

The Operation Management and Energy Consumption Analysis of the District Cooling System

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Abstract: Based on the investigation of the district cooling system of the Zhongguancun Square in Beijing, we thoroughly analyzed the process of its operation management and the main factors that affect energy consumption. The basis was provided for the operation management. It can be concluded that the district cooling system not only can save energy and protect the environment, but also is economically feasible. It should be developed and popularized in China because of its significant advantages.

Key words: District cooling, Operation management, Energy consumption analysis

1. INTRODUCTION

District cooling system is a method that supplies the chilled water for the units that need to be chilled in some range by a big centralized refrigerator. An independent district cooling system includes 5 basic parts: 1) The plant that supplies the chilled water 2) cool storage equipment 3) the system of chilled water transportation 4) the connection of trunk net and the user 5) the software used in the system. For its superiority in energy saving and environment protection and operation, the district cooling system has been studied and used widely, space availability of building and credibly of system can be improved. Though it is the beginning that the development of the district cooling system in china, it expands quickly. There were many district cooling systems in china. For example, the Putong international

airdrome thermoelectricity and cool system and the Zhongguancun district cooling system,

Zhongguancun west district is the core of the Zhongguancun science and technology garden, which will become the centre of the high-tech industry quotient district. The floor space of the west district is 51.44 hectare, the planning covered area over ground is 1,000,000 square meter, the planning covered area under ground is 500,000 square meter. Most of the buildings are commercial buildings. The NO.1 refrigeration station has been applied, which provided cool for the building whose covered area is 450,000 square meter. The design peak load is 12000RT, the total design cool load is 148792 RTh, the total cool storage is 28640 RTh. The operation management and the main factors of the energy consumption in the Zhongguancun district cooling system were analyzed, and the optimize operation management was induced.

2. THE ECONOMIC OPERATION OF THE WATER CHILLING UNIT

The water chilling unit which Zhongguancun district cooling system allocated is the centrifugal water-cooling bi-behaviour screw stem water chilling unit. It is lack of the experience of the operation management and the performance of the unit domestic. Fig. 1 shows the relationship between COP of refrigeration units changing and the refrigeration units load rate. It is showed that the efficiency of the unit is highest when the cool load is 80 percent. It is the validity way of energy saving for units to make cooling water be 80% of the cool load. It can improve

the system efficiency that adjusting the unit according to the building load, adjusting the number of pump and cooling tower to make the unit optimum operation.

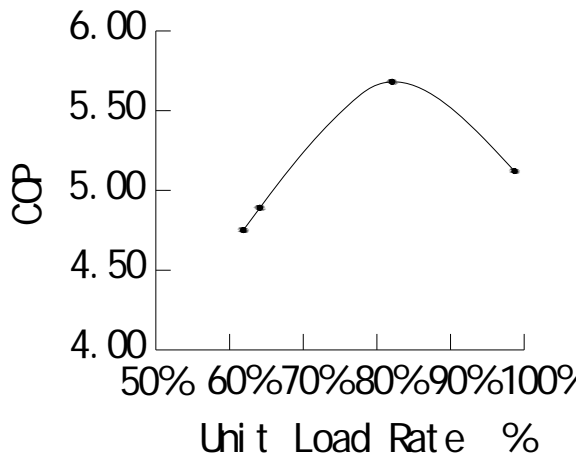


Fig.1 The unit performance with the unit load rate

3. OPERATION ECONOMY OF VARIATION WATER TEMPERATURE

During operation of the air conditioning, most part of the time the load is lower than the design load as the cool load changes with the personnel and the weather. It can improve the efficiency and induce the energy consumption if adjusting the operation parameter of the refrigerator, advance the evaporating temperature and the cool water supply temperature. The attempt that the cooling water supplied at varies temperature in the Pudong international airdrome and the effect is well.

3.1 Character of Air Conditioning Load Variation

The building load is constituted of heat load from enclosure construction, solar radiation, personnel and fresh air. The air conditioning load changes with the weather outdoor. The main building of the Zhongguancun west district is used for merchant. The characters of the merchant building is: firstly, the unit operates below the 90 percent in the 83 percent of the year, secondly, the unit operates below the 50 percent in the 60 percent of the year.

3.2 The Refrigerator Performance of the Cool Water Temperature

The operation was affected by the change of the

weather and the regulation of the parameter. The weather parameter was impersonality; the air conditioning system can be operated efficiently through regulating the operation parameter. The COP can be improved if the evaporating temperature was increased according to the thermodynamics analysis. Fig.2 shows the relationship between COP of refrigeration units and outlet temperature of chilled water

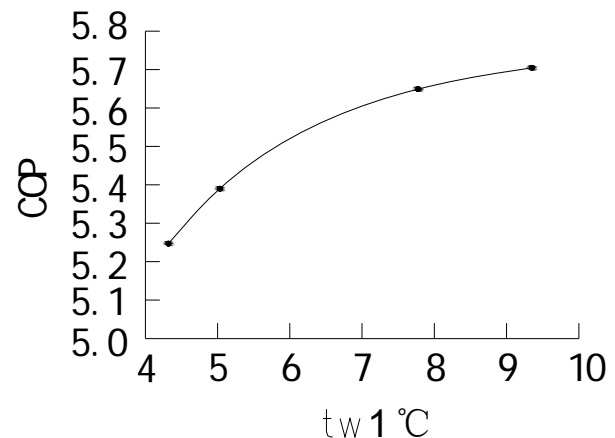


Fig. 2 The unit performance with different cool water temperature

It can be seen that the COP increases with the exit temperature increases in the diagram from Fig. 2. The evaporating pressure and temperature will increase with the cool water temperature, so the capability of the unit will be improved and the COP will be increased. When the air conditioning system cool load changed, the entrance bucket can be regulated to change the steam suction volume to adopt the change.

