

# Influence Analysis of Discharge Electrode on Performance of an Electric Precipitator

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**Abstracts:** The influence factors of discharge electrodes on the performance of an electric precipitator are comprehensively analyzed in this paper. The factors are mainly the following: 1) electrode forms and matches with collecting electrode, 2) electrode insulation, 3) dust deposit or scab, and 4) malfunction of electrode wires, such as distortion, shift, shake and disjunction and so on.

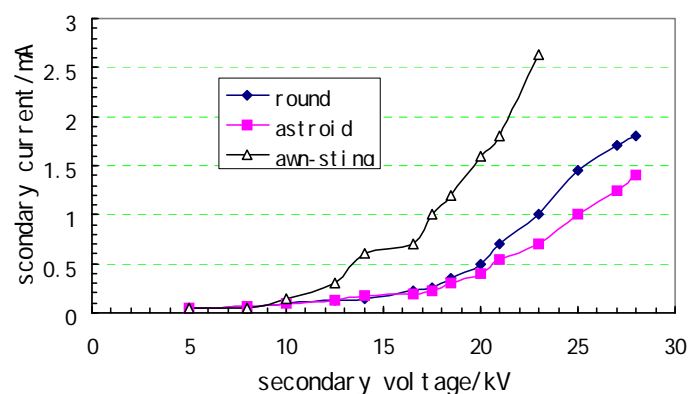
**Keywords:** discharge electrode; electrode forms; electrode insulation; dust deposit or scab; malfunction of electrode wire

The influence factors of an electric precipitator's performance are mainly smoke or dust nature, operating conditions, equipment structure and so on, and the last one lies on designer's design idea and level, greatly influenced by some subjective factors. One of key steps of electric precipitator design is selecting electrode forms and the matches between discharging and collecting electrodes, which are related to an electric precipitator's running steadily. It is a significant work for dust efficiency, design and

maintenance to analyze influence factors of discharging electrode on performances of an electric precipitator.

## 1. FORMS OF DISCHARGE ELECTRODE

One of key steps of electric dust-catcher design is to select electrode forms and matches between discharging and collecting electrodes, which are related to electric precipitator's running steadily. Gao<sup>[1]</sup> and his co-workers have furnished a laboratorial tubular electric precipitator, which dimension of dust collecting tube is  $\phi 89 \times 1$ . Three forms of discharge electrode, namely round, astroid and awn-sting electrode, are set in the model and no-load tested under different conditions respectively: room temperature, heating, heating and humidifying. The corresponding volt-ampere characteristics were analyzed. And especially, on the condition of heating and humidifying, the corresponding volt-ampere characteristics are illustrated in Fig. 1, and the initial electro-corona voltages and the breakdown voltages of three electrode wires are shown in table 1.



**Fig.1 Comparison of volt-ampere characteristics between three electrode forms**

**Table 1: Comparison of initial electro-corona voltage, breakdown voltage between three electrode forms**

electrode forms	round wire	asteroid wire	awn-sting wire
initial electro-corona voltage(kV)	14	15	9
Breakdown voltage(kV)	28	28	24

Fig. 1 and Table 1 indicated that: (1) the awn-sting electrode is characterized as lower initial electro-corona voltage and breakdown voltage, higher current density, better discharge performance than the other two electrode types; (2) the awn-sting electrode is more suitable for small electric precipitator for its adequate rigidity. If fixed its upper extreme, it won't swing in electric field when in small subsection scope.

However, it still needs more engineering examinations whether the above no-load volt-ampere traits are of extensive significances to actual projects, for the performance of an electric precipitator is affected by various operating conditions and system structure traits.

Because of low initial electro-corona voltage, strong discharge ability, uneven distribution of current on the electrode plate and low breakdown voltage, an awn-sting electrode is suitable for foreside of an electric field with high dust concentration. Moreover, in the project applications, the awns may fall off, it is a noticeable problem. If the awns fall into the lower ash hopper, locking the cinder valve, dust-unloading motor is possible to be burnt out, then ash-unloading is impeded.

Well, the spiral asteroïd electrode presents such characteristics as high initial electro-corona voltage, slightly lower discharge ability than the awn-sting electrode, even distribution of current on the electrode plate, high breakdown voltage. In a certain scope of voltage, the dust efficiency has a direct ratio with the running voltage's square. Therefore, this type of line should be utilized in rearward of an electric field, which is favorable to improve the performance of dust catcher.

Electric-charging is the premise of dust moving. According mechanism of dust electric-charging, the nearer to discharge electrode, the higher is the probability of collision between electron and particles. The intensity of electric field of certain position may

be expressed by the following formula<sup>[2]</sup>:

$$E = \frac{U}{R_1 \times \ln(R_2/R_1)} \quad (1)$$

Where: E—electric field intensity (N/C); U—secondary voltage (V); R<sub>1</sub>—radius of discharge electrode (m); R<sub>2</sub>—spot position in electric field (m).

The smaller an electrode radius is, the larger electro-corona radius and field intensity are, as well as higher probability of particles electric-charging. Having ensured tensile strength, the discharge electrode should be thin as soon as possible in order that particles can be electric-charged preferably under low secondary voltage.

