Diagnosis and Analysis of Thermal Power Plant Operation in Heating Season

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Abstract: In order to further improve the operation level of the thermal power units of the provincial grid thermal power plant, optimize the data quality of the online monitoring system of the provincial thermal power units, through the diagnosis and analysis of the operation data of the thermal power online monitoring system, and from an all-round perspective, analyze and evaluate the peak shaving and frequency modulation capabilities of the heat supply units of the thermal power plant from the aspects of the load carrying capacity of the heat supply units, the optimization of the startup mode of the whole plant, and the heating capacity, to provide support for the accurate scheduling of the heat supply units. This paper analyzes the heat supply, peak regulation and frequency regulation capacity of the whole thermal power plant through the operation data, draws the peak regulation interval and heat supply capacity interval, and provides support for the optimal operation of the whole plant.

key word: Thermal power plant, Heating capacity, Peak shaving capacity, diagnostic analysisg

1. Introduction

In order to further improve the operation level of the thermal power units of the provincial grid thermal power plant, optimize the data quality of the online monitoring system of the provincial thermal power units, through the diagnosis and analysis of the operation data of the thermal power online monitoring system, and from an all-round perspective, analyze and evaluate the peak shaving and frequency modulation capabilities of the heat supply units of the thermal power plant from the aspects of the load carrying capacity of the heat supply units, the optimization of the startup mode of the whole plant, and the heating capacity, to provide support for the accurate scheduling of the heat supply units.[1-2] This paper analyzes the heat supply, peak regulation and frequency regulation capacity of the whole thermal power plant through the operation data, draws the peak regulation interval and heat supply capacity interval, and provides support for the optimal operation of the whole plant. [3]

2. Summary of Thermal Power Plant

There are 4 units in the thermal power plant, including # 4, # 5, # 6 and # 7 units, all of which are condensing units. The data quality of the thermoelectric system is good, and the parameters of the measuring points meet the requirements.

The No. 4 and No. 5 units in the second phase of the thermal power plant are 330MW subcritical, primary intermediate reheat, single shaft, double cylinder and double exhaust, reaction condensing steam turbines, with the model of C330-16.7/0.8/538/538. The No. 6 and No. 7 units in the third phase of the thermal power plant are the first million kilowatt units in the world to apply the secondary intermediate reheat technology. The steam turbine adopts the ultra supercritical secondary intermediate reheat condensing steam turbine, which is arranged in series with ultra-high pressure cylinder, high pressure cylinder, intermediate pressure cylinder and two low pressure cylinders. The parameter is 31MPa/600℃/620℃/620℃. The design index is about 1% higher than the world's best secondary reheat generator unit, and the generating efficiency of the unit is more than 47.95%, about 2.2% higher than the average efficiency of domestic conventional ultra supercritical primary reheat unit. Under BRL working condition, the boiler's thermal efficiency is guaranteed to be no less than 94.65%, and the steam turbine's heat consumption is guaranteed to be no less than 7051kJ/kWh, making it the most efficient thermal power generation unit in the world.

In 2020, the power generation will reach 9913 million kwh (including 4.314 billion kwh for Unit 6 and 5.599

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billion kwh for Unit 7), the accumulated utilization hours will be 4812 hours, the auxiliary power consumption rate will be 2.74%, and the coal consumption for power supply will be 265.58g/kwh, reaching the level of national thermal power benchmark units.
In 2020, Unit 6 and Unit 7 have successively participated in in-depth peak shaving for 306 times. The peak shaving time is up to 1051 hours, 50-40% peak shaving time is 1022 hours, and 40-30% peak shaving time is 29 hours. The deep regulation output of the unit reaches 36% of the rated capacity.

