A Discussion about Strategy of Flue Gas Dust Removal for Indian Coal Fired Boiler

LIN Guoxin
(Fujian Longking Co., Ltd., China, 364000 E-mail: 13906078081@fj172.com)

Abstract: This paper analyses the effect of characteristics of Indian coal and ash on various modes of dust removal, using the Indian BALCO power plant as an example, and discusses the strategy of flue gas dust removal for Indian coal fired boiler. A new technique of Electrostatic-Fabric Organic Integrated Precipitator (hereafter referred to as EFOIP) developed by Fujian Longking Co., Ltd. is also introduced in this paper.

Keywords: Strategy, characteristics of coal and ash, mode of dust removal, Electrostatic-Fabric Organic Integrated Precipitator (EFOIP**)**

1 INTRODUCTION

In recent years, in order to meet the need of industrial production in India, power industry is developing quickly. The total installed capacity, which was slightly more than 100,000 MW in 2001, is expected to reach around 215,000 MW in 2011 in India. In which about 55% of the installed capacity is contributed by coal fired power plant. [1] In other wards, there is 6000 MW capacity increased per year in India.

So far, 95% of the Indian coal fired boilers are equipped with electrostatic precipitator (hereafter referred to as ESP). In 2005, the dust emission standard for 210 MW and above was 150mg/Nm3. At that time, amongst the 83 coal fired power plants, there were 27 plants, about 32.5%, with emissions not meet the required standard [1]. If the total installed capacity was 85,000 MW in that year, then there were 27,000 MW power plants with their ESPs requiring enhancement and refurbishment, because the emissions did not meet the required standard. .The current emission standard in India has been raised; therefore the total capacity of ESP units which need rebuilding is more than 27,000MW.

This shows that there is a substantial ESP market in India.

At present, quite a number of Chinese enterprises are undertaking construction of coal fired power plant in India, and they are developing rapidly. And as a result, Chinese environment protection enterprises also entered the Indian market. Therefore, we have to face the problem of how to solve the emission problem from the Indian coal fired boiler. For specific characteristics of Indian coal, strategy of flue gas dust removal must be considered carefully.

For example, BALCO power plant, which belongs to BHARAT Aluminum Co., Ltd, locates at KORBA in India. There were 4 units of 135 MW which had been applied in succession from the year 2005 to 2006. Due to the difference between the burned coal and the designed coal, the original designed ESP was unfit. The stack emission did not meet the required standard in most cases. In order to solve the issue, SO_3 conditioning system was installed in March 2007. Although the emission was reduced, in most cases it still exceeded the stipulated requirement, i.e. more than 100mg/Nm^3. We will discuss further about this.

2 CHARACTERISTIC OF INDIAN COAL AND ASH

When we consider the mode of dust removal for Indian coal fired boilers, the influence of Indian coal and ash characteristics must be taken into account sufficiently. The characteristics of coal and ash of three kinds Indian coals collected from BALCO power plant in June 2nd 2007 are listed in table 1 and table 2. They are part of the generally used coal in this plant, and they have definite representative properties.

Table 1 Ultimate analysis of typical Indian coal

Sample serial number			MJ0706142-01	MJ0706142-02	MJ0706142-03
Sample name			Indian coal MCI (T)	Indian coal RTC	Indian coal GEWAR
Total Moisture	Mt	%	6.1	4.4	5.0
Moisture of air dry based	Mad	%	5.35	3.78	4.56
Ash of air dry based	Aad	%	41.08	52.56	48.08
Volatile matter of air dry based	Vad	%	24.28	21.02	21.05
Fixed carbon of air dry based	FCad	%	29.29	22.64	26.31
carbon of air dry based	Cad	%	39.91	31.76	35.89
Hydrogen of air dry based	Had	%	2.84	2.27	2.49
Nitrogen of air dry based	Nad	%	0.73	0.58	0.63
Sulfur of air dry based	Stsad	%	0.43	0.25	0.39
Oxygen of air dry based	Oad	%	9.66	8.80	7.96
HHV of air dry based	Qgr.ad	MJ/kg	15.65	12.62	14.20
LHV of received based	Qnetad	MJ/kg	14.80	11.97	13.51

