300MW Class Units Circulating Pump for Heating Network Electric to Steam-Driven Comparative Study of Two Kinds of Economic Transformation Program

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Abstract. Jilin Province is located in the northern cold regions, winter heating period of up to five months, the thermal power plants in the larger proportion of the heating unit to improve the economy is a priority issue before us. Most thermal power plant in our province are used in electric network circulating pump run, a larger share of electricity plants, such as the use of steam-driven run, can reduce electricity consumption increased grid power plant, with better economic benefits, and whether the transformation potential, we need to demonstrate feasibility. To speed up the transformation project power industry the pace of industrial upgrading, power plant emissions-reduction targets.

1 Introduction

At present, with the high coal price and the fierce competition in the power market, how to ensure the power plant to reduce the cost of power generation to improve its competitiveness is a major issue for every power plant. Most of the domestic cogeneration units are 300MW units, and the maximum flow rate of circulating water pump in the heat network of these units can reach 10000 m³/h. Most of the thermal power plants are located far from the suburbs, most of the heating radius of more than ten kilometers, relatively high resistance. Therefore, the heat network circulating pump generally need to be equipped with a large head, large power pump. The average active power of the pump is 1000kW, and the power of the heating plant is high. Under the current situation of power grid, increasing the profitability of power plants needs to further reduce the auxiliary power consumption. The heating system of the thermal power enterprise is mainly to convert the steam produced through the temperature reducer and the steam extracted from the steam turbine into low-temperature water for heating to the residents through the heat network heater of the heat exchange station, heating power equipment required is the use of motor-driven heat network circulating pump. The study on changing electric heat network circulation pump to steam heat network circulation pump can effectively reduce the power consumption rate of comprehensive plant in thermal power enterprises.
2 Technical scheme of changing electric heat network circulating pump into steam-driven pump in a thermal power plant

2.1 Summary of heat-supply network system

The power plant is a 330MW heat-supply unit, the heating and heating system is indirectly connected by "three-ring system". The heating network is composed of the first-level heating network and the second-level heating network. The first-level heating network is a high-temperature water system, and the second-level heating network is a low-temperature water system. The heating hot water network is mainly supplied by the first station of the heating network inside the power plant, and is connected to all the heating stations in the whole heating area with the water supply temperature of 130 °C and the return water temperature of 70 °C, the secondary heating hot water network is heated by water heat exchanger in the heat distribution station, and the secondary heating hot water network is connected with the heat user (the water supply temperature is 85 °C, the return water temperature is 60 °C).

The unit system is used to heat steam in general heating network. The steam is extracted from the tail of the medium pressure cylinder of a steam turbine. The steam turbine generally provides two heating extraction ports, which are directly connected to the heating network to heat the steam master pipe. Heating units are generally equipped with four heating network heater, when one of the heating network heater failure, the rest of the heating network heater can meet more than 75.1% heat load. Generally, the heat exchange area of each heater is 1231 m², and the heat supply capacity of two heating units can basically meet 649 MW.

The maximum extraction steam of 300MW heat-supply unit is 525.9 t/h. At the time of maximum heat supply in winter, two heating units can run simultaneously to meet the maximum heat load. The rated heating steam extraction capacity is 336.8 t/h, and two heating units can meet the heating demand of heating load. Only 6 heaters are needed for 8 heating networks in power plants.

The circulating water system of heating and heating network is usually operated by unit system and connected by connecting pipes on the water supply and return pipelines.

The outlet of the heater is the water supply temperature of the heating network, the designed water temperature is 130 °C, and the designed return water temperature is 70 °C. The design water supply temperature of the secondary heating hot water network is 85 °C, and the design return water temperature is 60 °C.

The maximum heating load, namely 649MW, is about 9411 t/h. The first unit of the power plant is equipped with three heat-supply circulating water pumps with a capacity of 2017 t/h, the second unit is equipped with three heat-supply circulating water pumps with a capacity of 1400 t/h and one with a capacity of 2800 t/h to provide all hot water for heating heat load. There are 7 circulating water pumps in power plant. The number of circulating water pumps can be adjusted flexibly according to the actual demand of hot water supply.

The function of the circulating water pump of the heating network is to send the return water of the heating area to 70 °C, to the hot water heated to 130 °C in the heating network heater, and then send the hot water to the hot consumer.

Two heat-supply units in the power plant are equipped with a water supply deaerator and two heat-supply units are equipped with two water supply pumps. The chemically softened water uniformly enters the return jellyfish pipe through a make-up pump.

In general, the drainage system of heat net heater is unit system, and each unit is connected by connecting pipe. Heat network heater equipped with 50% capacity of the heat
network drainage pump three, the heat network heater condensate water sent to the deaerator.