2.1 Heating condition of thermal power plant

According to the design data, the maximum steam extraction flow of # 4 and # 5 units is 240t/h, and according to the operation data, the maximum steam extraction flow is 300t/h# 6. The rated steam extraction flow of # 7 unit is 350t/h, and the maximum steam extraction flow is 400t/h; In 2019, 1 million square meters of heating area will be added, and 60t/h of steam extraction will be added. The newly increased area must be brought by Phase II, so a 1 million unit must be opened. The heating return water in the whole phase has a connecting valve. Due to different pressures, for safety reasons, the heating return water will not be mixed and will return to each initial station. At present, 4 million square meters are undertaken in Phase I and 4.5 million square meters in Phase II. The steam extraction capacity of small units needs to reach 240 t/h, which has reached the rated steam extraction capacity of the unit. Theoretically, the heat supply can be operated in the middle period of one big and one small, but the load of 330MW unit is required to reach about 200MW.
The thermal power plant has a design heating area of 4.5 million square meters for high-temperature hot water, and 100 tons of industrial steam per hour. The actual heat supply capacity of high-temperature water is 6 million square meters. Due to the large leakage loss of the heat supply pipeline from the industrial steam supply to the hot urban area, the steam supply was stopped in 2014. In 2016, the industrial steam was supplied to industrial users within 3 kilometers around, with 35 tons/hour. High temperature water heating management mode is wholesale, and industrial steam management mode is self operated. In 2015-2016 heating season, the heating capacity of high temperature water is 1.1655 million GJ, and the heating area is 4.1 million square meters.

2.2 Industrial steam extraction system of thermal power plant

(1) Thermal system of high pressure industrial steam supply pipeline
The high pressure industrial steam supply pipe is connected to the primary reheat low temperature steam pipe and supplied to the user after temperature and pressure reduction. The desuperheating water for high-pressure industrial steam supply comes from the primary intermediate tap of the feed pump and is connected to the desuperheating and pressure reducer after pressure reduction. The electric shut-off valve, pneumatic control valve, manual shut-off valve, filter screen, check valve and flow measuring device shall be set on the desuperheating water pipeline in order of flow direction.
(2) Thermal system of low pressure industrial steam supply pipeline
There are two steam sources for the low-pressure industrial steam supply pipeline, which are respectively connected from the primary reheat low-temperature steam pipeline and the secondary reheat low-temperature steam pipeline. The desuperheating water for low pressure industrial steam is from the condensate pipe, connected from the condensate booster pump, and then connected to the desuperheating and pressure reducer after pressure reduction. The electric shut-off valve, pneumatic control valve, manual shut-off valve, filter screen, check valve and flow measuring device shall be set on the desuperheating water pipeline in order of flow direction.

2.3 Description of heat supply calculation

The thermal power plant uses industrial extraction flow and heating extraction flow to calculate heat supply. The calculation formula of all units is the same, so it will not be repeated here. The calculation formula of # 4 unit is as follows:
#Heating and heating capacity of unit 4=# 4 heating and steam extraction flow × (# 4 heating extraction enthalpy - # 4 heating extraction drainage enthalpy);
#Industrial heat supply of unit 4=# 4 industrial steam extraction flow 2 (cold standby) ×# 4 Industrial steam extraction enthalpy 2 (cold standby)+# 4 industrial steam extraction flow 1 (cold standby) ×# 4 Industrial extraction enthalpy 1 (cold reheat).

3. Thermal Power Plant Capacity Summary

3.1 Summary of heating capacity of thermal power plant

The statistics shall be carried out according to three stages of heating: initial stage, middle stage and final stage. Statistics of heat extraction capacity, heat supply capacity, thermoelectricity ratio, power generation capacity, power supply capacity, converted heating area and other indicators of a single unit and the whole plant, the converted heating area is calculated as 40W/m^2, and the above thermoelectricity parameters are calculated as per unit operating hours.
Statistics of residential heating capacity and heating area in the last three heating seasons of the thermal power plant: 2977722.51 GJ of residential heating capacity and 7062400 m^2 of residential heating area in the heating season from 2019 to 2020; In the heating season from 2020 to 2021, the residential heating capacity will be 3559045.76GJ, and the residential heating area will be 8.4411 million m^2; In the heating season 2021-2022, the annual residential heating capacity is 299982042GJ, and the residential heating area is 7114800 m^2. The thermoelectric data statistics are normal, and the heating area calculation conforms to the actual situation. According to the rated external heating capacity of the power plant, the alternative heating area of the unit is

analyzed, and the results are shown in Table 1. According to the report of the power plant that the rated heating steam extraction flow of one large and one small is 240t/h and 400t/h respectively, the alternative heating area margin of the thermal power plant is 17.7742 million m^2.

