Research of Rebuilt and Application of Dust Collector in Coal-Fired Power Plants

Qizhen Liu, Yanjing Sun, Lei Jia, Yihua Zhang, and Zhigang Shen

***Abstract*—Power plant A and Power plant B launched the rebuilt pilot project of bag house and power source of electrostatic precipitator in order to further increase the dust removal efficiency in coal-fired power plants and then improve air quality in Shanghai. Results showed that dust reduction rate rose to 69.5% and the concentration of particulate matter dropped to 9.2 mg/m^3 after the rebuilt of bag house. On the other hand, dust reduction rate was 48.8% and the concentration of particulate matter was 17.9 mg/m^3 after the rebuilt of electrostatic precipitator.**

***Index Terms*—Coal-fired power plants, dust collector, dust removal efficiency, particulate matter.**

I. Introduction

During the "The eleventh five-year ", Shanghai focused on the total pollutant emission reduction, actively promoted the construction of desulfurization facilities in coal-fired power plant, strengthened the works like industrial structure adjustment, clean energy substitution and extensive industrial pollution elimination, etc. The atmospheric pollutants prevention and control in Shanghai has made great progress and atmospheric environmental quality maintained steady improvement. While, there still existed a big gap between Shanghai and other international metropolis in air quality, including the annual concentration of PM_{10} is 3 to 4 times more than that in Seoul, Hong Kong, Singapore, and other international metropolis. On the other hand, with the constant change in pollution structure, the new air pollutant such as gray haze or photochemical smoke which a caused by particles has already been quite serious. Therefore, particulate pollution (especially PM_{10} and $PM_{2.5}$) has become both the bottleneck to restrict the further improvement of environmental air quality in Shanghai and one of the keys and difficulties for Shanghai to promote ecological city construction and international metropolis construction.

To further deepen particle emission control of the coal-fired power plant, and improve the atmospheric environment quality so as to protect human health, the ministry of environmental protection of China clearly required in "State environmental protection 'The twelfth five-year' basic planning ideas" that particulate matter pollution control should be wholly strengthened: "Conduct industries should widely use high-efficiency dust removal facilities like bag house, electric composite filter bag, and the city whose particulates are seriously exceed the standard should implement the total quantity control of particulates". At the same time, the upcoming atmospheric pollutant emission standard of thermal power plant (GB13323-2012) shows that particulate matter emission limits declines, from originally 50 mg/m^3 to 30 mg/m^3, and smoke dust emission limits in key areas is 20 mg/m^3.

According to the statistics, the dust removal efficiency of electrostatic precipitation facilities used in most coal-fired power plants in Shanghai can achieve above 99%. While the particulate matter emission concentration of most power plants is during 20 to 50 mg/m^3, which mean that it is difficult to achieve emission limits of 30 mg/m^3. The problem is influenced by several factors, such as electrostatic precipitation technology, coal change, operating conditions and so on. On the other hand, the stability of particulate matter emission efficiency is not very high, which has constant impact on the stable operation of desulfurization facilities Gas Gas Heater (GGH), especially to ultrafine fly ash capturing whose rate is low. This part of the fine particles is main in which size is less than 2.5 μm, which surface enriched trace metal elements and organic pollutants, and become more harmful to human health and ecological environment [1]-[4].

Therefore, in order to further increase the dust removal efficiency in coal-fired power plants and improve air quality, Shanghai actively promote rebuilt pilot project of dust collectors in coal-fired power plants, they are 1# Unit bag house rebuilding in Shanghai power plant A and power source rebuilding in Shanghai power plant B.

II. The Rebuilt Pilot of Bag House

Bag dedusting is a kind of high-efficiency dust removal technology which is different with electrostatic precipitation. It uses fiber materials (filter-bag) to capture particulate matter. The outstanding characteristic is its high dust removal efficiency. The actual application dust removal efficiency can reach above 99.99%. After filtering, the concentration of dust in flue gas is generally lower than 30 mg/Nm^3, some even below 10 mg/Nm^3. Bag dedusting has a quite high dust removal efficiency on the fine particles below 2.5 μm, which is the most harmful to human body, it has a efficient removal to particulate mercury in flue gas, while the dust removal efficiency isn't affected by the characteristics of particulate matter. It operates stably and has already been widely used in industry like steel, nonferrous metal and building materials. It

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is a high efficient air pollution control technology [5]-[8].

