Designing ESP Systemically to Reduce Dust Emission

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Abstract: As the raising of relative environmental emission standards, the application of ESP is challenged now. This article focuses not only on the ESP equipment itself, but more important, on the system environment where ESP's working. We analysis the different stages: the flue gas still not get into the ESP fields, in the fields, and passed from the fields, and discuss the details in different stages, correspondingly propose some methods and new facilities.

Keywords: ESP, dust agglomerate, dust re-fly, moving electrode

1 INTRODUCTION

The technology of electrostatic precipitator (ESP) has developed for over 100 years. As the most efficient and most widely used dust collecting technology, the relative and supporting technologies have developing greatly too, and promote the ESP technology continuing to improve. Now, the substantially improved dust emission standards and people's more and more emphasis on the fine dust emissions and the whole environmental problems, challenged the application of traditional ESP.

The application of traditional ESP, without special designing consideration, can barely achieve dust emission less than 50mg/N•m^3, not to mention the $PM_{2.5}$ fine dust collection. For this reason, many experts and institutions in home and abroad research deeply and a lot of new techs and improve-ments applied in projects.

Generally, the application process of ESP is (take the coal-fired boiler for example): flue gas come from the air pre-heater of boiler, get into the inlet of ESP, there is a gas distribution device which will spread the flue gas to the section of the field, and then in the fields, the particles in the flue gas will charged, collected by the collecting plate, removed by the rapping system and the ash transportation system. The purified gas, through the outlet of ESP and the stack, finally emit to the atmosphere.

This paper will focus on every stage of the application process of ESP, introduce some new techs and facilities in different stages.

2 INTRODUCE AND DISCUSSING

2.1 Before the Flue Gas Get into the Electric Fields

As possible as it can be, we hope there is a straight duct connecting the inlet of ESP, and the length of the straight duct is at least 5 times its equivalent diameter, so that when the flue gas get into the inlet, it's almost laminar state, that's very good for gas distribution. But in fact, seldom the length of the straight duct can be so long, because of possibly site constraints, especially in retrofit projects, and consideration of anti-fouling, etc.

However, many effective measures can be taken in the straight duct, like flue gas conditioning device, water cooling device, particle pre-charging device, dust agglomerator and so on.

The flue gas conditioning device is an assistive device, it help ESP to collect high resistance dust which is hard for ordinary ESP. The device is installed in the straight duct, and sprays some special material like SO_3 into the flue gas before it get into the ESP inlet, this can improve the dust collecting effects obviously. But this method doesn't worthy of recommendation, taking into account of the complexity of system and increase of costs, users can seldom accept this method. In particular, added material like SO_3 will finally emit to atmosphere that will be worse pollutants.

The water cooling device is similar to flue gas conditioning device, it can increase flue gas humidity and at the same time decrease its temperature by spraying the atomized droplet into the flue gas. The increase of humidity will increase the conductivity of particles, and the decrease of temperature will decrease the resistivity of particles. Because of these two positive factors act together, the device can better the ESP's collecting effects obviously. But it will make the whole ESP system more complex, and there are more problems and more costs of investment and system running, so its application always constrained.

The particle pre-charging device is a new device developed in recent years, it's attracted widely attention as soon as the device appeared. Till now, there are many relative patients domestic and abroad, and many devices have been used in projects, most of them have obvious effects, especially for collecting $PM_{2.5}$ particles and heavy metal particles.

Fine particles is usually considered as an important problem of health, because they can suspend in the atmosphere for very long time, and get into human body inner parts, and they always contain a high concentration of heavy metals. At the same time it's a main component of smog in many places, it decreases sight ability directly.

The particle pre-charging device can decrease dust emissions of ESP greatly by making the fine particles cohere to larger particles, so they can be captured easily in the electric fields. Data compares from many projects show that the device can help ESP decrease $PM_{2.5}$ dust emission by about 80% and the heavy metal emission decreased obviously.

Before the flue gas get into the electric fields, it will pass through the gas distribution device which installed in the ESP inlet. The velocity of flue gas is about 10~15m/s when it come out of duct, the system will decrease it to about 1m/s before the flue gas get into the fields, meantime the gas distribution effects in the whole field section will be assured. The working effects of gas distribution device will affect the dust collecting of ESP's first electric field, and even the second field to some extend, and consequently the total working effects of ESP and the dust emissions. So a well-designed and effective gas distribution device needed.

Generally, the gas distribution device composed of hole-plates, supports and other spares. Theoretically, there is a best combination of the system components, including the number of hole-plates' layers, the distance between neighboring layers, the hole-ratio of each plate, the number and distribution of guide plates, etc. and it can be got by using a special analysis software, and the computer's calculation. But in fact, the on site conditions are very different from the given conditions when calculating in computer, the output data can't be used in real projects. And the gas distribution modeling test station shows its importance in many applications.