Table 2 Ash analysis of typical Indian coal

Sample serial number				MJ0706142-01	MJ0706142-02	MJ0706142-03
Sample name				Indian coal MCI(T)	Indian coal RTC	Indian coal GEWAR
Ash element	Silica	SiO_2	%	56.92	62.12	65.21
	Alumina	Al_2O_3	%	27.22	27.02	23.46
	Iron oxide	Fe_2O_3	%	6.86	3.82	4.58
	Calcium oxide	CaO	%	1.97	1.62	0.46
	Magnesia	MgO	%	1.27	0.83	1.86
	Titanium oxide	TiO_2	%	0.98	1.22	1.28
	Sulfuric anhydride	SO_3	%	0.12	0.06	0.10
	sodium oxide	Na_2O	%	0.14	0.40	0.26
	potassium oxide	K_2O	%	0.75	0.74	1.02

Remark: The data in table 1 and table 2 are extracted from report NO. MJ0706142 prepared by China's Shangdong Power Coal Quality Supervising Inspection Center, dated June 27 2007.

From the results of typical Indian coal ultimate analysis and its ash element analysis, we can see that the characteristics of Indian coal and ash are: high ash content, low sulfur in coal, high silicon and aluminum oxides, and low sodium oxide in ash. Among them, the content of S_iO_2 in ash is more than 60%, which is seldom seen in Chinese coal ash, and it is about 1.1-1.2 times the amount in China coal ash. These characteristics of coal and ash show that high particle concentration, low SO_2 amounts with a little conditioning function in flue gas, and ash characteristic of high resistivity, high rigidity, and bad soakage property. The actual measured inlet particle concentration may be up to 100 g/Nm^3 and the dust resistivity of 1012 Ω·cm at BALCO plant.

These typical characteristics of Indian coal and ash must be taken care of sufficiently and properly as we confirm the project of dust removal.

3 COMPARISON OF MODE OF DUST REMOVAL

3.1 Electrostatic Precipitators

Based on the typical characteristics of Indian coal and ash, when adopting electrostatic precipitate for dust removal for coal fired boiler, the specific collecting area (SCA) must be sufficiently large, flue gas velocity should be as low as possible. When the required outlet particle concentration is 100~150mg/Nm^3, SCA must be larger than 180m^2/m^3/s of flue gas flow (as the gas passage width is 400 mm), the number of electric field should be more than 6 and the flue gas velocity should be less than 0.8 m/s.

The design value of SCA for Indian BALCO power plant was 120m^2/m^3/s of flue gas flow, which didn't match with the actual condition. Inadequate SCA was the major reason for poor performance which could not meet the emission requirement.

Owing to electrostatic precipitators with small pressure drop, commonly less than 250 Pa, convenient for maintenance with less load required, therefore ESP's are widely used in India.

3.2 Flue Gas Conditioning

Flue gas conditioning can enhance the performance of electrostatic precipitators. Due to high silicon, high aluminum, high iron content and low alkali metals content in Indian coal ash, it belongs to acidity ash. High SiO_2 content makes dust with poor soakage property, so the conditioning function has definite influence when adopts SO_3 conditioning. Adding ammonia would give additional improvement, probably due to dust agglomeration.

Testing with SO_3 and NH_3 for flue gas conditioning was conducted in Indian BALCO power plant. The test results show that the outlet particle concentration was reduced by 50% when using SO_3 alone and outlet concentration was reduced by 65% when using both SO_3 and NH_3. Therefore, the contribution by NH_3 alone was 15%. The test data is shown below in Table 3.

Table 3 Stack monitoring report

Unit No	SPM Without SO_3 & NH_3 Dosing	SPM with SO_3 Dosing	SPM with SO_3 & NH_3 Dosing
Unit-1	834	343	302
Unit-2	822	422	370
Unit-3	784	370	208
Unit-4	544	330	176

Practice indicates that flue gas conditioning can improve the performance of ESP, but the improvement has a limit. It is necessary to have a certain minimum SCA to meet the emission requirement. We must understand this point when adopting the mode of conditioning plus ESP.

The SO_3 conditioning system consists of sulfur storage tank, air heaters, sulfur burner, converter, controller, injection probes and so on. System resistance of ESP is uninfluenced

To retrofit ESP for performance enhancement, SO_3 or NH_3 conditioning is adopted, sometimes both of SO_3 and NH_3 are used together in India.

