern China, in order to make full use of sunlight radiation, external shading should not be used.

2 9 Energy saving roof

Until now, the most of roof designs are flat roofs. But from the aspect of energy saving, it is not reasonable. Incline can make use of attic to remove heat by ventilation; Reversed roofing is good for waterproof and enhances the durability. Any how, energy saving roof is the ongoing trend of building structure and materials. In preferential design, micro-ventilation structure, low density, low absorption, low conductive materials are adopted.

3. Energy conservation control of HVAC system

By using automatic control technique, high performance and energy efficiency can be ensured in air-conditioning systems. With the advancement of electronics technique, computer and network, the automatic control technique is making great progress in both software and hardware. Such as the adoption of intelligence control technique, in which monitor the fresh air and return air are monitored in real time, so as to fulfill both the new standard of ventilation by ASHRAE(ASHRAE Standard 62-1989)and the aim of energy saving.

Along with the perfection of energy conservation technique, the intelligent technique is adopted, instead of less comfortable standard or low air quality demand. So the key point of energy conservation are searching for advanced automatic air-conditioning control methods and developing advanced energy monitoring systems.

4. Automation of HVAC equipment management system

4.1 Mode of modern equipment management

4.1.1 Intelligent equipment management

Building automatic system uses network to coordinate the running data among on-site input and output from control station, operator station and engineer station with the technology of integrated communication network, it can quickly and conveniently transfer data or control commands, provide platform between data network and control network through gateway. Because we do not need to depend on the central controller only any more, it reduces the possibility of system paralysis(shunt down) in data collection and control, it also decentralizes the risk; highly upgrade the reliability of the whole system.

This type of network integrates data collection,

analysis, control and network communication, especially suitable for equipment management and controlling of the intelligent buildings. A well defined protocol is adopted, point to point communication greatly simplifies the system design. Because of the communication protocol is standardized, different products, even different systems can be inter connected together.

4.1.2 The development tendency of modern equipment management systems

The research in equipment management has got much attention outside China. Early in the 80`s, there were some innovator technologies used in real projects. Nowadays, in most of commercial buildings have a floor area more than 5000 square meters in America, automatic equipment management systems are adopted. These systems already bring great convenience to equipment engineer in daily maintenance of air-conditioning; fire extinguishing, safeguard and illumination etc. While in China still has a comparatively backward ways of equipment management, many types of equipment run themselves without watching or monitoring. Ductwork is mainly maintained manually. So, it is urgent to research both in the theories and plans of equipment management and to develop practical systems fit for the situation of our country.

Information technology itself will be continuously developed with the whole high-tech; many applications of intelligent equipment management in the future will be based on network technologies. So the integration of management system and information network becomes the new task of building management of the next generation. The key point to distributive equipment management system is network integration between buildings.

5. Conclusions

They are equal important for facility management and facility running, to ensure the normal use of a building, modern facility management also calls for modern technique. The development and application of facility management system will doubtless motivate the development of intelligent building, which has significant meaning in ensuring the normal running, quick fixing of breakdown facility and fault preventing. Besides, the energy will be saved, productivity be enhanced, and then social benefit created. It is a new question for discussion about fault tracing and fault diagnosis in HVAC systems, it refers to the knowledge of several subjects, such as the professional knowledge of air-conditioning, refrigeration, computer, auto control, management and application mathematics. Right now, the application of these techniques still has a long way to go. Generally speaking, either we consider from the economic aspect or on the whole performance of the building, we need to pay more and more attention on the research of fault tracing and diagnosis technique

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