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Boiler Combustion Adjustment and Economic Operation Affect Boiler Combustion Factors

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Abstract: Thermal power generation, as the most stable power output in China, plays a rather crucial role in the construction of China's economy. The most important power generation equipment of thermal power plant is the boiler, only good control of the boiler operation of the power plant, in order to better enable it to participate in the power generation work. Combined with the Linfen Thermal Power Co., Ltd. related boiler unit operation status, combustion adjustment optimisation content analysis, give the corresponding recommendations, so as to make the boiler operation more stable, safe, environmentally friendly, power plant power generation to make the corresponding contribution.

Keywords: Boiler; Combustion Adjustment; Economic Operation; Influencing Factors.

1. Introduction

It's crucial to maintain the optimal combustion load in thermal power plant boilers. By regulating and optimizing combustion, operators can achieve the ideal balance between fuel consumption and energy output. This ensures that the boiler operates efficiently, minimizing waste while generating stable heat[1-4]. Adjusting parameters such as air-fuel ratio and combustion chamber temperature helps increase the combustion rate of boiler fuel, ensuring it matches the plant's energy demand. Effective combustion regulation is vital for the safe operation of thermal power plants. By optimizing combustion, operators stabilize boiler equipment voltage and maintain combustion temperatures within standard parameters. This stability is essential for preventing equipment failures and ensuring a consistent power supply, safeguarding both plant personnel and assets. Optimizing combustion leads to efficient and stable boiler operation. By fine-tuning combustion processes, operators can ensure that the boiler functions seamlessly with the rest of the power plant[5-8]. This enables the boiler to respond effectively to changes in demand, maintain consistent steam production, and operate efficiently across various operating conditions. Additionally, stable combustion reduces maintenance downtime and extends the lifespan of boiler components, enhancing overall plant performance and reliability.

2. Factors Affecting Combustion in the Boiler

2.1. Fuel Properties

Different types of fuels have different burning rates and stability. For example, some fuels may burn at a faster rate, while others may take longer to burn. Understanding the combustion characteristics of a fuel can help to adjust the fuel supply and air ratio to ensure adequate and stable combustion. The combustion temperature and calorific value of the fuel directly affects the amount of heat and energy efficiency produced by the boiler. Higher calorific value fuels provide more heat, thus increasing the thermal efficiency of the boiler. The control of combustion temperature is also an important factor in ensuring combustion efficiency and safe operation of the boiler. The ash content and ashing characteristics of the fuel affect the performance of the fuel during combustion. Fuel with high ash content may lead to burner fouling and boiler tube clogging, reducing the heat transfer efficiency of the system and increasing the cost of equipment maintenance. The volatile content of the fuel affects the combustion performance of the fuel and the characteristics of the flue gas produced during combustion. High volatile content fuels may result in increased VOC content in the flue gas, affecting compliance with environmental emission standards. The water content of the fuel directly affects the heat release and combustion efficiency during the combustion process. Excessive moisture content can result in more heat being consumed to evaporate the water during combustion, reducing the actual heat output [9-12].

2.2. Air Supply

The mixing ratio of air to fuel is an important factor affecting combustion efficiency. Insufficient air supply results in incomplete combustion of the fuel, generating large amounts of incomplete combustion products, as well as lower combustion temperatures and increased energy losses. Too much air supply will lead to excess air, which will also reduce the combustion temperature and combustion efficiency and increase emissions. Therefore, the correct adjustment of the air-fuel ratio is the key to ensuring the combustion efficiency and environmental friendliness of the boiler.

Combustion temperature can be raised and combustion efficiency increased by preheating air. Preheating the air reduces the loss of the fuel's own heat used to heat the air, increases the amount of heat released during combustion, and reduces fuel consumption, increasing the energy efficiency of the boiler.

The concentration and distribution of oxygen in the air supply also affects combustion. Reasonable distribution of oxygen allows the fuel to burn fully and avoids the generation of incomplete combustion products. Especially during the combustion process, the distribution of oxygen should be uniform to ensure that combustion can be carried out adequately throughout the entire combustion area.

Proper air supply ensures the stability of the combustion process. Insufficient or uneven gas supply can lead to unstable

combustion, or even combustion misfire or combustion oscillation and other phenomena, affecting the operational safety and stability of the boiler.

