Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Air-Conditioning Technology with Multiple Water Sources and Its Application

He Manchao[1], Hu Hong[2], Xu Nengxiong[2], Li Chunhua[3]

1 China University of Mining and Technology (Beijing), Beijing, 100083, P.R.China

2 China University of Geosciences (Beijing), Beijing, 100083, P.R.China

3 Geothermal Mnagement Division of Tianjin City, Tianjin, 30019, P. R. China

hemanchao@263.net, honghu3@yahoo.com

Keywords: air-conditioning technology, multiple water sources, application

ABSTRACT

Low enthalpy energy sources include low enthalpy geothermal water, shallow ground water, surface water and disposed industrial water and domestic waste water. In some places in China, geothermal water is in shortage but disposed waste water and surface water are relatively rich and easy to get. The air conditioning technology with multiple water sources is put forward and applied to heating and cooling. The principle of this technology is to use the temperature differences between the water and the atmosphere in summer or in winter. Geothermal water is used for peak adjusting in severe period of time. Tianjin 975 Project used this technology for heating and cooling. It has been proved that this method is energy-saving, pollution-free and low running cost. The technology has great value of application and dissemination especially in the places which lacks geothermal resources.

1. INTRODUCTION

With the increase of the level of living standard, the demand for energy resources for heating and cooling is increasing greatly. Burning coal has been causing severe pollution in many cities in China. More and more attention is paid to the problem of pollution in recent decades. Coal burning for heating is prohibited in many cities in northern China. Natural gas, geothermal energy and solar energy are widely used instead. However, reserves of conventional energy resources such as oil and natural gas are limited, and solar energy is not always available or reliable. On the contrary, geothermal resource, as a clean, green energy, displays the virtue of reliability and economy. During the last 20 years, direct utilization of low enthalpy geothermal resources has developed rapidly in many cities in China and showing the trend of increasing in more places. But over withdrawal of geothermal water can cause geological disasters such as subsidence and decrease of the ground water level. Therefore, new technology and energy sources for district heating and cooling are needed to cope with the complicated situation.

The utilization of water source heat pumps develops the definition of energy sources. Heat energy can be extracted from lower-temperature fluid to heat up the higher-temperature fluid. So many kinds of low enthalpy fluid such as shallow ground water, surface water and treated waste water can be used as heat sources when geothermal water is not sufficient; or as cold energy sources for cooling in summer.

Nowadays in most cities of China, industrial waste water and domestic sewage are produced enormously everyday. More and more waste water treating factories are built in China. They are supposed to decrease the pollution caused by waste water discharging and recycling waste water to save valuable ground water. This treated waste water serves as plentiful and reliable low enthalpy water resource.

2. AIR-CONDITIONING TECHNOLOGY WITH MULTIPLE WATER SOURCES

Air-conditioning technology with multiple water sources is a new technology of energy utilization. Besides geothermal water, treated waste water and surface water are altogether used as energy sources for space heating or cooling to ease the pressure of the shortage of energy resources and meet the increasing demand for energy.

2.1 Technological principles

In winter time, water temperature is higher than air temperature; in summer time, water temperature is lower than air temperature (He et al, 2004). Treated industrial waste water, domestic sewage and surface water are used as sources of cooling or heating. Water source heat pumps are used to extract heat energy from low enthalpy waters for heating in winter or extract cold energy for cooling in summer. Geothermal water is used for peak adjusting needed in severe cold weather (He, et al, 2004).

2.2 Technological flow

The system adapts an indirect supply method. The circulating water is heated or cooled by water source heat pumps. Parallel and cascade design styles are used for different water sources. Cascade style is employed when geothermal water acts as heat source in order to extract the heat energy sufficiently. Parallel style is employed when treated waste water or surface water is used as heat source.

Different joint designs are needed for these three types of water sources to connect with heat pumps. Geothermal water has the characteristics of high temperature and small flow rate compared with treated waste water and surface water. A special water mixing instrument is needed to mix geothermal water and the other two types of water when needed. A set of water purifying instruments are needed for surface water to get rid of sand and other insoluble particles before it enters into heat pump groups. A fountain system is ready for radiating heat when necessary. Figure 1 shows the design sketch.

