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Analysis of Energy-saving Upgrade and Technological Transformation of Sub-high Temperature and Sub-high Pressure Boilers

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Abstract

In the cogeneration industry, the upgrade and technological transformation of sub-high temperature and sub-high pressure boilers to high temperature and high pressure boilers represent the development direction of advanced technology and have become an important way to adjust the energy structure in recent years. This study elaborates on the situation analysis of high temperature and high pressure boilers after technological transformation based on the current status and existing problems of the cogeneration industry, which has certain theoretical value and practical promotion significance.

Keywords

Sub-high Temperature and Sub-high Pressure CFB Boiler; Energy Saving and Carbon Reduction; Near-zero Emissions.

1. Background

Central heating projects are industries prioritized for development by the state. They offer comprehensive benefits such as energy conservation, environmental improvement, and enhanced heating quality. They are one of the necessary means to control air pollution and improve energy utilization efficiency. As a public infrastructure to improve people's quality of life, they align with the national sustainable development strategy.

2. Company Status

The 75 t/h sub-high temperature and sub-high pressure circulating fluidized bed (CFB) boiler has been operating for over 20 years, resulting in frequent routine maintenance and reduced unit efficiency. It is difficult to meet the company's increasing heating load demand. Therefore, it is necessary to upgrade the existing sub-high temperature and sub-high pressure units. This upgrade is also essential for achieving a circular economy, improving resource utilization, protecting and improving the environment, and realizing sustainable development.

Starting in 2023, the existing sub-high temperature and sub-high pressure CFB boiler and its supporting units will be upgraded to a 75 t/h high temperature and high pressure unit using the original production plant. One set of boilers will be completed and commissioned in September 2024.

The technology adopted for the project mainly involves the combustion system, thermal system, power system, and environmental protection system, all employing advanced coal-fired cogeneration technology. Additionally, energy efficiency improvements will be made to the original CFB boiler, back-pressure steam turbine unit, induced fan, water supply pump, and supporting environmental protection treatment devices. Automated production will be

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achieved through set process parameters, significantly enhancing production efficiency and improving the overall energy utilization efficiency of the project. Production Process Diagram of High Temperature and High Pressure Thermal System After Technological Transformation is shown in Figure 1. Electrical Wiring Diagram of the Project is shown in Figure 2.

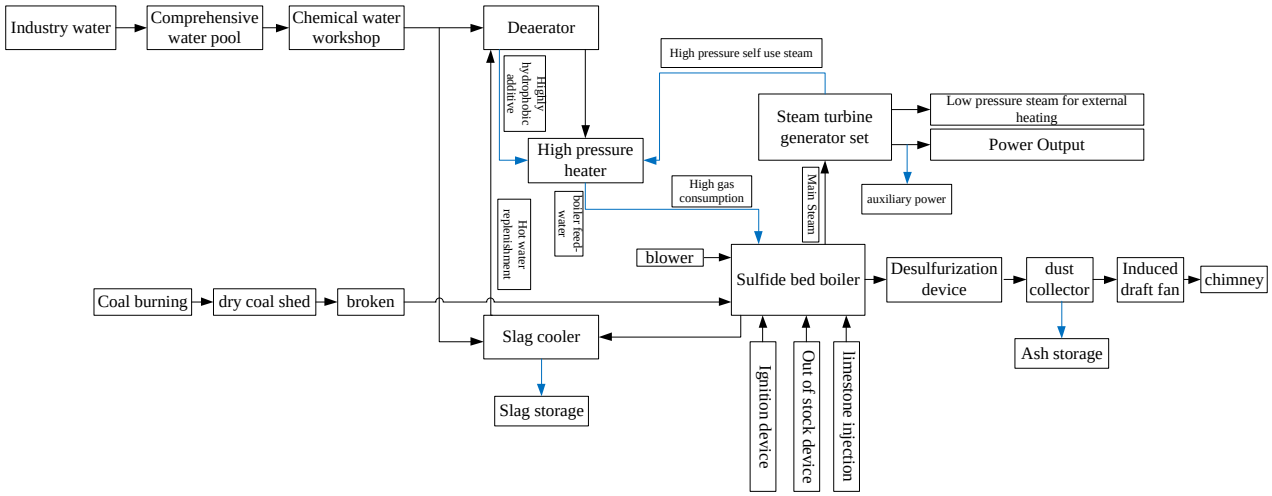

Figure 1 Production Process Diagram of High Temperature and High Pressure Thermal System After Technological Transformation

