

Automatic Control Design of Circulating Fluidized Bed Boiler

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ABSTRACT. With the continuous innovation of industrial technology, a kind of high-efficiency and low-pollution circulating fluidized bed boiler has been introduced through innovative research and development, and it has been widely used in power plants, and other industrial fields. Automatic control system has been one of the main factors that contribute to the development of circulating fluidized bed boiler, if automatic control system doesn't function well, the bed boiler can't work normally. And if there is no automatic control system in a bed boiler, it will result in an increase in machine wear and coal consumption. This article will introduce the structure and operating principle of circulating fluidized bed boiler, try to explore the design of automatic control system, and offer improvement measures.

KEYWORDS: Circulating fluidized bed, Automatic control system, Improvement measures, Structure, Operating principle

1. Introduction

With the continuous innovation of industrial technology, a kind of high-efficiency and low-pollution circulating fluidized bed boiler has been introduced through innovative research and development, and it has been widely used in power plants, and other industrial fields^[1]. Circulating fluidized bed boilers are of high efficiency and are more compatible with different kinds of coals. They are gradually replacing traditional boilers. However, if the wear problem cannot be solved, it will damage the safe, economical and efficient operation of circulating fluidized bed boiler. Therefore, increasing the improvement of the automatic control system of the circulating fluidized bed boiler has become a vital task in the current boiler industry.

2. Composition of Circulating Fluidized Bed Boiler

The circulating fluidized bed boiler is composed of two parts, the boiler body and auxiliary equipment, which in turn contain smaller units of equipment.

2.1 Boiler

mainly includes startup burner, air chamber, air distribution device, furnace, gas-solid separator, material return device, steam drum, downcomer, water wall, superheater, economizer, air preheater, etc.

Among them, the furnace is also called a fluidized bed combustion chamber. The combustion chamber is divided into two areas. The combustion process and desulfurization process are mainly completed in the combustion chamber. This equipment integrates heat exchanger, desulfurization, and fluidization processes. , Is the main body of the entire combustion system.

Some circulating vulcanization boilers also use external bed heat exchangers. This device mainly cools the separated materials, and then sends them to the boiler for combustion through the return device. This equipment can solve the problem of uneven heating surface in the circulating fluidized bed boiler bed. The temperature of the superheated steam can also be adjusted. In addition, the adaptability of the boiler to fuel is strengthened, and the metal consumption of the heating surface of the boiler is reduced.

2.2 Auxiliary Equipment

mainly includes blowers, induced draft fans, return air fans, crushers, coal feeders, slag coolers, dust collectors,

desulfurization and denitration equipment, chimneys, etc ^[2].

3. Structure of Circulating Fluidized Bed Boiler

The primary structural feature of the fluidized bed boiler is the material circulation system, which is composed of air distribution device, combustion chamber, gas-solid separator, return device, ignition device and other equipment, among them, the combustion chamber, separator and return device are regarded as the three core components of circulating fluidized bed boiler. Besides, they constitute the unique particle circulation circuit of the whole circulating fluidized bed boiler, making the circulating fluidized bed boiler distinctive from other boilers.

Circulating fluidized bed boiler is different from conventional boilers. Its combustion method is that the desulfurizing agent and fuel enter the furnace at the same time, and they are in a suspended state during the combustion process. This solid material also has strong mixing properties and can stay in the furnace for a relatively long time, ensuring the full progress of fuel combustion and desulfurization chemical reactions. This combustion method can save combustion raw materials, reduce operating costs, and is more in line with national standards for energy conservation and emission reduction.

In addition, this kind of boiler can burn a variety of fuels, waste tires, coal gangue, etc. can be fully burned in the circulating fluidized bed boiler, which strengthens the further use of resources. And the consumption of water in the combustion process is relatively small, which greatly saves our country's water resources. The internal structure of this kind of boiler is relatively reasonable, occupies less ground, and also saves our country's land resources. Circulating fluidized bed boilers have been greatly improved in terms of performance and structure. These technological advancements have marked the progress of China's thermal power generation technology and have greatly improved the technical level of China's power industry and machinery manufacturing industry.

4. Operating Principle of Circulating Fluidized Bed Boiler

After the crusher breaks the fuel to suitable size, the fuel will be fed from the upper position of the air plate into the combustion chamber through the coal feeder, and the fuel will be mixed with the boiling material in the combustion chamber, under the high temperature, the fuel will be quickly ignited and burned. After combustion, with the high-speed air flow, a large number of small solid particles will fill the entire furnace, and then be taken out from the combustion chamber into the gas-solid separator. After been separated, the solid materials will be returned to the furnace for a second combustion.

