ESP Renovation in Da Wukou Power Plant, Ningxia

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Abstract: This article introduces the renovation scheme of 4#, 3# boiler ESP in Da Wukou Power Plant, Ningxia. Under the limited space condition, the outlet concentration is not over 300 mg/Nm^3, the de-dusting efficiency≥ 99.5 %, which offers good experience for the renovation of the similar equipment in China.

Keywords: ESP, pre-charging mechanism, outlet double-layer maze-type channel plate, wide spacing

1 INTRODUCTION

4# boiler from Da Wukou Power Plant is WGZ-410/ 100-5 type high pressure natural cyclical coal powder boiler produced by Wuhan Boiler Factory. Originally, it was equipped with two LDI/DWK3*4-100.8-4 type horizontal ESPs manufactured by Lanzhou Electric Power Works. Since they were put to use in Nov.1987, the de-dusting efficiency of these two ESPs has been falling down step by step due to one reason or another. Therefore, between September to October, 1991 and September, 1997, two technical renovations were given, which slowed down the worsening emission. However, later on, the ESP efficiency dropped year by year. So a new renovation on ESP is a must. In June, 2001 and July, 2002, our company renovated 4# boiler ESP and 3# boiler ESP respectively in Da Wukou Power Plant.

2 BRIEF INTRODUCTION OF THE ORIGINAL ESP

The original 4# boiler is equipped with two ESPs with the same design parameter and structure. Refer to Table 1 for the design parameter and technical performance of each ESP.

3 MAIN PROBLEMS AND CORRESPONDING ANALYSIS BEFORE THE ESP RENOVATION

As for the characteristic of the firing coal in Da Wukou Power Plant, based upon our analysis, we can find out that the firing coal is classified into low heat value, middle and high dust content, low water content, middle and low sulfur content, which is difficult to be kindled and to be fired completely. Great coal consumption, huge amount of gas, high dust concentration and increased dust specific resistance are harmful to the dust collection. Refer to Table 2 for the chemical composition of the coal in Da Wukou Power Plant.

From Table 2, we know that as the collecting catalyst, Fe_2O_3, K_2O, Na_2O, SO_3 are good for dust collection, but they are relatively small, so it's difficult to collect dust. SiO_2, Al_2O_3, CaO, MgO are harmful to dust collection, the number in the table is big, especially, there's light specific gravity and thin particle size Al_2O_3 content , which attains about 40%. It's easy to cause back corona. Rapping will easily lead to reentrainment, it is difficult to collect dust. With SiO_2, the total volume is over 88%, which is one of the most difficult coals for the dust collection. Through analyzing the specific resistance, the Al_2O_3 content is high, so is the specific resistance. Between 120 □-180 □, the specific resistance is 10^{13}, which will further impede the appearance of the electric field strength, make substantive electric charge have futile emission and give rise to the decline of the de-dusting efficiency.

Table 1 Design parameter and technical performance of the original 4# boiler ESP

Item	Original Design	After the first renovation	After the second renovation
Section area of the field (m^2)	100.8	100.8	100.8
Flue gas treatment amount (m^3/h)	444560 (178 □) 417500 (146 □)	460200	450000-525000
Design velocity of the field (m/s)	1.22-1.15	1.27	1.45-1.24
Active length (m) and number of the field	4 * 3.48	4 * 3.48	4 * 3.48
Number of gas passages and clear distance between Coll. Plates (mm)	28*300	Field 1: 28*300 Field 2, 3, 4: 20*420	Field 1: 21*400 Field 2, 3: 20*420 Field 4: 24*350
Coll. plates area (m^2)	9354.24	7349.76	7099.2
Type of collecting electrode	480C type		

Type of discharging electrode	Field 1, 2: jaggies Field 3, 4: herringbone needle with auxiliary electrode		
Specific collection area ($m^2/m^3/s$)	73.09	56.54	48.68
Inlet dust concentration (g/m^3)	59		20-30
Outlet dust concentration (mg/m^3)	590		
De-dusting efficiency requirement (%)	99	99	99
Rapping mechanism of collecting electrode	Single-sided tumbling hammer		
Rapping mechanism of discharging electrode	Single-sided upper and lower frame fork hammer		
Number and type of high voltage (HV) transformer rectifier (T/R)	Yinchuan Electric Power Works GGAJO2-1.2/60 4sets	DJ-1 cabinet produced by Jinhua Power Instrument Factory was used since 1990	
Test result of the ESP efficiency before and after the renovation (%)	99	90-93/98.9-99.3	

Table 2 Chemical composition of the coal of the original design before and after renovation

Item	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	K_2O %	Na_2O %	SO_3 %	others %
Design coal	51.86	39.52	5.42	1.11	0.76			0.34	
Before the first renovation	50.00	38.58	6.54	1.07	0.53	0.91	0.23	0.08	2.06
After the first renovation	50.30	39.59	5.05	1.29	0.13			0.15	2.03
After the second renovation	46.735	35.72	4.095	0.82	0.4125	0.405	0.2225	0.041	
test value in Feb.2001	50.26	40.48	3.14	0.73	0.38	0.19	0.63	1.28	1.69

The velocity of the flue gas in ESP is excessively fast. Because it needs some time for the charged dust to be accumulated on the collecting plates (Coll. Plates). If the velocity of the flue gas is too fast, the charged dust will be taken away by the gas stream without anytime for falling down and accumulation, which easily results in reentrainment. Furthermore, the fast velocity will cause the severe abrasion of the inlet distribution plates and guide plates and uneven gas distribution follows.

