Application of Ultra-Clean Electrostatic-Fabric Integrated Precipitator on 1000MWe Units

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Abstract. The ultra-clean Electrostatic-Fabric Integrated Precipitator (EFIP) is a new technology through updating the conventional EFIP with technical innovation. The dust concentration in the outlet of EFIP can realize ≤10mg/m³ and the pressure drop can be less than 800Pa by using this new technology. In order to illustrate the reliability of the application of ultra-clean EFIP on 1000MWe units, this study analyzed the dust concentrations in the outlet of precipitators, dust concentrations at stacks, fluctuations of dust concentration and pressure drop of four ultra-clean EFIPs on 1000MWe Power Plants in Pingdingshan, Henan, China and Shazhou, Zhejiang, China. The results showed that the outlet concentrations of the EFIPs were less than 10mg/Nm³ with small fluctuation, the outlet concentrations of the stacks were less than 5mg/Nm³ with small fluctuation, the pressure drop during running was less than 800Pa. The results proved the reliability of the ultra-clean EFIP for the 1000MWe units, and provided a new route for the 1000MWe units to achieve the ultra-low emission.

1. Introduction

With the frequent occurrence of haze weather since 2013, a series of policies for the strict control of the emissions of pollutants from coal-fired power units have been released by the Chinese government, including the Action Plan for Prevention and Treatment of Air Pollution, as well as policies of coal restriction, coal control, and energy transformation and upgrading. However, China’s characteristics of energy reserve are rich coal, meager oil and little gas, and it determines that the energy production and consumption mainly depends on coal. This situation is difficult to be radically changed in the short time. Thermal power industry faces the severe pressures and challenges from environmental protection, emission reduction and itself development. In order to protect environment and develop thermal industry, coal-fired power companies actively respond to meet the emission standards of the pollutants in flue gas from the coal-fired and compressor-turbine power units, and strive to achieve the target that “coal-fired power units can achieve ultra-clean emission like the natural gas-fired power units” through technical reconstruction. Ultra-clean EFIP emerges under this background and is widely used in the coal-fired power plant with the promulgation and implementation of ultra-low emission policies, such as ‘the Action Plan of Upgrading and Retrofit for Energy Saving and Emission Reduction of Coal-fired Power Plants’, and ‘the Work Plan for Full
Implementation of Technical Reconstruction in Coal-fired Power Plants to Achieve Ultra-Low Emissions and Saving Energy.

The 1000MWe coal-fired unit is the largest capacity power unit, which has been put into operation in China, and has extremely high requirements for the reliability and stability of the equipment. After successful application of Ultra-clean EFIP on 100MWe, 300MWe and 600MWe coal-fired units, ultra-clean EFIP had been tried to apply to 1000MWe units. In terms of structural design, selection of key parameters and selection of key equipment, the EFIP for the 1000MWe unit is quite different from that for the unit below 600MWe. The completion of large-scale ultra-clean EFIP technology depends on its successful application on 1000MWe units. In this study, the performance of ultra-clean EFIP used in the 1000MWe Power Plants in Pingdingshan and Shazhou from four aspects: emission, stability, coal suitability and pressure drop was evaluated and the results can prove the reliability of ultra-clean EFIP used in the 1000MWe Power Plants and improve this new technology development.

2. Ultra-clean EFIP technology

2.1 Technical Principle

The ultra-clean EFIP technology refers to the EFIP technology with the outlet dust concentration ≤5 or 10mg/Nm³ to achieve ultra-low emission. It is also an ultra-low emission technology that simplifies the flue gas treatment system without wet electrostatic precipitator. The ultra-clean EFIP has the advantages that the outlet dust concentration is not affected by the change of compositions of coal and fly ash, and the outlet dust concentration is low and stable. In addition, the filter bag has long operational life, low operation and maintenance cost, and it can ensure high efficiency and stable operation for a long time. In principle, the ultra-clean EFIP is a new technology through updating the conventional EFIP with technical innovation. The EFIP is a compound technology with the integration of electrostatic dedusting technology and fabric filter dedusting technology. It fully utilizes the characteristics of high dust collection efficiency and particle charge in the electrostatic area, and greatly reduces the dust concentration of the flue gas before entering the filter bag area. The filter bag filtration load is reduced, the coarse particles are prevented from wearing and scouring the filter bag, and the charged dust filtration mechanism is utilized to improve the comprehensive performance of EFIP [1].

2.2 Technical Measures

Compared with the conventional EFIP, the ultra-clean EFIP needs to adopt the following main technical measures:

1) The electric zone and the bag zone are optimally coupled and matched. In order to achieve the best technical and economic performance, the optimal inlet dust concentration into the bag zone was confirmed to make the best match between the electric zone and the bag zone based on the coal condition and the key parameters of the electric zone and the bag zone.