The control of gas supply also directly affects the combustion temperature and emission control. Through reasonable gas supply control, the combustion temperature can be controlled within the appropriate range, to avoid excessive temperature caused by fuel burning and equipment damage, but also can effectively control the generation of emissions and emission concentration, to ensure environmental protection requirements [13-16].

2.3. Combustion Equipment Design and Operating Parameters

The burner is the key equipment for mixing and igniting the fuel and air, and its design directly affects the combustion efficiency and stability. Burner design should take into account factors such as fuel type, combustion chamber structure, and gas flow conditions in order to achieve adequate mixing and complete combustion. Different types of fuel and boiler types may require different burner designs. The structure of the combustion chamber affects the stability of fuel combustion and heat transfer efficiency. A proper combustion chamber design should provide sufficient space for adequate mixing and combustion of fuel and air, as well as good heat transfer and heat rejection to maximise thermal efficiency.

Operating parameters such as gas supply, air pressure, combustion temperature, etc. directly affect the combustion effect. By adjusting these parameters, the stability and efficiency of the combustion process can be controlled. For example, increasing the air supply can increase the combustion rate of the fuel, but you need to make sure that it does not lead to excess air, which would reduce the combustion efficiency. Combustion temperature is one of the most important parameters affecting combustion efficiency and emissions. By controlling the temperature in the combustion chamber, adequate combustion of the fuel and control of emissions can be achieved. Proper combustion temperature ensures adequate combustion of the fuel and also reduces the generation of harmful substances such as NOx. Maintenance and cleaning of the combustion equipment also has a significant impact on combustion performance. Regular cleaning and maintenance of the burner can keep it in good working condition and avoid unstable combustion and reduced efficiency.

2.4. Combustion Control System

The combustion control system ensures combustion stability by monitoring and adjusting key parameters in the combustion process, such as fuel supply, air supply, combustion temperature and so on. By precisely controlling the supply of fuel and air, the combustion control system can keep the combustion process running smoothly, avoiding problems such as insufficient combustion and combustion misfire, and ensuring the safe and stable operation of the boiler.

The optimised design of the combustion control system can improve the combustion efficiency. Through real-time monitoring and adjustment of combustion parameters, such as air-fuel ratio, combustion temperature, etc., the combustion control system can make the fuel fully combusted to maximise the release of heat energy, thus improving the energy efficiency of the boiler.

Combustion control systems also have a significant impact on environmental emissions. By controlling key parameters in the combustion process, such as combustion temperature and oxygen supply, the combustion control system can effectively reduce the generation and concentration of emissions, protect the environment and meet the environmental requirements.

Combustion control systems usually have automated control functions, which can realise the automatic monitoring and adjustment of the combustion process. This can reduce manual intervention, improve operational efficiency, and also avoid the safety hazards caused by human error.

Combustion control systems usually also have troubleshooting and maintenance functions, which can timely detect and alarm abnormalities in the combustion process. By monitoring and analysing the status of the equipment, the combustion control system can give early warning and guide the maintenance personnel to carry out repair and maintenance to ensure the reliable operation of the equipment.

2.5. Operation and Maintenance

Proper operation and regular maintenance can ensure the stability and efficiency of the boiler combustion process. Regular cleaning of equipment components such as burners, combustion chambers and boiler pipework, as well as adjustment of combustion parameters, can keep the combustion process adequate and stable, improve combustion efficiency and reduce energy waste.

Proper operation and timely maintenance can ensure the safe operation of the boiler. Regularly check the operating status of the boiler equipment, find and remove potential safety hazards, repair equipment failures in a timely manner, and ensure that the operation of the equipment complies with safety standards and regulations in order to prevent accidents and personal injury.

Good operation and maintenance can reduce boiler emissions and reduce pollution to the environment. Regular cleaning of combustion equipment and flue gas treatment equipment, timely replacement of damaged parts, as well as the adjustment of combustion parameters, all help to reduce the generation of emissions and emission concentrations, and protect the environment.