## 2. INSULATION OF DISCHARGE ELECTRODE

The porcelain shaft plays the role of insulation supporting and transmitting torque during high-temperature operating. In many situations, smoke temperature reaches above 300°C, and the system runs continuously for a long time in serious polluted environment. The porcelain shaft should present such characteristics as high mechanical intensity, high heat-resisting and electric-insulating ability. At present, many domestic electric precipitators are cathode-beat structure, which greatly improve efficiency of dust removal. But the insulation backbone—porcelain shafts are easily damaged, which brings electric precipitators high failure probability. The raw material of "95" porcelain contains above 95% alumina replacing silica, so "95" porcelain is characterized as α-Al<sub>2</sub>O<sub>3</sub> crystal. The performance indexes comparison between "95" porcelain and some ordinary one was investigated by Long Tao, and it is shown in table 2<sup>[3]</sup>. According to table 2, the machinery intensity, heat-resisting and electric-insulating natures of the former are greatly superior to the latter.

**Table 2: Performance index contrast of “95” porcelain and ordinary one<sup>[3]</sup>**

Material	Density (kg/cm <sup>3</sup> )	Tensile strength (MPa)	Compressive strength (MPa)	Bending strength (MPa)	Elasticity coefficient (10 <sup>5</sup> MPa)	Volume resistivity 400°C (Ω·cm)	Applicable temperature (°C)	Anti-distorte d strength (MPa)
Ordinary porcelain	2.2~2.6	25~45	450~550	40~80	0.55~1.0	10 <sup>5</sup> ~10 <sup>6</sup>	≤150	60
“95” porcelain	3.5~3.8	150~240	1700~2400	280~360	2.8~3.2	10 <sup>10</sup> ~10 <sup>12</sup>	≤800	300

The special compositions and technology process of “95” porcelain bring on superior mechanical, heat-resisting and electric-insulating quality. So, “95” porcelain is suitable especially for application of insulating sustentation and transmitting torque, and regarded as a favorable material replacing ordinary ceramic and quartz material of electric precipitators.

### 3. ELECTRODE PLUMP BECAUSE OF DUSTY DEPOSIT OR SCAB

Dust deposit on discharge electrode and awn should be cleaned via oscillatory beat, in order to keep excellent discharging ability. Although the dust deposited on discharge electrode is small, if it's not cleaned in time, the sediment will make electrode plump, and make awn scabby, which cause the discharging ability weaken, and the electro-corona current diminished, and then the efficiency of dust removal become worsen, or even the system stop moving thoroughly.

The possible causes are mainly as following: (1) electrostatic force makes dust adhere to electrode; (2) dust concentration or humidity is too high, or viscosity is too strong, for example, oil fume etc.; (3) humidity or cold air infiltrate into electric field through the ash hopper; (4) oscillatory beating intensity is inadequate, (5) malfunctions of beating parts, for examples: beating shaft is blocked by some foreign matter, or it shift toward to shaft, beating hammer can not fall freely because of sediment hindrance, beating poles become too flexible, hammerhead falls off, and so on.

As for situations described above, some measures should be applied to clean dust deposit and scab on the discharge electrode in time, for examples, spraying electrode with compressed air, or beating

the electrode with wooden hammer. However, washing electrodes with water make them rusty. On the other hand, the flue gas can be pretreated to reduce the specific resistivity to less than  $5 \times 10^{10}$  Ω.cm, in order to avoid counter-electro-corona effectively.

### 4. DISTORTION AND SHIFT OF DISCHARGE ELECTRODE

The frame of discharge electrode, which is mostly made by welding process, is easy deformed and shifted by repeated beating and heat stress because of their weak structures. While beating electrode frames, the hammers' deviating from normal position will make their acceleration decreased and the shaking strength weekend, and then it will seriously affect the power supplying and the efficiency of dust removal. Especially, if the system started and stopped frequently, discharge and collecting electrode are both deformed seriously by continually repeated heat stress, and then distances between electrodes changed vary irregularly. In such situations, flashover discharge may occur frequently even if voltage is comparatively lower.

### 5. LOOSING AND BREAKING OF ELECTRODE WIRE

Slim round, spiral and astroid electrodes were utilized in many precipitator systems in early stage, and mostly fixed on welded frames. They easily became loosed and broken because of continually heat stress, gas corrosion, arc discharging and so on. The causes are mainly as follows:

(1) The subsection of electrode wires is too long (2.5 m or longer), the expansion and contraction caused by heat stress are inconsistent between electrode wires and frames.

(2) Discharge electrodes are connected with frames by pothook, arc discharging appear at the spots of connection while they are being beat, and then electrode wires may be burn out.

(3) Electrode wires were broken by continually gas corrosion because of condensation of moisture or cold air infiltrating into electric fields.

(4) If electrode wires become loose, the distances between electrodes changed vary irregularly. In such situations, flashover discharge may occur frequently, and then electrode wire may be burn out.

Some measures can greatly reduce electrode wire loosing and breaking, for examples: shortening subsection of electrode wires, adopting awn-sting electrode, tightening two ends of electrode wires with screws, and so on.

## 6. CONCLUSIONS

(1) The diversity of electrode forms and their matches bring on variation of volt-ampere characteristics of electric precipitators. Awn-sting, round and astroid discharge electrodes present respective characteristics, and they are suitable for different operating conditions.

(2) The special compositions and technology process of "95" porcelain bring on superior mechanical, heat-resisting and electric-insulating

quality. So, "95" porcelain is regarded as a favorable material replacing ordinary ceramic and quartz material of electric precipitators.

(3) Dust deposit or scab on discharge electrode and awn should be cleaned in time, in order to keep excellent discharging ability. The causes may be airflow and dust nature, malfunction of beating components, operation and maintenance etc.

(4) Distortion, shift, shake and disjunction of electrode wires are crucial factors affecting system performances, and the causes may be continually heat stress, gas corrosion, arc discharging, beating malfunction and so on

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