Analysis of High Back-pressure Heating System of 350MW Wet Cooling Unit

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Abstract. In order to solve the problem of increasing heating demand of 350MW supercritical condensing steam turbine unit in a power plant, this paper introduces a high back pressure heating technology of wet cooling unit, and describes the key problems in this technology. By increasing the pressure of low-pressure cylinder exhaust, the condenser transformation fully makes use of the steam latent heat heating circulating water of low-pressure cylinder exhaust. The double-rotor exchange technology can form high back pressure in the heating season and low back pressure in the non-heating season, which can not only improve the exhaust parameters of steam turbines in the heating period, but also can operate in pure condensing conditions in the non-heating season.

Keywords: high back-pressure; double-rotor; condenser transformation; exhaust parameters.

1. Background

At present, China's economic development has shifted from a stage of high-speed growth to a stage of high-quality development, and the structure of economic growth is undergoing historic changes. In the stage of high-quality development, the constraints on resources, energy and the environment have become more and more obvious, the pressure on the ecological environment continues to increase, and the constraints of resources and the environment on economic development will always exist and be strengthened. To achieve a high-quality and high-efficiency growth model, it is imperative to replace old growth drivers with new ones, deepen energy conservation and emission reduction, and create a new model of economic development. Shandong province's total energy consumption and major pollutant emissions all rank among the top in China. The task of reducing the total coal consumption and reducing the proportion of coal consumption is very arduous. Therefore, Shandong electric power enterprises need to shoulder their own social responsibilities, advocate green heat, and achieve clean, low-carbon, safe and efficient supply of energy.

Under the encouragement of the national energy conservation and emission reduction policy, as well as the role of various regions to promote energy conservation and emission reduction, more and more power generation enterprises in the original pure condensation conditions of heating units in the original central heating conditions, forming a variety of new ways of combined heat and power. The heating replacement market [1] for small and medium-sized coal-fired boilers is large. Therefore, it is particularly important to carry out high back-pressure heating transformation for units to achieve heating growth and respond to national and local energy conservation and emission reduction policies [2-4].

2. Reconstruction of low pressure flow section of steam turbine

2.1 Technical difficulty of the transformation scheme of steam turbine through-flow section

2.1.1 Axial system and unit stability

Since the low-pressure bearing seat of the unit is cylinder type, the exhaust temperature and pressure of the low-pressure cylinder will increase accordingly and the exhaust temperature of low pressure. However, in the low-pressure outer cylinder, the high back pressure working condition and the static and dynamic characteristics of the shaft in pure condensation condition.

Because the biggest difficulty in the unit transformation is the thermal expansion of high low pressure cylinder makes low pressure bearing elevation with the cylinder deformation, and this change will directly affect the low pressure rotor and high pressure rotor matching can run safely, the structure of low pressure rotor needs to adjust how to meet the safe operation of high back pressure condition, axis elevation how can arrange more balance the safe operation of extreme conditions. To this end, we should first determine the deformation of the low pressure cylinder. According to the thermal data of different working conditions, we used the finite element program to calculate the low-pressure cylinder under high back pressure (54KPa) and pure condensation condition (4.9KPa), and calculated the elevation change value of the bearing position in two different working conditions.

The influence of bearing elevation settlement on stability and safety and mechanical properties of the extreme condition.

2.1.2 Coordination of double-rotor swaps

To ensure the interchangeability of the newly designed heating rotor and the original pure condensing rotor, the two axial ends of the heating rotor adopt exactly the same structural design as before the transformation. That is, screw plug holes for the balance of the rotor; the coupling adopts rigid connection; the end surface of the large gear and coupling gasket are processed into compatible positioning flange to adjust the relative position of the low pressure rotor to ensure the required dynamic and static gap; open screw holes on each coupling for separate couplings.

2.1.3 Low-pressure cylinder sprinkler and shaft sealing system

In order to meet the needs of summer and winter conditions, a new set of low-pressure cylinder sprinkler system is required, the original configuration can meet the low back pressure operation and increase the effect of the low-pressure cylinder, so as to achieve precise control of spray temperature reduction.

2.2 Technical scheme and technical measures of low pressure flow section

2.2.1 Advanced overall flow design technology AIBT

AIBT is an overall flow design technology formed by the seller after years of experience in flow design. Compared with the traditional flow design technology, AIBT technology is advanced in:The technology includes the overall flow channel layout, leaf optimization selection, differential expansion gap design, leaf top belt and leaf root design and other functions, carried out in an overall way, do not need to match step by step as the traditional way.

The program function is complete and powerful, which can realize the automatic matching of the efficiency and intensity of the flow flow, the automatic matching of the safety and efficiency of the differential expansion, and the automatic matching of the module interval and the cascade. Generally, no longer need a step by step calculation adjustment. The output blade data and through-flow data are very detailed and can meet the requirements of blade processing design and structural processing design. Figure 1 shows a live picture of the leaves.



Figure 1. Material diagram of AIBT blade

The flow design is carried out in the overall way, which does not need to be matched step by step as the traditional way. The flow design has basically does not involve the structural design major, with few interactive operations, which effectively shortens the design cycle of the transformation unit and greatly improves the flow design efficiency of the transformation unit;

From the aerodynamic perspective, AIBT flow technique proposes the design principle of variable reactionary, that the reaction of each blade level is unequal. Reaction is corresponding to the blade geometric size, enthalpy, entry and exit Angle characteristics, with the best airflow characteristics to determine the reaction at all levels, rather than the unified reaction to sacrifice some aerodynamic performance, make all 3 D blade level are in the best aerodynamic state, different combination of blade levels will improve the flow efficiency of the whole cylinder.

