

ELECTROSTATIC SMOKE PRECIPITATOR (ESP)

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Abstract—With the recent surge in Electrostatic Precipitator (ESP) installations and future predictions of continued growth, ESP technology has been and will continue to be utilized for many applications.

Electrostatic smoke precipitators work by forcing dirty flue gas past two electrodes (electrical terminals), which take the form of metal wires, bars, or plates inside a pipe or smokestack. The first electrode is charged to a very high negative **voltage**. As the dirt particles move past it, they pick up a negative charge. Higher up the pipe (or further along, if it's a horizontal pipe), there's a second electrode consisting of metal plates charged to a high positive voltage. Since unlike charges attract, the negatively charged soot particles are attracted to the positively charged plates and stick there. From time to time, the collecting plates have to be shaken to empty away the soot; that can be done either manually (by someone brushing them clean) or automatically (by some kind of automated shaking or brushing mechanism in a process called rapping).

I.History

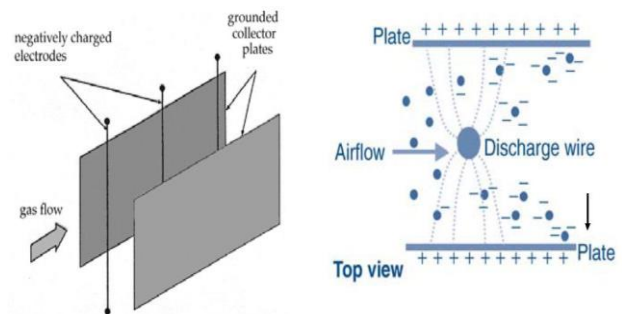
The first reported ESP in commercial service was a wet ESP installed in 1907 for acid mist control. The first dry ESPs followed in the 1910's in the non-ferrous metals and cement industry. Dry ESPs in the coal-fired boiler industry went into service in 1923 at one of Detroit Edison's power plants in the U.S. While dry ESPs have been in use in many industries for decades as a primary particulate control device, wet ESPs have found their use primarily in the sulfuric acid industry as a piece of process equipment to collect sulfuric acid. Not until regulatory authorities established emission limits on fine particulate matter has there been a wider need for wet ESP emission technology.

II.What is Electrostatic Smoke Precipitator?

Electrostatic smoke precipitators use static electricity to remove the soot from smoke. Dirty air moves past negatively charged wires so the soot particles pick up a negative charge. The negatively charged particles of soot then stick to positively charged plates. Much cleaner air emerges from the pipe as a result. Most precipitators also have simple [fabric filters](#) to remove larger soot particles.

- Particulate Collection Device used in industries to minimize air pollution
- Principle of operation -Electrostatic attraction
- Efficiency of 99% in many industries

- Can handle large gas volumes with a wide range of inlet temperatures, pressures, dust volumes, and acid gas conditions.
- Can collect particles of varying sizes in dry and wet states.



III.Principle of Operation

Electrodes at high voltage create a corona effect (ionized atmosphere) surrounding them. This charges the passing particles. Once charged, particles are subject to a transverse electrostatic force that pulls them toward the collecting plates. Plates are periodically “rapped” (vibrated) to make the collected particles fall down into a receiver basket in the bottom of the apparatus.

Ionization - Charging of particles

Migration - Transporting the charged particles to the collecting surfaces

Collection - Precipitation of the charged particles onto the collecting surfaces

Charge Dissipation - Neutralizing the charged particles on the collecting surfaces

Particle Dislodging - Removing the particles from the collecting surface to the hopper

Particle Removal - Conveying the particles from the hopper to a disposal point

IV. Precipitator Components

All electrostatic precipitators, regardless of their particular designs, contain the following essential components:

- Discharge electrodes
- Collection electrodes
- High voltage electrical systems
- Rappers
- Hoppers
- Shell

Discharge electrodes are either small-diameter metal wires that hang vertically (in the electrostatic precipitator), a number of wires attached together in rigid frames, or a rigid electrode made from a single piece of fabricated metal. Discharge electrodes create a strong electrical field that ionizes flue gas, and this ionization charges particles in the gas.

Collection electrodes collect charged particles. Collection electrodes are either flat plates or tubes with a charge opposite that of the discharge electrodes.

High voltage equipment provides the electric field between the discharge and collection electrodes used to charge particles in the ESP.

Rappers impart a vibration, or shock, to the electrodes, removing the collected dust. Rappers remove dust that has accumulated on both collection electrodes and discharge electrodes. Occasionally, water sprays are used to remove dust from collection electrodes.

Hoppers are located at the bottom of the precipitator. Hoppers are used to collect and temporarily store the dust removed during the rapping process.

The *shell* provides the base to support the ESP components and to enclose the unit.

V. Types of Electrostatic Smoke Precipitator

There are two types of plate type precipitator:

- 1) Wet plate type precipitator
- 2) Dry plate type precipitator

Wet side ESPs is used where:

Wet ESPs are used for industrial applications where the potential for explosion is high .

- When dust is very sticky, corrosive, or has very high resistivity.
- It does not have problems with rapping entrainment or with back corona.

Dry side ESPs is used where:

- Particles are charged and collected in a dry state .
- Dust particles collected are removed by rapping.
- Used in steel furnaces, cement kilns and fossil-fuel-fired boilers.