3.3 EFOIP of Longking Type

EFOIP here means a kind of combined precipitator with fabric filter together. Fujian Longking began to study this kind of EFOIP in 2003. It is consisted of two parts in series, electrostatic precipitator area at the front and filter bag area at the rear. The structure is shown in figure 1. It is known as Electrostatic Fabric Organic Integrated Precipitator (EFOIP). [2].

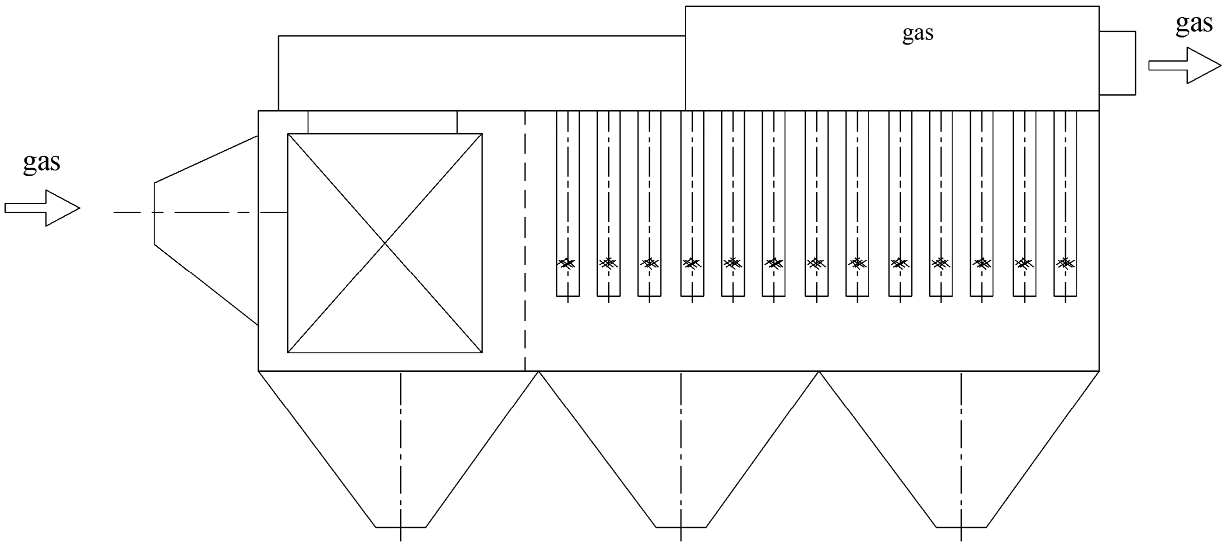

Fig. 1 EFF of Long King type known as EFOIP

Dust is charged and most of them are collected in the front electrostatic precipitator area, and the dust amount entering the filter bag area is small in quantity, fine in size, but also loosened on the filter bag surface. As a result, the gas flow resistance in filter bag area is largely reduced, the cleaning period extended much longer, and the abrasion of filter bag caused by scouring of coarse grain can be avoided.

Practice indicates that the outlet particle concentration of EFOIP is less than 50mg/Nm^3, resistance less than 1000 Pa, and the life of filter bag is longer than 4 years. But filter bag requires a lot of maintenance.

4 DISCUSSION ABOUT STRATEGY OF MODE OF DUST REMOVAL

4.1 Analysis of Feasibility and Reliability

The above mentioned three modes of dust removal can all satisfy the requirement of Indian coal fired boiler flue gas cleaning if selected properly.

For electrostatic precipitators, due to specific characteristic of Indian coal and ash, size of ESP must be sufficiently large. The performance stability of ESP is affected by coal levity burning in Indian power plant. High particle concentration and high SiO_2 content increase the abrasion of inlet and outlet nozzle, hopper, and air conveyer ducts. Improper design can easily cause equipment outage.

For flue gas conditioning, the limitation of conditioning function must be sufficiently recognized. It must be realized that the ash physical and chemical properties affect the conditioning, and one must ensure that the matched ESP has a certain minimum SCA to start with. Because the flue gas conditioning system is independent from the ESP system, it has the advantage of short outage time required in ESP enhancement retrofit.

