

AN ANALYSIS OF THE CURRENT SITUATION OF SEWAGE-SOURCE HEAT PUMPS IN NORTHEAST CHINA

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ABSTRACT

Maintaining that sewage is a utilizable low-temperature waste heat source, this paper first presents an analysis of the features of sewage source heat pump, as well as the current situation of sewage discharge and heat pump application in Northeast China. Then it points out the feasibility and the great prospects that in Northeast China, the second-class outlet sewage or untreated sewage from urban sewage plant can be utilized as heating/refrigerating source for water source heat pump.

Key Words: urban sewage, water source heat pump, sewage treatment, heat energy.

1 INTRODUCTION

Since China's open-door policy was promoted, there has been great progress in industry, agriculture, and urbanization in the northeast region, the old industrial base of China. In recent years, the need for a large amount of water for industrial use has been rapidly increasing, causing the corresponding increase of urban sewage discharge, which, with its high temperature and stable supply, provides a vast amount of heat energy. If this waste heat is recycled by sewage source heat pump system, a tremendous amount of energy can be saved, and sewage treatment cost reduced. It is an effective way not only of saving the energy in hand, but also of exploiting and utilizing new types.

2 CHARACTERISTICS OF SEWAGE SOURCE HEAT PUMP SYSTEM

Sewage source heat pump, a type of the water source heat pump, is a heating/refrigerating system, which employs urban sewage as its basic source for energy recovery and storage to supply heat to buildings in winter and refrigeration in summer. The operation principle of the system is shown in Fig. 1.

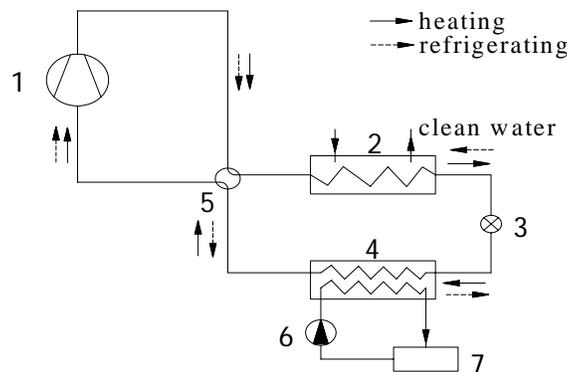


Fig. 1 Principle operation of sewage source heat pump system. 1.compressor; 2.heat-exchange; 3.throttle valve; 4.heat-exchange; 5.four-way reversing valve; 6.sewage pump; 7.sewage treatment pool.

When operated in winter, heat-exchange facility 4 works as evaporator, heat-exchange facility 2 as condenser. When urban sewage goes through the evaporator, it emits the heat reserved within. Meanwhile, refrigerants in the evaporator evaporate and absorb the heat. The vapor is then drawn in by the compressor, compressed to a high pressure and put into the condenser. The refrigerant vapor with high temperature and pressure condenses in the condenser and heats the heat-medium (water), meeting the needs of the heating system. In such a system, when refrigerants continuously undergo the process of evaporation, compression, condensing and expansion, the heat reserved in the sewage is transferred to the system in need of heat supply. Thus, heating can be done.

When operated in summer, heat-exchange facility 4 works as condenser, heat-exchange facility 2 as evaporator. The working process is just opposite of that of the heat pump in winter. After the refrigerants go through the process of expansion, condensing, compression and evaporation, they lower the indoor air temperature. Thus the heat is transferred into the sewage, and refrigeration is done.

Introduced above are the components of sewage source heat pump and its operation principle. It can be seen that sewage source heat pump which gives no ignition and noise pollution features high efficiency and reliable operation. Such a pump is not only easy to operate and maintain, but requires small installation area, small amount of construction investment and maintenance. Above all, such heat pump is superior in energy saving: it can save more than two thirds of the electricity as consumed by an electric boiler, or more than one half of the energy as used by fuel boiler. Its heating/refrigeration index mounts to 3.5~4.4, about 40% higher than that of the traditional air source heat pump, the operation costs only 50%~60% of those with common central air conditioning (Li and Chen, 2002).

Because of the above mentioned characteristics of the sewage heat pump, the study of it will bring great help to energy-saving and environmental protection in Northeast China.

