International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1264-1268 **DOI: 10.26540/ijgsr.v7.i1.2020.147**
***Available Online* at www.ijgsr.com**

Research Paper

Electrostatic precipitator global pollution control device

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Received: 30/12/2019
Revised: 13/01/2020
Accepted: 01/02/2020

Abstract: Electrostatic precipitator, also called electrostatic air cleaner, a device that uses an electric charge to remove certain impurities either solid particles or liquid droplets from air or other gases in smokestacks and other flues. The precipitator functions by applying energy only to the particulate matter being collected, without significantly impeding the flow of gases. Originally designed for recovery of valuable industrial-process materials, electrostatic precipitators are used for air pollution control, particularly for removing particles from waste gases at industrial facilities and power-generating stations.
Keywords: Electrostatic precipitator, light-industry, corona

INTRODUCTION

The two-stage electrostatic precipitators used in light-industry applications are compact devices which can be fitted into the ventilation system. These air cleaners are normally used to clean air from dusts, smokes, and fumes in industrial workplaces. The basic features of these devices are the separate sections for particle charging and collection. The charging section con sists of thin metal wires installed between grounded metal plates. The distance between the discharge wire and grounded plate electrodes is typically in the range of 1.5-3 cm. The collection section consists of a set of parallel metal plates installed in a way that every second plate is connected to the high voltage, while every second plate is connected to the ground potential. The separation between the plates is typically 5-10 mm. Rodolfo (2005).

Positive corona discharge is normally used, mainly because of lower ozone production than with negative corona discharge. The corona voltage is in the range of 9-13 kV. The collection voltage is typically half of the corona voltage. In some constructions the collection voltage equals the corona voltage. The length of the collection section is typically 10-30 cm, and the airflow velocities are in the range of 0.5-3 m/s. (Suzanne and Nils Mueller, 2014)

The most important application of electrostatic precipitation is, however, the solving of environmental pollution problems caused by many heavy-industry processes. The dimensions, corona voltages, and currents of these gas-cleaning systems are much larger than for ventilation electrostatic precipitators. Typical applications of industrial electrostatic precipitators are

1. collection of fly ash from electric power boilers,
2. particle collection from furnace operations in metallurgical processes,
3. particle collection from black-liquor recovery furnaces in paper mills,
4. particle collection from cement and gypsum manufacturing processes, and
5. cleaning of stack emissions in municipal incinerators.

Pipe-type electrostatic precipitators are used to collect liquid aerosols (e.g., mists and fogs). They are also used in applications which require water flushing of collection electrodes. The diameter of precipitator pipes is typically in the range of 15-40 cm, and the length is in the range of 3-6 m. The number of pipes depends on the total gas flow. The gas-flow rates in pipe-type electrostatic precipitators is normally much lower than in duct-type precipitators.

Duct-type electrostatic precipitators are the most important electrostatic gas-cleaning devices today. Duct-type electrostatic precipitators are made of vertically mounted collection plate electrodes, with discharge electrodes placed midway between plates. The width of the collection plates in a large electrostatic precipitator can be several meters and the height up to 15 m. An electrostatic precipitator system may include several sections energized from separate high-voltage supplies. The spacing between the plates is typically in the range of 20-40 cm. The gas-flow velocity is typically 0.5-2 m/s. The ratio of collection area to the volumetric gas flow is in the range of 20-150 $(m/s)^{-1}$. The corona voltages of large electrostatic precipitator systems are typically in the range of 40-100 kV, and the corresponding corona current densities (i.e., corona current divided by collection area) are in the range of 0.05-1 $mAJm^2$. It is worth noticing that the corona voltage is normally generated by means of a thyristor-controlled transformer/rectifier system. Thus, a cyclic corona voltage and current are applied to a precipitator section.

Electrostatic precipitators are operated near the sparking limit; i.e., corona voltage is continuously adjusted to maximize the collection efficiency. This is normally achieved at the sparking rate of 10-50 sparks per minute. Sparking occurs mostly in the front section(s) of an electrostatic precipitator. In the case of high-resistivity ($>10^{10}$ Ω cm) dust, special techniques must be used to avoid the formation of back corona. This requires sophisticated systems for controlling corona voltage and current. The formation of back corona can also be reduced with intermittent or low-frequency energization. This technique is based on the extension of the time period between corona current bursts. Thus, much higher current bursts can be used without causing back corona. Pulse energization is a more elaborate technique, which is based on current bursts of microsecond duration.

Besides optimal energization of an electrostatic precipitator, several other factors must be controlled to achieve a good performance. The gas velocity profile should be even to fully utilize the capacity of an electrostatic precipitator. Also, the gas flow outside the active collection sections (sneakage) should be minimized. Keeping

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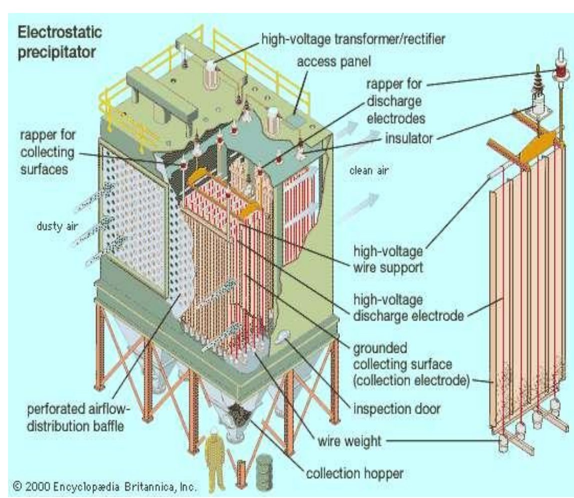
the electrodes clean is also of great importance, especially when eliminating the harmful effects of high-resistivity dust. The collected dust is normally removed by rapping forces, which are generated by mechanical impacts or by vibration of electrodes. Collection plates are normally cleaned with either a magnetic-impulse rapper or a rotating-hammer rapper. Adjustment of the rapping frequency and intensity is of great importance for the controlled removal of collected dust without excessive particle re-entrainment.