For EFOIP, the advantages of electrostatic precipitator and fabric filter are combined in one entity. The performance is not effect by characteristics of coal and ash with long period of stable operation and high efficiency. It is the best way to solve the issue of flue gas dust removal of Indian coal fired boilers. When comparing with electrostatic precipitators, filter bag operation resistance is higher and with much higher workload for filter bag maintenance. To compare with fabric filter, operation resistance can be lower by 1/3, and the life of filter bag is longer.

4.2 Analysis of Capital Investment and Operation cost

Capital investment and operation cost depends on mode of dust removal and precipitator size, but the mode of dust removal and precipitator size depends on characteristic of coal and ash and performance target. For example, for a 500 MW unit with some Indian coal fired boiler and typical characteristics of Indian coal and ash, one 500MW unit, the budgetary details for the three modes of dust removal are shown in Table 4.

Table 4 Economic budgetary comparison

	Out let concentration mg/Nm^3	One-off investment (equipment fee)(104$)	Operation cost/year		
			Power consumption 104 kwh	Sulfur consumption T	Maintenance fee (104$)
ESP	100	1439	1440		30
Conditioning + ESP	100	1399	1226	345	24.5
EFOIP	< 50	1146	985		7.5+28

Because the typical Indian coal used in this project, and submitted typical characteristic of Indian coal ash, with 0.25% sulfur content in coal, high silicon, high alumina, low alkali metals in ash, only with 0.08% of sodium oxide content, high inlet particle concentration of up to 97.7 g/Nm^3, therefore, it is required to use a SCA larger than 200 m^2/m^3/s of gas flow, 4 parallel ESP each with 2 chambers and 8 fields, gas velocity must be lower than 0.65 m/s. If conditioning plus ESP is adopted, considering limitation of SO_3 conditioning, for achieving 100 mg/Nm^3 outlet requirement would need to use 6.5 fields of above mentioned ESP as the basic requirement. If EFOIP is adopted, it only need to keep 2 fields of the above-mentioned ESP, and use 2.5 fields space as filter bag area. When comparing with the above mentioned ESP, investment of 3.5 fields ESP can be saved. Therefore, one-off capital investment of EFOIP is the lowest, ESP is the highest. The capital investment for gas conditioning plus ESP is lower than ESP, but higher than EFOIP.

Power consumption is estimated according to 24 hours per day, 300 days per year. Operation power of ESP is assumed to be 2000 kW. Conditioning plus ESP requires 1625 kW for ESP part, 78 kW for fan and heating power consumption of conditioning, and a total of 1703 kW. EFOIP requires 500kw for ESP part, and filter bag area requires 868kw due to increased power consumption of fan and air pressure equipment, giving a total of 1368 kW.

Sulfur consumption is estimated according to 48kg per hour, 24 hours per day, and 300 days per year.

For maintenance cost, ESP is estimated according to the cost of emitting and collecting system with a 20 years life. EFOIP, the ESP part is according to the cost of emitting and collecting system with a 20 years life and the fabric filter parts is based on the cost of filter bag replacement of 5 years. Conditioning plus ESP is according to ESP cost of emitting and collecting system with a 20 years life.

Considering power consumption, sulfur consumption and maintenance fee, operation costs of the three modes of dust removal are comparable. But power consumption for EFOIP is the lowest.

4.3 Strategy of Dust Removal

The above analysis indicates that whether compared in reliability of performance or in economic terms, and in the view of the specific characteristics of typical Indian coal and ash, the first choice of dust removal for Indian coal fired boiler should be EFOIP, and then ESP or conditioning plus ESP.

5 BRIEF SUMMARYS

When coal fired boiler burning typical Indian coal, because of the specific characteristics of ash, a very big SCA is needed to satisfy the performance requirement for ESP. Moreover, SO_3 conditioning also requires adequate SCA as a base. Therefore, there is even more advantages when adopting EFOIP. In order to assure performance of dust removal or on economic terms, EFOIP should be the first choice. It not only has a stable performance, high efficiency of dust removal but also has low power consumption. Along with progress of sieve material technique, the economic advantage will be even more outstanding. Large maintenance for filter bags and troubles of replacement are the disadvantages of EFOIP

REFERENCES

1. A. Chandra Performance Improvement of Electrostatic Precipitator: Some Experimental Study ,June, 2006.
2. Huang Wei, Lin Hong, Development and Application of FE Type Electrostatic abric Organic Integrated Precipitator in Longking. The 12th Chinese Electrostatic Precipitate Academic Conference paper collection, October, 2007.