2) The charge of the particles is strengthened and the reliability of the electric zone is improved. Firstly, the polarity matching type in the electric zone with high-discharge performance, high intensity electric field is used to improve the particle charging and the dust removal efficiency of the electric zone. Secondly, the technology with power supply in front and rear small partition is adopted to improve the reliability of the electric zone.

3) The high-precision filter material is used. In industrial production, the filtration precision of the filter material of PTFE coated filter material is higher than ultra-fine fiber gradient filter material and ordinary filter material in the same condition. PTFE coated filter material is the filter material with highest filtration precision at present, followed by ultra-fine fiber gradient filter material, both of these are high-precision filter material, and are the best choice for EFIP with ultra-low-emission. The more precise the filter material is, the more reliable the ultra-low emission of EFIP achieves, the stronger the ability to adapt to the working conditions is and the lower the longer-term running resistance is.
(4) The airflow distribution has high uniformity. The airflow distribution is further subdivided based on that of the conventional EFIP, and the flow field are exquisitely designed to achieve high uniformity of airflow distribution in the EFIP (the relative deviation of airflow uniformity in each room of the bag zone using the ultra-clean EFIP is less than 3%).

3. Application of Ultra-clean EFIP

3.1 Case study
Both the 2×1000MWe power plant in Pingdingshan, Henan, China and the 2×1000MWe units built recently in Shazhou, Zhejiang, China used the ultra-clean EFIP for dust removal. The Ultra-clean EFIP was the firstly used in 1000MWe unit in Pingdingshan power plant, and this technology was the firstly used in a new-built 1000MWe units in Shazhou power plant. Both of them played an important demonstration role.

The 2×1000MWe units in Pingdingshan were equipped with dry type Ultra-clean EFIP, which were horizontal arranged with 6 chambers, 2 electric fields and 6 channels. The Specific Collection Area (SCA) was designed to be 40.53 m²/m³/s, and the air flow speed in the filter was ≤0.97 m/min, the designed inlet dust concentration was 53.8 g/Nm³, the designed outlet dust concentration was ≤10 mg/Nm³ and the designed dust removal efficiency was 99.98%. The ultra-low emission process route used in this plant was combined Selective Catalytic Reduction (SCR), Ultra-clean EFIP and wet Flue Gas Desulfurization (FGD).

The Ultra-clean EFIP for Shazhou power plant also was dry type and horizontal arranged with 6 chambers, 2 electric fields and 6 channels. The designed SCA was 28.65 m²/m³/s, the air flow speed in the filter was ≤0.84 m/min, the designed inlet concentration was 21.719 g/Nm³, and the designed dust removal efficiency was ≥99.953%. The ultra-low emission process route in this plant was also combined SCR, Ultra-clean EFIP and wet FGD.

3.2 Performance Test Result of Ultra-clean EFIP
Based on “Test Method for Performance of EF” (GB/T 32154-2015), the Suzhou branch of Xi’an Thermal Power Research Institute tested the emissions and performances of 2×1000MWe units of Shazhou power plant in December 2017 and January 2019, respectively, and the Henan Electric Power and Science Institute tested the emissions and performances of 2×1000MWe units of Pingdingshan power plant in 2015. The test results of inlet particle concentrations, dust removal efficiencies and running resistances are shown in table 1.

Table 1. Test results of particle concentrations, dust removal efficiencies and running resistances at the inlet and outlet of Ultra-clean EFIP.

| Item                     | Inlet particle concentration (g/Nm³) | Outlet particle concentration (mg/Nm³) | Dust removal efficiency (%) | Running resistance (pa) |
|--------------------------|-------------------------------------|---------------------------------------|----------------------------|-------------------------|
| Shazhou Power Plant3#    | 15.9                                 | 8.8                                   | 99.94                      | 784                     |
| Shazhou Power Plant4#    | 17.0                                 | 9.1                                   | 99.95                      | 776                     |
| Pingdingshan Power Plant1# | 45.8                                 | 9.2                                   | 99.98                      | 646                     |
| Pingdingshan Power Plant2# | 46.9                                 | 8.2                                   | 99.98                      | 655                     |

The outlet dust concentrations of the Ultra-clean EFIP of Shazhou power plant and Pingdingshan power plant were less than the designed value of 10 mg/Nm³, and the running resistances were less than 800 Pa, all the operational performance met the designed requirements. The above results showed that the emission of the Ultra-clean EFIP could meet the requirements of the desulfurization system and ensure the standard emission from the stack outlet.
3.3 Stability of dust removal using Ultra-Clean EFIP

The dust removal effect of ESP is affected by many factors including coal condition, flue gas composition, particle composition, technical conditions and operating conditions of the precipitator, therefore, the outlet dust concentration of ESP often fluctuates greatly and the stability that the outlet dust concentration reaches the standard is poor. The study showed that the dust removal effect of bag filter or EFIP was not affected by the fluctuation of coal condition and combustion condition due to the filtration of filter bag itself. Figure 1 and figure 2 showed the online monitoring results of outlet dust emission of Ultra-clean EFIP in Shazhou power plant and Pingdingshan power plant for several months, respectively.