The design and operation of a large electrostatic precipitator requires lot of practical knowledge about the general properties of electrostatic particle separation. In addition, the properties of the dust must be known, and correct techniques (e.g., altering dust resistivity by means of gas conditioning) must be utilized. Depending on the application, the performance of an electrostatic precipitator can be affected by several factors in a rather complicated way. Therefore, practical work with electrostatic precipitators often requires empirical information about the separation process. Thus, the experimental results from existing installations are of great importance when designing new ones. Even though theoretical calculations provide less feasible information for design purposes, they still help to understand the basic factors influencing the overall performance of the electrostatic precipitator.

Electrostatic precipitators are widely used to trap fine particulate matter in applications where a large amount of gas needs treatment and where a wet scrubber is not appropriate. Coal-burning electric generating plants, primary and secondary smelters, and incinerators often use electrostatic precipitators, in which particles are removed when the dirty gas stream passes across high-voltage wires, usually carrying a large negative DC voltage. The particles are electrically charged as they pass these electrodes and then migrate through the electrostatic field to a grounded collection electrode. The collection electrode can be either a cylindrical pipe surrounding the high-voltage charging wire or a flat plate like that shown in Figure 21-7. In either case, it must be periodically rapped with small hammer-heads to loosen the collected particles from its surface. Rodolfo and Morris (2011).

As the dust layer builds up on the collecting electrode, the collection efficiency may decrease, particularly if the electrode is the inside of a cylindrical pipe. Moreover, some dust has a highly resistive surface and does not discharge against the collection electrode but sticks to it. Heated or water-flushed electrodes may solve this difficulty. Electrostatic precipitators are efficient collectors of very fine particles. However, since the amount of dust collected is directly proportional to the current drawn, the electrical energy used by an electrostatic precipitator can be substantial, with resulting high operating cost. Pratima Bajpai (2018;) Yen-Hsiung (2018) Woodard and amp (2006); Reza (2000); Nicholas and Paul (2010); Harker et. al., (2013).



Electrostatic precipitator

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ADVANTAGES OF ELECTROSTATIC PRECIPITATOR

• The High Efficiency of Removal of Particles/Pollutants.

The efficiency of an electrostatic precipitator depends on a lot of factors like the resistivity of the particles, the corona power ratio etc. For removal of particles under normal circumstances, their efficiency is very high, up to 99% removal of dust particles. Electrostatic precipitators have relatively high collection efficiencies (99-100%) over a wide range of particle sizes (~0.05-5 μm).

•Collection of Dry as Well as Wet Pollutants

There are two types of electrostatic precipitators: wet and dry. Dry ESPs are used for collection of dry pollutants like ash or cement particles. Wet ESPs are used to remove wet particles like as resin, oil, paint, tar, acid or anything that is not dry in the conventional sense.

•Low Operating Costs

Operating costs for electrostatic precipitators are low and in the long run, they are economically feasible.

DISADVANTAGES OF ELECTROSTATIC PRECIPITATOR

•High Capital Costs

Electrostatic precipitators have a high initial capital cost, which makes it prohibitive for small-scale industries. They are expensive to purchase and install.

•Requires Large Space

In addition to being costly, they require large space to be set up. Again the value proposition for small-scale industries gets reduced as they are costly as well as need a lot of space to be set up.

•Not Flexible Once Installed

Electrostatic precipitators do not offer the flexibility of operation. Once installed, it is difficult to change the capacity of the ESP or move it to a different location. So proper planning needs to be done regarding the capacity, type and location for installing the ESP.

•They cannot be used to collect gaseous pollutants

An electrostatic precipitator can be used for collecting only dry and wet pollutants and not for gaseous pollutants. This is a major **disadvantage of ESP**s. So, after going through the advantages and disadvantages of electrostatic precipitators, we are in a position to conclude whether we should install ESPs in a thermal power plant. Initial cost is definitely high and that makes it difficult for small-scale industries to install it. But with government support, the cost can be reduced for these sectors. With proper planning and land allocation, the disadvantage of being inflexible and large space requirement can be negated. ESPs can be used every effectively for dry and wet pollutants. Hence installing them can bring a lot of benefits to the plant in the long run and keep the environment safe.

ACKNOWLEDGEMENT

Author express gratitude to the I.I.R.D department, which has allowed me for the training and has provided valuable information regarding B.H.E.L. I deeply express our heartfelt and sincere thanks to Mr. Sumeet Chatterjee (Dy. Manager, HR), Mr. Rajeev Agarwal (Manager, T.R.E.) and Mr. V. V. Gogalkar (Manager, Bay-8) for guiding and helping us for preparing this work.

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