Flue Gas Measurement Experiments and Effect Analysis of FRP Flue on the Removal of Pollutants

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Abstract. In order to reduce the emission concentration of solid particle, the 1# unit of Guohua Sanhe power plant has carried out ultra-low transformation: low-temperature economizer transformation, high frequency power supply, the demister of desulfurization absorption tower and the installation of fiber reinforced plastics (FRP) flue. In this paper, the flue gas sampling and measurement experiments of FRP flue were carried out to evaluate the effect of FRP flues on the emission of solid particles: the FRP flue can remove the solid particle from flue gas effectively with the removal efficiency of 47.73% and also plays an important role in saving water to some extent.

1. Introduction

At present, the task of environmental protection and environmental governance of China is tough. Although the views of environmental governance and pollutant emissions achieve the desired results persistently, the requirements of emission reduction to coal-fired power plant are more and more stringent. In 2014, the state promulgated the “Action plan of energy saving upgrading and transformation for coal-fired power plant (2014-2020)”: coal-fired power plant with the transformation conditions strive to realize the ultra-clean emissions (the emission concentrations of dust, sulfur dioxide and nitrogen oxide are less than 10, 35, 50 mg/m^3 respectively under the oxygen concentration of 6%) [1]; the new coal-fired power plant achieve the ultra-low emission level.

Table 1. Energy structure in China [2] (%)

Year	Coal	Oil	Gas	Water	Nuclear	New energy
1985	72.8	20.9	2.0	4.3	/	/
2000	70.0	19.5	4.0	6-.0	2.0	/
2050	60-70	5.0	5.0	6.0	10-20	5

There are many common devices and technologies used to reduce the pollutant emission and controlling for coal-fired power plant, such as selective catalytic reduction, wet electrostatic precipitator, desulfurization tower, plasma rotating electrode processing, tabutar electrostatic precipitator and so on [3,4]. All these devices above can removal certain pollutants and cannot be used to remove different pollutants synergistically. In order to achieve the requirements of ultro-low emission, Guohua Sanhe power plant has implemented the transformaiton of 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].

2. Parameters and Methods

2.1 Basic parameters of the power plant.

The first project of Sanhe power plant installed two sets of steam turbine generator (2*350 MW) and the subcritical pressure controlled circulation boiler was produced by the Mitsubishi: primary reheating, single furnace, tangential combustion, steel structure full suspension, semi-open layout, dry slag extraction. The water cooling walls of the boiler adopt the airtight welding structure with internal thread pipe.

The FRP flue tests were implemented on the working platform with elevation of 39.200m and 38.873m to measure characteristics of FPR. The instruments involved in test mainly contain: particle sampling detector (SICK GRAVIMAT SHC502), automatic smoke detector, flue gas analyzer, electronic thermometer, thermocouple, atmospheric pressure gauge, electronic balance, micro manometer, etc.

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

2.2 Experimental Methods.

Based on the isokinetic sampling measurement, the filter was used to measure the sampling volume of flue gas, flue gas temperature, static pressure, dynamic pressure, atmospheric pressure and sample weight in the inlet and outlet of FPR flue. Then, the specific calculation formulas for solid particle concentration in inlet and outlet of FPR flue were presented as follow [6]:

$$C = (G_2-G_1)/V_{SND} \tag{1}$$

C: dust concentration after sampling, mg/Nm^3 (standard, dry basis, 6%O_2);

G_2: the weight of filter after sampling, mg;

G_1: the weight of filter before sampling, mg;

V_{SND}: the standard volume of sampling flue gas, Nm^3.

The removal efficiency of solid particles of FPR flue:

$$\eta=\frac{C_{in}-C_{out}(1+\Delta\alpha)}{C_{in}}\times 100\% \tag{2}$$

η: the removal efficiency of solid particles of FPR flue, %;

C_{in}: the concentration of solid particle in the inlet of FPR flue (standard, dry basis), mg/m^3;

C_{out}: the concentration of solid particle in the outlet of FPR flue (standard, dry basis), mg/m^3;

$\Delta\alpha$: gas leakage rate, %.

The total pressure of flue gas in the inlet and outlet of FPR flue were mearsured and then the resistance of FPR flue was calculated as follow:

$$\Delta P=\overline{P}_{in}-\overline{P}_{out} \tag{3}$$

ΔP: the resistance of FPR flue, Pa;

$\overline{P}_{out}$: the total pressure of flue gas in the inlet of FPR flue, Pa;

$\overline{P}_{in}$: the total pressure of flue gas in the outlet of FPR flue, Pa.

3. Results and Discussion

The coal quality parameters during test were listed in Table 2 and the measured parameters of FRP flue for #1 unit during test (average values for 3 parallel tests) were listed in Table 3.

Table 2. Coal quality parameters during test

Total moisture	moisture of analysis coal	Ash of analysis coal	volatiles	fixed carbon	carbon canister calorific value	lower heating value
Mt(%)	Mad(%)	Aad(%)	Vad(%)	Fc, ad(%)	Qb, ad(MJ/Kg)	Qnet, ar(MJ/Kg)
16.70	5.12	14.95	29.83	48.40	25.67	21.73

From Table 3 we can see under the work condition: the FRP flue can remove the solid particle from flue gas effectively because the reduced concentrations (1.4) of solid particle in the inlet and outlet of FRP flue were 3.26 mg/Nm^3 and 1.70 mg/Nm^3 respectively, with the solid particle removal efficiency for FRP is 47.73%; the FRP flue resistance was 200 Pa; the flue gas temperature in the outlet of FRP flue was lower than it in the inlet with 0.8 ℃ and the relative humidity of flue gas drop via the FRP flue, forming condensed water, which played a role in saving water to some extent and also carried some solid particles from the flue gas at the same time. It can be said that FPR flue possess an significant effect of energy saving and emission reduction.

Table 3. Measured parameters of FRP flue for #1 unit during test (average value)

Items	Unit	Inlet	Outlet
Dry flue gas flow	Nm^3/h	1074581	1072872
Flue gas dynamic pressure	Pa	273	271
Flue gas static pressure	Pa	661	461
Flue gas total pressure	kPa	849	648
Flue gas velocity	m/s	18.6	18.5
Flue gas temperature	℃	51.2	50.4
atmospheric pressure	kPa	101.9	101.9
Humidity of flue gas	%	11.2	11.1
flue gas oxygen content	%	3.22	3.20
Wet flue gas flow	m^3/h	1419747	1415160
measured concentration of solid particles	mg/Nm^3	3.86	2.02
Reduced concentration of solid particles (1.4)	mg/Nm^3	3.26	1.70
solid particle removal efficiency of FRP flue	%	47.73	
FRP flue resistance	Pa	200	

4. Summary

In this paper, the flue gas sampling and measurement experiments for the flue gas in the FRP flue were implemented to measure and evaluate the effect of FRP flues on the view of ultra-clean emission: the FRP flue can remove the solid particle from flue gas effectively with the removal efficiency of 43.37%; the flue gas temperature in the outlet of FRP flue was lower than it in the inlet with 0.8 ℃ and the relative humidity of flue gas drop via the FRP flue, which shows a significant effect for FRP flue in saving water.

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