![Graph showing outlet dust emission of Ultra-clean EFIP in Pingdingshan Power Plant.]

**Figure 1.** Outlet dust emission of Ultra-clean EFIP of Pingdingshan Power Plant.

![Graph showing outlet dust emission of Ultra-clean EFIP in Shazhou Power Plant.]

**Figure 2.** Outlet dust emission of Ultra-clean EFIP of Shazhou Power Plant.

As shown in the above figures, the outlet dust concentrations of Ultra-Clean EFIP in Shazhou power plant were between 8.5mg/Nm$^3$ and 9mg/Nm$^3$, and that in Pingdingshan power plant were between 5mg/Nm$^3$ and 8mg/Nm$^3$. These two dust concentrations were both less than 10mg/Nm$^3$ and met the designed requirements. The fluctuation of outlet dust emission was less than 2mg/Nm$^3$ during
operating, and the emission was almost unaffected by the change of operating load, coal condition and other operational conditions. The outlet dust emission could continuously and stably reach the standard emission. It meant that the particulate matter emission from the outlet of the stack would meet the ultra-low emission standard as long as the following desulfurization system was in normal operation.

Figure 3 and Figure 4 were the online monitoring results of outlet dust emission from the stack in Pingdingshan power plant and Shazhou power plant for several months. It can be seen from the figures that the dust emission concentrations from the stack in two power plants were both less than 5mg/Nm$^3$, which was relatively stable and met the ultra-low emission standard. The results showed that the ultra-low emission process combining Ultra-clean EFIP and Wet Desulfurization could meet the dust emission standard of 5mg/Nm$^3$.

3.4 Running Resistance of Ultra-clean EFIP

The running resistance of EFIP is one of the key indexes to evaluate its performance [2]-[9]. The running resistances of Ultra-clean EFIP in the initial stage for Pingdingshan power plant and Shazhou power plant were shown in the Figure 5 and figure 6, respectively. It indicated that the running resistance of Ultra-clean EFIP was between 100Pa and 400Pa in the initial operating period. As the running time increased, the running resistance gradually rose and stabilized at 200 to 800Pa, it was due
to the gradual ash accumulation on the surface of the filter bag and the fly ash gradually entering into the fiber gap of the filter bag [10]-[11].

The running resistance of Ultra-clean EFIP was small and even smaller than that of conventional EFIP and common bag filter based on the test results in the these two power plants. The running resistance of EFIP includes friction resistance and filtration resistance, and the filtration resistance accounts for a larger proportion and is affected by quantity of dust and dust properties. The pre-charge action of the EFIP changed the dust property and helped to reduce the running resistance of the precipitator [12]. In addition, the SCA of the front electric field of the Ultra-clean EFIP was larger than that of the common EFIP, which could remove more fly ash and greatly reduce the amount of fly ash entering the bag area. The unique structure of Ultra-clean EFIP reduced its running resistance, and the running resistance maintained a very stable state for a long-term running, it led to the outlet dust concentration unaffected by coal condition, operational condition and other factors. It proved that the application of Ultra-clean EFIP on 1000MW e unit is very reliable.

Figure 5. Running resistance of Ultra-clean EFIP in Pingdingshan Power Plant.

Figure 6. Running resistance of Ultra-clean EFIP in Shazhou Power Plant.
4. Conclusions
The Ultra-clean EFIP is a technical updating from conventional EFIP, which had made technological improvement in optimal coupling matching of electric zone and bag zone, coagulation of charged particles, high precision filtration, and high uniform of multi-dimensional flow field. It could remain a stable dust concentration at the outlet less than 10 (or 5) mg/Nm$^3$ for a long time running. The results of Ultra-clean EFIP applied to 1000MWe unit showed that the outlet dust concentration was stable and could meet the requirement of ultra-low emission for a long-term running. The running resistance was less than 800Pa and less than that of common bag filter and conventional EFIP.

The successful application of Ultra-clean EFIP on 1000MWe unit for many years promotes the optimization and improvement of Ultra-clean EFIP, and it means a successful application of Ultra-clean EFIP on large scale power plant for a long-time running, and develops a new process route to achieve ultra-low emission. It is of great significance for the wide application of Ultra-clean EFIP on coal-fired power plants.

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