The Technical and Economical Analysis on the Application of FGC in Large Scale Coal-fired Units

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Abstract: In this paper we describe that large scale coal-fired units are designed basing on the working condition of burning several coals because of the internal coal resources status in China at present. It differs a lot for ESP to collect the dust when using different coals. Taking the dedusting technology of ESPs equipped with FGC system of Guangdong Pinghai Power Station 2×1000 MW units as an example, after adopting combined dedusting technology, the ESP can be designed basing on the easily dedusting coal, which reduces the overall investment of dedusting system. FGC system is completely separated from ESPs, which has the advantage of flexible operation. Furthermore, compared with other dedusting technologies, it keeps the characteristic of low pressure loss, high reliability, low cost of running and maintenance, which has competitive advantages in technology and economy.

Keywords: Burning coal, Large scale coal-fired units, ESP, FGC, Technicality and economic efficiency

1 TREND OF CURRENT FIRED COALS CONSTRUCTION FOR LARGE SCALE COAL-FIRED UNITS AND ANALYSIS ON ELECTRIC COLLECTION IN CHINA

Design and check coal for the new large scale coal-fired units(≥300 MW)in China is various currently. Influenced by the coal resources distribution in China, high quality coal resources is lack and reserves of high quality coal with high calorific value and low ash content such as Shenfu Dongsheng coal, Jinbei coal, Datong soft coal etc. can't satisfy the increasingly developing electricity market requirements any longer, as a result, designers still consider adopting the high-quality coal as design coal for many new schemes of large scale coal-fired units during the feasibility research and conceptual phase, while preparing an strip mine with large scale coal reserves as check coal. Within them, Zhungeer coal in Inner Mongolia is always firstly considered as the prepared coal because of its large scale reserves. The newly designed or bidden schemes such as Guangdong Yangxi Power Station 4×600MW units, Shajiao Power Station 2×1000 MW units, Guangdong Pinghai Power Station 2×1000 MW units, Nansha Power Station 2×300 MW units of China Resources Power Holding Co., Ltd. and Zhongshan Power Station 2×300 MW units of GUANGDONG YUDEAN GROUP CO., Ltd. so on, all adopt this coal-fired construction. With the fulfilling of China National energy policy and energy saving and emission reduction demands, more and more new power stations have been designed basing on this construction burning several coals. Considering the economic benefit, many old power stations burn deviated design coal with higher ash, which results in outlet dust emission concentration of former ESP can't satisfy the emission requirements. It differs a lot for ESP to collect the dust when using different coals. The following is to take the design and check coal parameters of one plant as an example.

Table 1 The parameters of design coal and check coal of one plant

Description	Unit	Design coal	Check coal
Coal		Shenfu Dongsheng coal	Inner Mongolia Zhungeer coal
Proximate Analysis			
Volatile as dry ash-free basis	%	35.0	37.15
Moisture of air dry based	%	8.0	7.22
Ash as received	%	8.0	20.19
Total moisture	%	14.14	9.0
Net calorific value as received basis	MJ/kg	22.76	21.080
Ultimate analysis			
Carbon as received	%	62.83	55.26
Hydrogen as received	%	3.62	3.31
Oxygen as received	%	9.94	10.75
Nitrogen as received	%	0.7	1.08
Sulfur as received	%	0.77	0.41
Hard Grove Index		56	57
Erosive wear index		1.9	1.8
Ash characteristic			
Deformation Deg.C	℃	1120	1400

Description	Unit	Design coal	Check coal
Hemisphere Deg.C	℃	1160	1450
Flow Deg.C	℃	1180	1500
Ash analysis			
Silicon dioxide	%	36.71	43
Alumina	%	13.5	44
Iron Oxide	%	11.36	3.5
Manganese dioxide	%	-	0.02
Titania	%	0.5	1.4
Kalium oxide	%	0.73	0.4
Sodium oxide	%	1.23	0.2
Lime	%	22.92	3.0
Magnesia	%	1.28	0.3
Sulfur trioxide	%	9.3	2.2
Phosphoric anhydride	%		0.2
Others	%		1.78

Considering the dedusting scheme of ESP, the two coals mentioned above differ a lot on the dust collection efficiency. The design coal (Shenfu Dongsheng coal) is a high quality coal with medium dust resistivity, which is easily collected. It shows:

1) Low ash content (8%), low ESP inlet dust concentration. Small capacity of the absolute quantity of fine dust which is difficultly collected by ESP and the load of ESP is small.