Reasonable operation and regular maintenance can extend the life of boiler equipment and improve its reliability. Regularly checking the operating status of the equipment, preventing wear and corrosion of the equipment, and timely replacement of aging parts all help to extend the life of the equipment, reduce the equipment failure rate, reduce downtime, and improve the reliability of the equipment operation.

Good operation and maintenance can reduce the operating costs of the boiler and improve its economic efficiency. By improving combustion efficiency, reducing energy consumption, and reducing the number of repairs and downtime, the operating costs of the boiler can be reduced and the economic efficiency of the equipment can be improved.

2.6. Environmental Factors

Atmospheric temperature, humidity, high altitude and other environmental factors will also affect the effect of boiler combustion. Under extreme environmental conditions, the combustion parameters need to be adjusted accordingly to adapt to changes in the external environment. Atmospheric

conditions, such as temperature, humidity and oxygen content, directly affect the oxygen supply and fuel combustion efficiency during boiler combustion. At high altitudes, thin air and low oxygen content may lead to inadequate combustion; while in humid environments, fuel combustion requires more heat to evaporate water, affecting combustion efficiency.

Climatic conditions can also affect the selection and availability of available fuels. In cold climates, the mobility of some liquid fuels may be limited, increasing the need for solid fuels. In humid climates, some fuels may need to be pretreated to improve combustion performance.

Regional environmental emission standards and regulations impose stringent requirements on boiler combustion technology selection and operation management. In some regions, emission standards for coal-fired boilers are getting higher and higher, which promotes the upgrading and transformation of boiler combustion technology, such as the use of more advanced combustion control systems, desulphurisation, denitrification and other technologies to reduce emissions.

Environmental factors can also affect fuel supply and costs. For example, climatic conditions have an impact on the placement and transport of natural gas pipelines, while the cost of natural gas is also affected by climatic conditions and geographical factors. In addition, the utilisation of renewable energy sources such as wind and solar power is constrained by local climatic conditions, which also have an impact on the choice of boiler fuel and how it is used.

3. Control Measures

3.1. Influence of Thermal Calculation Results

The accuracy of thermal calculation results directly affects the reliability of system design and operation. If the thermal calculation results are inaccurate, it may lead to system design deviation, operation abnormality or performance degradation, thus affecting the stability and reliability of the system; the thermal calculation results are directly related to the efficiency of energy utilisation. Through accurate thermal calculations, the energy flow and conversion process of the system can be determined, thus identifying potential problems in energy use and directions for improvement. Effective thermal calculation results can help optimise system design and operation, and achieve energy saving and energy efficiency; thermal calculation results also have an important impact on environmental protection. Reasonable thermal calculations can help assess the emissions and environmental impacts of the system, so that corresponding measures can be taken to reduce emissions and environmental pollution, and achieve the goal of sustainable development; the results of thermal calculations are also directly related to the costs and benefits of the system. Reasonable thermal calculation can assess the investment cost and operation cost of the system, thus providing decision makers with scientific basis and economic benefit analysis [17-20].

In the real thermal power plant boiler combustion operation, scientific boiler combustion optimisation and adjustment experiments can find the most reasonable wind-coal ratio, determine the optimal operating parameters that should be set for the boiler combustion equipment in the experiments, and at the same time formulate a reasonable and scientific computer control curve, so that the control curve can be used to guide the operation and operation of the boiler combustion. In the process of the experiment, the professionals have to ensure a large number of orthogonal experiments and single-factor experiments, and this kind of adjustment experiment consumes a lot of time and energy, so this kind of experiment is generally applied in the trial operation of new units, combustion equipments of old units, types of fuels used, and the operation mode of the units and so on.

3.2. Adjust the Air Supply Capacity of the Boiler for Combustion

In order to enhance the market competitiveness, so that the thermal power plants can better base on the market, the boiler combustion air supply should be adjusted according to the actual situation, in the process of optimizing the air supply can be scientifically optimized boiler combustion, the actual need to be changed from the following points. First of all, we should give full play to the initiative of the staff, so that they can do a good job in the management work, effectively control the boiler combustion system, and timely observe the existing problems. For example, when the air supply is more, it is easy to appear coking problems. If the air supply is not well controlled, it is easy to cause the problem of low boiler combustion efficiency. Therefore, the coking problem can be prevented through the control of the air supply volume. Secondly, scientific and reasonable schemes should be designed to effectively adjust the air supply volume to ensure the stable operation of the system and prevent the emergence of problems.

