Five Stages Electrostatic Precipitator Principles and Application

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Abstract: In order to meet the urgent demands of energy saving and pollution emission standards, Five Stages Electrostatic Precipi- tator (FS-ESP) for Electrostatic Precipitator (ESP) innovation was raised and developed, its mechanism was studied, and the optimi- zation experiments were done in industrial conditions. At the end we described FS-ESP applications for ESP innovations which have satisfactory performances and run reliably and stably in four-year operation.

Keywords: ESP, Rotary Plate Electrostatic Field, Flow-Uniforming Electrostatic Field, Re-Charging Electrostatic Field

1 INTRODUCTION

ESP is one of the major equipments for industrial furnace flue gas control, due to its advanced mechanisms, energy-saving, high performances, reliable running, simple maintenances and low running costs. But recently ESP technology has been challenged in many aspects:

1) Environmental emission standards are more and more highly required. The standard of less than 100 mg/Nm^3 or 80 mg/Nm^3 is executed in metallurgy and cement industry, while in electric power industry that of less than 50 mg/Nm^3 is being progressively executed. The performances of existing ESPs are under a suspicion that whether they could meet the standards or not.

2) ESP innovation by conventionality technologies has insignificant upgrades. Such as in coal-fired power industry, when the summation of Al_2O_3 and SiO_2 contents in flue dust is more than 85%, conven- tionality ESP technologies like expanding section area and adding electrostatic fields are difficult to meet the required collection efficiency.

3) The dust content of flue gas from Sinter head is lower than that of flue gas from other furnaces, like electric power plant, cement kiln and sinter tail. Because of low density of dust in the last electrostatic field, even if three electrostatic fields (so far as four fields) were used, ESP is also difficult to meet the emission standard of less than ≤50 mg/Nm^3.

4) Because of ground limitation, innovation technologies like extending residence time or reducing flue gas velocity are not adopted; while expanding electric field height increases engineering period. On the other hand, all of these innovation technologies have great investment costs.

Based on the aforementioned requirements and restricts, FS-ESP which can not change dimensions of original ESP was developed by Xi'an YuQing environmental engineering technology Company Ltd (XAYQ) and Envi- ronmental Equipment Center of Xi'an University of Technology, cooperating with Baoshan Steel Shock Co. Ltd and Shijia- zhuang Steel plant. Based on mechanism analysis, theoretical calculations, simulation experiments and sinter ESP innovations, industrial test research of FS-ESP technology was done, and its enhanced effects on collection efficiency was also validated.

2 MAJOR TECHNOLOGIES

2.1Technological Scheme

Scheme of FS-ESP technology is that: using original ESP shell, not changing section area and number of electro- static fields, new technology is adopted in the shell in order to increase collection efficiency [1]. FS-ESP mechanisms are: increasing dust (especially in high particle concentration fields) charged ratio; multiple charging- collecting particles; improving ESP mechanisms; increasing collection efficiency of fine particles; modifying rapping intension of electrode arrangements; maximally reducing reentrainment; modifying airflow distribution in order to increase collection efficiency.

2.2 Concept

FS-ESP technology consists of collecting particles technology, airflow distribution technology and cleaning particles technology.

1) Particle collection: As we know, common ESPs differentiate into single stage ESP and double stage ESP. In addition to these stages, FS-ESP has the other three stages: Rotary Plate Electrostatic Field (RPEF), Flow-Uniforming Electrostatic Field (FUEF) and Re-Charging Electrostatic Field (RCEF).

2) Airflow distribution: Airflow is modified in ESP shell in order to get uniform airflow distribution or skewed airflow distribution.

3) Particle cleaning: depending on working conditions and equipment structures, Adjustable Sound Device as assistant set could be used in order to improve dust cleaning. See as Fig. 1.

2.3 Principles

Taking a two-electrostatic-field ESP as an example(see Fig. 2): After flue gas entering ESP inlet, particles are charged when flue gas passing through FUEF, and some of charged particles are collected. So FUEF in which rapping system was placed has four functions: agglomeration particles, charging particles, collecting particles, and uniformizing airflow. In FS-ESP, RCEFs are placed in front of two original electrostatic fields, so that equality & fully charging ratio of particles and collection efficiency could be improved. RPEF which is installed at end of the second electrostatic field charges and collects particles so that particle emission concentration is evidently reduced.