2) The total content of SiO_2 and Al_2O_3 in ash is 50.21 percent, which is a small content and easy for electric collection.

3) The content of alkali metal oxides (Na_2O and K_2O) in ash is a little higher, even the content of Na_2O up to 1.23 percent. The dust ion activity is strong and dust volume conductivity is good, which is easily charged.

Dust resistivity of check coal (Inner Mongolia Zhungeer coal) reaches $10^{13}\Omega\cdot cm$, which is difficult for electric collection. It will be showed below:

1) Sulfur content is low and 0.41 percent in coal as Ash content is 20.19 percent. ESP inlet dust concentration is a little higher. It is difficult to form effective surface conductivity and ESP load is large scale.

2) The total content of SiO_2 and Al_2O_3 in ash is high and reaches 87 percent. Al_2O_3 is especially hard to be collected because it's extra fine.

3) The total content of alkali metal oxides (Na_2O and K_2O) in ash is only 0.6 percent. Dust ion activity is weak, which is difficultly charged.

It is an urgently resolved problem of how to economically select the dedusting scheme to resolve the dust emission problem in such large scale coal-fired units for Chinese environmental enterprise specialized in dust treatment. It is no doubt that fabric filter is the dedusting equipment with highest efficiency and best dedusting reliability at present. However, every bag is used as single dedusting unit and coupled in parallel. With the increasing capacity of generator sets and flue gas flow, it will ask for more and more filter bags, which will bring great inconvenience to the running and maintenance. Furthermore, the initial cost of bag filter is high as well as the cost of running and maintenance because bags need to be replaced at regular interval. So, fabric filter is not the best dedusting scheme with high technicality and economic efficiency to resolve the dust emission problem in such large scale coal-fired units. If ESP selected, it should be designed basing on the difficultly collected coal, the amount of electrical field and specific collection area need be greatly increased, while technicality and economic efficiency declines. According to the coal-fired experience of Inner Mongolia Zhungeer coal, if dust emission concentration is required to be less than 100 mg/Nm^3, specific collection area need be increased greatly at the cost of losing technicality and economic efficiency. In contrast, the scheme of ESP equipped with SO_3 FGC system for resolving the flue gas treatment of such large scale coal-fired units shows competitive advantages of high technicality and economic efficiency.

2 DEDUSTING SYSTEM OF GUANGDONG PINGHAI POWER STATION 2×1000MW UNITS

2.1 Coal-fired Construction and Design Requirements of Guangdong Pinghai Power Station 2×1000 MW Units

(1) The design coal is composed of Inner Mongolia Zhungeer coal and Indonesia coal (1:1), while the check coals are Indonesia coal and Inner Mongolia Zhungeer coal. Table 2 and 3 below show the coal and ash analysis.

Table 2 Coal analysis of design coal and check coals

Description	Unit	Design coal	Check coal (No.1)	Check coal (No.2)
Coal		Mixed coal (1:1)	Indonesia coal	Inner Mongolia Zhungeer coal
Moisture as received	%	18.1	25.8	10.3
Moisture as air dry	%	9.57	14.21	5.41
Ash as received	%	8.75	1.54	16.24
Volatile as dry ash-free	%	43.65	50.32	37.54
Carbon as received	%	56.26	53.90	57.87
Hydrogen as received	%	3.79	3.94	3.62
Oxygen as received	%	12.11	13.96	10.73

