High Dust Concentration ESP for Coal-fired Boiler of 300 MW Generator

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Abstract: In the dry Flue Gas Desulphurization(FGD) system, ESP plays an important role; one of its outstanding characteristics is that it can treat with high dust concentration flue gas. Compared with conventional ESP equipped for coal-fired boilers, the successful application of this kind of ESP is a great breakthrough. This article described the main characteristics of this kind of ESP such as different electrodes, distribution in the inlet plenum and fields, internal design, pre-collection etc.

Keywords: electrostatic precipitator, high dust concentration, gas distribution, pre-collection, corona block

1 INTRODUCTION

As the world's second largest country in total installed capacity, China gets 80% of its power from coal-fired boilers. So China has a serious situation of pollution in SO_2. With an increased human demand for better residential environment, all kinds of technologies in FGD and dust removal are widely applied, especially dry and semi-dry FGD technologies with the characteristics of small investment, low power consumption, less occupational room and no waste water. Among similar FGD technologies, Reflux Circulating Fluidized Bed Flue Gas Desulphurization (RCFB-FGD) is the most popular in 300 MW steam generator. The High Dust Concentration ESP introduced in this article is the dust removal equipment in RCFB-FGD system.

2 BRIEF INTRODUCTION OF DRY FGD SYSTEM

A RCFB-FGD system is mainly compose of absorbent preparation system, pre-collector, absorb tower, recycling system, postpositive dust collector, water spraying system, ash handling system, electrical equipment and control system.

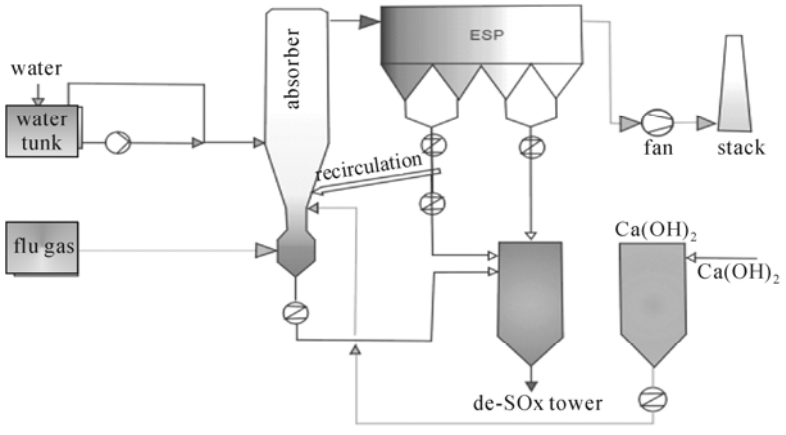
The flue gas from air-heater with temperature of 140 □ goes into the bottom absorber via the pre-dust collector, the flue gas is speeded up by the venturies which locates the bottom of the absorber. The absorbent is sprayed into the tower at the outlet of the venturi blowers. The temperature of flue gas decreases to 70 □-90 □ by atomized water, meanwhile the water is further atomized because of the high gas velocity. The absorbent mixed with wet flue gas, react to SO_2, and then produces $CaSO_3$, $CaSO_4$. The flue gas with lager amount of particulate exhausts from the upper part of absorber, then goes into the postpositive ESP (or bag filter). Most of particulate collected by the postpositive ESP returns to absorber for further reaction via the recycling system under the postpositive ESP. This recycle repeat about 100 times-250 times, a little of ash is discharged to the ash hopper. The cleaned flue gas is exhausted to stack through ID fan. (Please refer to the following basic process flow diagram).

The process characteristics of this kind of postpositive ESP:

The inlet dust concentration is very high, normally as 1000 g/Nm^3.

The main particulate component are $CaSO_3$, $CaSO_4$ and $Ca(OH)_2$.

The particulate is fine, the average diameter (50% sieve residue) is 7±3 μm, the specific surface area of the $Ca(OH)_2$ generated by hydration reactor is about 18 m^2/g -20 m^2/g.



Basic process flow diagram

The flue gas temperature is low, normally at 80 ℃.

The gas volume treated by one ESP is larger. There is only one ESP in this kind of FGD which using in the 300 MW coal-fired boiler, but the usual 300MW coal-fired boiler always configuration two ESP.

The particulate collected by the forward fields of this kind of ESP recycles to absorber for further reaction.

The ash collected by the forward fields has a large amount. There is up to 2000m^3/t ash is collected by the first two fields.

The ESP is able to satisfy both FGD and non-FGD condition.

3 CHARACTERISTICS OF POSTPOSITIVE ESP

In the electric fields of ESP, there are two kinds of electric charge. One is ionic charge, and the other is particle charge. Both kinds of charge constitute the space charge of this space; total space charge in unit volume is invariable. As the particle charge is increase, the ionic charge decrease correspondingly, the current decreases because ionic charge runs hundreds times faster than particle charge. The higher particle concentration, the higher particle charge, and the lower current even zero current, this phenomenon is called corona block.

High dust concentration affects the stability of the electric field, As the dust concentration increases, spark voltage decreases while the voltage required for maintaining current density increases, when dust concentration high enough, due to the distance shortening between two voltages, the larger fluctuation in dust concentration results in the spark over discharge. So the performance of ESP is instability.