3 CURRENT APPLICATION OF SEWAGE SOURCE HEAT PUMP IN NORTHEAST CHINA

3.1 Features of Sewage in Northeast China

The quality of sewage is determined by the chemical contents of the water supply source, the amount of water used daily, and the quality and quantity of the substances discharged into the sewage system (Yin, Chen, and Wang, 2003). The quality of the sewage in Northeast China is mainly affected by the industries and enterprises of the region. Elements of pollution are the hardness of the sewage, and the degree of its mineralization. Major pollutants include nitrate, nitrite, iron, and manganese. Other pollutants are sulfate and chloride. The temperature of the sewage in the region is stable, with a small range of variation. Take Harbin, the capital of HeiLong Jiang Province, as example. The sewage of the city, as shown in Fig. 2, is warm in winter, 10°C or above, and cool in summer, about 23°C. The heat content of the sewage is high, which is estimated to account for 40% of the waste heat produced by the city (CADDET, 1997). Besides, because the climate has little effect on the sewage temperature, the sewage can be utilized in a wide area.

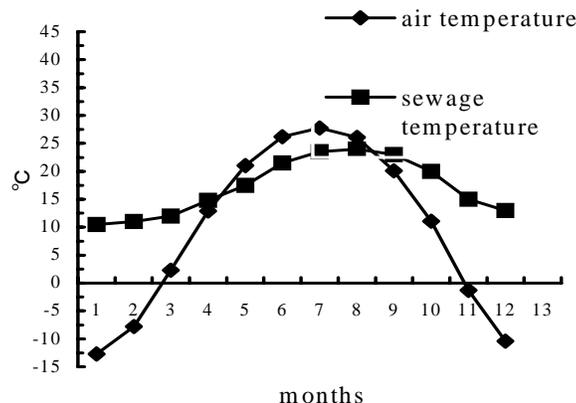


Fig. 2. Curve diagram of air and sewage temperature changes in Harbin

3.2 Current Situation of Sewage Discharge and Treatment in Northeast China

The three provinces in Northeast China, HeiLong Jiang, Jilin and Liaoning, have a tremendous amount of sewage discharge due to the rapid industrial and agriculture development and city construction. According to incomplete statistics, in 2001, the total sewage discharge in the Song-Liao Region was 64.32×10^8 t, with 33.03×10^8 t from the Songhua River region, and 31.29×10^8 t from the Liao River region. Fig. 3 indicates the total sewage discharge of the three provinces in 2000.

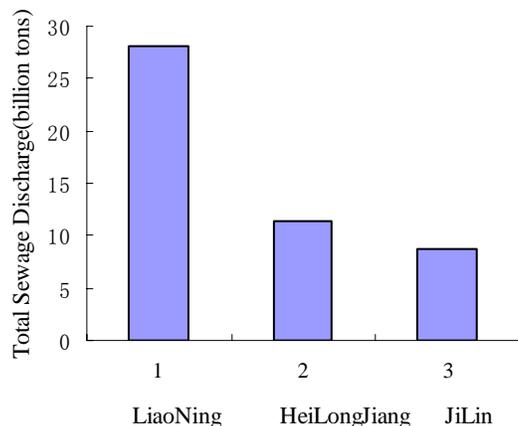


Fig. 3. Total sewage discharge in Northwest China in 2000

The concerning environmental protection authorities in China demand that, in order to reduce the sewage pollution to water resources, the rate of urban sewage treatment in Northeast China should reach 60%. To increase the capacity of sewage treatment, many plants have been built in the big and medium-sized cities. In Harbin, Taiping and Wenchang Sewage Treatment Plants, each with a treatment capacity of 32.5×10^4 m³/d, are responsible for the sewage treatment of the whole area along the Songhua River. Treated in the plants, the sewage which takes up 60% of the total urban sewage volume in Harbin, can meet the national standards for second-class sewage discharge. In Shenyang, the capital of Liaoning Province, there are five sewage treatment plants, and they are Bei Bu, with a capacity of 33×10^4 t/d; Man Tang-he, with a capacity of 2×10^4 t/d; Shenshui-wan, Wuli-he and Xian'nu-he, with a total capacity of 55×10^4 t/d. The urban sewage treatment rate got 70% in 2004. Changchun's (the capital of Jilin Province) five plants have a total sewage treatment capacity of 59×10^4 t/d, and they manage to treat over 70% of the daily sewage discharge. The quality of the treated sewage meets the national standards of second-class sewage discharge. While the amount of sewage discharge and treatment is considerable, only

a small part of the sewage is utilized by the plants or by the communities near them for garden watering, toilet flushing, and scenic uses. The majority of it is discharged directly into the Songhua River and the Liao River, and the heat energy reserved in it has not been fully recycled, thus resulting in serious waste of resources. If the temperature of the treated sewage can be made 1°C lower by the source heat pump, heat energy of 1 t/h vapor can be obtained to heat an architectural area of $1 \times 10^4 \text{ m}^2$ (Ma, Yao and Zhao, 2003). Therefore, building heat pump station at proper sites to recycle sewage waste heat can help save energy used for industrial and residential heating.

