Study on the Influence of Fiber Reinforced Plastics Flue on the Pollutant Emission of Coal-fired Power Plant

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Abstract: The common ultra-low emissions transformations for coal-fired power plant are low-temperature coal economizer transformation, high-frequency power, and wet electrostatic precipitator and so on. This paper aims to research the effect of fiber reinforced plastics (FRP) flue on the pollutants emission via experimental and theoretical analysis methods. The results show that: under the work condition, the introduction of FRP flue can reduce the content of solid particles and liquid droplets from flue gas at some content, which present significant effect of energy saving and environmental protection and is beneficial to the realization of ultra-low emission for coal-fired power plants.

1. Introduction

Coal occupies an important position in primary energy structure in China, and this energy structure will exist for a long time in the future [1]. However, the combustion process of coal will produce sulfur dioxide, nitrogen oxides, solid particulate matter and other pollutants, resulting in serious atmospheric pollution, such as the fog and haze in winter. The implementation of ultra-low emission of coal-fired power plants can reduce the emission of pollutants from the source and reduce the degree of atmospheric pollution. The document “Energy saving emission reduction upgrade and transformation action plan for coal-fired power plants (2014-2020)” points out the direction of ultra-low emission [2]: the emission concentration of dust, sulfur dioxide and nitrogen oxides are not higher than 10, 35, 50 mg/m^3 respectively, under the condition of 6% oxygen content.

The common used pollutant removal devices in coal-fired power plants are SCR reactor, dry electrostatic precipitator, desulfurization tower and wet electrostatic precipitator, etc. [3-4]. These devices all have certain pertinence to the removal of certain pollutants and cannot be used to remove different pollutants synergistically. In order to achieve near-zero emission, 1# boiler of Guohua Sanhe Power Plant has implemented the transformation of original electrostatic precipitator (low temperature economizer transformation, high frequency power, and desulfurization absorption tower demister transformation) and increases the wet electrostatic precipitator and fiber reinforced plastics (FRP) flue [5]. This paper aimed to research the effect of FRP flue on the pollutants emission.

2. Experiment and Parameters

The parameters of FRP flues were listed in Table 1. The FRP flue tests were implemented on the working platform with elevation of 39.200m and 38.873m to measure characteristics of FPR and collected liquid droplets via automatic smoke detector.

Table 1 Parameters of FRP flue

Parameters	Values
Inner diameter	5.2 m
#1 flue length	390 m
Flue length of back to the chimney	113 m
Number of elbows	9
Number of triplets	2
Number of fixed combined support Q420 steel (anticorrosive)	15
Number of sliding combined support Q420 steel (anticorrosive)	15
Number of non-metallic compensator	15
Number of baffle door	2

3. Results and Discussion

3.1 Amount of condensed water in FRP flue. When the power plant runs normally, the flue gas is saturated in FRP flue, due to the effect of the desulfurization tower and the wet electrostatic precipitator. The length of FRP flue of #1 is 390m, and flue gas condenses to water after the flue without external insulation as the reduction of temperature.

During the test (condition of 100% load), the temperature induction of flue gas from the entrance to the exit of FRP flue is 0.8 ℃. According to the moisture content of saturated flue gas in different temperatures and the amount of flue gas, the theoretical amount of condensed water in FRP flue could be calculated, as listed in Table 2. The experimental amount of condensed water in FRP flue of #1 unit is 3.98 t/h. From table 2 we can see, the amount of condensed water is negative correlated with temperature, especially in winter with large temperature difference.

Table 2 Relation between temperature reduction of flue gas at 100% load and the amount of condensed water for #1

Number	Temperature reduction	Unit	amount of condensed water	Unit
1	0.2	℃	1.01	t/h
2	0.5	℃	2.51	t/h
3	0.8	℃	3.98	t/h
4	1.1	℃	5.43	t/h
5	1.4	℃	6.85	t/h
6	1.7	℃	8.25	t/h
7	2.0	℃	9.63	t/h

3.2 Components analysis of condensed water in FRP flue. Four condensed water samples were selected in the wet dust collector, the starting point, section and end point of FRP flue, with the content of 5L for each sample. The specific components and characteristics were listed in Table 3.