### 2.2 Alternative renovation options

Heat network circulating water pump electric pump to steam pump scheme according to the requirements of power plant:

- **Scheme 1:** Two circulating water pumps with a flow rate of 2500 m³/h are selected for the heating network, the operation mode is driven by steam turbine, and the heat flow rate of the two heating units is 10000 m³/h to meet the requirements of Heating Network in heating period.

- **Scheme 2:** A circulating water pump with a flow rate of 2800 m³/h is selected for the heating network, and the operation mode is driven by a small steam turbine. During the whole heating period, the two heat-supply units with a total flow rate of 9016 m³/h meet the operation requirements of heating network.

The pros and cons of the two options:

**Scheme one:** two heat-supply circulating water pumps are all driven by steam turbine, the operation economy is good, but the area is relatively large, and the capacity of the other two pumps is 10248 m³/h, which is larger than the normal flow rate of 9000 m³/h, when the steam-driven heat-supply network water pump needs to be completely cut off due to the leakage of the circulating cooler in the heat-supply network, all the other standby electric heat-supply network water pumps are put into operation, which can meet the requirement of circulating water flow rate of 10248 m³/h heat-supply network, to ensure the normal operation of heating hot water network.

**Scheme 2:** steam-driven Heat Network circulating water pump and electric-driven heat network circulating water pump work together, the operation mode is not as economical as the first scheme, but the use area is relatively small, maintenance and construction are more convenient than the first scheme, dismantling an electric pump, the capacity of the other electric pumps is 11648 m³/h, which is larger than the normal flow rate of 9000 m³/h, and the capacity of the standby electric pumps is larger. When the leakage of the circulating cooler of the heat network occurs, the steam-driven heat network water pump needs to be completely cut off, the other spare electric water pumps are put into operation, which can meet the demand of circulating water flow and ensure the normal operation of heating water network.

The average circulating water flow rate is 9000 m³/h in the power plant heating network. Therefore, both the first and the second reconstruction schemes guarantee the demand of the flow rate. The four-stage extraction steam is chosen as the driving steam source of the small steam turbine. Considering the stable operation of the heat-supply unit under low load, and also considering the switch between the steam sources of other stages to ensure the safety of heat supply and the stability of the unit, the original electric pump of the power plant has more capacity, and most of the electric pumps have been retained in the two retrofit schemes, can meet the backup needs, so the two sets of transformation program do not do the backup steam switch settings.

The reason for not keeping the spare steam source is: when the four-stage steam extraction cannot supply steam, the higher quality three-stage steam extraction is used as the spare steam source, which affects the generating capacity of the unit, the three-stage steam extraction is of high quality and can only supply steam to the small steam turbine through temperature and pressure reduction, which wastes most of the working capacity and has poor economy. The number and capacity of the electric pump in the power plant meet the normal operation, so it is reasonable to keep the electric pump without reserve gas source.
2.3 Energy saving calculation

According to the calculation, the exhaust pressure of the small steam turbine is 0.105 MPa, the steam consumption of the small steam turbine of the heat-supply unit is 79 t/h, and the power saving is 2025kW. Heating rated conditions, to ensure that the heating network heating capacity unchanged, heating units need to draw more 1.007 t/h Heating Steam; Option 2, the steam consumption of the small steam turbine is 45 t/h, and the power saving is 1135kW. Heating rated conditions, to ensure the heating network heating capacity unchanged, heating units need to draw more 0.712 t/h Heating Steam. When the main steam inlet flow rate of heat-supply unit is constant, the load of heat-supply unit decreases with the increase of heating steam.

Through the data analysis provided by the power plant, better economic benefits can be achieved when the steam-driven heat network is adopted as the circulating water pump. The steam driven pump of the heat-supply unit operates at full load during the whole heating period, The first option saves about 6,770,000 kW·h, saves about 2,167,000 RMB in electricity cost benefit, and increases steam flow. The conversion annual consumption of standard coal is 306.48 t, and the unit price of standard coal is 650 RMB / t, calculated the annual offset income of 199,200 RMB, and the annual electricity consumption of 6,100 RMB for an additional drain pump with a lack of steam cooler, The profit of one heating unit is 1,962,300 RMB a year; option 2 saves about 3,700,000 kW·h, saves about 1,186,300 RMB in electricity cost benefit, and increases the steam flow rate. The annual consumption of standard coal is 216.81 t, and the unit price of standard coal is 650 RMB / t, it calculates that the annual offset revenue is 140,900 RMB, the annual electricity cost of adding a drain pump with a lack of steam cooler is 3,400 RMB, and the annual profit of a heating unit is 1,042,000 RMB.

