The R&D and Application of Electrostatic-Fabric Organic Integrated Precipitator in China

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Abstract: In recent years, the Chinese government vigorously promotes the "energy -saving and emission reduction" policy and the conventional ESP and fabric filter technologies applicable in all different industries face some new challenges. FE type Electrostatic-Fabric Organic Integrated Precipitator (EFOIP for short) is a new type of dust removal technology successfully developed by Longking, which has been applied in a number of projects in China. Practice shows that the technology has the following characteristics such as significant energy saving, stable, reliable, low-emission and so on. It is an ideal next generation dust removal device.

Keywords: Electrostatic-Filter organic integrated precipitator, high-frequency electric power, electric field, filter field, new dust removal technology

1 INTRODUCTION

With the expansion of industries, the exhaust volume of industrial equipment increases rapidly. For example, a 600 MW coal-fired boiler unit with exhaust capacity of 3.3 million m^3/h and if the dust concentration in the exhaust gas is 32 g/m^3, then the daily amount of dust in the exhaust may be up to 2500 t . Therefore, it's necessary to assemble a precipitator with a highly efficient and stable operation to reduce the pollutants discharged into the atmosphere at the rear end of the boiler. In recent years, Chinese government vigorously promotes the "energy-saving and emission- reduction" policy, which aims to realize the energy consumption, to reduce the harmful gases, and to reduce dust pollution to the environment.

Since the 1980s, ESP's have been installed in China's coal-fired boilers. Because the industry scale is small at that time, the state dust emission concentration requirement was < 200 mg/Nm^3. At present, this stipulation has been revised to 50 mg/Nm^3. For many areas (such as Beijing, Tianjin) the emission requirement has been revised to < 20 mg/Nm^3. Under this new circumstance, the conventional precipitator faces some challenges. In order to fulfill the Chinese government's new requirement of 'energy-saving and emission reduction', Fujian Longking successfully developed the EFOIP. Over the past few years, engineering practice shows that this technology has more advantages such as significant energy saving, stable, reliable and low-emission. EFOIP is an ideal new generation dust removal device.

2 CHALLENGES FOR THE CONVENTIONAL DUST REMOVAL TECHNOLOGY

The working principle of electrostatic dust removal technology is that charging dust in the electric field and depositing them to the collecting plate by electric force. The amount of electric charge carry by the dust is determined not only by the electric field conditions, but also influenced to a large extent by the flue gas components and the dust physical and chemical properties. Usually, the design of an ESP is mainly based on the coal category. But due to various reasons, the coal category may have great variations during the operation of the boiler. This will result in a lot of volatility on ESP collection efficiency. If the design of each dust collector is based on the most difficult coal (that means the dust could be difficult to be charged), it will greatly increase the equipment capital investment.

At present, the volatility of coal and the variety of fuel cause many difficult in the ESP design and operation .The volatility of specific dust resistivity, flue gas volume and dust concentration in the gas will affect the ESP collecting efficiency. As a consequence, the original ESP design which could meet the emission requirement is no longer adequate.

This is particularly so when the emission standard is raised to 50 mg/Nm^3 or even 30 ~ 20 mg/Nm^3, where the design, manufacturing, installation, operation of the ESP will require higher requirements. For example, the dust particle re-entrainment in the field due to rapping will affect the dust emission from the precipitator, which should be given special attention. In addition, the reliability of equipment is particularly important. Broken wirings and drop-out of hammer should be absolutely prevented. The quality of the insulation and electric power supply in the electric field should be guaranteed to prevent power failure to the complete collecting area.

According to the principle of ESP, its collection efficiency variation is based on an index. That is, when the concentration of emission requirement is reduced, the dust collecting plate projected area will increase by an index. Under normal circumstances, when the emission requirement is 20 mg/Nm^3- 30 mg/Nm^3, the number of precipitator electric field required may be up to 5-6, which causes the dramatic increase on equipment costs and power consumption.

Although the bag filter can achieve a very low concentration of emissions, but with a high pressure drop loss, and high blower fan electrical consumption. The filter bag replacement also poses a great pressure on the maintenance cost. Therefore, it's difficult to meet energy efficiency and resource consumption reduction requirements.

3 USING HIGH-FREQUENCY POWER CAN SIGNIFICEANTLY IMPROVE THE EPOIP PERFORMANCE

The design idea of EFOIP is to remove majority of the dust during the flue gas passage in the first field (based on the principle that the ESP efficiency varies by an index), and then let the charged dust move into the filter bag area. This will greatly reduce the filter bag resistance and achieve low-emission energy-saving. Above all, the charged effect in the electric field is more important. If the dust is fully charged, then there will be more dust deposit to the collecting plate under the electric force. The charged dust escaped from the electric field with more charges has a low filter resistance when the dust particle enters into the bag field.

