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Analysis of Influence of Adjusting Air Distribution Mode on Boiler Combustion under Different Loads

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Abstract. In view of the main problems faced by power plants, many scholars in China have focused on the problem of distribution adjustment of secondary air. This paper also conducted research on the adjustment of secondary air distribution. In this paper, a 200MW four-corner tangential boiler of a power plant is taken as the research object, and the overall size of the boiler and the modification of the damper are clarified. The boiler is tested under different loads and different working conditions. Through the inverse balance calculation of boiler thermal efficiency on the SCR inlet NO_X analysis, the combination of numerical simulation and test method provides an important reference for the four-corner tangential boiler optimization and variable load operation in the future. At present, the domestic research on the numerical simulation of boiler combustion is mainly to change the different secondary air distribution methods. In this paper, the analysis of the effects of different number of tertiary air nozzles on the combustion of boilers under different loads is studied under the condition of equal secondary air.

1. Introduction

China is in the forefront of coal production and coal consumption [1]. In 2018, the country's total energy consumption was around 4.55 billion tons of standard coal, of which coal accounted for about 60% [2,3] .Therefore, thermal economy and pollution control of thermal power are still the top priority of the power industry. Many scholars at home and abroad are working on the simulation and experimental research of different air distribution methods for four-corner-cut boilers, and have achieved excellent research results. This paper takes a 200MW four-corner tangential boiler of a power plant as the research object for transformation. Firstly, the NO_X emission of the boiler before and after the transformation was compared. Then, the modified boiler was opened with different layers of tertiary air under different load conditions to simulate the thermal efficiency and NO_X emission of the boiler. The research results of this paper have certain theoretical guiding significance for the efficient and stable operation of power station boilers.

For the numerical simulation process of boiler pulverized coal combustion, numerical simulation analysis of boiler under different air distribution conditions, and boiler simulation research on reducing nitrogen oxides, a lot of research work has been done at home and abroad [4]. The main research work of this paper is the effect of different loads with different number of tertiary air nozzles on the thermal efficiency of four-corner tangential boilers and the emission of nitrogen oxides. In this paper, the boiler combustion simulation uses CFD software for numerical simulation analysis.

2. Boiler Introduction and Model Construction

Taking a DG670/13.7¬-19 boiler of a thermal power plant as the research object, which is the ultra-high pressure, natural circulation steam drum furnace, single furnace, one intermediate reheat, single-tube tubular structure, and four-corner tangential combustion method. The intermediate storage hot air feeding system is adopted.

2.1. Burner Arrangement

The introduction of the combustion area before the transformation is shown in Figure 1. Among them, the secondary air has 8 layers of AA layer, AB layer, BB layer, BC layer, CC layer, CD layer, DE layer and EE layer. The first floor is the OFA compact burnout wind, and the primary air has four layers of A, B, C and D. In the lower part of the combustion zone, there are secondary air and primary air spacing arrangements, and three secondary air outlets in the combustion zone are arranged in the middle of B and C of the primary air outlet. Figure 2 shows the arrangement of the burners at the four corners of the furnace after retrofitting. The modified burner is arranged in such a way that the DE secondary air becomes the lower tertiary air of X-X-1, and the secondary air of the EE layer is changed into the tertiary air of the upper layer of X-X-2. Three layers of separate burnout winds have been added to the OFA compact burnout.

OFA
E-E
D-E
D
C-D
C-C
B-C
B-B
B
A-B
A
A-A

Figure 1. The layout of the burner in the four corners of the boiler before the renovation.

SOFA-3
SOFA-2
SOFA-1

OFA
X-X-2
X-X-1
D
C-D
C-C
B-C
B-B
B
A-B
A
A-A

Figure 2. The layout of the burner in the four corners of the boiler after the renovation.

There is a schematic diagram of the main burner arrangement in Figure 3, and a schematic diagram of the SOFA burner arrangement in Figure 4 .

