

Research of waste heat energy efficiency for absorption heat pump recycling thermal power plant circulating water

Li Zhang^{1,3}, Yu Zhang¹, Liansheng Zhou¹, Zhijun E², Kun Wang¹, Ziyue Wang¹, Guohao Li¹ and Bin Qu¹

¹ Tianjin Electric Power Science & Research Institute, Tianjin, 300384;

² State Grid Tianjin Electric Power Company.

³ zhanglihust@163.com

Abstract. The waste heat energy efficiency for absorption heat pump recycling thermal power plant circulating water has been analyzed. After the operation of heat pump, the influences on power generation and heat generation of unit were taken into account. In the light of the characteristics of heat pump in different operation stages, the energy efficiency of heat pump was evaluated comprehensively on both sides of benefits belonging to electricity and benefits belonging to heat, which adopted the method of contrast test. Thus, the reference of energy efficiency for same type projects was provided.

1. Introduction

With the development of urban construction, the residents heating area is increasing year by year. Thus, the contradiction between the increasing heating load and the corresponding environment pollution problem is prominently increasing. How to utilize the existing heating resources to improve heating load without any increase in energy consumption and environmental pollution is an urgent problem needed to solve. For thermal power plant, using the absorption heat pump to recycle the waste heat of circulating water is a kind of effective method. It can not only reduced the steam turbine cold source loss and achieve the purpose of energy conservation and emissions reduction, but also can increase heating load to alleviate the insufficient of thermal power plant heating ability.

Guo et al. [1] analyzed the issues about the power plant waste heat utilization from circulation water using heat pump. Chen et al. [2] expounded the supply methods of heat pump to use the waste heat and investigated the comprehensive thermal performance of the heat pump system. Wang et al. [3] analyzed the economy of absorption heat pump recycling thermal power plant circulating water. The result showed that it can effectively improve the unit energy utilization rate and efficiency and the economic benefit of power plant after using the heat pump system.

2. Heat pump system

As an example of a 330MW heat-supply unit, in order to further improve the heating efficiency, the power plant Choose 8 absorption heat pump to recycle waste heat from circulation water with extraction steam as drive steam. It can reduce the flow of the extraction steam from the heat-supply unit with enough heating load. In other words, the heat-supply unit can supply more heat with same extraction steam. Thus, the purpose of energy-saving emission reduction is achieved. Figure1 shows the system of absorption heat pump recycling thermal power plant circulating water.



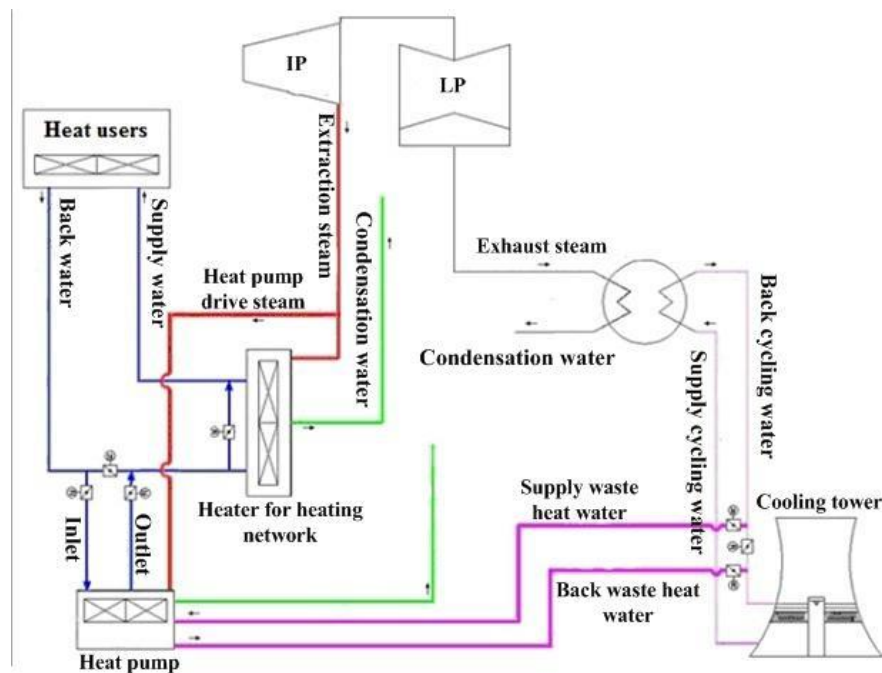


Figure 1. Heat pump recycling waste heat recovery system diagram of heat and power plant.