Reasonable allocation and good electrode structure are the factors that impact the dust charge level in the electric field. Additionally, it is important to equip with a power device of good performance. Longking high-frequency power is an excellent new power supply, which not only has a small size, light weight and high efficiency (generally higher than 90%) and high power factor (generally higher than 95%) ,but also has a running current about 30% to 50% higher than conventional power supplies. Therefore, the dust in the electric field can be fully charged. Fig. 1 shows the voltage and current curves of conventional and high-frequency power supply units.

From the Fig. 1 we can see that the voltage of high frequency is close to DC whose current value is greater than the conventional power supply. Table 1 is the experimental results carried out on a 50 MW unit electrostatic-fabric organic precipitator (EFOIP), in which we compared the results using conventional power supply and high frequency power supply units. The precipitator had a different resistance and different current values. Currently, Longking has applied the high frequency power supply to EFOIP on 300 MW units and obtained good results.

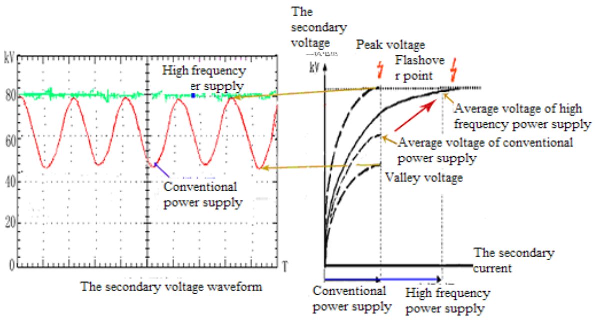

Fig.1 Voltage of the two power supplys

4 THE R & D OF STRUCTURE MODE ON EFOIP

The Electrostatic-Fabric Organic Integrated Precipitator (EFOIP) combines the technologies of ESP and fabric filter in one precipitator. How to get an organic integration of two structures to achieve the best allocation is a very meaningful research. During the research process, Longking has explored the following forms.

Table 1 A compare between the two power supplys

	U_2 kV	I_2 mA	ΔP Pa	Emission mg/Nm
Conventional Power supply	50	350	856	10
High frequency power supply	50	500	630	5

4.1 Horizontal Arranging Mode of Electric Field and Fabric Filter

The gas flue enters from the left port, through the air distribution plate and then enters each channel of the field area. Each channel and the electric field are horizontally arranged with bag filter. The dust is charged in the electric channel. The charged dust and non-charged dust move to hole-collecting plate together with the air flow, with some charged dust deposited on the plate and the other non-charged or charged dust flowing into the filter bag, which will stop the dust outside the filter bag. The clean gas can enter the upper air cleaning chamber through the filter bag intra-cavity, and then to be discharged from the draught flue.

This arrangement has the following advantages: the short flowing distance between the charged dust and filter bag in the electric field in which the charged dust will not lose the electric charge. However, it also has some shortcomings:

(1) During the working process, the electric field will generate electric spark inevitably which could damage the filter bag easily.

(2) After the charged dust arrives at the plate, it will leave the plate again by the driving force of the air flow and re-enters the filter bag. Therefore, it reduces the collecting efficiency.

(3) Low volume utilization rate. While dealing with the same volume of dust, compared with the second type, this first arrangement requires 1.6 times of the volume for the second arrangement in the following.

For these reasons, this arrangement has not been adopted in any project currently.

4.2 Vertical Arranging Mode of Electric Field and Fabric Filter (Fig. 2)

The flue gas is imported from the left inlet nozzle and moves into the electric field through the gas distribution plate. The dust is charged in the electric field and most of them are collected in this area. The remaining particles enter the bag field on the right end, and remains outside the bag surface. The clean gas can enter the upper air cleaning chamber through the filter bag intra-cavity, and then to be discharged from the draught flue.

This type has advantages such as: The collected dust can not be easy carried away by the air flow in the electric field which can gain high dust efficiency. It also can greatly reduce the load of filter bag. Secondly, it is appropriate for the old ESP refurbishment. For the general 3-electric field ESP, merely substitute fabric filters for the two electric fields on the back-end and the retrofit can be easily implemented. There is no need to refurbish the old hopper and the conveying system, and there is no need of a major change in the civil foundation. Therefore, this arrangement is widely used at present.