2.4 Calculation of payback period of investment

The static investment payback period of the project is calculated according to the annual energy saving direct economic benefit calculated by the annual energy saving mode.

Scheme 1: The project investment is estimated to be 4,800,000 RMB, 2 steam turbines of circulating water pumps for heating network times 3,000,000 RMB, 2 circulating water pumps for heating network times 200,000 RMB, 1 Steam Cooler Times 800,000 RMB; The cost of laying the pipeline, valve and bracket is 400,000 RMB, and the construction cost of the project land is 400,000 RMB.

Static investment payback period: 4,800,000 RMB, divided by 1,962,300 RMB, equals 2.44 years. After the completion of the project design transformation, all the cost funds can be recovered within three heating cycles.

Scheme 2: The project investment is estimated to be 3,100,000 RMB, 1 steam turbines of circulating water pumps for heating network times 1,500,000 RMB, 1 circulating water pumps for heating network times 100,000 RMB, 1 Steam Cooler Times 800,000 RMB; The cost of laying the pipeline, valve and bracket is 350,000 RMB, and the construction cost of the project land is 350,000 RMB.

Static investment payback period: 3,100,000 RMB, divided by 1,042,000 RMB, equals 2.98 years. After the completion of the project design transformation, all the cost funds can be recovered within three heating cycles.

3 Conclusions and recommendations

Through analysis and calculation, the conclusions are as follows:
(1) When the network circulating water pump is put into the steam-driven pump, it can get good benefit. When the steam-driven pump of the heat-supply unit runs at full load in the whole heating cycle, the energy saving is 6,770,000 kW·h, the electricity saving is about 2,160,000 RMB, and the net profit is about 1,960,000 RMB. When the steam-driven pump of the Scheme 2 heat-supply unit runs at full load in the whole heating cycle, the energy saving is 3,700,000 kW·h, the electricity saving is about 1,180,000 RMB, and the net profit is about 1,040,000 RMB.

(2) After the implementation of the project, on the premise of keeping the heat supply constant, the load can be increased, thus increasing the grid power. The first scheme reduces the station power consumption rate by about 0.67%, and the second scheme reduces the station power consumption rate by about 0.32%.

(3) Scheme 1 has the advantages of high net income, large investment, large land area and fast capital recovery; Scheme 2 has the advantages of less investment, smaller net income, smaller land area and slower capital recovery. Considering the safe and stable operation of the heat-supply unit, the steam-driven pump cannot be operated due to failure, and the heat supply capacity of the backup electric pumps of the first and second schemes can meet the normal operation requirements of the heat-supply network. In summary, considering the economic benefits of operation, it is suggested to implement the design scheme of Scheme 1. When the power plant heat-supply units normally provide heat to the outside, all steam pumps can be used for operation. When the steam pumps are in trouble for maintenance, the electric pumps have sufficient reserve capacity, and both have good economic benefits, and ensure the safe and stable operation of heat-supply units.

(4) Through the design investment of this project, it is found that scheme 1 is 4,800,000 million RMB, scheme 2 is 3,100,000 RMB, the initial investment is relatively large, but after the project is put into operation, the investment cost can be recovered in three heating periods, therefore, this renovation project is recommended.

(5) Through understanding the power plant project which has been put into operation successfully in China, the technical method can be carried out by changing the electric heat network circulating water pump into the steam circulation water pump.

(6) To ensure the safe and stable operation of the heating unit during the heating period, and to keep the circulating water pump of the original electric heating network as the backup as far as possible, so as to ensure the normal heat supply of the unit in case of sudden accidents, failures or overhauls of the small steam turbine.

References

1. Li Yansong. Power System Automation M. Beijing: China Electric Power Press, (2014).
2. Shu Bin, He Xiaohong, Sun Shien, Zheng Lijun. Economic Analysis of heat supply of heat-supply network circulating pump driven by Steam Turbine J. Steam Turbine Technology; Issue No. 3 (2014).
3. Zhu Binshuai, Li Yangyi, Song Guoliang. Energy-saving optimization of circulating pump drive in Heating Network of Heat-supply Unit J. Energy efficient technologies; issue Issue No. 4 (2014).
4. Jiang Weijia, Ge Jun, Sun Shouhang. Discussion on heat economy of steam-driven circulating pump in Heat Network J. Jilin Electric Power; Issue No. 1 (2012).
5. Li Qing. Fossil-fuel power station energy saving technology and its applications. Beijing: China Electric Power Press, (2014).
6. Wang Yong, Sun Wenjie. The steam turbine equipment operates M. Beijing: China Electric Power Press, (2014).