

Research and Application of New Condensing Extraction Backpressure heating technology of 330 MW unit

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Abstract. This paper introduces the retrofit scheme of the New Condensing Extraction Backpressure heating technology, and the technology is recommend for use by comparing and analysing the combined heat and power system based on a 330MW unit retrofit. After improvement, the heating capacity has been Obvious improved, the generation power has been greatly reduced and the capacity of peak load regulation has been significantly improved, which can not only realize the thermoelectric decoupling, but also obtain the remarkable economic benefit.

1 Foreword

Cogeneration central heating is a way that can combine heat and electricity for heating. It gradually becomes the main heating method in Chinese cities because of its high efficiency in energy utilization^[1-3].

China's new energy is developing rapidly under the strong guidance of national policies. However, new energy generation is intermittent and random, there has been the problem of wind and light abandoning in recent years. Because of the less flexible power supply in the power structure, the high proportion of thermal power units, resulting in the lack of peak road regulation capacity. In particular, the heating units in thermal power units are constrained by thermoelectricity, and their capacity of peak load regulation is reduced during heating supply period. It further increases the system peak adjustment difficulty, causes the new energy consumption contradiction to become increasingly prominent. In order to improve the flexibility of thermal power units and improve the system's capacity of peak load regulation and new energy consumption capacity, this paper studies the New Condensing Extraction Backpressure heating technology. The results show that the technology can not only meet the demand of heating supply, but also solve the problem that the heating unit cannot deeply adjust the peak load during heating period^[4-8].

2 Introduction

The unit is a 330MW steam turbine. It produced by Nanjing steam turbine electric co., LTD., subcritical, intermediate reheat, two cylinders and two rows of steam, extraction steam condensing steam heating turbine, Model: N330/C275-16.67/0.4/537/537, maximum continuous output of 345.7MW, rated output of 330MW.

High pressure cylinder series: 1 regulation stage +9 pressure stage; Intermediate pressure cylinder series: 8 pressure level; Series of low-pressure cylinder: 2×5 pressure stage, 28 stages in total. Medium pressure cylinder exhaust steam extraction for heating, rated steam extraction capacity 330t/h, pressure 0.40MPa (a), up to 270.6MW electric load; At the maximum heating extraction capacity (450t/h), the unit can have a maximum electric load of 248.2MW.

The unit has a maximum heating extraction of 450t/h and a maximum heating load of 320MW, converted to 1152GJ/h.

3 Heating retrofitting technology

The combined heat and power system is the simultaneous production of electric energy and useful thermal energy from the same energy source, which is a kind of "cascade utilization" of energy^[9]. From the perspective of maximum energy utilization, making full use of cold end heat for heating will greatly improve energy utilization efficiency. There are several technical routes as follows: Absorption heat pump technology, high back pressure heating technology, Rotor bladeless heating technology, New Condensing Extraction Backpressure heating technology.

3.1 Absorption heat pump technology

The recovery of exhaust steam and waste heat in power plants can be achieved by using absorption heat pumps, usually heat-increasing absorption heat pumps, working medium is lithium bromide solution, driven by high-quality steam, to extract heat from waste heat source with lower temperature, and to heat circulating water in heating supply network, so as to improve energy utilization efficiency^[10].

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The operation mode of the heat pump is simple and flexible, which has little influence on the output of the unit. The waste heat of circulating water cannot be fully utilized when the heat load at the beginning and end in the heating season because of the lower thermal load. Part of the circulating water can still be cooled on the cooling tower, and the power supply is not limited by the amount of heat, It improves the security of heating by add a heat source. However, the absorption heat pump technology also has some disadvantages: it needs to build a new plant, covers a large area, the construction scope is large, the cycle is long, the investment is large and so on^[11-12].

3.2 High back pressure heating retrofitting technology

The high back pressure heating retrofitting technology refers to the technology that the exhaust pressure of the low pressure cylinder of the steam turbine after the improvement is greater than the design value, the back pressure range is 34~54kPa, and the temperature of the heat network water heated by the exhaust steam can reach 80°C, which is a technology that can fully use the exhaust steam waste heat of the low pressure cylinder in the heating season^[13]. The unit uses a low-pressure rotor with relatively reduced turbine maneuvering blade and turbine static blade series during heating period. The original design is equipped with pure condensing turbine rotor for non-heating period. The condenser operates at high back pressure during heating period and operates at low back pressure during non-heating period.

High back pressure steam turbine can realize zero loss of cold source of steam turbine, greatly improved heating capacity, and mature technology, good economic benefits, but the investment is large, which has great influence on the power generation of the unit, and the flexibility of the unit is poor. In addition, it needs to shut down twice a year to replace the rotor, so the maintenance workload is large, and the operation and maintenance costs are high.

3.3 Rotor bladeless heating technology

The rotor bladeless heating technology is to replacing the original low-pressure rotor with the rotor bladeless when the unit needs external heating, using an rotor bladeless to directly connect the medium pressure rotor and the generator rotor, and completely disconnecting the low-pressure cylinder. That is, all the medium pressure cylinder exhaust steam into the heating network. After the end of heating, replace the low-pressure rotor bladeless with the original low-pressure rotor, restore to the original design state of the pure condensing unit completely^[14].