<u>2.2.1 Design for heating system in winter time</u>

Treated waste water is the major heat source. Treated waste water enters into water source heat pumps which are connected in parallel. Water source heat pumps extract heat energy from the water and transport heat energy to water in closed circulating pipe. The return disposed waste water goes back to the disposed waste water pipeline after pressure compensation through pressure difference adjusting pump. If downstream of the system consumes no water, man-made lake water can be an alternative. In severe cold period, geothermal water is needed for peak adjusting. In this case, geothermal water flows into a water mixing instrument after purifying process in a water purifying instrument. According to the demand of heat energy, mix the geothermal water and disposed waste water at a certain proportion. The mixture goes into the pumps which connect in cascade. The return temperature reduces to below 10□. After heat extraction, the water will be re-injected or sent back to the disposed circulating system according to their mixing proportion. Figure 2 shows the design for winter case.

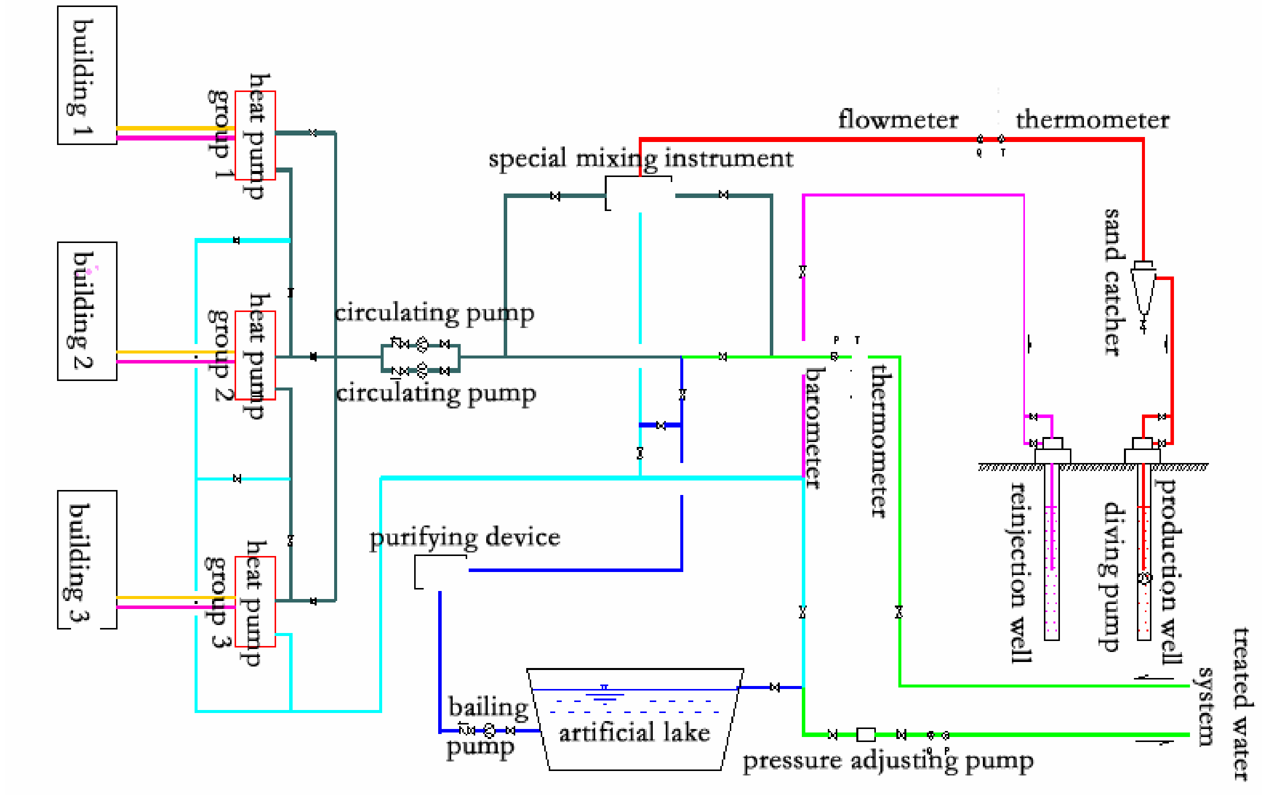

Figure 1: Technological flow of air-conditioning system

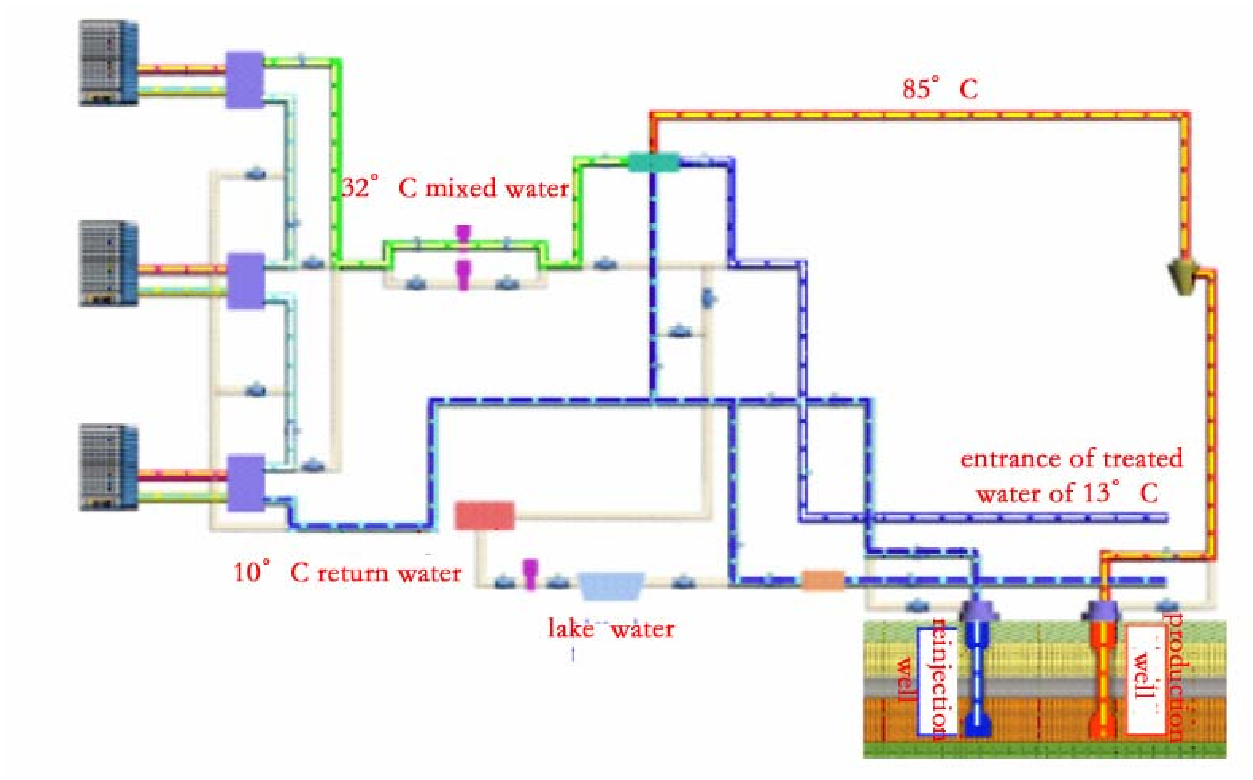

Figure 2: Winter case: Design diagram for air-conditioning system

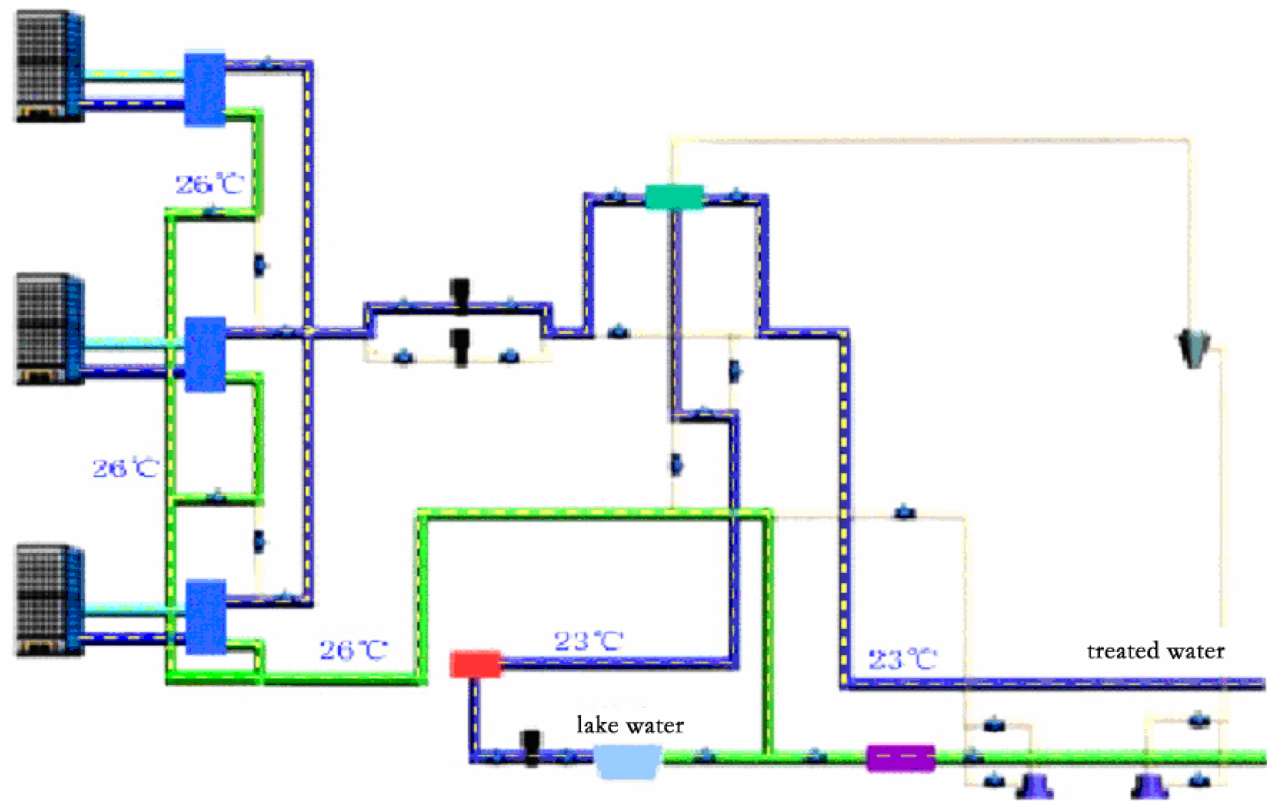

Figure 3: Summer case: Design diagram for air-conditioning system

2.2.2 Design for cooling system in summer time.

Disposed waste water and surface water are used as cold sources for cooling system in summer. Treated waste water or surface water enters the water source heat pumps connected in parallel. Cold energy is extracted by water source heat pump. The return water with higher temperature goes back to the circulating disposed waste water system or to the river or lake respectively. Figure 3 show the design sketch.

3. APPLICATION TO TIANJIN 975 PROJECT

3.1 Outline of the Tianjin 975 project

975 projects covers the area of 20.81ha, among it, water covers 6.12ha, green land 1.05ha and construction area 90500m^2. Figure 4 is its overlook map.

Figure 4: Overlook map of Tianjin 975 project

Near the project area, there is a sewage processing factory and another one is under construction. The disposed waste water goes into the disposed waste water pipeline system and some of it recharges a man-made lake inside the project area with an area of 47,000m^2 and a volume of 90,000m^3.

3.2 WATER SOURECES FOR HEAT AND COLD ENERGY

There are 4 water sources available for the air-conditioning system of this project.

Disposed waste water: in winter, the average temperature is 12□-13□, the lowest is 10□; in summer, the average temperature is 20□ and the highest 25□.