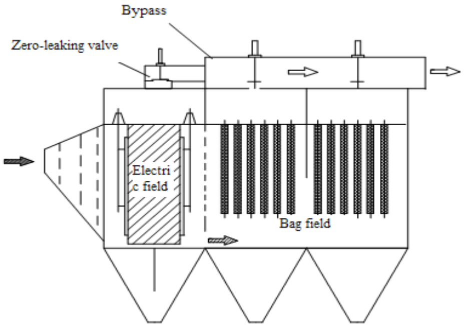

Fig. 2 Vertical arranging mode of electric field and fabric filter

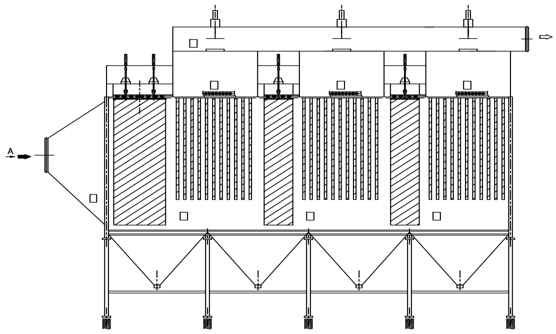

Fig. 3 EFOIP outside the electric field

Arrange EFOIP outside the electric field (Fig. 3) is developed based on the second type (Fig. 2), which increases a number of short fields between bags district. The flue direction will flow level instead of from the bottom up. After the dust leaves the electric field for some distance, it flows through the multiple electric fields and will be charged again which enhances the dust electric charge and collection. Dual electric field can be located about 1 to 3 number according to the length of bags.

4.3 Vertical EFOIP (Declared Patent)

For large fabric filter, owing to the aspect ratio design restrictions of dust collector, the length of plate is 15 m. But the filter bag only has a maximum length of 8 ~ 10 m due to technical reasons. Therefore, if we adopt the structure of 3.2 or 3.3, the lower part of bag will have a large space, which results in low utilization of equipment volume. Fig.4 shows the vertical structure of EFOIP, the lower part of precipitator contains the electric fields while the upper part contains the fabric bags. The dust enters the hopper from the bottom, and then up to the first electric field, where the most charged dust to be collected while the other particles move up to the bag field .The dust movement was resisted on the surface of bag and the clean gas pass through intra-cavity of the filter bag , then exits from the side.

This type of EFOIP has a compact structure, light weight and with good economy.

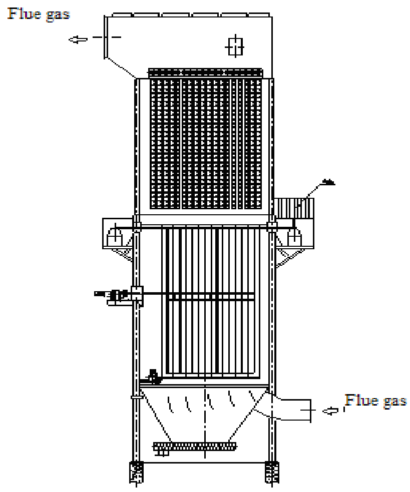

Fig. 4 Vertical structure of EFOIP

5 THE APPLICATION OF EFOIP IN CHINA

Longking has been undertaking 70 projects since developed EFOIP in 2001, which has been applied in more than 20 sets of 50 MW ~ 300 MW power plant units. From these practices we gain the following experience.

5.1 Long-term and Stable Low Emissions

Practice has proved that in all operating projects, EFOIP has an emission much lower than the national standard concentration requirement of 50 mg/Nm^3. At the same time, regardless of the coal category used in power plants, temperature and volume fluctuation of flue gas, the EFOIP emissions hardly changed. Therefore, factories and enterprises near urban and scenic areas are particularly suitable to adopt this type precipitator.

5.2 Lower Running Resistance

In the bag filter area, the effect of the electric field reduces the dust concentration into the bag on the one hand, at the same time it charges the dust and the electrostatic cohesion of dust leading to the regular orderly arrangement on the filter bag surface. This greatly reduces the pressure difference across the inside and the outside of the filter bag. Fig. 5 shows he test data on an EFOIP. Many on-site practices shows that, the differential pressure is only 200 Pa-400 Pa, while the overall pressure of running EFOIP is only 600 Pa-800 Pa.

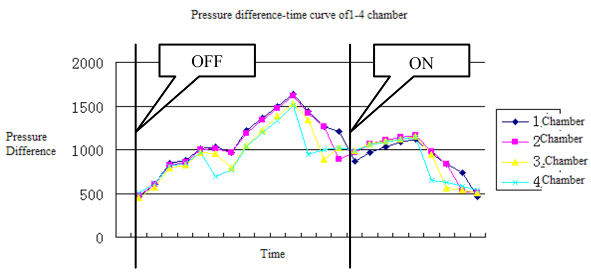

Fig.5 Resistance performance of FE-type EFOIP

Low-resistance performance of FE-type EFOIP has significant energy saving effect. According to the actual statistics of Nanjing Meishan energy company where one 50 MW unit was refurbished by adopting FE-type EFOIP and compared with the previous 3-field structure ESP, substantial reduction of the emission concentration was achieved and also saved 50 units of electricity per hour. It is estimated that one 300 MW unit EFOIP can save at least 2.1 million kwh of electricity annually compared to the bag filter dust collector. Therefore, the EFOIP is the new generation of energy-saving equipment.