After the steam turbine improvement, the heating capacity of the unit is increased, and the power generation is reduced. It also can participating in peak load regulation of power system in winter. However, this technology requires the unit to be shut down twice a year for rotor replacement, which results in a large amount of

maintenance work and high maintenance cost. Therefore, the unit is unable to generate more electricity in favorable period of heating season, and the unit is not flexible enough to adjust.

3.4 New Condensing Extraction Backpressure heating technology

The new condensing extraction backpressure heating technology is different from the condensing extraction backpressure heating technology with 3S clutch, which breaks through the traditional design concept of steam turbine industry in China. This technology can realize the flexible switching between low-pressure cylinder steam inlet and non-steam inlet through the newly installed fully sealed and zero-leakage hydraulic butterfly valve opening and closing of the connecting pipe of the Low pressure cylinder and medium pressure cylinder connection tube. At the same time, the cooling steam bypass system and the rear cylinder temperature monitoring and control system are installed The middle pressure cylinder exhaust steam almost all into the first heating network station and there is no steam going into the low pressure cylinder under the condition that the low-pressure cylinder rotor continues to turn and the whole shafting is always running at the same frequency. This technology greatly increases the heating capacity of the unit, and reduces the generating power, thus achieving the purpose of increasing the heating capacity and reducing the generating power of the unit at the same time.

This technology has a short construction period, less investment, and good flexibility of the unit. It can switch between extraction and New Condensing Extraction Backpressure conditions at any time according to the needs, which can not only increase the heating capacity of the unit, but also reduce the generating capacity of the unit, and the unit has a strong peak load regulation.

The above technical solutions have their own characteristics: Heat pump technology needs to build a new plant, the investment is large, time-consuming; High back pressure heating technology and Rotor bladeless heating technology need to replace the low-pressure cylinder rotor in heating season and open the cylinder twice a year, it reduced the safety of the unit.

4. Retrofit scheme for New Condensing Extraction Backpressure Heating technology

4.1 New Condensing Extraction Backpressure heating retrofit technology

The electric butterfly valve at the connecting pipe and the intermediate pressure cylinder and low pressure cylinder connecting pipe has been replaced by hydraulic control, that can be closed to zero completely sealed zero leakage valve.

Add low-pressure cylinder cooling steam pipeline system. The exhaust steam of the middle pressure

cylinder of the unit is adopted as the cooling steam source, and an appropriate amount of cooling steam is drawn from the heating extraction steam pipeline into the low-pressure cylinder. This extraction steam is used for taking away the heat of blast air inside the cylinder.

Improvement of low-pressure cylinder water spraying system: replace the valve set of the back cylinder water spraying system with a high-precision control valve set; At the same time, orifice flowmeter is installed to test the water spraying quantity during operation.

Add the temperature measuring point at the last stage rotor blade and the sub-last stage of low pressure cylinder: After the improvement of the unit, the steam temperature near the final stage blade needs to be monitored. It is suggested to install thermocouple for temperature monitoring after the last stage and sub-last stage.

Improvement of the first station in the heating supply network: According to the actual operation of the power plant, the first station in the heating supply network shall

be expanded after the New Condensing Extraction Backpressure Heating Retrofit. The first station shall be equipped with circulating pump, heater, condensate jar, drain pump and other equipment.

4.2 Heating capacity analysis

On the premise that the heating parameters of the unit remain unchanged, the unit is reformed. The rated heating extraction volume before the improvement is 330t/h, the maximum value is 450t/h; After the improvement, 656t/h steam is used for heating. Rated heating load before the improvement is 240MW, the maximum heating load is 320MW, converted to 1152GJ/h, after the improvement, the heating capacity is increased by about 150MW, converted to 540GJ/h and the maximum heating load is 470MW, converted to 1692GJ/h. A single unit can provide a maximum heating area of 11.75 million m², it added 3.75 million m² of heating space, as shown in Table 1.

Table.1 Analysis of heating capacity before/after improvement

Item	Unit	before improvement	after improvement
Maximum steam extraction volume	t/h	450	656
Heating extraction pressure	MPa	0.4	0.4
Heating extraction temperature	°C	245.7	245.7
Heat extraction enthalpy	kJ/kg	2956.5	2956.5
Hydrophobic pressure	MPa	0.07	0.07
Hydrophobic temperature	°C	90	90
Hydrophobic enthalpy	kJ/kg	376.97	376.97
Maximum heating capacity	MW	320	470
Maximum heating area	Million m ²	8	11.75
Increased heating	MW	150	
Increase heating area	Million m ²	3.75	

4.3 Capacity of peak load regulation analysis

The cooling steam flow of the low-pressure cylinder is greatly reduced, and the unit's thermoelectric ratio is greatly improved after the improvement of the New Condensing Extraction Backpressure Heating.

