Application of ESP and Fabric Filter in Power Plants in China

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Abstract: Electrostatic precipitators have been used in power plants of China for decades. As the dust emission limit becomes stricter than before, fabric filters come into using in power plants. This paper presents two examples of electrostatic precipitator and fabric filter and analyze their technique economy.

Keywords: Electrostatic precipitator, Fabric filter, Power plant

1 INTRODUCTION

Electrostatic precipitator (ESP) and fabric filter (FF) are the two most widely used methods for industrial gas cleaning. The ESP application in power plants has been more than tens of years. The collecting mechanism of the ESP relies on that when the dust gas passes through the high voltage field of the precipitator, the particles will be charged and then move towards collecting plates under the electrical force. The advantage of ESP is of low resistance, usually 200 Pa-300 Pa, and a high cleaning efficiency, about 99.5%. But the particles' resistivity has a great influence on the collecting efficiency. When the dust emission criterion is a bit stricter, especially lower than 50 mg/Nm^3 (present criterion for coal-fired power plant), it is hard to maintain the new requirement.

For FF ,people has little knowledge about it. This article presents a comparison between the two methods from the technical and economical aspects.

2 DESIGN CONDITIONS and EQUIPMENT CHOICE

For ESP, properties of coals have great influence on the equipment performance and operating price, while FF hardly has these limitations. We use two illustrations to make technique economy analysis on the two methods. Two kinds coals are used. One is a normal kind and the other is a hard-collecting kind in allusion to the ESP.

2.1 Normal Kind Coal

2.1.1 Design Conditions

Components of the coal and the corresponding fly ash are shown in Table 1.

Table 1 Components of the coal and the corresponding fly ash

	Item	Unit	Designed coal
Industrial analysis	Mt	%	4.6
	Mad	%	2.6
	Vdaf	%	32.25
	Aar	%	27.25
Elements analysis	Car	%	47.62
	Har	%	3.88
	Oar	%	6.09
	Nar	%	0.84
	St.ar	%	0.83
	Car	%	56.51
Lower heating value Qar.net.p		kJ/kg	22240
		HGI	78
	Deform temperature DT	℃	□1500
	ST	℃	□1500
	Fluid temperature FT	℃	□1500
Fly ash components	S_iO_2	%	50.72
	Al_2O_3	%	35.8
	Fe_2O_3	%	2.59
	CaO	%	2.83
	MgO	%	0.5
	SO_3	%	1.24
	Na_2O	%	0.6
	K_2O	%	0.6
	TiO_2	%	0.73
	MnO_2	%	0.14
	Others	%	4.25

Inlet flu gas temperature: 123 ℃
Inlet flu gas velocity: 1,900,000 m^3/h
Inlet dust concentration: 27 g/Nm^3
Emission dust concentration: □50 mg/Nm^3

2.1.2 Particle Removal Equipment Specification

Based on the flu gas condition above, EP and FF are designed separately as follows.

2.1.2.1 Electrostatic Precipitation

Type: 2FAA6×35M-2×120-150
Effective collecting area: 52500 m^2
Specific collecting area: 99.5 $m^2/(m^3/s)$
Equipment resistance: 250 Pa
Equipment power consumption□2095 kW
Suction fan (only considered Required power for overcoming Equipment resistance): 155 kW
High voltage: 1700 kW
Hoppers energy consuming: 240 kW
Land area: 27 m×45 m (front and rear heads not included)

2.1.2.2 Fabric Filter
Type: 2LKPB179
Effective collecting area: 35800 m^2
Filtration velocity: 1 m/min
Equipment resistance: 1350 Pa
Equipment power consumption: 1097 kW
Suction fan (only consider resistance due to precipitator): 945 kW
Air compressor: 72 kW
Hopper heating, lighting and so on: 80 kW
Land area: 28 m×28 m (front and rear heads not included)

2.2 Hard-Collecting Kind Coal

2.2.1 Design Conditions

Components of the coal and the corresponding fly ash are displayed in Table 2.
Inlet flu gas temperature: 130 °C
Inlet flu gas velocity: 2,150,000 m^3/h
Inlet dust concentration: 30 g/Nm^3
Emission dust concentration: □50 mg/Nm^3

Table 2 Components of the Coal and the Corresponding Fly Ash

	Item	Unit	Value
Industrial analysis	Mad	%	3.84
	Car	%	43.85
	Vdaf	%	38
	Var	%	23.09
	Aar	%	26
Elements analysis	Car	%	47.62
	Har	%	3.01
	Oar	%	8.77
	Nar	%	0.88
	St.ar	%	0.47
	Mar	%	13.25
	Aar	%	26
Lower heating value Qar.net.p		kJ/kg	17981
		kcal/kg	4300
		HGI	57
Abrasion index			≤1.5
	DT	℃	1250
	ST	℃	□1400
	FT	℃	
Ash component	S_iO_2	%	40.75
	Al_2O_3	%	47.26
	Fe_2O_3	%	4.73
	CaO	%	0.89
	MgO	%	0.20
	SO_3	%	1.06
	Na_2O	%	0.33
	K_2O	%	0.39
	TiO_2	%	1.84
	Others	%	2.55

2.2.2 Particle Removal Equipment Specification

Based on the flu gas condition above, EP and FF are designed separately as follows.