Description	Unit	Design coal	Check coal (No.1)	Check coal (No.2)
Nitrogen as received	%	0.82	0.72	1.00
Sulfur as received	%	0.17	0.14	0.24
Net calorific value as received	MJ/kg	21.13	20.01	22.13
Hard Grove Index		58	55	63
Erosive wear index		0.54	0.36	

Table 3 Ash analysis of design coal and check coals

Description	Unit	Design coal	Check coal (No.1)	Check coal (No.2)
Coal		Mixed coal (1:1)	Indonesia coal	Inner Mongolia Zhungeer coal
Silicon dioxide	%	34.63	21.13	38.62
Alumina	%	44.11	18.93	45.71
Titania	%	2.19	1.08	2.64
Iron Oxide	%	5.26	22.70	3.77
Lime	%	6.45	16.90	4.79
Magnesia	%	2.21	7.91	1.09
Kalium oxide	%	0.87	0.83	0.61
Sodium oxide	%	0.46	0.41	0.40
Sulfur trioxide	%	3.17	9.44	1.73
Manganese dioxide	%	0.014	0.023	0.014
Others	%	0.64	0.65	0.63
Deformation Deg.C	℃	1430	1220	>1500
Hemisphere Deg.C	℃	>1500	1230	>1500
Flow Deg.C	℃	>1500	1240	>1500

(2) Flue gas flow per boiler (B-MCR)

Design coal: 4733575m³/h;

4261162 m³/h (Dry flue gas) .

Check coal (No. 1): 4846724 m³/h;

4304306 m³/h (Dry flue gas)

(3) Inlet temperature of ESP

Design coal: 122□(Leakage of air preheater considered)

Check coal (No. 1): 121□(Leakage of air preheater considered)

(4) Inlet dust concentration of ESP

Design coal: 11.39 g/Nm³ (Dry flue gas)

Check coal (No. 1): 2.44 g/Nm³ (Dry flue gas)

(5) Guaranteed dust collection efficiency:

Guarantee that the dust collection efficiency is not less than 99.65 percent when burning the design coal or only Zhungeer coal.

Guarantee that the outlet dust concentration of ESP is less than 45 mg/Nm^3 when burning check coal (No.1).

2.2 ESP Equipped with SO_3 FGC System

Through the multipartite demonstration and review among GUANGDONG Electric Power Design Institute, Pinghai Power Station and Fujian Longking CO., Ltd. also considered the coal-fired construction of Pinghai Power Station, the combined dedusting technology of ESP equipped with FGC system has been adopted with high technicality and economic efficiency.

(1) Type and specification of dedusting equipment

Every boiler is equipped with two ESPs of four fields (Type: BE666/3-4) and one FGC system (Type: 120 kg/h). One sulfur tank with storage capacity of 40 m^3 is served for two boilers.

SO_3 FGC system, which uses SO_3 as conditioning agent, is the most reliable and mature technology of flue gas treatment for coal-fired units, improving surface conductivity and reducing dust resistivity. As to this scheme, it burns check coal (No.1, Indonesia coal) with low ash content and high moisture. The total content of SiO_2 and Al_2O_3 in ash is low, which results in the low dust resistivity and being easily collected. It can meet the dust emission requirement of less than 45 mg/Nm^3 while only using ESP without FGC. In contrast, when burning check coal (No.2, Inner Mongolia Zhungeer coal) with high total content of SiO_2 and Al_2O_3, high dust resistivity and low content of alkali metal oxides (Na_2O and K_2O) in ash, the dust collection efficiency will reach 99.65 percent with SO_3 injection of 15 ppm in operation. When burning design coal (Mixed coal of Zhungeer coal and Indonesia coal,1:1), ash is mainly composed of Zhungeer ash. However, due to the high moisture and low ash content in mixed coal, it's conducive to electrostatic dedusting. Actual opacity may decide whether to use FGC system or not. If SO_3 needed, it will meet the design requirement with low SO_3 injection rate of no more than 5 ppm.

FGC system is separated from ESP. Fig. 1 shows the main equipments of FGC.