To go on a project's modeling test, it's needed to install a scale model of the front duct and the ESP's inlet in the modeling test station, and then place the scaled hole-plates and guide plates into the inlet as designed, start the ID fan, test the gas velocities in the selected field section, calculate the RMS difference of the data. If the calculated result is not meet the requirement, modify the design of the gas distribution device, replace the model of it in the test station, test data again, till the calculated result meet the requirement. It's proved in many projects that the data test on site is approximate equal to, and in many cases better than the data test on the modeling station. The modeling scale is 1:*N*, usually *N* is not bigger than 10.

2.2 When the Flue Gas in the Electric Fields

The electric field area is the most critical part of ESP, in this stage the particles will be collected and the gas will be purified. For so many years, specialists and experts researched the use of collecting plates and discharging electrodes, the use of power supply, the matching of different type negative electrodes and positive electrodes, the distance between electrodes, etc. and there are many papers and reports about those research published all the years. For the purpose of the contents discussed in this paper, only the high-frequency power introduce here.

The high-frequency power supply (abbreviation in this paper: HFPS) device is another new device developed in recent years, the "high-frequency" means its working frequency is much higher than the traditional low-frequency rectifier (T/R). The working frequency of a HFPS device which available on the market now is about 20 kHz, and the traditional T/R's working frequency is normally 50 Hz.

Compared with the traditional T/R, the HFPS has many outstanding benefits: it can supply approximately DC output, increase average voltage and effective currency in the fields obviously, has a good adaptability to the change of dust properties. And when the rapping system put into work, HFPS will decrease power output, to assure the effects of rapping and meantime reduce re-fly of the collected dusts.

It's worth concerning that the accumulation of dust in the hoppers may be a big problem when the ESP is working and meantime the dust transportation system's working state is not so well. This problem has happened in many projects. When the dust transportation system hasn't enough capacity to send away the dust accumulating in a hopper, the level of dust in the hopper will getting higher and higher, it will close to and touch the bottom of electric field, finally cause short-circuit in the field, even worse it will result to deformation of the electrodes in the field and permanent damage of the components of the field.

2.3 When the Flue Gas Get out of the Fields

After cleaning in the electric fields, the flue gas will get into the outlet of ESP, and then the gas-out duct, through the ID fan, stack, finally emit to atmosphere. But the re-fly dust when rapping and the fine dust not collected in the fields will emit with the flue gas together. It's proved effective that installing a C-type plate device or moving electrode device to decrease dust emission.

The C-type plate device is following the last field and installed in the outlet of ESP, the device is mainly composed of one or two set hydrodynamic designed C-type plates, practice proved the device can collect some fine dust emitted from the fields.

The moving electrode, developed and applied in the pilot project earliest in Japan, is different from the fixed electrodes normally used. It's installed after the last fixed electrode field and followed by the C-type plate device, it can be considered as the last part of the whole ESP field. As far as the fixed electrode field concerned, it's very hard to collect fine dusts with high resistivity, and it's harder to clean the collecting plate surface when the fine dusts or dusts with high viscosity on it by rapping only. And by scrapping or brushing the collecting plate surface directly, the moving electrode can keep the surface always clean, and collect fine dusts easier and clean them to the bottom hopper very easy.

There is a manufacturing factory domestic, who introduced the moving electrode device technology from Japan, used the device in an ESP, it's reported the dust emission concentration is below 50 mg/N·m^3.

3 CONCLUSIONS

The running of ESP is affected by many factors, including the running state of the mechanical components of itself, the running state and the type of the power supplies, the condition of flue gas it treated. Meantime the running of the host equipment (like the boiler) and the auxiliary equipment (like the dust transportation system) will affect ESP's running directly or indirectly.

To build an efficient ESP, it's needed to consider the relative design factors comprehensively and to analysis the actual project situation and the ESP's running environment systemically. Before the flue gas get into the fields, steps should be taken to pre-treat it, for example, use a pre-charging device to agglomerate fine particles to larger particles, and use a modeling test proved effective gas distribution device to distribute the gas to the section of the field. In the electric fields, the flue gas will be purified thoroughly, and when it come out of the fields, there should be some post-treat measures, by using the moving electrode device and the C-type plate device. In a word, for the purpose of low dust emission, not only the ESP itself but the auxiliary measures or devices in every stage are all important.

REFERENCES

1. Li Zaishi, ESP's Designing, Installation, Operation and Management, China Electric Power Publishing House, Beijing, China, 2004.
2. Rodney Truce, John Wilkins, Li dingfu, Li Chaoyan, Enhanced fine particle and mercury emission control using the Indigo Agglomerator, Proceedings of 12th Conference of ESP (2007), 321-328.
3. Zhang Guxun, High Frequency Power Supply, Proceedings of 12th Conference of ESP (2007), 351-355.