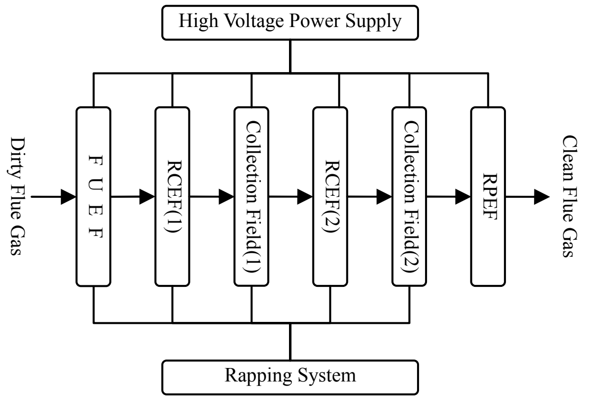
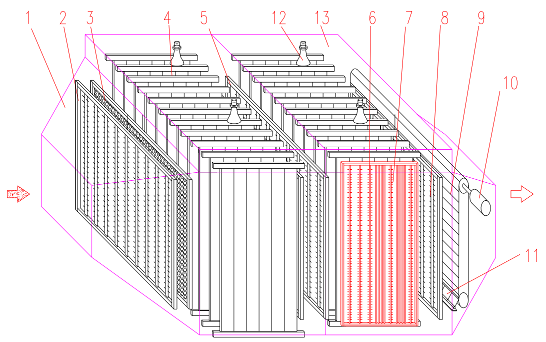


Fig. 1 Technological process of FS- ESP



1. Inlet, 2. Discharge electrode in FUEF, 3. Collecting electrode in FUEF, 4, Original positive electrode, 5. Re-discharging electrode, 6. Original negative electrode, 7. Original auxiliary electrode, 8. Discharge electrode in RFEF, 9. Collecting electrode in REFF, 10. driving gear, 11. Brush, 12. Adjustable sound device, 13. Shell

Fig. 2 Equipment construction

3 MAJOR QUIPMENTS

3.1 RPEF

(1) Structures and principles

RPEF consists of discharging electrode, rotary collection plate, driving gear, brush and rapping system for discharging electrode. Negative discharging electrode is connected with single high voltage power supply or adjacent electrostatic field. In working conditions discharging electrodes which have a strength frame may adhere positive charged particles which must be cleaned by rapping system in order to keep a fine discharging state. While rotary collection multi-hole plates are slowly moved by driving system, dust is precipitating on these plates. When rotary plates shift to the button of ESP, adhered particles are removed by brushes and no re-entrainments occurs. RPEF could be installed in inlet or outlet.

(2) Effects and characteristics

The main effects of RPEF are that: making fine and high specific resistivity particles fully and equally charged and enhancing collection efficiency. The characteristics of RPEF are: Optimized electrode arrangements have stable electric performances, great electric intensity and uniform current density; Electric force of negative charged particles has the same direction with air flow; fixed brush in RPEF can keep collection plate clean and effectively prevent from re-entrainment and back corona.

3.2 FUEF

(1) Structures

Discharging electrodes connected with single power supply or first electrostatic field are installed before the last layer of airflow distributing plates in inlet and make up of an electrostatic field with these plates, the electrostatic field is called FUEF which could uniform airflow and collect particles. Otherwise rapping systems are installed both for distributing plates and discharging electrodes.

(2) Effects and characteristics

FUEF has four effects: charging particles, agglomerating particles, collecting particles and distributing airflow. In FUEF that electric force has the same direction with air flow benefits for electrostatic capturing and interception; Structures of discharging electrode and airflow distributing plate are optimized depending on flue gas and particle conditions, so particles charge more equally and FUEF performance is more stable; Special rapping system could keep surfaces of discharging electrode and airflow distributing plate cleaner and V-I characteristics better.

3.3 RCEF

(1) Structures

Discharging electrodes system with super corona performance makes up of RCEF which can be repeatedly installed in front of original electrostatic fields.