The analysis above indicated that the efficient of unit can be improved if the supply water is reasonable. The energy can be saved if the temperature was defined reasonably according to the change of the weather and the load.

3.3. The Performance of Jensen Cooler with the Cool Water Temperature

It is shown from the Fig.3 that the connection of cool supply with the deferent cool water temperature and flux. The temperature and flux synchronously can be regulated. For example, the 60 percent water at 8 can supply 80 percent cool, but 60 percent water at 10 can only supply 64 percent cool.

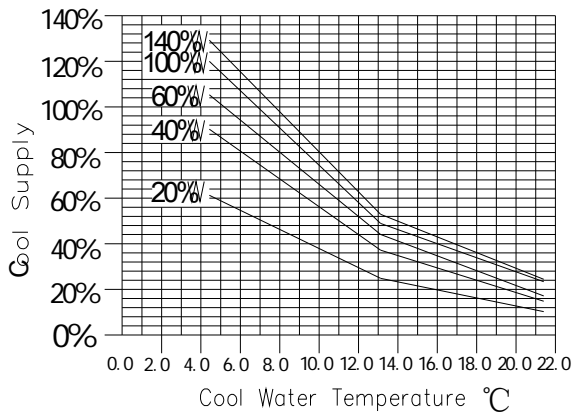


Fig.3 The performance of Janssen cooler with the cool water temperature [4]

4. THE ANALYSIS OF THE PUMP OPERATION

The operation cost of the pump is considerable in the HVAC project. It can reach 30% of the general cost in some HVAC system. So the measures adopted to reduce the operation cost of the pump will be great significant. The investigation of Zhongguancun west district indicates that the flux and the head of delivery were on the great side. So they had to turn down the valve to increase the resistance and then reduce the redundant flux and the head of delivery. There are two main reasons as follows:

(1) The scale of running was smaller than the designed. All of them were smaller than the designed, which made part of the head of delivery of pump become margin.

(2) The influence of the HVAC load. The weather condition changed seasonally. This character makes the load of air-conditioning become asymmetric. The air-conditioning system ran in the part of load most part of the time. In this condition, air-conditioning system controlled the number of the refrigerating machine and the pump, the head of delivery need to be reduced in the further. Now the valve should be turned down to cancel the redundant pressure to reach the system's demand.

For the two reasons above, we can only change the resistively curve to adjust the system. However this way is at the cost of operation consumption of the pump.

The technology of frequency control was used

widely since 1980s. It can change the power supply frequency of the stator equality to change the rotate speed of the electric engine smoothly. The technology of frequency conversion applies in the refrigeration and air conditioning can save the energy under the part load. At the same time, the technology of frequency conversion increases the frequency and the pressure, the rotate speed of the electric engine advances step by step; it can make the startup softly and reduce the attack of the electric network.

According to the similarity theory, the efficient is constant when the revolution of pump changes, but the flux, delivery lift and the power changes as below:

$$\frac{Q'}{Q} = \frac{n'}{n}, \frac{H'}{H} = \left(\frac{n'}{n}\right)^2, \frac{N'}{N} = \left(\frac{n'}{n}\right)^3 \dots (1)$$

Where Q, H, N, n — The flux, delivery lift, power and the revolution of pump before the frequency conversion,

Q', H', N', n' — The flux, delivery lift, power and the revolution of pump the frequency conversion later.

The theoretical revolution of the synchronous machine n :

$$n = \frac{60f}{p}(1-S) \text{ r/min} \dots (2)$$

Where f — Alternate current frequency (Hz),

P — Pole pair of electric engine,

S — Revolution slip of the electric engine.

The revolution of the asynchronous machine n is direct ratio to the alternate current frequency, so the alternate current frequency can be regulated to change the revolution and the flux can be regulated through the revolution. The valve of the most disadvantage pipeline can open entirely and the energy consumption caused by the valve can be reduced. The frequency conversion can change the frequency of the electric engine according to the load. The effect is significant and the regulation can be control flexibly. The centrifugal water pumps are derived by the high pressure electric engine, the price

of the converter is high. So the frequency conversion can be used base on the blade wheel cut.

5. THE APPLICATION AND STUDY OF THE ICE STORAGE COOL IN THE DISTRICT COOLING SYSTEM

For the air conditioning system with intermittent operation and greater peak and valley difference, the cool can be stored when the load is lower at night and delivered when the load is peak. Installed capacity of refrigeration plant, electric consumption and operation cost will be reduced.

Zhongguancun district cooling system adopts the ice storage cool, its initial cost is lower than that of the refrigeration station separately. And the total installation capability decreases, the refrigerate equipment area reduces too. The big, high quality, high efficient refrigerate equipment were choose, making use of the D-value of the peak to valley price to decreases the operation rate and the capacitance installation rate, improving the reliability and the efficient can make the environment protected.

6. CONCLUSION

The economic operation model was set down through the theory analysis and the investigation. That vary water temperature operation which combined with the technology of the district cooling system base on the ice storage cool should be adopted. This operation model can put down the peak load and fill up the valley load, improve the load rate of the equipment and the electric network, reduce the environment pollution, decrease the operation cost and the maintenance cost. The advantages can make the district cooling system more and more competitive.

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