

SOME ASPECTS OF APPLICATION OF WATER-LOOP HEAT PUMP SYSTEMS IN CHINA

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ABSTRACT

Water-loop heat pump systems have been developed and spread rapidly in China recently. But some failing samples hindered the further promotions. The authors believe that some aspects need to be especially concerned in the process of application under the specific conditions of China to achieve a successful project. First, a detailed technical and financial analysis should be made to determine if the water loop heat pump system is feasible to the project. Noise level is also a critical factor for a successful application in China because Chinese people are more sensitive to noise than people in other countries. Some noise control methods both for equipment manufacture, project installation and system design are advised in this paper to meet the requirements of Chinese people. Some other viewpoints on how to apply water-loop heat pump systems in China are also discussed on the basis of authors' experiences and case studies.

Keywords: *water-loop heat pump systems, application, noise control.*

1 INTRODUCTION

The Water-loop heat pump (WLHP) system is one of the most often used systems to apply heat pumps both for space heating and cooling. In WLHP systems, individual air-to-water heat pumps are connected to a common heat transfer water loop. When an individual heat pump is providing cooling, it rejects heat into the water loop. When an individual heat pump is providing heating, it draws heat from the loop. Heat sources are needed for times when the total heating load of the system exceeds the total cooling load. Similarly, heat rejection equipment, such as a cooling tower, is needed to get rid of excess heat when the total cooling load of the system exceeds the total heating load.

The WLHP system was introduced in China in the early 1990's. Initially it was used in some projects invested by overseas land agents or in some demonstration buildings. Because of remarkable advantages for some kinds of applications, it has rapidly spread in China at the beginning of 21st century. The WLHP system is added to the latest revised Chinese national code for HVAC design, namely, GB50019-2003. It notes: "If heating or/and cooling is needed all-year, the block load for each area is widely different and heating and cooling is needed simultaneously in one building for a long time, the WLHP system can be applied after technical and financial analysis."

The WLHP system is a relatively new technique to Chinese engineers. Although there are many

successful cases in China, there are also some failed projects. In this paper, the authors will discuss the status of WLHP systems in China and give some suggestions to someone who wants to practice or promote WLHP systems in China.

2 GENERAL STATUS OF APPLICATION IN CHINA

Today, there are many WLHP systems in operation in Beijing, Shanghai, Guangzhou, Shenzhen and some other big cities in China. Their service objects involve office, hotel, marketplace and residential buildings. Even some sports centers for the 2008 Olympic Games have determined to use WLHP systems, and the largest application case is more than 250,000 m² in China. It is anticipated that there is a promising market for WLHP systems in China.

2.1 Market

The leading heat pump manufacturers in the market of China almost all come from United States. Trane, Climatemaster, Mcquay, Mammoth and FHP have taken a majority of share. Most of their products are produced in United States. Some manufacturers, such as Mcquay and Mammoth, also can do the job in their factories in China by request of the owner. Besides, more and more domestic producers, such as Dongyu and Shenghuan, have begun to sell their products, which are much cheaper, in China recently. But efficiency and control technology are soft spots for their products. Moreover, there are only less than 10 domestic candidates to be chosen in China today although the quantity of the manufacturers increases sharply.

The quoted price of imported equipment is about USD1200/ton and that of domestic products is about USD800/ton. According to the specific requirements of Chinese clients, some Chinese producers released a new type of split heat pump instead of imported compact ones to reduce the noise in the rooms. The quoted price of the split heat pump is lower than the compact ones, which are about USD600/ton. Because of its characteristics of low noise and inexpensiveness, the split WLHP is gradually taking over the market share of compact ones in China.

2.2 Features of most concern

WLHP systems have many useful features such as they have a way of transferring heat from the core zones of buildings to perimeter spaces during cold weather, the efficiency and capacity of the individual heat pump units do not have to be vulnerable to the outside air temperature etc. As for project owners in China, they pay more attentions to some other characters listed below:

2.3 Kinds of energy sources optional for WLHP systems

Virtually any type of heat source can be connected to the system through the water-loop. Some “free” and renewable sources, such as solar collectors and ground water, can be added to the system easily as a heat source or heat sink. The heating cost will be greatly decreased and cooling efficiency will be distinctly improved when some renewable energy source is introduced into the system. This is what the project developers mostly regard. In China, about half of the systems in operation are combined with well water, surface water, soil of ground or some other sources. For example, in Dalian a pool, which is used to cool the circulating water for a power mill, is employed to supply heat to a WLHP system for some residential buildings. Nowadays, ground water is restricted to be used as a source of HVAC system in many cities in China for fear that the water will not be injected into ground or be contaminated. Furthermore, now that China has already had one of the largest markets for solar water heating systems, most of building owners hope the solar hot water will be an important source for WLHP systems when heating is provided.

2.3.2 Advantages for management and maintenance

Although it does not have an obvious effect, and even consumes more energy, to apply the WLHP systems in the southern parts from Yangtze River, especially in the areas of south China^[1], there are still quite a few WLHP systems to be used considering their special advantages on management. For one thing, it provides a simple method of zone control by means of individual controller for each unit. The user can choose heating or cooling at will at any time. And the operating, maintenance and repair cost can be easily allocated in multi-zone buildings. Moreover, revisions to space can generally be accommodated easily by adding or removing units.