The separated burnout wind is placed in the upper part of the main combustion zone after the boiler is retrofitted. The angle between the burner line of the four corners and the wall surface is 45 degrees and 49 degrees, respectively, and the four jet lines crossing each other form a tangential circle in the central area of the furnace. Therefore, the size of the tangential circle can be controlled by the inlet angle of the burner, thereby adjusting the turbulence intensity of the furnace at the burnout wind, which is beneficial to the full combustion of the pulverized coal and the control of the NO_X emission.

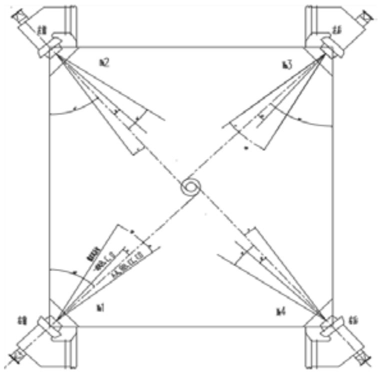

Figure 3. Schematic diagram of the main burner layout.

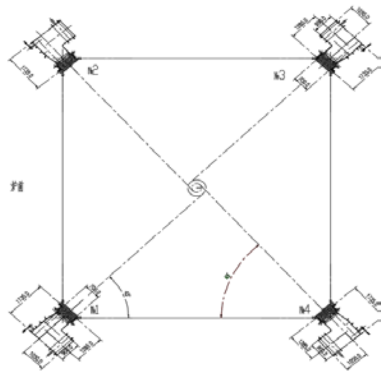

Figure 4. SOFA wind layout.

3. Numerical Simulation and Experimental Analysis of Different Loads of Boiler after Reconstruction

Analysis of the influence of tertiary air on different furnaces, such as thermal state, boiler flue gas composition, emission type, thermal efficiency, etc. Table 1 shows the opening and closing of the tertiary air damper under different loads.

Table 1. Closing conditions of different dampers for different loads.

Variable load condition	Primary air damper closed	Secondary air damper closing
100% Rated load	No closure	No closure
75% Rated load	D layer primary air	OFA,CD layer secondary air
50% Rated load	C,D layer primary air	OFA,CD,CC,BC layer secondary air

As is shown in Figure 5, Figure 6, and Figure 7,there are the curves of NO mole fraction with furnace height for different working conditions of 100%, 75%, and 50% of rated load, respectively. The blue line is the working condition of the two-layer tertiary air damper opening. The red line is the working condition of the upper tertiary air damper opening, and the black line is the working condition without tertiary air damper opening. It can be seen from the figure that the NO mole fraction of the three operating conditions decreases with the increase of the height of the furnace, and the first pole of their decline is about 10 meters, and drops to the second pole by about 20, and finally, the curve gradually becomes steady.

The curve of the furnace height above 20 meters is slowly rising, and finally tends to be stable. Without the tertiary air, the NO concentration is the lowest.The concentration of NO mole fraction was the lowest without tertiary air,followed by one-layer tertiary air input,and the concentration of NO with two-layer tertiary air was the highest.

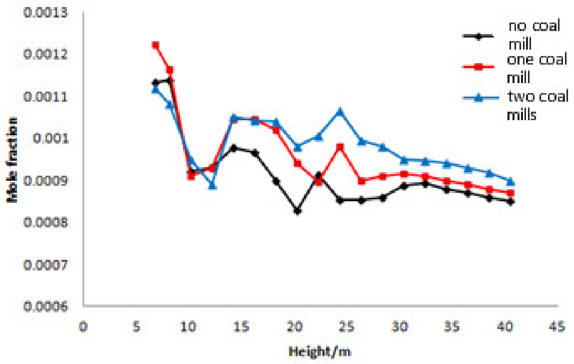

Figure 5. Variation curve of NO mole fraction with furnace height under different working conditions of 100% rated load.