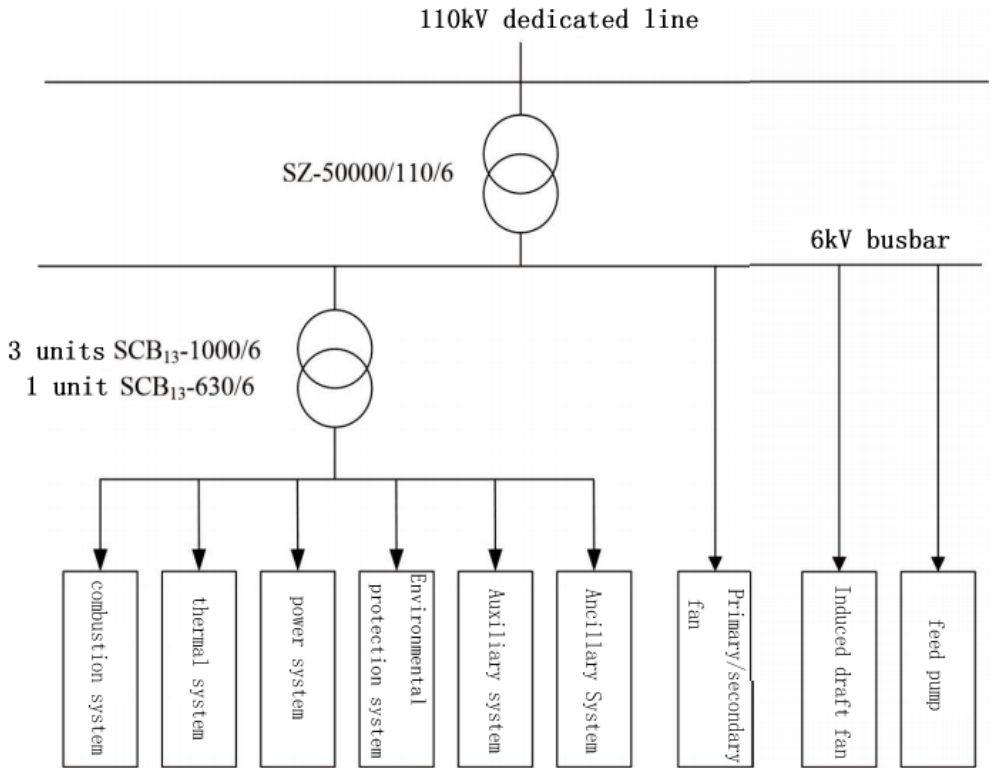

Figure 2 Electrical Wiring Diagram of the Project

Energy Consumption Table After Technological Transformation of the Project is shown in Table 1.

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Table 1 Energy Consumption Table

No	Project		Unit	Annual physical consumption	Equivalent value conversion scalar	Equivalent value conversion quantity
1	Supply of energy	Coal	t	41529	30146	30146
2		Diesel oil	t	12.5	18	18
3		New water	Ten thousand t	26	67.5	/
4		Subtotal	/	/	30231.5	30164
5	Energy production	Power supply capacity	ten thousand kWh	3154	3877	5263
6		Heating capacity	GJ	621445	21191	21191
7		Subtotal	/	/	25068	26454
8	Total		/	/	5163.5	3710

Note: Coal conversion factor: 0.7259 tce/t; Fresh water conversion factor: 2.571 tce/10,000 t; Electricity conversion factor: 1.229 tce/10,000 kWh (equivalent value), 1.6685 tce/10,000 kWh (equal value); Heat conversion factor: 0.0341 tce/GJ.

3. The goals achieved after the project

The goals achieved after the project implementation are analyzed as follows:

3.1. Energy Saving and Carbon Reduction Goals After Project Implementation

Through the implementation of the cogeneration energy-saving renovation project for the boiler and supporting equipment, the project adopts the process of CFB boiler + high temperature and high pressure back-pressure unit. By introducing advanced equipment, the stability of the process and equipment is further improved, thereby enhancing automation levels and energy utilization efficiency. It is estimated that after the technological transformation of the boiler system, 7791 tce can be saved, resulting in a reduction of 13358 t of CO2 emissions.

3.2. Economic, Environmental, and Social Benefits of the Project

1.According to preliminary calculations, while maintaining the same amount of coal consumption, each set of boiler units after the project transformation will annually reduce heat output by 4,207 t and increase electricity output by 16.91 million kWh. With an electricity price of 0.5058 yuan/kWh and a steam price of 220 yuan/t, the benefits of the transformed boiler and turbine system will be 7.63 million yuan.

2.Environmental and Social Benefits

This technological transformation is for the boiler upgrade project. Efficient environmental protection measures will be implemented for the proposed boiler to control pollutant emissions, with near-zero emissions as the control target. The emission concentration of soot will be controlled within 5 mg/Nm3, SO2 emission concentration within 35 mg/Nm3, and NOx emission concentration within 50 mg/Nm3, minimizing total environmental emissions and making significant contributions to urban emission reduction control.

Therefore, the construction of this project:

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(1) Can save production costs for enterprises. Emissions from coal-fired boilers are a major source of air pollution. The transformation can reduce coal consumption and pollutant emissions such as carbon dioxide, nitrogen oxides, particulate matter, etc. This helps improve air quality and reduce environmental damage. Furthermore, high temperature and high pressure coal-fired boilers emit fewer pollutants, reducing the operation and maintenance costs of environmental protection equipment.

(2) Can reduce energy waste. Sub-high temperature and sub-high pressure coal-fired units have lower energy efficiency. The transformation can improve the thermal efficiency of the units, thereby reducing energy consumption. This helps alleviate China's energy shortage.

(3) Can effectively reduce carbon dioxide emissions, mitigating global warming and sea-level rise caused by the greenhouse effect.

(4) Reduces energy consumption per unit of GDP. This project employs efficient and clean energy coal-fired cogeneration units, which significantly reduce the standard coal consumption for power generation and heating compared to separate power and heat production units. It also offers higher heating reliability and better thermal economy. The overall thermal efficiency of new cogeneration projects can reach over 80%, which is at least 25% higher than that of decentralized small coal-fired boilers and approximately 10% higher than that of current sub-high temperature and sub-high pressure units. Additionally, it saves significant land resources and reduces repeated investments in energy-consuming equipment, making a significant contribution to reducing regional energy consumption per unit of GDP.

The real-life project image is shown in Figure 3.

Figure 3 The real-life project

4. Conclusion

In summary, the application of high temperature and high pressure units in cogeneration effectively reduces energy losses, decreases atmospheric pollutant emissions, and significantly improves energy utilization efficiency. Based on the technological transformation of existing equipment, improving the energy-saving and emission-reduction technology of cogeneration

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parameters has very broad application prospects and can promote economic recycling and development.

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