3. The energy-saving benefits evaluation method of heat pump system

In order to evaluate the energy-saving benefits of the heat pump system, three tests with different conditions were conducted. Test 1: Rated condition with heat pump running; Test 2: Same heating load of Test 1 without heat pump running; Test 3: Same power load of Test 1 without heat pump running.

In these three tests, the main steam parameters (pressure, temperature, flow) remained the same. There are three influences on the power load and heat load after the heat pump running. 1) In order to guarantee the temperature of waste heat water to satisfy the requirement of heat pump operation, the exhaust steam pressure of steam turbine low pressure cylinder (LP) will increase, thus the unit electricity production will reduce; 2) After the heat pump operation, the flow of extraction steam will reduce when same heat load supplies. Therefore, the flow of stem inlet to LP increases, which increases the unit electricity production. 3) After the heat pump operation, the unit can increase the heat load with same extraction steam.

Therefore, the evaluation method for energy-saving benefits can be conducted in two aspects: 1) during the heating slack period, when the original heating capacity of the unit can meet the demand of the network, the heat load remains the same after the heat pump operation. In this way, the energy-saving benefit of heat pump system is to increase the unit electricity production, which calls “benefits belonging to electricity”. 2) During the heating peak period, when the original heating capacity of the unit cannot meet the demand of the network, the heat load can be effectively increased after heat pump operation. In this way, the energy-saving benefit of heat pump system is to increase the heat load, which calls “benefits belonging to heat”.

3.1. Benefits belonging to electricity

In test 1 and test 2, the main steam parameters (pressure, temperature, flow) remained the same. After the heat pump operation, the energy-saving benefit is the increasing electric energy production, which transforms to standard coal as:

$$\Delta B_e = \frac{\Delta P \times b_f \times h}{1000} \quad (1)$$

Where ΔB_e is the saving quantity of standard coal after heat pump operation; ΔP is the increment of the power load after heat pump operation; h is the annual utilization hours of the heat pump, which regards as 2880 h/a.

3.2. Benefits belonging to electricity

In test 1 and test 3, the main steam parameters (pressure, temperature, flow) remained the same. After the heat pump operation, the energy-saving benefit is the increasing heat load, which transforms to standard coal as:

$$\Delta B_t = \frac{\Delta Q \times \theta \times h}{1000} \quad (2)$$

Where ΔB_t is the saving quantity of standard coal after heat pump operation; ΔQ is the increment of the heat load after heat pump operation; θ is the heating standard coal consumption of the unit; h is the annual utilization hours of the heat pump, which regards as 2880 h/a.

4. Results and discussion

Table 1 shows the power load and heat load of these three tests.

Table 1. Comparative test results.		
Test	Power load (MW)	Heat load (GJ/h)
Test 1	277.98	1152.1
Test 2	265.34	1167.2
Test 3	273.98	884.0

Synthesizes the deviation of the power load and heat load in the comparative tests and the Changes of the service-power consumption rate after the heat pump operation, the energy-saving benefits of the heat pump system can be summarized as follows:

- 1) After heat pump operation, by comparing test 1 and test 2, the increment of power load was 13.84 MW. Based on the computational formula of “Benefits belonging to electricity”, the energy-saving benefit of standard coal was 8316.6 ton per year.
- 2) After heat pump operation, by comparing test 1 and test 3, the increment of heat load was 343.2 GJ/h. Based on the computational formula of “Benefits belonging to heat”, the energy-saving benefit of standard coal was 38058.9 ton per year.
- 3) Considering the different modes of heat pump operation, we regard the energy-saving benefit is consist of 30% “Benefits belonging to electricity” and 70% “Benefits belonging to heat” in a year. Thus, the energy-saving benefit of standard coal was 29136 ton per year.

5. Conclusions

With the mature of heat pump technology and the reducing of the cost of investment, the absorption heat pump can recycle waste heat from thermal power plant circulating water without any increase in coal consumption and environmental pollution. It not only can reduce the loss of cold source of the unit and achieve the purpose of saving energy and reducing consumption, but also can ease the pressure from the shortage of heating load of thermal power plant and improve the economic and social benefits.

References

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