3.3. Do well in the Water Quality Treatment and Waste Heat Utilization of Operating Boilers

Through the water quality purification equipment and the boiler water preheating system under the premise of waste heat application to form a reasonable management of water quality. On the one hand, the impurities in the water are removed by water purification, which sharply reduces the possibility of hardening in the furnace; on the other hand, the preheating of the water is formed by double backup container, and the hard water ions such as calcium and magnesium in the water are effectively settled, and then the water is injected into the furnace. This way objectively guarantees the boiler water in the maintenance process, and does not affect the heat conduction waste produced in the boiler water-mediated heating process. In the application of furnace temperature and waste heat, it is necessary to form a good insulation and thermal radiation management of the external wall of the boiler, and to use the internal wall combustion and cooling water internal circulation as far as possible to improve the application of the waste heat of the furnace body. The residual temperature collected through this model can be incorporated into the flue residual temperature for unified application.

3.4. Reduce Smoke Exhaust Loss

In the combustion process of thermal power plant, the heat loss of smoke exhaust should be optimized. The staff can find and control the air leakage problem through strict maintenance, and find the cause of air leakage. First, the oxygen content of smoke exhaust should be analyzed, and the corresponding data should be collected for the boiler operation. After finishing the soot blowing operation, check the soot blowing gun in time to ensure that it reaches the ideal site. For the whole furnace should also be done well in the relevant operation, to ensure that each link of the equipment is in the sealing situation, to avoid air leakage problems.

Relevant staff to check the empty preheater, to clean up in time. In the case of ensuring no relevant chemical residue, rinse with water, and then dry with drying equipment. In this process, we should avoid the existence of ash scale in the heat storage layer. The ash blowing operation of the boiler furnace and the heating surface should also be optimized and carried out regularly and regularly according to the different loads to provide guarantee for the stable combustion of the boiler.

3.5. Maintain a Stable Boiler Load

The stability of boiler load is the key to discuss the waste heat recovery system above. In the waste heat recovery system, the boiler load is linear with the waste heat generation, and the waste heat recovery, especially the application process, is basically constant. This requires benign compliance in the process of boiler design and debugging, and find the maximum utilization balance point. Based on this, in the process of boiler management to avoid frequent start and stop, combined with the actual boiler operation of the boiler load stability control in the range of about 80% of the range can play a better operation effect.

3.6. Adjust the Boiler Combustion Capacity Control

To optimize the combustion operation of the power plant boiler, firstly, the amount of fuel should be reasonably controlled, and the coal supply in the boiler furnace should be adjusted based on the load change of the generator set. In the fuel volume control system, the use amount of pulverized coal should be adjusted and controlled according to the change of primary air supply volume to ensure that the boiler combustion efficiency can be improved. Secondly, the measurement monitoring points should be set up reasonably, and scientific coal monitoring means should be adopted to obtain reliable and accurate real-time monitoring data. After timely feedback of these data is fed back, the operation control system can be optimized and adjusted, the coal quantity can be predicted and the coal supply can be controlled according to the predicted results.

4. Conclusion

The boiler combustion optimization of thermal power plant is a very complex system engineering. At present, under the joint efforts of electric workers at all levels, the boiler combustion technology is improving, the boiler combustion efficiency is constantly improved, and its safety and stability are not upgraded. However, as the national attention to environmental protection and electric power company to profit requirements, combustion optimization technology still has a deep mining potential, there are still many combustion optimization problems to be solved, boiler combustion system optimization technology for boiler safety, high efficiency and low pollution operation has an important role, for energy sustainable development, environmental protection is of great significance.

References

[1] Pronobis, Marek;Wejkowski, Robert;Kalisz, Sylwester; Ciukaj, Szymon. Conversion of a pulverized coal boiler into a torrefied biomass boiler. [J]. Energy, 2023, Vol.262: 125442.

[2] Demir, Yunus.An iterated greedy algorithm for the planning of yarn-dyeing boilers[J]. International Transactions in Operational Research,2024,Vol.31(1): 115-139.