(2) Effects and characteristics

ECEF charges particles equally and fully again before entering next electrostatic field and lays the foundation for high collection efficiency. The optimized RCEF depending on electrostatic field structure has high electrostatic field strength and high current density, so particles especially in high consistence areas are fully charged.

3.4 Airflow Adjustment

(1) Structures and principles

Airflow adjustment equipment consists of airflow guide plates in pipes and in inlet, airflow distributing plates in inlet and in electrostatic fields, airflow guard plates in bypasses and adjustable plates in outlet. Its principles are that: before entering the flange of ESP high velocity airflow is rectified and conformed to the required velocity direction by guide plate in pipes. Then guide plates in inlet make airflow macroscopic uniformity in cross section, and several layers of distributing plates conform airflow to required airflow distribution before entering electrostatic fields. Airflow distribution in electrostatic fields and bypass airflow interception are respectively carried out by guide plates in electrostatic fields and guard plates in bypass, while airflow deterioration behind the last electrostatic field is prevented by adjustable plates in outlet [2].

(2) Effects and characteristics

Structures and positions of airflow adjustment equipment are designed depending on the results of hydrokinetics numerical analog computation. This adjustment can get special airflow distribution (uniformity distribution or skewed airflow distribution) depending on flue gas conditions, physicochemical properties of particles, structures and performance of ESP [3].

3.5 Adjustable Sound Device

(1) Structures and principles

Adjustable sound device consists of com-pressed air source, electromagnetism valve, oil water separator, decompression valve, oil mist filter and control system. Compressed air is used as dynamical source of Adjustable sound device, high strength membrane as Sound source. The periodicity vibration of sound source enlarged by exponential horn forms low frequency and high energy sound. When this sound spreading in space, dust layers on interspaces components vibrate at the sound frequency, which conquers the adhesive forces between component surfaces and dust layers, particles in dust layers and makes particles floating. Coupled with gravitation and airflow effects, particles fall off from component surfaces into hoppers.

(2) Effects and characteristics

The adjustable sound device clears particles in special areas where rapping system can't clean. That could keep all electrode arrangements uniformly cleaned and beneficial for charged particles being collected.

The adjustable sound device is a patent technology developed by XAYQ. It over-comes rapping force decaying and defect of un-uniformly cleaning caused by traditional methods, reduces abrasion of mechanical components (like rapping and transmission) and operating costs, and enhances collection efficiency. Strength of adjustable sound device could be adjusted to achieve the best performance of particle clean depending on flue gas conditions and particle characteristics. Adjustment sound device could be used as assistant equipment in five stage ESP technology.

4 INDUSTRIAL APPLICATION

In August, 2003, five stages ESP technology was used for renovation of 60 m^2 sinter two electrostatic fields ESP and achieved the expected purpose. After six months' running, measured emission concentration is less than 50 mg/Nm^3, emission concentrations continuously tested in 4 years are under 70 mg/Nm^3. In June 2005, five stages ESP technology was used for renovation of two ESPs (before and after ring-sinter) and received significant improvement: emission concentration reduced from more than 500 mg/Nm3 to less than 120 mg/Nm^3. In August, 2005, five stages ESP technology was used for renovation of 120 m^2 sinter ESP and met desired performance, emission concentration reduced from about 160 mg/Nm^3 to less than 80 mg/Nm^3.

5 CONCLUSIONS

Five stages ESP applied for ESP renovation has achieved good purposes, and after renovation emission concentrations can be reduced by 30% to 70%. As evaluating and improving in four years the technology has become increasingly mature.

REFERENCES

1. Cui Juemin, Xu Guosheng, Xu Libo. Retrofitting for GD-II Type ESP before Sinter Sinter and Pelletizing, 2006, 5: 28-31.
2. LI Limei, Xu Guosheng. Skewed Gas Flow Experimental Research. Heavy Machine, 2005, 3: 35-40.
3. Xu Guosheng, He Jian, Li Limei. Skewed Gas Flow Experimental Research. The Eleventh National Conference on Electro- static Precipitation, Zhengzhou, China, 2005.