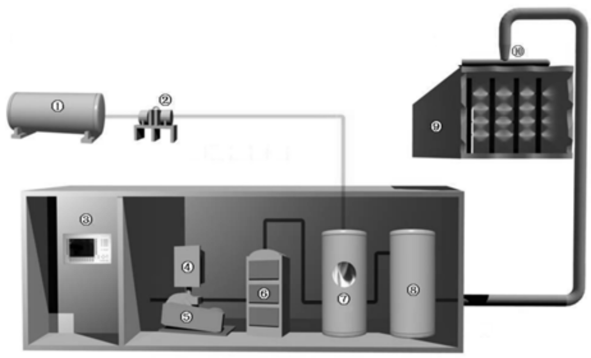

Fig. 1 FGC chart flow of LONGKING

1 Sulfur storage tank; 2 Sulfur dosing pump; 3 Electrical controlling cabinet; 4 Air filter; 5 Air blower; 6 Air heater; 7 Sulfur burner; 8 SO_3 converter; 9 Inlet duct of ESP; 10 SO_3 injector

(2) Economy compared with only ESP

Approximate invest comparison between ESP and ESP equipped with FGC.

a) The scheme of ESP used only should be designed basing on Zhungeer coal. Migration velocity is only 3.51 cm/s according to the actual testing data. If 99.65 percent of dust collection efficiency reached, specific collection area will be above 160 $m^2/m^3/s$ with collecting plate spacing of 400mm as well as six fields. In contrast, specific collection area is only 90 $m^2/m^3/s$ in the scheme of ESP with four fields equipped with FGC system. Compared with ESP of four fields, ESP of six fields will add 1800 tons of ESP equipments and twelve sets of high-voltage power supplies, which increases the investment of 16,000,000 RMB.

b) The scheme with ESP of four fields equipped with FGC system need add the SO_3 FGC system which may cost 7,500,000 RMB.

c) Compared with the ESP of six fields, the scheme with ESP of four fields equipped with FGC system can save the transport cost about 500,000 RMB, installation cost about 1,000,000 RMB and ash transport investment about 1,000,000 RMB.

Therefore, the scheme with ESP equipped with FGC system can save equipment investment about 11,000,000 RMB than ESP only.

The running cost of ESP of four fields equipped with FGC system is composed of electric cost and sulfur consumption cost. Sulfur consumption is related to the occupation coefficient and actual SO_3 injection rate. The overall operating cost is lower than ESP of six fields.

3 TECHNICAL AND ECONOMICAL ANALYSIS OF LARGE SCALE COAL-FIRED UNITS EQUIPPED WITH FGC SYSTEM

(1) The scheme of large scale coal-fired units equipped with FGC system can reduce overall investment of dedusting system and adapt to the working condition of burning several coals.

ESP should be designed basing on the most difficultly collected coal and the worst working condition. Above it, ESP should be designed basing on the check coal (Zhungeer coal) with high dust resistivity, which has a high equipment investment and poor technicality and economic efficiency. If ESP equipped with FGC system, ESP should be designed basing on the easily collected coal, which greatly reduces ESP specification. As the capacity of coal-fired units has small influences on the FGC equipment investment and large scale coal-fired boiler has better economic efficiency, it can reduce the overall investment of dedusting system.

(2) Independent device, flexible operation and low cost of running and maintenance of FGC system

The cost of running and maintenance is closely related to the burning coal. When burning the easily collected coal, ESP can meet the emission requirement without FGC system. When burning the difficultly collected coal, ESP still succeeds with FGC system used. And the injection rate is automatically controlled by boiler load and opacity, realizing the optimum running.

(3) Keep the characteristic of low pressure loss and high reliability of ESP

(4) Large scale coal-fired units ($\geq$300 MW) often adopt the wet desulphurization. ESP dust emission is commonly required about 100 to 150mg/Nm3 due to the 70 percent around dust emission efficiency in the next wet desulphurization. So the dedusting scheme of ESP equipped with FGC can guarantee a low long-term dust emission and high technicality and economic efficiency.

REFERENCES

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