The end of the emitting electrode inside the field is obtuse and the emitting is not good. There's so much dust sticking to the dust collecting plates and the back corona phenomenon is serious and rapping is invalid.

Wind is leaky in the ash transportation system and the ash clogging phenomenon of the hoppers is serious.

4 RENOVATION SCHEME

4.1 Content of Renovation

Remove the two ESPs proper noumenon and claddings of the original 4# boiler□with the front to the inlet nozzle flange, the back to the outlet nozzle flange and the lower end to the bottom ring beam of the casing. If we put these together, one ESP with 2 chambers and 4 fields appears. That means the original concrete structure column is applied and the inspection walkway of the original 2 ESPs is well utilized as the complement of the collecting area of the field. In the meantime, we heighten the field and make the circulation area increase by 42%. It can greatly lower the flue gas speed, the fine powder of Al_2O_3 can have enough charging time under low speed circumstance (<1 m/s) and the reentrainment can be reduced as much as possible. FAA type is used in the structure.

4.2 Diagram

Refer to Table 3 for the technical parameter of 4# boiler ESP before and after renovation. Attached drawing 1 is the general layout.

5 RENOVATION SCHEME

5.1 Different Discharging Wires are Used in the Former and the Latter ESP Fields

Due to the high inlet dust content, new RS type spiked emitter is used in Field 1 and 2 to collect big-sized dust, as for Field 3 and 4, because a lot of fine particle need strong field strength, spiral wire made of stainless steel with high chromium and high nickle is used, because the discharging property of spiral wire is the evenest among all discharging wires. Its soft discharging coverage makes discharging wider than that of sharp wires. In the meantime, spring-shaped wires can transmit the rapping force in a good manner. The surface is clean and bright, which is anti-corrosion and dust of high specific resistance is not easy to stick together. Furthermore, spiral wires have high strength, the broken rate is low and erection is handy and quick.

5.2 Pre-charging Mechanism is Added

An auxiliary field is set in the inlet nozzle, the distribution plates are used as collecting plates. Between the two-layer distribution plates, herringbone needles are set as the discharging electrode. In the meantime, the distribution plate rapping mechanism is set to make the collected dust fall

down into the hopper at the lower part of the nozzle. This pre-charging facility (attached drawing 2) can complement the collecting area and attain the purpose of guaranteeing the de-dusting efficiency in the long run.

5.3 Improve the Eveness of Gas Distribution

Inside the inlet duct work of the ESP, guide plates using anti-corrosion material are set to make the ESP gas stream have even distribution. In the inlet nozzle, the combination of porous plates and guide plates are used. Diversion, deflection and distribution are combined to make the flue gas enter the field evenly. It changes the traditional method of changing the gas strength by blocking the hole. It can make the gas distribution have a more accurate and convenient adjustment. At the same time, based on the design requirement, we conduct the simulation tests in the company to provide data of the gas distribution eveness on the site spot for reference. The scale of the simulative model is 1:10-1:16.

5.4 Wind Leakage Adjustment

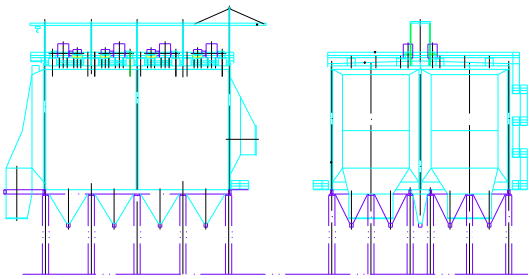
All the manhole doors use new-type improved inner and outer-door double structure. In the meantime, fibre glass glue is used as the sealing element, which is high temperature-resistant, anti-aging and long-term operation can guarantee that the wind leakage rate is less than 3%.

5.5 Hopper Design

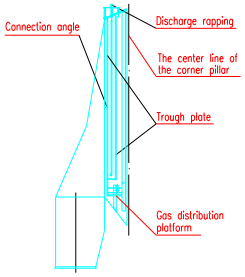
The structure design of the hopper fully takes the smoothness of the dust falling into consideration and lowers the reentrainment of dust. Besides the correct calculation of the plate angle of dust hopper, edge angle arc shape is added and baffle plates are set inside the hopper. Furthermore, sizing calculation work of the bottom interface of the hopper is well done together with the dust transmission department of the design institute. Ash blocking or full ash due to the small-sized ash transportation equipment should be avoided.