The high-temperature flue gas from the separator passes through the back flue and exchanges heat with the convection heating surface, and then will be discharged from the chimney through the dust collector. The above-mentioned system that consists of coal, air and smoke is called the combustion system of the boiler, that is, the "furnace". On the other hand, the water is pumped into the economizer for preheating, then into the steam drum, and then into the downcomer and water wall. After heated and evaporated, the water returns to the steam drum. After the steam-water separation, the steam enters the superheater for heating, and then will be delivered to the user through the main steam pipeline. The above mentioned is a steam-water system, commonly known as "pot" ^[3].

5. Technical Features of Energy-Saving Fluidized Bed Boiler

5.1 Higher Thermal Efficiency

Thermal efficiency is the most critical technology for measuring circulating fluidized bed boilers, but there are many factors that affect thermal efficiency. Exhaust smoke loss, heat loss, etc. will have a certain impact on the thermal efficiency of the circulating fluidized bed boiler. The thermal efficiency of the circulating fluidized bed boiler can reach more than 88% (bituminous coal); the carbon content of the boiler fly ash is not more than 6% (bituminous coal); the carbon content of the bottom slag is not more than 2% (bituminous coal) ^[4].

5.2 Lower Power Consumption

This kind of boiler adopts the design of low bed pressure, low flow rate, and reasonable primary and secondary air ratio, thereby reducing the wind pressure requirements of the fan, and power consumption.

5.3 Stronger Capacity of Continuous Operation

The annual operation time of the boiler is not less than 8,000 hours; the continuous operation time of the boiler is not less than 7,000 hours.

6. Environmental Protection Features of Circulating Fluidized Bed Boiler

The current social and environmental problems are getting more and more serious. The circulating fluidized bed boiler implements the principle of sustainable development advocated by the country, strengthens the control of pollution during the combustion process, and greatly improves the environmental performance of the combustion process.

6.1 Low Sulfur Emissions.

Adjust the heating surface of the boiler to ensure that the combustion temperature of the furnace is between 860-880°C, which is the optimal temperature range for limestone desulfurization. Limestone powder is injected into the furnace, with an efficient separator, finer particles will be captured to ensure that limestone and flue gas are mixed and reacted multiple times, so as to achieve the highest utilization rate of limestone in the furnace, and to make sure that the desulfurization efficiency in the furnace is more than 90%; and after being processed by the external desulfurization tower, the original SO₂ emission will be below 35mg/Nm³.

6.2 Low Nitrogen Emissions

In this kind of boiler, the bed temperature is as low as 860-880°C; and the oxygen content is low, the oxygen content in the combustion process will be controlled at 3%; besides, air supply is strictly graded, the proportion of secondary air volume is increased by more than 50%, and the position of secondary air inlet is higher to ensure anoxic zone can be combusted in the furnace; the initial NO_x emission concentration of the boiler is not more than 100mg/Nm³; the SNCR denitration interface is reserved at the inlet of the separator; and there will be space for SCR equipment between the two groups of economizers in the rear flue; After passing denitration device, the final NO_x emission concentration of the boiler will not be more than 50mg/Nm³. Now in China, environmental protection requirements are strict, and the contradiction between coal combustion and environmental protection is becoming increasingly prominent, under this circumstance, Circulating fluidized bed boilers have become the first choice for new efficient combustion devices with low pollution.

7. Design of Automatic Control System of Circulating Fluidized Bed Boiler

At present, the level of science and technology in my country is constantly improving, and it has also been widely used in circulating fluidized bed boilers. The automatic control design strengthens the automatic operation efficiency of the circulating fluidized bed boiler, which further improves the boiler work efficiency. At the same time, automation can also ensure the personal safety of the staff to a large extent.

7.1 Design Ideas of Automatic Control System of Circulating Fluidized Bed Boiler

Only through technological transformation, can the intelligent automatic control of circulating fluidized bed boiler be realized. Through integration and intelligent upgrade, the traditional controller is combined with computer technology, communication technology and integrated data processing technology to improve the performance of the traditional controller, so that the automatic operation of the circulating fluidized bed boiler can be safer and more stable.

The intelligent automatic control system of the circulating fluidized bed boiler includes multiple modules, among which the main modules are CPU module, protection module, function module and display module. Multiple modules work together and complement each other, they can conduct real-time monitoring of boiler temperature, wear condition and other related data to complete data processing and transmission, so as to achieve boiler automation and protection.

7.2 Advantages of Intelligent Control of High-Voltage Switchgear

Intelligent control of high-voltage switchgear has been widely used in other industrial fields. The use of circulating fluidized bed boilers has strengthened the intelligent operation of this system and also improved the efficiency of this

system.