The power load of Shanghai power plant A 1# Unit is 320 MW and the maximum continuous evaporation capacity of boiler is 1038 t/h. The boiler is subcritical pressure controlled circulation boiler, using single furnace - type layout, one-time reheated in the middle, and four corner fired. The outlet of boiler preheater is originally equipped with two double room three electrostatic precipitators produced by Shanghai Mining and Metallurgy Machinery Factory, whose model is 2FAA3×45m-2×80-135-A22, and it changed to bag house modeled SCLM37060 from April to June, which was put into operation formally on June 12, 2010.

According to CEMS data from 1# Unit online monitoring system, the estimated dust removal and transformation effect is: Before rebuilding the bag house, the daily average emission concentration of 1# Unit of Shanghai power plant A is about 27.1 mg/m^3 and daily average emission is about 0.59 t; After rebuilding, daily average emission concentration is about 9.19 mg/m^3 and the average emission is about 0.18 t, the reduction rate has reached 69.5% (see Fig. 1 and Fig. 2).

Fig. 1. The variations of particulate matter concentration emission of 1# Unit from Shanghai power plant A.

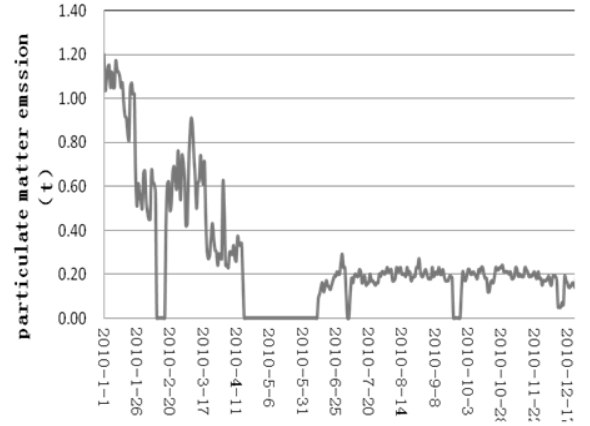

Fig. 2. The variations of particulate matter emission of 1# Unit from Shanghai power plant A.

III. The Pilot of High Frequency Power Source Rebuilding

High frequency power source changes three-phase power source to direct current through rectification, to high-frequency alternating current through inverter circuits, and then into high frequency pulse current collector though boosting from rectifier transformer, it's working frequency is about 20 Hz, which can apply various voltage waveform to electrostatic precipitator, and improve the dust removal efficiency by improving charging efficiency of particulate matter and the speed of stive migration. At the same time, in the advance of the particulate matter having enough charge that can reduce invalid field ionization, then largely reduces power energy loss of electrostatic precipitator, overcoming the particular phenomenon--"back corona" under the high dust resistivity, both improving the dust removal efficiency and largely saving power consumption. Using means of flexible control, providing the most suitable voltage waveform according to the working standard of electrostatic precipitator that can improve the dust removal efficiency and power supply efficiency so as to save energy [9], [10].

The 8# Unit from Shanghai Power Plant B whose installed capacity is 1000 MW is the domestic largest installed capacity of ultra supercritical steam turbine. It was put into production on July 17th, 2008. The Unit equipped with four electric field of electrostatic precipitators to be put into synchronous operation with the unit.

Since the original electrostatic precipitators adopt the traditional two-phase 380V AC power source which has high energy consumption and large particulate matter emission concentration, power plant reduces electrostatic energy and particulate matter emission concentration in response to the call of the national energy saving. Began to rebuild the power source of electrostatic precipitator on October, 2009, this time they adopted advanced high-frequency power supply technology. Each unit equipped with 24 Jia-Huan model 3000C series power facilities which rated capacity are 72 kV, 2000 mA, and high-voltage power supply rated power is 3456 kW total. The transformation was completely finished on March, 2010. After optimization and adjustment, the total power operation of electrostatic precipitator is between 1300 to 1400 kW, among which the low vibration total heating power is about 400 kW.

According to CEMS data from 8# Unit online monitoring system, the estimated dust removal and transformation effect: Before rebuilding the bag house, the daily average emission concentration of 8# Unit of Shanghai power plant A is about 34.5 mg/m^3 and daily average emission is about 2.15 t; After rebuilding, daily average emission concentration is about 17.9 mg/m^3 and the average emission is about 1.19 t, the reduction rate has reached 48.8% (see Fig. 3 and Fig. 4).

Fig. 3. The variation of particulate matter emission concentration of 8# Unit from Shanghai power plant B.