Tab 1 Analysis on heating area of thermal power plant

Thermal power plant	Rated heating steam extraction flow (t/h)	Rated heating area (10000 m^2)	Actual heating steam extraction flow(t/h)	Actual heating amount(GJ)	Actual heating area(10000 m^2)	Alternative heating area allowance (10000 m^2)
#4 Units	240	466.67	85.86	623981.68	147.99	318.68
#5 Units	240	466.67	65.90	445836.55	105.74	360.93
#6 Units	400	777.78	180.03	1393382.56	330.47	447.31
#7 Units	400	777.78	93.46	536619.63	127.27	650.51
Whole plant	1280	2488.90	365.90	2999820.42	711.48	1777.42

3.2 Analysis and summary of power load adjustment capacity of thermal power plant

During heating period, the adjustable output range of # 4 unit under heating and heating is 178.48MW~301.79MW, and the adjustable output range under comprehensive heating is 180.24MW~296.26MW.# 5. The adjustable output range of the unit under heating and heating is 173.03MW~296.77MW, and the adjustable output range under comprehensive heating is 175.48MW~289.13MW. # 6. The adjustable output range of the unit under heating and heating is 583.39MW~995.88MW, and the adjustable output range under comprehensive heating is 594.32MW~951.76MW.# 7. The adjustable output range of the unit under heating and heating is 614.28MW~1021.15MW, and the adjustable output range under comprehensive heating is 619.60MW~999.69MW.

Analysis of deep peak shaving and derating of thermal power plant units during heating period. See Table 2 for specific data.

Tab 2 Deep peak shaving and derating of thermal power plant units

Thermal power plant	**Unit rated capacity (MW)**	**Minimum output of unit (MW)**	**Minimum adjustable output of integrated heating (MW)**	**Maximum adjustable output of integrated heating (MW)**	**Whether it has the ability of deep tuning**	**Deep regulation load (MW)**	**Reduced output load (MW)**
#4 Units	330	165	180.24	296.26	no	0.00	33.74
#5 Units	330	165	175.48	289.13	no	0.00	40.87
#6 Units	1030	500	594.32	951.76	no	0.00	78.24
#7 Units	1030	500	619.60	999.69	no	0.00	30.31

4. Conclusion

(1) Through calculation, the residential heating area of the thermal power plant in the three heating seasons since 2019 is 7062400 m^2, 8441100 m2 and 7114800 m^2 respectively. At present, the designed heating area of the thermal power plant is 24.889 million m^2, and the margin of alternative heating area is 17.7742 million m^2.

(2) At the beginning, middle and end of the 2021-2022 heating season, the actual average heating flow for people's livelihood is 350.84t/h, 383.50t/h and 327.24t/h respectively, and the actual average industrial heating flow is 167.76t/h, 164.16t/h and 150.84t/h respectively.

(3) During heating period, the minimum adjustable output of Unit # 4 under comprehensive heating is 180.24MW, which does not have deep peak shaving capacity. The maximum adjustable output under comprehensive heating is 296.26MW, which reduces the rated output by 33.74 MW.# 5 The minimum adjustable output under comprehensive heating is 175.48MW, which does not have deep peak shaving capacity. The maximum adjustable output under comprehensive heating is 289.13MW, which reduces the rated output by 40.87 MW.#6 The minimum adjustable output under comprehensive heating is 594.32MW, which does not have deep peak shaving capacity. The maximum adjustable output under comprehensive heating is 951.76MW, which reduces the rated output by 78.24MW.# 7 The minimum adjustable output under comprehensive heat supply is 619.60MW, which does not have deep peak shaving capacity. The maximum adjustable output under comprehensive heat supply is 999.69MW, which reduces the rated output by 30.31MW.

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References

1. Shi Qingli, Wen SheJiao.Application of thermal test in thermal power plants [J]. Qinghai Electric Power, 2004, 23 (4): 4-10.
2. Weng Sicheng.Thermal performance test of SAIC 300MW steam turbine (Wangting Power Plant Unit 12) [J]. Shanghai Turbine, 1983 (01): 5-20.
3. Ji Ansen.Results and Analysis of Thermal Performance Test of Unit #12 in Wuhu Power Plant before Overhaul [J]. Anhui Electric Power Technical Information, 2000, 000 (002): 7-8.