5.3 Simple Operation and Easily Maintenance

More than one product's practice have proved that, due to the little electric field inside precipitator, the failure rate of the consequential component in electric field is low, and there are less high-voltage power supply and low voltage electrical faults. In addition, because of the structural characteristics of FE-type EFOIP, there is no bag rotary device and can be operated reliably. According to the user's feedback, the FE-type EFOIP had required very little maintenance after installation, so the workload is smaller than the previous ESP.

5.4 Long Servicing Life of Filter Bag and Low Maintenance Costs

Because of the low dust concentration of flue gas in the bag field, as well as charged dust, FE-type EFOIP has a low cleaning pressure (general 0.2-0.25 MPa), long cleaning cycle, (normally 2500-6000 seconds) and the filter bag has experienced only minor damage from bag cage. For example, Shanghai Jinshan cement plant has used filter bag for more than four years, which still maintain the filter bag undamaged.

5.5 Attentions on the Design Selection of Core Components of EFOIP

The performance of FE-type EFOIP is closely related to the quality of the core components in bag field. These core components are: filter bag, bag cage, and pulse valve, figured pattern plate, air bag and pulse pipe and so on.

The filter bag is the core component of EFOIP. Users choose a suitable fiber material according to the composition, temperature, etc. Then consider the emission requirements and filter bag life, as well as the economic affordability to choose the different filter structure. Filter with different structure has different emission performances, resistances and servicing lives. In recent years, the international community gradually realized that different types of coal-fired boiler (chain furnace, circulating fluidized bed boiler, and pulverized fuel fired boiler) need to choose different filter structures because of the different components of dust and flue gas, which requires our attention. For some low-temperature (<120 ℃), non-acid-base corrosion flue gas (such as blast furnace iron plant) in steel industry, you can choose polyester Zhen Cizhan overlay film filter. For filter selection, refer to Table 2.

Table 2 Flue gas and according filter

Flue Type	Temperature ℃	Filter	Emission (mg/Nm^{3})	ΔP pa
Cement Loading End	< 250	E-covered fiberglass	< 20	< 1000
Coal-burning Boiler	< 160	PPS+PTFE Overlay Film	< 20	< 1000
		PPS+15%P84	< 30	< 1000-1200
		PPS+Surface Treatment	< 50	< 1200-1500
Blast furnace iron plant	< 120	Dacron punched	< 20	< 1000

Bag cage is the supporting components of filter bag, whose structure affects the filter bag life to a large extent. To reduce the pressure on bag cage from the filter bag, it is necessary to control within 0.0062 m^2 area per pane, the vertical reinforcement should be larger than Φ3 mm, and the cross reinforcement should be larger than Φ4 mm. The welding joints should be firm, with a smooth surface. Sub-link cage bag part must be connected firmly and can be easily installed and removed .The bags used for power plant should be treated by silicone spray.

Pulse valve is the key component of filter bag cleaning, which must guarantee the following two important properties. The first is the blowing volume. For example, a 3 valve under 0.25 Mpa pressure, its blowing volume should not be less than 400 L when the pulse width is 0.15 s .The second is the pressure wave after the blowing. The pressure altitude rate should be large during blowing, the pressure waveform should approach a square form, so the filter bag can get a better cleaning effect.

6 CONCLUSIONS

As a new type of precipitator, FE-type EFOIP developed by Longking has the following characteristics: long-term stable low-emission and energy-saving etc, which have increasingly been accepted by users. At present, there are many 200 MW-300 MW units of EFOIP applied in the power industry and 600 MW EFOIP project is being designed. The first EFOIP product used in 1500 t/d rotary kiln has run more than five years, with the resistance below 800 Pa and intact filter bag.

Under the nation's new emission standards, many precipitators are facing refurbishment. If adopting FE-type EFOIP for refurbishment, it can maintain the original casing, no need to increase the original space and without changes in the civil foundation, which has outstanding merits for reducing the construction period and reducing the cost.

Practice has proved that Longking EFOIP has been more widely used as its excellent performance in China's industrial dust removal areas. At the same time, the EFOIP technology still requires continuous improvement and innovation.

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