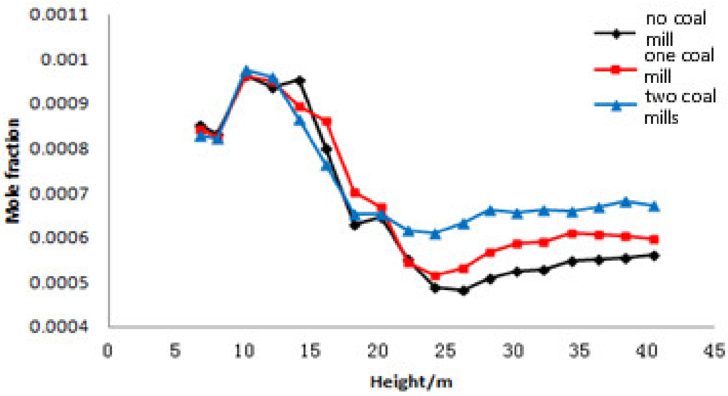

Figure 6. Variation curve of NO mole fraction with furnace height under different working conditions of 75% rated load.

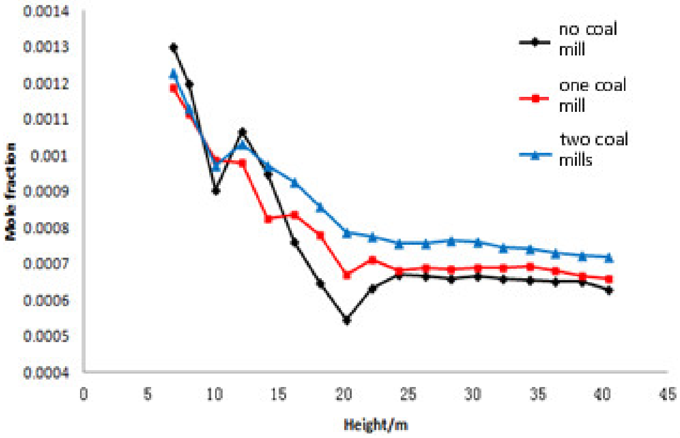

Figure 7. Variation curve of NO mole fraction with furnace height under different working conditions of 100% rated load.

Comparing the combustion numerical simulation results with the actual nitrogen oxide measurement, it can be concluded that the NO concentration fraction of the 165MW load non-pulver machine is the lowest, and one coal mill is put into operation, and the two coal mills are put into operation with the highest concentration of NO. In the actual measurement, the non-grinding operation condition is reduced by 85mg/m^3 compared with the double-grinding operation condition, and the

SCR inlet NO_X content is reduced by 5mg/m^3 compared with the single-grinding operation condition. At 140MW, no coal mill is put into operation, and the molar fraction of NO is the lowest, one coal mill is running second, and the two coal mills is put into operation with the highest concentration of NO; In the actual measurement, the non-grinding operating condition is reduced by 217mg/m^3 compared with the double-grinding operating condition, and the SCR inlet NO_X content is reduced by 20mg/m^3 compared with the single-grinding operating condition. At the time of 110MW, no coal mill was put into operation, and the molar fraction of NO was the lowest. One coal mill was put into operation, and the NO concentration of the two coal mills was the highest. In the actual measurement, the NO_X content of the SCR inlet was reduced by 195 mg/m^3 compared with the double-grinding operating condition, and the NO_X content of the SCR inlet was reduced by 155 mg/m^3 compared with the single-grinding operating condition.

Through the experimental data and theoretical simulation analysis, it can be known that the theoretical simulation of nitrogen oxides in different working conditions and the different load discharge trends are consistent with the actual experimental measurements, The numerical simulation method has certain theoretical support for the actual transformation of the boiler operation.

4. Conclusion

On the basis of the original boiler, the burnout wind and part of the secondary air were changed to the tertiary air. The concentration of the boiler furnace outlet after the transformation was lower than the NO concentration before the reform, and the boiler transformation effect was obvious. No coal mill was put into operation, and the molar fraction of NO was the lowest, one coal mill was second, and the two coal mills was put into operation with the highest concentration of NO.

This paper mainly considers the simulation of the tertiary-air-storage four-corner tangential boiler with different layers under the condition of equal secondary air. In the future, the influence of the tertiary air on the four-wall tangential and the hedge boiler can be considered.

Acknowledgements

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