When the heating load is 135MW, 240MW and 360MW, the influences of boiler minimum output (Q_{min}), boiler rated output (Q_{nom}) and the New Condensing Extraction Backpressure (Q_{ncb}) improvement on the unit's capacity of peak load regulation are compared:

When the heating load is 135MW, the power generation under Q_{min} condition is 180.00MW; the power generated under Q_{nom} condition is 309.45MW; The power generation under Q_{ncb} condition is 115.45MW.

When the heating load is 240MW, the power generation under Q_{min} condition is 219.93MW; the power generated under Q_{nom} condition is 293.47MW;

The power generation under Q_{ncb} condition is 155.34MW.

When the heating load is 360MW, the power generation under Q_{min} condition is 263.77MW; the power generated under Q_{nom} condition is 275.21MW; the power generation under Q_{ncb} condition is 199.38MW.

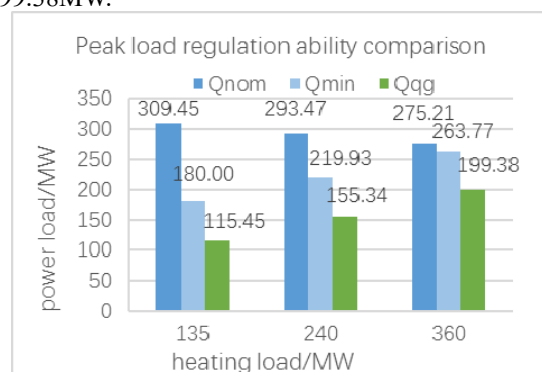


Fig.1 Capacity of peak load regulation before and after improvement

FIG. 1 shows the comparison of peak load regulation of units before and after improvement. Compared with the boiler's minimum output (Qmin) condition before the improvement, the new condensing extraction backpressure improvement can reduce the power generation by about 64MW under the condition that the external heating load remains unchanged, and significantly improve the unit's capacity of peak load regulation.

4.4 The economic analysis

The maximum heating capacity of unit was increased from 320MW to 470MW after the improvement. The maximum heating area is 11.75 million m², and the additional heating area is 3.75 million m².

After the improvement, the heating capacity of the unit can be increased by 1.939,800 GJ in the heating season, and the heating income can be increased by 87.933,200 yuan (including tax). After the improvement, the annual coal saving amount was 55,400 tons, and the coal saving income was 47.4299 million yuan (including tax). The coal consumption is 75,100 tons, the fuel cost is 64,361,900 yuan (including tax), the amount of water replenishment is 184,700 tons, the cost of replenishment is 1,633,200 yuan (including tax), the electricity consumption was 16,837,900 kWh and the electricity cost was 6,576,200 yuan (including tax) based on the standard coal consumption rate of 38.73kg/GJ. The calculation results are shown in Table 2.

Table.2 Economic analysis of New Condensing Extraction Backpressure heating retrofit

Item	Unit	value
added heating supply each year	million yuan/GJ	1.9398
Heat price (tax inclusive)	yuan/GJ	45.33
Revenue from heat sale (tax inclusive)	million yuan	87.9332
Save standard coal quantity every year	megatons	5.54
Unit price of standard coal (tax included)	yuan/ton	856.73
Coal revenue saving (tax inclusive)	million yuan	47.4290
The heating coal consumption	kg/GJ	38.73
added heating coal consumption each year	megatons	7.51
Unit price of standard coal (tax included)	yuan/t	856.73
Fuel cost (tax inclusive)	million yuan	64.3619
Annual water replenishment	megatons	18.47
Supplementary water price (including tax)	yuan/t	8.84
Supplementary water cost (tax included)	million yuan	1.6332
electricity power consumption rate for heating	kWh/GJ	8.68
electricity power consumption for heating	million kWh	16.8379
Feed-in tariff (including tax)	yuan/kWh	0.39
Electricity cost (tax inclusive)	million yuan	6.5762

The static investment of the reconstruction project

is 89.78 million yuan, the loan interest is 840,000 yuan during the construction period, and the dynamic investment is 90.62 million yuan, internal rate of return is 16.51%, investment payback period is 6.08 years, project capital internal rate of return is 22.61%, and the profitability is good.

5 Conclusion

This paper studies the feasibility of a New Condensing Extraction Backpressure heating technique with a 330mw unit. Through the comparison and analysis of several heating retrofitting technologies, the paper recommends the New Condensing Extraction Backpressure heating technology to retrofit the unit. This paper introduces the modification of the New Condensing Extraction Backpressure heating technique. At the same time, the heating capacity, peak shaving capacity and economy after the modification are analyzed. The results show that the New Condensing Extraction Backpressure heating technique is feasible for 330MW units.

1) The heating capacity of units has been improved after the improvement: the aximum heating capacity was increased from 320MW to 470MW, increased heating capacity by 150MW. The maximum heating area is 11.75 million m², and the additional heating area is 3.75 million m².

2) The unit can reduce the power generation under the condition that the external heating load remains unchanged, and significantly improve the unit's capacity of peak load regulation after improvement

3) The dynamic investment is 90.62 million yuan, internal rate of return is 16.51%, investment payback period is 6.08 years, project capital internal rate of return is 22.61%, and the profitability is good.

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