Table 3 Components analysis of condensed water for FRP flue in #1 unit

Item	Unit	Discharge of WDC	Condensed water of FRP flue		
			Starting point	Middle	End
Hg	mg/L	0.00014	0.00009	0.00013	0.00010
Cd	mg/L	＜0.05	＜0.05	＜0.05	＜0.05
Ni	mg/L	2.22	0.06	0.12	0.41
Cu	mg/L	0.16	0.28	0.63	0.73
Zn	mg/L	0.66	0.53	0.93	0.86
Pb	mg/L	＜0.2	＜0.2	＜0.2	＜0.2
Cr	mg/L	0.051	0.045	0.018	0.021
sulfide	mg/L	0.103	0.010	0.038	0.029
COD	mg/L	163	16	29	326
SS	mg/L	43	12	60	574
sulfate	mg/L	2.73×10^3	72	107	118
fluoride	mg/L	0.61	0.47	0.40	0.55
As	mg/L	0.0174	0.0032	0.0009	0.0013
pH value	/	0.66	1.72	1.56	1.56

From table 4 we can see: expect the contents of cadmium and lead are lower than the instrument detection limit, other components are all measured, presenting that the condensed water caused by temperature reduction can carry part of pollutants out from FRP flue. Detection results of suspended matter, sulfate and pH are representative.

SS: the contents of SS in emission water of wet dust collector drainage, the starting point and section of FRP flue are similar, but increases significantly in the end of FRP flue, resulting in the SS of condensed water is mainly from the solid particles in flue gas and further explaining the dust collection effect of FRP flue, which is also consistent with the experimental solid particles removal efficiency of 47.73% of FRP flue.

Sulfate: on the one hand, the content of sulfate in wet dust collector drainage is larger than the condensed water of FRP flue significantly due to the function of drop removal of wet dust collector, which can reduce the content of drop in FRP flue; on the other hand, along with the flue gas direction of FRP flue, the content of sulfate in condensed water increased, illustrating the FPR flue also has drop removal function to some extent.

pH value: the pH value of wet dust collector drainage is 0.66, the pH values for three samples of condensed water are all larger than 1.5, manifesting the temperature reduction can form the condensed water to dilute the water and increase the pH value.

3.3 Liquid droplet in the inlet and outlet of FRP flue. The desulfurization tower usually installs a demister or cycle coupling device to removal the liquid droplet produced in desulfurization tower. If the desulfurization tower outlet emission too much liquid droplets, the chimney will form “gypsum rain” which can pollute the environment [6]. Thus, it is necessary for coal-fired power plants to take measures or advanced processes to reduce the droplets in the flue gas after the desulfurization.

Using a liquid droplet collector for sampling flue gas, the oxygen content of flue gas in the import and export of FRP flue are measured. Through the analysis of the contents of Mg^{2+} in

absorber slurry and condensed water, the droplet concentration is calculated. The specific requirements are according with the GB/T 21508－2008.

Under the test condition, the contents of liquid droplet in the inlet and outlet of FRP flue (α=1.4) are 1.42 mg/Nm^3 and 0.64 mg/Nm^3 respectively, the liquid droplet removal efficiency is 55.1% for FRP flue. Usually, the droplet content in the export of desulfurization tower is measured between 10~30 mg/Nm^3. Due to the removal effect of wet dust collector, the content of liquid droplet in the FRP flue is relatively low and the droplets in the flue can be transformed to condensed water further, avoiding the formation of “gypsum rain”.

4. Summary

The idea of using FRP flue in coal-fired unit is innovative. On one hand, the flue gas can form condensed water to reduce the supply of system circulating water, with significant effect of energy saving and environmental protection; on the other hand, the process of forming condensed water can remove the solid particles and reduce the pollutant emission of flue gas.

5. References

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