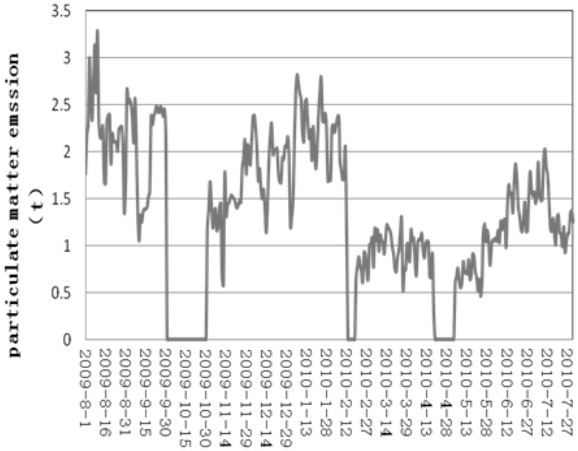

Fig. 4. The variation of particulate matter emission of 8# Unit from Shanghai power plant B.

IV. Results Discussion

After transformation, the smoke dust emission concentration of bag house reduces from 15-45 mg/m^3 to 5-15 mg/m^3, the particulate matter reduction rate is about 69.5%. Dedusting effect is very significant, especially in burning high ash coal. Compared with the electrostatic precipitator before, it has a good adaptability. It considerably reduces the ash clogging of GGH and improves the operation rate of desulfurization system 2 to 5 percentage points.

After the transformation of power source, electrostatic precipitator, the operation of electrostatic precipitator is stable and reliable. The dust removal efficiency improves obviously and energy-saving effect remarkably. One year of online monitoring data shows that the outlet particulate matter emission concentration of electrostatic precipitator's reduces from 20 to 45 mg/m ^{3}before transformation to 8 to 35 mg/m ^{3}, the reduction rate of particulate matter emission is about 48.8% after transformation.

The expense of high frequency power source transformation is very low, about 5 yuan/kW, and it is estimated that the expense of high frequency power source transformation of electrostatic precipitators in whole city's coal-fired power plant is about 74.09 million yuan; and the transformation of bag house is about 60 yuan/kW, and it is estimated that the expense of high frequency power source transformation of bag houses in whole city's coal-fired power plant is about 8.8908 billion yuan.

After transformation of the high frequency power source, the total energy consumption of the high-voltage power supply of electrostatic precipitator reduced from 871 kW before transformation to 266 kW and the energy saving rate reaches 69.5%.

Bag house: Operating stably and easy to control, no high-voltage equipment, well safety, few interference factors to dust removal efficiency, discharging stably. As the filtering bag is a core component and a heart of bag house and relatively fragile and vulnerable, the management is demanding.

Electrostatic precipitator: There are lots of interference factors on the dust removal efficiency when operating and the emission is instability. High voltage equipment requires high safety requirements.

Bag house is largely influenced by the temperature of flue gas. If the flue gas temperature is too low, the condensation may cause "paste bag" and casing corrosion. If the flue gas temperature is so high that over the permissible temperature of the filter, it may cause "burn bags" and damage the bag. So the unit power load must be controlled, to avoid the temperature be too low or too high. Compared with the unit power load, the load seldom affects the electrostatic precipitator.

V. Summary

After transformation, the particulate matter emission reduction rate of bag house is about 69.5% and the average particulate matter concentration is about 9.2 mg/m^3 after transformation. The particulate matter efficiency of electrostatic precipitation equipment is slightly lower after transformation, which is about 48.8%, and the particulate matter concentration is about 17.9 mg/m ^{3}. All emission concentrations reach the new standard. It is estimated that the expense of high frequency power source transformation of electrostatic precipitators in whole city's coal-fired power plant is about 74.09 million yuan; and the transformation of bag house is about 60 yuan/kW, and the expense of high frequency power source transformation of bag houses in whole city's coal-fired power plant is about 8.8908 billion yuan.

As the rebuilding pilot of the electrostatic precipitator transformation of power plant boiler in Shanghai is the first time and the running time is slightly short, it still exist many new problems to research and to be solved. Such as the running resistance the bag house operates is very high, flue leakage rate is too serious, and the instability of particulate matter emission after the rebuilt of power source of the electrostatic precipitator. Thus, it is suggested to deeply carry out the monographic study about precipitator transformation of power plant units, further improving the technology of bag filtering and power source transformation by research, basing on the experience from concluding the pilot, wholly promote the dust collector transformation project.

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