Energy Saving Analysis of Circulating Water Waste Heat Recovery from Water Source Heat Pump

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Abstract: By analyzing the way of circulating water-water source heat pump heating and direct pumping heat supply, the water source heat pump recovers low-grade power plant circulating water waste heat, which has significant energy saving potential. The water source heat pump technology is used to recover the residual heat of circulating water in low-temperature power plants, realizing the conversion of energy from low grade to high grade, in line with the principle of energy cascade utilization. The critical parameters of water source heat pump heating are better than conventional heating by calculation and analysis. The actual example shows that when the pumping temperature reaches 188 °C, the water source heat pump is more energy efficient than the pumping heat.

1. introduction

At present, the heating units in China are in the state of pumping operation in winter, accounting for about 30% of the total installed capacity of thermal power plants. From the current situation, there are still some shortcomings in the traditional methods of pumping and heating. After the pumping capacity of the heating steam turbine increases, the primary frequency modulation capability of the unit decreases, and the self-balancing ability of the power grid should be fully considered to reduce the safety hazard of the power grid [1]. The study found that the use of heat pump heating instead of traditional pumping heat increased the total thermal efficiency, and the coal saving capacity increased. Under the rated pumping condition, the heat pump heat supply performance is better than that of pumping. Heating conditions [2-3]. Therefore, it is necessary to analyze the traditional heating method and pay attention to the energy saving of heating.

The power plant contains abundant waste heat resources. The heat of fuel combustion, about 60% of the heat is taken away by the exhaust of the boiler and the circulating water flowing through the condenser. It is lost in the environment, not only polluting the environment, but also vain. Waste a lot of waste heat resources. Generally, the temperature of the circulating water of the power plant is about 10 °C higher than the environment, and the operation requirements of the water source heat pump can be met in both summer and winter. If the waste water heat supply of the circulating water of the power plant is recovered by the water source heat pump, it has good energy saving potential compared with the conventional direct pumping heat supply.

2. Analysis of water source heat pump system

Compared with air source heat pumps, water source heat pump units can use rivers, lakes, groundwater, and power plant circulating cooling water as heat sources for heat pumps to improve the utilization of low-grade heat energy. Water source heat pumps use different heat sources and have different effects.

Table 1 describes the problems that water source heat pumps should pay attention to when using different heat sources. According to the Water Source Heat Pump of the Rivers and Lakes, according to the Water Law of the Chinese People's Republic and the Regulations on Urban Water Management in various places, water approval and water charges are required to make the water source heat pump increase the resistance in the water source [4]. For the power plant, the circulating water itself is indispensable to absorb the latent heat of vaporization of the turbine exhaust steam. For example, in the case of a 600 MW unit, the average circulating water flow rate of a certain day reaches 1372.4 t/h when the unit is running in winter [5]. The flow is huge, which provides ample water for the water source heat pump.

2.1 The working principle of water source heat pump

The water source heat pump achieves the purpose of heating and cooling the building space by utilizing the lower temperature water. In essence, it is a device that consumes a part of high-grade electric energy as a condition, and relies on circulation to excavate low-grade heat contained in an environmental medium to achieve utilization. Usually, the heat pump can provide 2-3 times or more of heat per 1 part of the power consumption [6]. Therefore, it can use low grade energy to save high grade energy.

The compression heat pump cycle process is shown in Figure 1. The basic working principle: Under the heating conditions in winter, the low-temperature and low-pressure refrigerant passes through the evaporator, absorbs the heat from the low-grade cold source (such as the circulating water of the power plant), and then the temperature rises, flows into the compressor, and is compressed into a high-pressure high-temperature. The steam then flows into the condenser to release heat to the heat source, and after being cooled and depressurized by the expansion valve, the low-temperature low-pressure refrigerant flows into the evaporator again, and is repeatedly circulated. In the summer, the function of the condenser and evaporator of the water source heat pump is switched [7-8].