2.3.3 Flexibility on investment and installation

In a WLHP system, the water-loop pipe net, central pump plant and energy source can be installed in an action first. The heat pump unit can be purchased and installed later to meet the requirements of the occupiers or tenants. This is also beneficial for the project owner whose budget is tight or who doesn't want to finish the installation in one session.

2.3.4 Noisier compared to conventional HVAC systems

Chinese people are more sensitive to noise than people in other countries. According to the Chinese standard, the noise level in a bedroom should be less than 35dB(A). For an office the limit is 50dB(A). Generally the water-loop heat pump unit is mounted close to the place where people are stationed. Thus, the noise released by the unit can easily affect the occupants. The noise is in the range of low frequency. Ordinarily, low frequency noise has a strong penetration power and is very difficult to attenuate. Furthermore, because the frequency of the noise is similar to the inherent frequency of the body, people feel more uncomfortable than in a situation that has the same level of the noise in the range of high frequency. In our survey, most of the unsuccessful projects in China are blamed on noise. Therefore, how to control the noise is also the problem of most concern in China.

3 SOME ASPECTS OF APPLICATION IN CHINA

Although WLHP systems have been being applied in China for more than ten years, there are still a lot of problems in the process of design, installation and management. The engineers are short of relative knowledge and experiences. To achieve a successful project, people should learn to minimize the efficiency shortcomings of WLHP systems. For example, the water loop adds another stage of heat exchange, which reduces heat pump efficiency; the loop circulation pumps require additional energy to operate; the systems emit stronger noise etc. At the same time, people also should learn to maximize the advantages mentioned above.

Here we will give some suggestions on how to obtain a satisfactory system in China on the basis of our experiences and case studies.

3.1 Feasibility study

A detailed feasibility study is very important to achieve success in a WLHP system. The final decision should be made after serious technical and financial comparison according to the local specific conditions. Commonly, WLHP systems are beneficial for the conditions as followed.

3.1.1 The primary requirement is heating, and some renewable energy can be utilized.

For WLHP systems, underground energy source is a broad known renewable candidate in feasibility study and is also the most preferred. Otherwise, solar energy should be a latent optional source because the great mass of heating area in China has very rich solar irradiation at the same time. Some other sources such as city sewage, ventilation air for subway and energy from rubbish combustion, are not available in China today. If some renewable sources can be used in a project, the owner will gain quite a few profit in fuel and coal saving.

3.1.2 Cooling and heating is needed at one time in one building for a long time.

WLHP systems have an inherent ability to recover heat from some zones and deliver it to others. In heating time, the heat can be transferred from the superheated core area to the perimeter area to save energy. Energy saving of the WLHP system is affected by both the ratio of core area to perimeter area and the cooling load of the core of the building. The mezzo inner load and the mezzo ratio of inner zone area to outer zone area are most suitable to the application of the WLHP systems. In China, some type of building, such as restaurant, entertainment center or huge malls, may have the characteristics according with the requirements.

3.1.3 Heating and Cooling is needed at random.

Office is one of the typical buildings. When some conventional central HVAC systems are used in a office building, the user who want to continue working beyond the routine time have to be faced with a unairconditioned space or very higher expense for additional usage of HVAC systems because the

operating cost per kW for the conventional HVAC system increases rapidly when it runs in partial load. You can find some similar things in hotel, restaurant or some other buildings. WLHP systems can deal it well for their flexibility in management. In China, it is generally the key factor that allures the owners to make up their minds.

3.2 Noise control

Chinese people are more sensitive to noise than people in other countries. Even in the buildings with fan coil unit, there are still a lot of people who always complain about the noise of HVAC system. Thereby, some measures must be carried out to lower the noise level when WLHP system is used in China to meet the requirements of the occupants.

There are two ways to control the noise. One is to lower the noise of the source. The other is to prevent the noise from diffusing to the occupied spaces. Some suggestions are listed below on our experiences.

3.2.1 Keep the noise of the unit as low as possible.

The master noise source of the heat pump unit is compressor. As mentioned above, most of the WLHP units used in China today come from United States. The manufacturers must pay special attention to the products exported to China to keep the noise lower than those that are sold in other countries. Moreover, soft connections for both duct and pipes and shock absorption suspenders are all needed in unit installation.

3.2.2 Some special measures are needed in the stage of design.

Firstly, the units should be placed in spaces apart from the occupants. If the units have to be mounted closed to the occupied rooms, it will be as well to limit the cooling capacity of the units to 2tons. Some measures also should be noticed to prevent the sound wave from going directly to the occupied spaces. When the units are hung above the ceiling, it will be as well to put some sound absorption materials on the ceiling under the unit.

3.2.3 If very low noise level is strictly required, it is recommended to use split unit or water to water unit plus fan coil unit.

In this way, there is only the noise come from the fans. It is much easier to deal with by some conventional ways.

3.3 Others

The water in the HVAC systems in China is very dirty. There are some complaints on pipe jam because the filters and the clearance of the exchangers in the units are thicker in the imported products. Sometimes hydraulic balances have to be adjusted manually because the automatic flow rate controllers are always expensive to Chinese users.

4 CONCLUSION

China has a very big market for construction. More and more new technologies have been introduced to China past ten years. WLHP systems can also take quite a big share in Chinese HVAC market if only corresponding measures are carried out. The overseas producers should also do some things to meet the requirements of the specific conditions of China. As long as there is a tight cooperation among manufacturer, designer and field engineers, the authors believed that a satisfied application would be easily acquired.

REFERENCES

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