Table 3 Technical parameter of 4# boiler ESP before and after renovation

Item	Parameter before renovation	scheme
Section area of the field (m^2)	Two sets 100.8	One set 288
Flue gas treatment amount (m^3/h)	900000-1050000	1000000
Design velocity of the field (m/s)	1.24-1.45	0.96
Active length (m) and number of the field	4*4.38	4*4.38
Number of gas passages and clear distance between Coll. Plates (mm)	Field 1: 21*400 (each set) Field 2, 3 : 20*420 Field 4: 24*300	48*400 (double chambers)
Coll. plates area (m^2)	7099.2 * 2	20160 (exclude precharging part)
Type of collecting electrode	480C	480C
Type of discharging electrode	Field 1, 2 , 3: Jaggies Field 4: herringbone needle with auxiliary electrode	Field 1 ,2: Spiked emitter Field 3: Spiral wire
Specific collection area ($m^2/m^3/s$)	56.79-48.68	72.576
Inlet dust concentration (g/Nm^3)	38.17	50
Outlet dust concentration (mg/Nm^3)	1030.6	≤ 300
De-dusting efficiency requirement (%)	97.3	≥ 99.4
Rapping mechanism of collecting electrode	single-sided tumbling hammer	
Rapping mechanism of discharging electrode	single-sided tumbling hammer	
Number and type of high voltage (HV) transformer rectifier (T/R)	GGAJO2-1.2/60 4* 2 sets	GGAJO2-1.2/72 8 sets GGAJO2-0.1/72 2 sets



Drawing 1 General Layout



Drawing 2 Pre-charging Mechanism

6 FURTHER MEASURES

The above are the major measures taken in the ESP renovation of 4# boiler ESP in Da Wukou Power Plant. In the 3# boiler ESP renovation, some new measures are added, they include:

6.1 Double-layer Maze-type Channel Plates are Set in the Outlet Nozzle

The dust particle entering the fourth field is very thin after passing the former three fields. The fine particle is easy to cause reentrainment under the rapping or gas stream eddy current in the field. To effectively collect the fine particle escaping from the fourth field, we set the double-layer maze-type channel plate in the outlet to improve the gas distribution in the field. Hence, the field can fully display its function and collect the dust escaping from the reentrainment of the last field. As a consequence, the de-dusting efficiency is enhanced.

6.2 Wide Spacing is Used in the Latter Fields

400 mm spacing is used in Field 1 and 2 and 438 mm spacing is used in Field 3 and 4. When the spacing is widened, the operation voltage rises and the corona area increases, which will be good for the dust charge. When the field strength of the collecting plates increases, the current density of the wide spacing plates inclines towards eveness, which is good for delaying the occurrence of back corona. In the meantime, because of the wide spacing, there are not so many collecting plates and there's little eddy current around the plates. So are the dust concentration of the opposite electrode and the reentrainment led to by the return of eddy current.

6.3 Electric Control

To the ESP operated under the condition of high specific resistance condition, we take the following measures in the electric control part.

We use intermittent power supply, industrial frequency half wave pulse power supply, new type "inflexion point" tracking power supply and etc. for T/R device, which can make the dust-accumulated charge on the collecting plates have enough releasing time and reduce the possibility of back corona phenomenon. This greatly perfects the control characteristic under actual work conditions.

Special intelligentized rapping control softwares are equipped. Through changing the output power of T/R device during the rapping period, we can change the adhesion force of the electrode to the dust and make the dust on the collecting plates evener. This is good for the cleaning work of the collecting plates and reduction of back corona. It's also conducive to the improvement of de-dusting efficiency.

In order to guarantee that T/R device can more reasonably offer corona power, different fields are equipped with T/R devices of different capacity. In addition, two pre-charging power supply are used: GGAJO2-0.1A/72 kV.

7 RESULT AFTER RENOVATION

18 months after the renovated use of 4# boiler ESP and 6 months after the renovated use of 3# boiler ESP in Da Wukou Power Station, Ningxia power research institute did the heat performance test to 4# boiler and 3# boiler ESP respectively in June and April of 2003. The test report showed that each item attained the design standard. Refer to table 4 for the concrete data.

Table 4 Test result of ESP performance

Test item	unit	4#boiler ESP	3#boiler ESP	Design value
De-dusting efficiency (revised value)	%	99.54	99.59	99.4
Outlet dust concentration	mg/ Nm^3	297.2	239.4	300
Pressure drop across ESP	Pa	327	208.5	400
Air infiltration in ESP (leakage)	%	3.17	2.4	4.5
Noise of the noumenon	dB	70.3	72.3	85

8 CONCLUSIONS

The renovation of 4# and 3# boiler ESP in Da Wukou Power Plant has offered us useful experience in treating the "3 highs" of ESP, i.e. "high concentration, high specific resistance and high altitude". It also sets an example for the renovation of ESP with the similar type.

REFERENCES

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