7.2.1 High Integration

In the intelligent automatic control devices of the circulating fluidized bed boiler, not only computer technology and communication technology are adopted, but also the more advanced digital technology is incorporated. Through the cooperation between multiple technologies, heat calculation, fault reporting, automatic protection, remote control, real-time monitoring, fault recording, and information transfer can be achieved. In this system, multiple technologies are integrated, and multiple functions are integrated. The highly integrated circulating fluidized bed boiler can finally become a highly intelligent one.

7.2.2 High Degree of Coordination

Under the design requirements of the designers, the intelligent automatic control device is transformed according to the operation of the boiler plant. In this way, a safe and reliable control program can be compiled and it can also be highly compatible with the factory's original power-off protection device. With the high degree of coordination between emerging technology and traditional technology, the result will be better than a single one. The intelligent control of computer-related software, together with the original high-temperature protection module, can produce a safe and reliable control system, and the safety and stability of the boiler can be maximized.

7.2.3 Simplification

Compared with the traditional control device, the intelligent automatic control device of the new circulating fluidized bed boiler is smaller and more intelligent. What's more, the application of computer technology has greatly improved the intelligence, and the operation and control of the switchgear have become very simple [5]. Through the application of the automatic control system, the original human monitoring, inspection and protection processes can all be replaced by machines, which can not only spare a lot of human efforts and material resources, but also can play a more reliable and safer function as a whole.

The electronic technology monitoring system can analyze the status of the boiler in real time, and can transmit the data back to the master control center to provide relevant professionals so that the relevant personnel can find the problems inside the boiler and solve them in time to reduce the boiler operation. Security risks.

8. Prospects of Automatic Control Technology of Circulating Fluidized Bed Boiler

Nowadays, in China, the automatic control system in circulating fluidized bed boiler mainly adopts CPU and single chip as the main components. However, the high-cost CPUs and single-chip microcomputers are not only inconvenient to the integration of control devices, but also have complicated circuits. So there will be some damages in the process of installation and use, causing unnecessary economic losses. Therefore, in order to realize the integration of the automatic control technology of the circulating fluidized bed boiler in China, the performance of the devices should be continuously optimized. Downsizing the devices can increase the degree of integration and reduce the costs so as to further increase the economic benefit. As the 5G mobile communication technology enjoys a rapid development in China, researchers can apply 5G technology to automatic control devices to realize the high efficiency and convenience of information transmission in products.

With the continuous improvement of my country's industrial level, the state has also strengthened its technical support and financial support for all walks of life, which has caused more and more people to invest in the development of this industry. It adds freshness and vitality to the boiler industry, thereby promoting the further improvement of my country's boiler industry technology and obtaining good economic and social benefits.

9. Conclusion

As early as the 1980s, foreign countries began to apply intelligent control devices in boilers. In recent years, with the development of computer technology and digital technology as well as the application of circulating fluidized bed boilers, the performance of the automatic control system has been greatly improved. China has gradually begun to pay attention to the research on the intelligent automatic control system of circulating fluidized bed boilers. Despite the late start, the research on boiler automatic control technology in China is still in its infancy, and there are still many problems in the specific operation process, which requires relevant personnel to step up the research on this technology, so that the circulating fluidized bed boiler can be used more widely In the manufacturing process of the local industry, with the continuous innovation of personnel and technology, this technology is bound to become more and more mature in China, which will provide more experience for the future boiler industry and promote China's industrial and

economic development. Lay a good foundation, promote this technology to go abroad, to the world, and greatly enhance China's international status in the world.

References

- [1] Li Junfeng, Zhao Jun. Automatic Control Design and Instrument Measuring Point of Circulating Fluidized Bed Boiler. *Urban Construction Theory Research (Electronic Version)*, No.18, PP.3945-3946, 2015.
- [2] Xie Tengeng. A Brief Discussion on the Instrument Selection Design of Circulating Fluidized Bed Boiler System. *Automation in Petro-chemical Industry*, Vol.52, No.2, PP.71-72, 74, 2016.
- [3] Chen Wei. Discussion on the Instrument Selection Design of Circulating Fluidized Bed Boiler System. *China Petroleum and Chemical Standard and Quality*, Vol.37, No.9, PP.116-118, 2017.
- [4] Liu Jianshuai. Design and Implementation of MCS Control Scheme for Small Circulating Fluidized Bed Boiler System. *Public Communication of Science & Technology*, No.13, PP.103-103, 136, 2014.
- [5] Zhang Bingwei. Research on DCS-based Energy-saving and Emission-reduction Automatic Control System of Circulating Fluidized Bed Boiler. *Automation and Instrumentation*, Vol.33, No.5, PP.35-39, 101, 2018.