2.2.2.1 Electrostatic Precipitation
Type: 2FAA6×35M-2×120-150
Effective collecting area: 97200 m^2
Specific collecting area: 162.8 $m^2/(m^3/s)$
Equipment resistance: 250 Pa
Equipment power consumption: 3025 kW
Suction fan (consider the required power for overcoming equip resistance): 175kW
High voltage resource: 25580 kW
Hoppers heating, lighting etc.: 292 kW
Land area: 38 m×53 m (front and rear heads not included)

2.2.2.2 Fabric Filter
Type: 2LKPB179
Effective collecting area: 35800 m^2
Filtration velocity: 1 m/min
Equipment resistance: 1350 Pa
Equip consumption□1097 kW
Suction fan (power for overcoming equipment resistance): 945 kW
Air compressor: 72 kW
Hopper heating, lighting etc.: 80 kW
Land area: 28 m×28 m (front and rear heads not included)

3 A TECHNIQUE ECONOMY ANALYSIS ON TWO DEDUSTING APPARATUS

Under the normal kind coal condition, an technology-economy comparison between two dedusting apparatus has been studied as shown in Table 3.

When boilers used the very-hard-collecting kind of coal, a technique economy analysis on the two dedusting apparatus has been studied as shown in Table 4

Table 3 presents the normal kind coal, when the specific collecting area achieves 100 $m^2/(m^3/s)$, the equipment costs of ESP and FF are almost equivalent but operating cost of FF is obvious lower than that of ESP. And for the hard collecting kind coal, cost of FF is much lower than that of ESP either in . aspect of equipment or operating.

Table 3 A technique economy analysis on the two dedusting apparatus (normal coal)

Item	ESP	FF
General arrangement	Two sets, two sections, five fields, 24 hoppers in total	Two sets□16 hoppers in total, 16 independent filter chambers
Dedusting efficiency	Reluctantly assurance to obtain as low concentration as 50 mg/Nm^3	Dust emission concentration as low as 50 mg/Nm^3 or even lower
Equipment resistance	250 Pa	1350 Pa
Power consumption	2080 kW	985 kW
Equipment investment	About 16 million □	About 16 million □
Cost for annual operating and maintenance	Power consumption. If the running time is about 7500 h per year and the price is 3 yuan/kWh, the whole year cost 2095×7500×3 =4,710,000 □; Cost for annual normal maintenance will be 30,000 □; If electrode plates and discharge wires are renewed ever ten years, this cost will be 40,000 □every year; Not considering extra fees for reconstruct the equipment due to yearly accumulated operation Total fees: 5,140,000 □	Fees for changing fabric cloth. If the cloth life span is about 4 years and annual spoilage is about 1%, the average cost will be 1.2 million □; Eight years for a change, annual fees 140,000 □; Considering annual running hours 7500h and electricity price 0.3 □/kWh, the whole year cost: 985×7500×0.3 =2,220,000 □; Cost for perishable articles, pulse valve etc.: 40,000 □ per year. Total fees: 3,600,000 □
Equipment overhaul	Cannot working online	Can working even under 100% load
Land area	27 m×45 m	25 m×28 m

Table 4 A technique economy analysis on the two dedusting apparatus (special coal)

Item	ESP	FF
General arrangement	Two sets, two sections, five fields, 24 hoppers in total	Two sets, 16 hoppers in total, 16 independent filter chamber
Dedusting efficiency	Though enough collecting area, no assurance to obtain as low concentration as 50 mg/Nm^3	Assurance as low dust emission concentration as 50 mg/Nm^3 or even lower
Equipment resistance	250 Pa	1350 Pa
Power consumption	3025 kW	1097 kW
Equipment investment	About 28million □	About 18million □
Cost for annual operating and maintenance	Including: Power consumption: According the annual running time 7500h the price 3 □/kWh, the whole year cost: 3025×7500×3 =6,810,000□; Annual normal maintenance cost: 30,000□; Assuming renewing of electrode plates and discharge wires every ten years, accordingly 40,000□per year; Not considering extra fees for reconstructing the equipment due to yearly accumulated operation damage. Total fees: 7,540,000□	Including: Fees for changing fabric cloth. Assuming the cloth life span about 4 years and annual damage about 1%, the average cost about 1.2million □; Fees for changing framework. Eight years for a change□ annual fees 140,000□; Power consumption: Considering annual running hours 7500h and electricity price 0.3 □/kWh, the whole year cost: 985×7500×0.3 =2,220,000□; Cost for perishable articles, pulse valve etc.: about 40,000□ per year. Total fees: 3,600,000□
Equipment overhaul	Cannot online overhauling	Can online overhauling even under 100% load

Floor covered area	38 m×53 m	28 m×28 m

To compare more clearly about ESP and FF, Figs. 1 and 2 illustrate the performances of the two apparatus under condition of combusting different kinds of coals.