4 THE MEASURES ON HIGH DUST CONCENTRATION

4.1 Pre-collection

The inlet dust concentration is normally about 30 g/Nm^3 for an ESP equipped for a conventional coal-fired unit but that high to 1000 g/Nm^3 for this kind of ESP. Under such condition, it is easy for an ESP to produce corona block, which causes decreased collection efficiency. In order to avoid corona block, it is required to decrease the dust concentration at ESP inlet. It is quite essential that dust be pre-collected before going into electric fields. In inlet plenum where designed a set of precollector which we have the patent right, its de-dust efficiency up to 40%.

4.2 The Selection of Plate and Wire Electrode

For an ESP in the FGD system, on one hand, the inlet dust concentration in the first field is still very high although it has been pre-collected in the inlet plenum. On the other hand, ash block, which is falling down from CE when rapping, will be dispersed because of high field height. For the above reasons, especially in the first field, the dust concentration at the field bottom is higher than that at the top, which is easy to cause corona block at the bottom. In order to improve the collection efficiency, a new type of barbed wires with stronger discharge capacity should be put on the bottom of electric fields.

4.3 Gas Distribution in the Field

As above mentioned, influenced by the high dust concentration, rapping of CE and gravity settlement, the dust concentration shall reduce gradually from bottom to top in height direction and from start to end in gas flow direction in each field, especially in the first field, if gas distribution is uniform at the section of first field. The dust concentration distribution is uneven in the whole field and thus causing T/R sets inefficient. For purpose of adjusting dust concentration distribution and improving collection efficiency, some equipment must be well arranged on the inlet and outlet plenum and the field internal so as to get more uniform distribution of dust concentration. A problem worthy to be pointed out is that the gas distribution plate is unnecessary to be made of wear resistant materials because the fly ash's abrasiveness is very weak no matter the FGD plant runs or not.

4.4 Points for Attention in Low Temperature ESP Operation

As required by improvement in SO_2 removal efficiency, the gas temperature at ESP inlet shall be as low as possible. Normally, the temperature is 80 □ or even lower , which is determined by operation conditions or other reasons. Compared with the operation temperature of 130 □ for conventional ESP, 80□ is closer to the dew point. It is easy to condense and thereby damaging the ESP body and internals. In extreme cases, it causes insulators shortcut because of condensation, which makes the electric fields not work normally. In view of the above mentioned, we should pay high attention to the following points: a) the thickness of ESP insulation shall vary according to the geographic position and environment, especially for ash hoppers where good heating equipment should be installed; b) access door shall be well insulated and avoided air leakage; c) the temperature and air flow must be appropriate if the insulators have reverse blowing system.

5 ASH HANDLING SYSTEM

5.1 Hopper

There is only one ESP equipped for a 300 MW generator. Both gas volume and dust concentration are high, so the hopper is quite high to meet the requirement of large hopper capacity. So the hopper rigidity must be enhanced. Adding more pipe supports is a good solution to enhance rigidity. In order to avoid distortion and collapse of hopper, the connection between hopper and ESP casing must be designed particularly.

The ash has a big repose angle. In order to avoid the ash deposition in hopper, the angle between hopper wall and ground surface should increase properly. Ash loosening equipment should be equipped at the hopper.

5.2 Ash Handling under the Hopper

Because of large quantities of ash in the former hoppers, air slide is usually taken as the ash handling equipment under hoppers. In air slide design, please note that a) the ash agglomeration should be avoided due to too much moisture in the air; b) the inclination of air slide should not be too small for avoidance of bad circulation; c) applicable air pressure and cloth material should be taken for avoidance of cloth abrasion; d) the pressure air should be distributed properly to avoid local block.

6 RAPPING SYSTEM

The ESP's total collecting area is in direct ratio to air flow. In such layout, the electric field is very high and ash and dust from the former pre-collect is very fine. A higher rapping acceleration is required. We recommend mechanism rapping system for both DE and CE rapping. In addition, effective rapping acceleration transfer should be paid attention in structure design.

Normally for a conventional ESP, no rapping system is equipped for gas distribution plate in inlet plenum. However, it is necessary for a high dust concentration ESP to install rapping system for gas distribution plate because the dust treated by such kind of ESP is fine, high concentration and low temperature.

7 SIZING OF THE ESP

When FGD plant runs, the dust concentration will be very high. It must take careful consideration while ESP sizing. When FGD plant doesn't run, the dust is hard to collect on account of fine particle size although the dust concentration is low. So it also needs more careful consideration when sizing, especially for special types of coal, so as to guarantee satisfactory emission.

8 THE T/R SET AND CONTROL SYSTEM OF THE ESP

The impedance characteristics of ESP vary with different dust concentration. However, the popular T/R set is fixed impedance. There are two kinds of work condition for high dust concentration ESP. The dust concentration under these two conditions is much different. It is an important issue how to solve the contradiction between two conditions and fixed impedance T/R set.

9 SUMMARY

In the field of high concentration dust removal, the ESP equipped for 300 MW coal-fired boiler is the biggest successful operated high concentration dust removal equipment. However, there are still many issues, for example, electrode matching model, pre-collection and control system, to be tackled. Shall we make great efforts to this kind of ESP.

REFERENCES

1. Li Zaishi The Size Install and Operational Guidance of Electricalstatic Precipitator China Electric Power Industry Publish Company, Beijing, IN, China, 2005.
2. Liu Houqi Lin Hong Electrostatic Precipitator China Building Industry Press, Beijing, IN, China, 1987..