[3] Yuliia Shyshko; Anatolii Cherniavskyi; Daria Shyshko; Olena Borychenko; Artur Zaporozhets; Ievgen Zaitsev. Increasing the Efficiency of Loading Devices for Biomass Boilers[J]. Energies, 2024,Vol.17(3): 590.

[4] Niraj Kakade;Aditya Mani; Chetan Bhatkar; Paresh Chaudhari; Rachit Roshan. A Study on Modification of Boiler Chimney against Fouling to Enhance The Efficiency of Boiler <img src= "https:// ijtonline. com/Images/ GoogleScholar.png">[J]. International Journal of Technology, 2023,Vol.13(1): 22-24.

[5] Adrian Marx;Dennis Hülsbruch;Andreas Müller;Bernd Epple;Falk Ewert;Jens Peitan.Online corrosion monitoring in industrial boilers [J].Thermal Science and Engineering Progress, 2023,Vol.43: 102009.

[6] Sarah Foster.Boiler System[J].ASHRAE Journal,2021, Vol.63 (3): 67.

[7] Nowling, Una.Marnie and Maya and the Case of the Strangled Boiler.[J].Power,2023,Vol.167(11): 31-33.

[8] Boiler Suit at Guy's Hospital[J].Northern Logger and Timber Processor,2023,(630): 40-43.

[9] Domby, Stefan.Boiler Room Confessions: Back on Campus. [J]. Engineered Systems,2023,Vol.40(4): 26.

[10] Sarah Foster.Combi-Boiler[J].ASHRAE Journal,2021, Vol.63 (3): 70.

[11] Drew Robb.VALMET BIOMASS BOILER FOR JAPAN [J]. Turbomachinery International,2022,Vol.63(1): 9.

[12] Xinyu Ning;Lei Han;Jian Huang;Haoxuan Ding; Bin Li; Lei Deng; Yiguo Li.Coupled modeling of combustion and hydrodynamics for a 600 MW Bunsen-type boiler[J].Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 2024,Vol.46(1): 262-274.

[13] BOILERS.[J].Plumbing & Mechanical,2023,Vol.41 (5):39.

[14] BINU KUMAR BHAGRIA;SIMRANJIT SINGH SIDHU; LALIT AHUJA and DEEPA MUDGAL.EFFECT OF BURNING BIO-MASS FUEL ON THE CORROSION PERFORMANCE OF STEELS IN THE 34.5MW BOILER [J]. Surface Review and Letters,2024,Vol.31(1): 2450004.

[15] Yan, Jingwen;Jin, Donghao;Liu, Xin;Zhang, Chaoqun;Wang, Heyang.A coupled combustion and hydrodynamic model for the prediction of waterwall tube overheating of supercritical boiler[J].Fuel,2023,Vol.334.

[16] Philip Brooke ;Martin Scales;Eric Guyer & …Mark Fecke.Metallurgical Case Studies of Early-in-Life Failures in Two Water-Tube Boilers[J]. Journal of Failure Analysis and Prevention,2023,Vol.23(1): 37-43.

[17] Kuldeep Kumar;Santosh Kumar & Harjot Singh Gill.Role of Surface Modification Techniques to Prevent Failure of Components Subjected to the Fireside of Boilers[J].Journal of Failure Analysis and Prevention,2023,Vol.23(1): 1-15.

[18] Jiaxin He;Junjiao Zhang;Lezhong Wang;Xiaoying Hu;Junjie Xue;Ying Zhao;Xiaoqiang Wang;Changqing Dong. Optimizing the Controlling Parameters of a Biomass Boiler Based on Big Data[J].Energies,2023,Vol.16(23): 7783.

[19] Mann, Anthony;Plaza, Floren;Alam, Nazmul;Ryan, Kelly. Reducing boiler maintenance costs with improved materials for air-heater tubes[J]. Zuckerindustrie, 2023, Vol. 148(11): 684-690.

[20] Oishi, Kensuke;Fujii, Kenichi;Kondo, Yasushi.CFD SIMULATION AND FIELD MEASUREMENTS ON BOILER EFFICIENCY FOR DISTRICT HEATING AND COOLING [J].Journal of Environmental Engineering (Japan), 2023, Vol.88(811): 726-733.