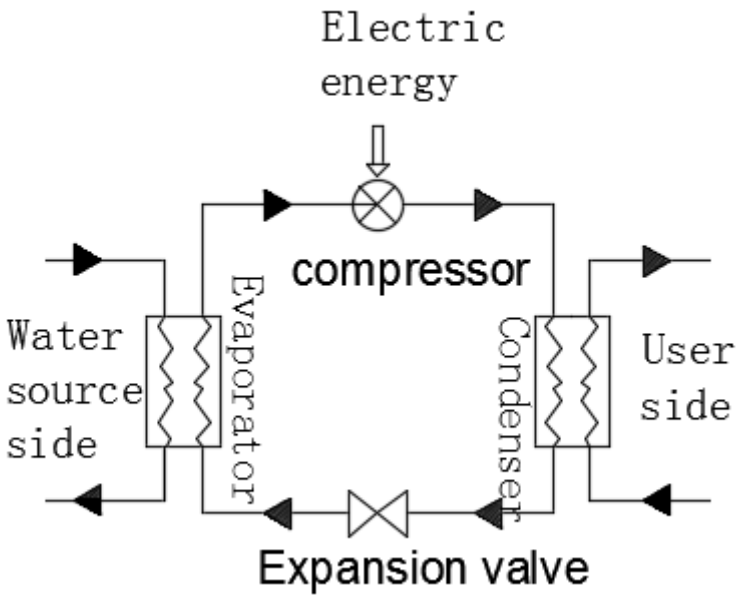


Figure 1 Flow chart of water source heat pump system

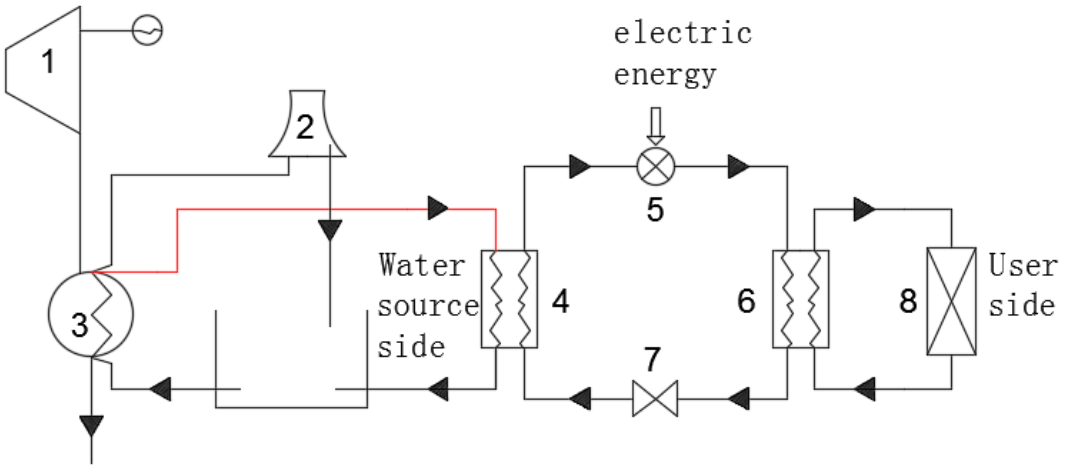
2.2 Energy-saving characteristics of water source heat pump system

The water source heat pump excavates and recovers low-grade heat energy by consuming a small portion of high-grade electric energy, and obtains more high-quality heat energy for heating or cooling. Research on heat pump technology used in thermal power plant circulating water waste heat recovery can make the power plant energy saving rate reach 32.8% [9]. When heating in winter, the circulating

water of the power plant is used as the low-grade heat source of the water source heat pump, which not only can reduce the temperature of the circulating water of the condenser inlet, improve the vacuum degree of the condenser, but also save the coal consumption of the power plant. To study the current coal combustion in China, for every 1 t of standard coal consumed, it will discharge more than 400 kilograms of carbon dioxide, more than 20 kilograms of sulfur dioxide, 15 kilograms of soot and 260 kilograms of ash [10-11]. For the water source heat pump system, the water source side is the circulating water of the power plant, and the waste heat is recovered to supply heat or heat the domestic water to achieve the purpose of energy saving and emission reduction. The temperature of the circulating cooling water of the power plant does not fluctuate greatly in one year, generally between 20-35 °C in winter and 25-45 °C in summer. Although there are certain differences between different units and different regions, the water source heat pump can still be guaranteed in its economy. Within the operating range, there is good energy saving value.

2.3 Water supply heat pump system heating scheme

With the reduction of small units and the rise of large-scale thermal power plants, power plant energy conservation issues have become more and more detailed. The use of water source heat pumps to extract low-grade waste heat from power plant circulating water has received increasing attention. In the winter, the water source heat pump uses circulating water to supply heat, which not only reduces the inlet temperature of the circulating water entering the condenser, but also increases the vacuum degree of the condenser. Reference [12] pointed out that for every 1 kPa increase in condenser vacuum, the coal consumption value of 2.5g/kWh can be reduced. While achieving low-grade heat supply, it can also save primary energy consumption. It can be seen that the use of circulating water for heating has good economic benefits and has good energy saving potential. Figure 2 shows the schematic diagram of the water source heat pump recovery power plant circulating water heating operation.



1. steam turbine; 2. cooling tower; 3. condenser; 4. evaporator; 5. compression; 6. condenser; 7. expansion valve;

Fig. 2 Schematic diagram of circulating water heating operation of water source heat pump recovery power plant

3. Conclusion

The water source heat pump uses the circulating water of the power plant as a heat source to recover the rich waste heat contained in the circulating water of the power plant, and does not need to consider the problems that should be paid attention to by heat sources such as rivers and lakes. According to the second law of thermodynamics, the water source heat pump uses electric energy as the power to realize the conversion of energy from low grade to high grade, which not only recovers heat but also

provides heat supply. Through analysis and explanation, the use of water source heat pump heating reflects the advantages of energy saving.

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