Second precipitating pool water; in winter the average temperature is 13□, the lowest is 12□; in summer, the average temperature is 23□, the highest is 25□.

Man-made lake water: in winter the average temperature below icy line is 5□; in summer, the average is 22□.

Geothermal water: the temperature at the top of the well is about 60□.

3.3 Meteorological parameters

Outdoor T for calculation in winter: -9□

Annually average T: 12.3□

Average T in winter: -1.2□

Comparative humidity: 50%-60%

Outdoor T for calculation in summer: 33.2□

Average temperature for cooling in summer: 26.9□

The highest T: 39.6□

Average wind speed for calculation: 3.2m/s

Deepest depth of icy soil: 0.8m

Where: T is temperature

3.4 Design scheme for air-conditioning

3.4.1 Design for heating system in winter

Disposed waste water is the major source for heating system in general conditions. Firstly mix 60℃ geothermal water with disposed waste water return water to 25℃. Then, this 25℃ mixture enters into cascade water source heat pumps. After entering the heat pump group, the heat energy of the mixture is extracted by three steps. After first heat extraction, the water temperature drops to 18℃; after second extraction, the temperature drops to 12℃; after the last heat withdraw, the temperature drops to 10℃.

This design is a combination of several single designs. For the mixture of geothermal water and disposed waste water, the proportion of these two kinds of waters is determined by:

$k_r=(t_M-t_N)/(t_r-t_N)x100\%$ (1)

The discharging rate of the mixture is: $Q_2=T/k_r$ (2)

The total heat load of the mixture for all these three steps is:

$Q_t=Q_2x1000x(t_M-t_B)/0.86x0.75$ (3)

Where: k_r is the geothermal water percentage of the mixture; t_M is the initial temperature of the mixture; t_N is the initial temperature of the disposed waste water; t_r is the temperature of geothermal water; Q_2 is the discharging rate of the mixture; T is the flow rate of the geothermal water; Q_t is the heat load provided by the water source heat pump after the second heat exchanges; 0.86 is coefficient.

3.4.2 Design for cooling system in summer

Disposed waste water acts as the major water source for cooling. It enters the parallel water source heat pump group. After heat exchanging, the temperature of the disposed waste water increases from 20℃ to 25℃. Then after pressure adjustment by pressure adjusting pump, the 25℃ return water goes back to the disposed waste water pipeline system. The water inside the cooling circulating system supplies cold water with 7℃ for the customers and the return water temperature is 12℃.

During the hottest period of time in summer, man-made lake water is also used as the water source. Lake water goes to the purifying instrument first to be purified. Then it goes to the heat pump groups. After heat exchanges, the temperature increases from 22℃ to 27℃. Then the 27℃ return water goes back to the lake to radiate heat with a fountain system. Meanwhile, inside the cooling circulating system, the heat pump group supplies 7℃ water to its customers. After circulation, the return water temperature goes up to 12℃

4. COMPARATIVE ADVANTAGES

Compared with the conventional designs and shallow well design, the design with multiple water sources has distinct advantages.

4.1 Environmental advantages

Compared with designs of geothermal water – L_iB_r air-conditioning system, gas boiler – cooling system, electrical boiler – cooling system and shallow well system, multiple water sources air-conditioning design is pollution-free, environmental friendly, energy-saving and land-saving. There is no coal consumption during running the system, but a small amount of electricity.

4.2 Economic advantages

Compared with the designs above mentioned, the initial investment of the multiple water sources air-conditioning design is higher than the design of gas heating-cooling system, but lower than any other designs. The running cost is about 70% of the design of shallow well system and half of the others'.

5. CONCLUSIONS

This technology is characterized by efficient and sustainable uses of geothermal resource and some other reliable water resources with low enthalpy. It provides a reasonable and practical design idea for the areas where are lack of geothermal resource or with a plenty of surface water and/or treated waste water.

The end users can be of variety by mixing the geothermal water and the other water resources in different proportion.

With the advantages of lower initial investment and running cost, pollution-free and energy-saving, this technology has great value of application and dissemination.

REFERENCES

He M. et al., China low enthalpy geothermal engineering technology, 2004