Advanced AIBT through-flow technology has been widely used in Shanghai Electric high-power new machine design, old unit renovation project and the latest combined cycle steam turbine, with rich application performance, mature and reliable technology. Among these units, the products designed by AIBT common flow technology reflect the characteristics of high efficiency and stability of the measured performance indicators. The following figure shows a schematic diagram of the AIBT through-flow blades.Figure2 shows a schematic diagram of the low-pressure cylinder through flow.

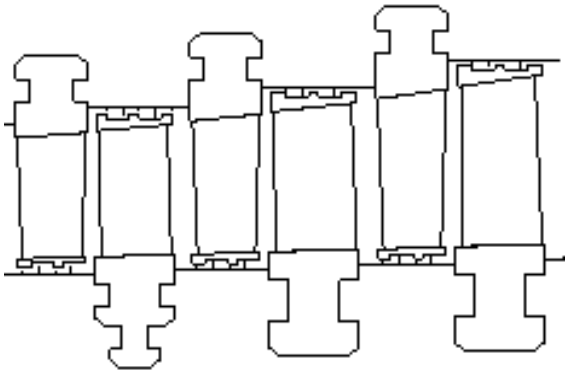


Figure 2. Schematic diagram of AIBT flux

2.2.2 Steam seal and radial steam seal of the low-pressure partition plate

Under the pure coagulation condition, the old rotor is used, and the moving blade will not be replaced. Therefore, the whole low pressure of the flow still adopts the original structural form. The low-pressure partition steam seal of the original unit is already a low-diameter steam seal. Therefore, the transformation of pure condensation condition of each gear blade and partition plate steam seal use the original structural form.

The heating conditions and the new through-flow size, the partition steam seal and radial steam seal are redesigned in the same structural form. Considering the heating condition of the unit, the low pressure inside and the outer cylinder of the unit due to the rising exhaust temperature to avoid the static parts caused by the lifting of the cylinder body, the low pressure partition steam seal and the radial steam seal are elliptical. After the sealing clearance is set according to the calculation results of the low pressure external cylinder deformation and considering a certain safety residual clearance, the elliptical sealing clearance is adjusted on the basis of the original gap.

3. Reconstruction and key technology of steam turbine of feed water pump

Keep the foundation of the original unit unchanged, and change the steam source switching mode from external switch to internal switch. At the same time, to adapt to the heating load change, in order to conduct the transformation of wide back load. The cylinder, rotor, blade and steam distribution mechanism of the unit are all replaced, and the seat frame, front bearing seat, front bearing and coil device all benefit the old original unit.

Since the main engine is a wet and cold unit, the feed supply pump small machine needs to operate within a large variable condition (back pressure 5.9kPa~55kPa). It should not only ensure sufficient steam intake capacity and the safety of the blades, but also take into account the economy of pure condensation conditions and heating conditions. Due to the large difference in pure condensation conditions and heat supply conditions, the cylinder efficiency should be guaranteed at the same time. Therefore, it brings great challenges to the adjustment level design and long leaf selection.

The steam turbine adopts advanced technology in its design: Two sets of high and low pressure can be used in the power supply pump and the four steam intake is insufficient to meet the power consumption; automatically switch in the main engine accident condition; have sufficient power surplus; wide range of continuous operating speed change.

4. Transformation of condenser

4.1 Technical difficulties

After the heating transformation of high back pressure double rotor of this unit, its condenser shall be reformed, the internal pipe plate and heat exchange pipe bundle shall be replaced, and the condenser shall be redesigned and installed according to the new back pressure and steam exhaust temperature. The condenser can meet the operation requirements of high back pressure of the unit in the aspects of water chamber pressure, pipe bundle and shell expansion, and transform the condenser cooling water pipeline and heat network circulating water pipeline to make the condenser cooling water system and heat network circulating water system flexible and reliable to meet the operation of unit heating and non-heating conditions [5].

4.2 Analysis of the design conditions and the main implementation contents of the condenser transformation

On the premise of realizing the heating period and the non-heating period, the safety of the condenser equipment and the non-heating period ensures the economy of the condenser equipment. In order to realize the high back pressure scheme of low pressure cylinder, the heating period of steam turbine is required to operate under high back pressure, that is, the operating back pressure is 54kPa and the exhaust temperature of steam turbine is about 83℃.Under the pure condensate condition, the condenser circulating water comes from the outlet water of the cooling water tower. The design temperature of the circulating water entering the condenser is 20℃, and the design pressure of the condenser water side is 0.6MPa.

During the heating period, the condenser circulating water comes from the heat net backwater, and the heat net backwater temperature entering the condenser is about 50℃. Raise the heat net circulating water backwater temperature from 50℃ to 80℃.

Since the working conditions of the condenser change greatly at high back pressure, considering the thermal expansion in the vertical and horizontal direction of the condenser and the equipment pipeline connected to the condenser, the pipe bundle expansion section between the condenser steam side housing and the front pipe plate, the sliding support support in the rear water room, and the circulating water inlet and outlet pipeline. Other optimization schemes to prevent thermal creep and thermal expansion. Such as prevent the expansion of the thermal expansion uneven and uneven.

5. Conclusion

High back pressure operation conditions: circulating water return pressure is 1.0MPa, temperature about 50℃, back pressure 54kPa, outlet temperature about 80℃; water volume 13700t / h.

Design conditions: design pressure of condenser 1.0MPa, test pressure 1.3MPa, temperature 100℃ and up to 120℃.

Under heating conditions: expansion joints should be added to the shell to prevent the weld cracking of the heat exchange pipe and pipe plate. There is an average temperature difference of

15 ℃to 20 ℃ between the shell and the heat exchange tube, which causes a large thermal expansion difference. The expansion difference between the shell volume and the tube line due to the temperature difference is 3mm, which is about 3 times the condensation condition.

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