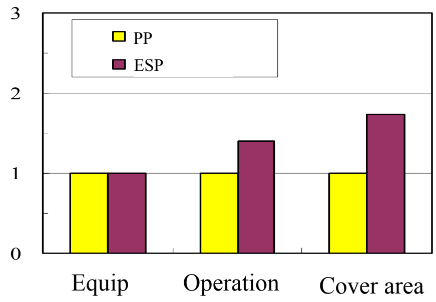

Fig. 1 A compare for the Normal Coal

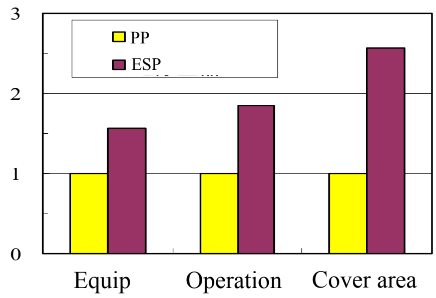

Fig. 2 A Compare for the Special Coal

As illustration above, the performance of ESP has a close relationship with the coal type. From the comparison we can see that under the recent market condition and if the specific collecting area of ESP on the verge of 100 $m^2/(m^3/s)$, FF has become an exceedingly competitive method to clean dust gas. For most FF applied in coal-fired plants, PP (polyphenylene sulfide) has the highest performance of technique economy among all the recent applicable fiber with high temperature resistance. Therefore, PP has been widely used as a filter material in coal-fired plants at home and abroad.

On one hand, the design of FF and the choice of filter material have a direct effect on the longevity of the apparatus, on the other hand, the operation condition, such as dust gas temperature, oxygen concentration, also has an important influence on the actual usage life. Though there are many cases that FF' service life are over 4 years at home and abroad, using PP as filter material, there are not a small amount cases that the life are less than 4 years. It is not a long time for our country to apply FF in power plant, so the accumulated experience is limited and the fact that whether the PP filter material can use 4 years is to be checked up in actual activity. However, in present field cases, the service life over 3 years of PP filter material is not a problem. Take a FF built by Feida Environment Corporation in Bafang power plant, Zhuji for example. The boiler with 75 t/h circulating fluid bed, was collocated a FF in August, 2004. The filter chamber has not damaged so far and the equipment resistance is lower than 1000 Pa. The service time of the first batch of filter bag in Fengtan power plant in Mongolia was also over 3 years.

Even the service time is considered to be 3 years in the apparatus operation cost, according to table 3, the actual operation cost of FF will increase from 3.6 million□ per year to 4 million per year. While according to table 4, the fees will increase from 4.08 million □ per year to 4.55 million □ per year. In this case, FF operation cost is also far below ESP.

If the space of power plants is restricted, FF is a better choice. And if we consider the space covered by front and rear head of apparatus, the ratio of floor area covered by the two apparatus is higher than the data shown by Figs .1 and 2.

However, it needs to be added that the data of this article is a general estimator. For the same flu gas condition, different apparatus' makers adapting respective designs have a substantial effect on the apparatus' price and operation cost as well as steels' price and filter bags' cost.

The criteria of the dust emission of power plant is 200 mg/Nm^3 before 2004. So the dust emission can meet the criteria if the effective collecting area is about 60 $m^2/(m^3/s)$ for most ESP. Under new situation, ESP are more economic than FF. However, when the dust emission criteria is becoming stricter, the equipments' price and operation cost will increase dramatically for ESP, and besides, whether the processing effect can meets the requirement is also a problem. But for FF, the dust emission concentration is not a problem even the criteria is higher. With the development of filter industry and improvement of FF's dependability and reduction of the cost, it will become a substantially competitive method in modern dust cleaning of coal-fired plants.

4 CONCLUSIONS

With improving criteria of environment protecting, the traditional dedusting method of ESP has been challenged by FF in the power plants in China. The stricter the criteria requires, the more difficult for ESP to maintain requirement but not for FF. In the aspect of easy-collecting coal, under present market price and the effective collecting area of EPS of 100$m^2/(m^3/s)$, the apparatus cost of FF is equivalent to the EPS, but the former' operation cost is far less than that of the latter. What's more, FF has a higher collecting efficiency and a lower covering floor. Thus the FF exhibits a stronger competition. With the increase usage of FF in power plant, people begin to gain a deeper understanding about it, and its cost gradually reduce as the beginning of domestic production of filter material. This imposes a higher requirement for EPS and urges more EPS manufactures to make more effect to face the challenge.

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