3.3 Current Situation of Sewage Source Heat Pump Application in Northeast China

Because of the global energy resource shortage and the increasingly strict requirements for environmental protection, refrigeration/heating system employing water source heat pumps become widespread in China. Sewage source heat pump technologies, however, are still at the stage of experiment and research, and their promotion and application has just started. Engineers in Harbin who have been doing research in this field for a comparatively long time built a water source heat pump employing underground water as source to heat some residential buildings. Another achievement was made in 2002 when they did R&D on residential heating, taking sewage as heat source for the pump. The system employed a SWQR/L100 heat pump, installed in a 600 m² European-style villa west to the Majia-gou River Xuanhua Bridge section. The system with a sewage source heat pump, depicted in Fig. 4, was put into trial use in October, 2002.

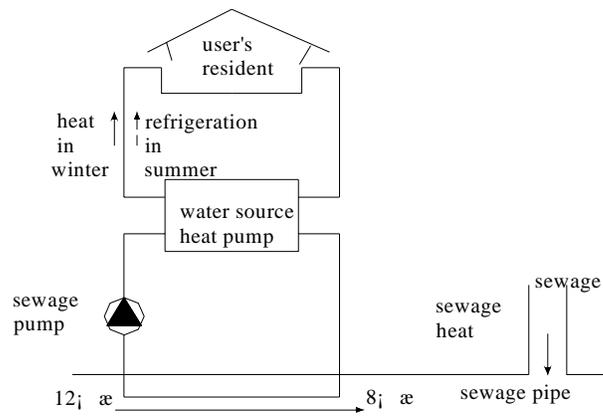


Fig. 4. Air Conditioning System with Sewage Source Heat Pump

There, on either side of the Majia-gou River, are two 2-meter-diameter sewage pipes, one of which is employed by the pump. The pump takes in sewage from a 60-meter-long section of the pipe and then cools down the sewage, averaging 12 °C in winter, by 4°C to get the heat within. The heat then goes through a compressor and makes the medium water to a temperature of 55°C. The fan coil is used to supply heat to the rooms, temperature of which can be risen to 24°C in winter. The input power of the heat pump is 25.3kw, heat capacity 80—100kw, electricity-heat conversion rate 1: 3.5. From Oct. 20, 2002 to April 20, 2003, it took 24 600kwh of electricity, i.e. RMB9 815. 40 Yuan of heating expense counted at the civic electric unit price 0. 399Yuan. This equals to a 24.34-Yuan -heating expense per architectural square meter, a cost lower than other clean heating energy expenses. The total investment in the villa's heat pump system was 130 000 Yuan, 215 Yuan per square meter, a cost lower than other central air conditioning investment. The statistics above prove that sewage source heat pump is efficient, energy –saving and environment-friendly equipment (Zhao and Liu, 2003). In order to promote such pump for heating/refrigeration, installed in Wangjiang Hotel in Harbin in 2003, was another pump which takes up an area of 15 000 m². It has been performing well in summer, and now provides heating and warm water for daily use.

3.4 Sewage Source Heat Pump Problems

Although in Northeast China there is much heat energy that can be recovered by sewage source heat pump system, there are certain problems:

3.4.1 Operational consideration

Sewage corrodes the heat-exchange facilities of the heat pump and floats in untreated sewage can even block them. Therefore, if the pump system is to operate well, methods of cleaning the filth on the surface of the facilities should be worked out to prevent blocking and corrosion.

3.4.2 Economic considerations

Sewage treatment plants and sewage pump stations are usually far from heavily populated areas. If a heat pump system is to utilize the treated sewage, it will be built far from the users' residences, too. Then additional energy would be used for the heat transportation, making the system less economical. If the sewage can be taken in directly from the pipe for its heat energy, the heat can be conveniently transported to the users. But one thing to be considered is that the sewage source has to be clean, involving Problem 1.

3.4.3 Heat source dependability

If sewage source heat pump is applied to provide heat and refrigeration for a large area, and if the time, place, and volume of the waste heat discharging do not match those of the user needs, a heat-reserving pool, a spare boiler, or some other supplementary heating equipment has to be considered to guarantee the normal heat supply.

4 CONCLUSION

There is a huge amount of sewage discharge in Northeast China, and the heat content of the sewage is high. This provides basic conditions for sewage source heat pumps to recover the sewage heat. Such a recovery of sewage and heat is not only a new way of turning urban sewage into a useful resource, but also an efficient means of changing the energy consumption pattern of Northeast China, for which coal is the major energy resource. Meanwhile, it also gives new space for the application and development of recoverable energy. In sum, in Northeast China, it is necessary and highly possible to promote, albeit with great efforts, sewage source heat pump. And the outlook for the application of such pump is fine.

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