VI. Theory of Operation:

Dry and wet ESPs are similar in their main purpose which is to collect non-gaseous particulate from a flue gas stream. Both technologies include a multi-stage process for removal of the particulate from the gas stream by creation of an electric field. First, a high voltage corona discharge is emitted from the discharge electrodes, ionizing the flue gas molecules between the discharge and collecting electrodes. The particulate entering this electric field are then charged by the ionized flue gas molecules and naturally attracted to the collecting electrode of opposite polarity. And finally, the collected particulate is removed from the collecting electrode.

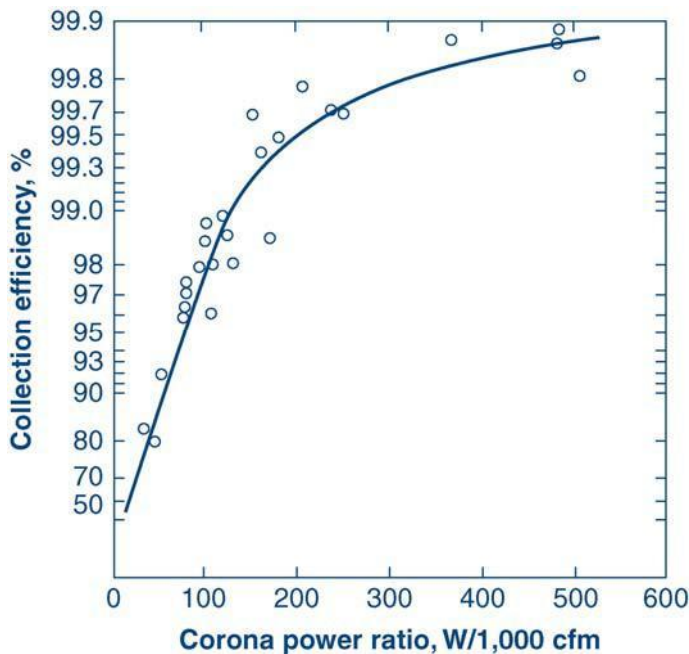
All ESPs use this method of particulate charging and collection; the differences between dry and wet ESPs are in the process of removing the particulate from the electrodes. Dry ESPs allow the collected particulate to build-up in a layer on the collection surface, which is then removed via mechanical rapping or vibration. Many different rapping variations exist including tumbling hammer, gravity impact, vibrators, pneumatic and droprod rapping. The collected particulate falls into a collection hopper where it is removed from the dry ESP with an ash handling system. Similar rapping systems are used on the discharge electrodes to minimize potential build-up that could inhibit corona generation.

In a wet ESP, the collecting electrodes are cleaned via use of intermittent water sprays or a continuous irrigation system preventing any build-up of particulate on the collecting electrode surface. If sprays are used, the affected electrical bus section must be deenergized to protect the transformer/rectifier sets whereas in an irrigation system the transformer/rectifiers may stay on as there is no interference with the electrical system. The water washes away the collected particulate on the collection surface. The difference in cleaning has a significant impact on function, location, operating temperature, materials of construction and performance.

VII. Configuration

Dry ESP design configuration consists of a horizontal flow of flue gas between two vertical plates with discharge electrodes in the middle, commonly referred to as a “platetype” ESP. Due to the large volume of gas and the heavy inlet loading of particulate that typically needs to be removed from a bottom hopper, the plate design has become the most common configuration.

Wet ESPs can come in a variety of configurations. They can be either plate or tubular; down-flow, up-flow or horizontal flow. Plate wet ESPs are very similar to dry ESPs with two vertical plates facing each other and discharge electrodes located between the plates. However, flue gas flow can be either horizontal or vertical. Alternatively “tubular” wet ESPs (tubular collecting surfaces with electrodes in the middle) are always vertical but the flow can be either up-flow or down-flow. Additionally, tube configuration can be round, square or hexagonal. Tubular designs, with all four sides containing the flue gas offer higher efficiency per square foot of gas treated and smaller size. However, when multiple electrical bus sections are required to achieve high removal, cleaning of the collecting surface is more of a challenge in a tubular design to minimize impact on the lower bus sections with interstage drains. Consideration of available real estate, flue gas volume, inlet loading, required removal, sectionalization, water usage, cost and maintenance access are all factors that come into play when selecting the most appropriate wet ESP configuration.



VIII. Advantages and disadvantages of Electrostatic Smoke Precipitator :

• Advantages of Electrostatic Precipitators:

- Electrostatic precipitators are capable very high efficiency, generally of the order of 99.5-99.9%.
- Since the electrostatic precipitators act on the particles and not on the air, they can handle higher loads with lower pressure drops.
- They can operate at higher temperatures.
- The operating costs are generally low.

• Disadvantages of Electrostatic Precipitators

- The initial capital costs are high.
- Although they can be designed for a variety of operating conditions, they are not very flexible to changes in the operating conditions, once installed.
- Particulate with high resistivity may go uncollected.

IX. Power supply to ESP:

The power supply system is designed to provide voltage to the electrical field at the highest possible level. The voltage must be controlled to avoid causing sustained arcing or sparking between the electrodes and the collecting plates.

Electrically, a precipitator is divided into a grid, with electrical fields in series (in the direction of the gas flow) and one or more bus sections in parallel (cross-wise to the gas flow). When electrical fields are in series, the power supply for each field can be adjusted to optimize operation of that field. Likewise, having more than one electrical field in parallel allows adjustments to compensate for their differences, so that power input can be optimized. The power supply system has four basic components:

- Automatic voltage control
- Step-up transformer
- High-voltage rectifier
- Sensing device
- Operating voltage: 20-30kV
- Operating current density: 5-50 nA/cm²

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