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A Review Paper on "Design Modification for Efficiency Improvement of Electrostatic Precipitator Filter "

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Abstract: *In recent years, increasing pollution of ambient fine particles (PM2.5) has drawn worldwide attention. Exposure to fine aerosol particles of bio-logical and non-biological origin in indoor environments has seriously negative effect on human health.Electrostatic precipitators have been used widely in industry and play an important role inenvironmental protection. Electrostatic precipitator (ESP) can be operated with a high collectionefficiency and a low pressure drop. Recently, ESP also has been used forcleaning indoorair.*
Key words: *Electroststic precipator filter, Ionization, collection area, dust particles size, Industrial Air Pollution*

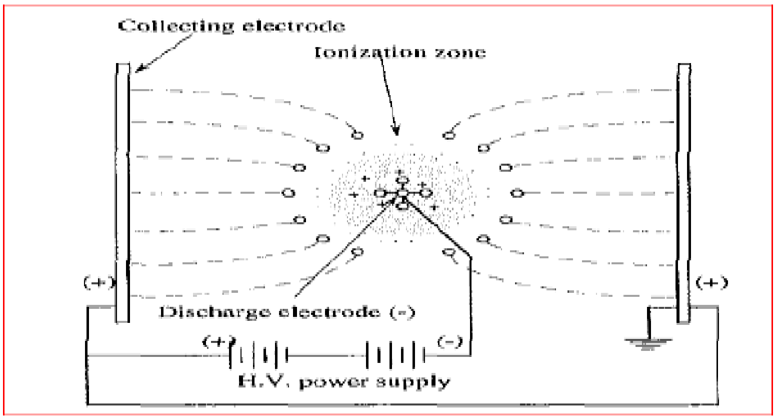
I. Introduction

Gaseousexhaustof different industries contains dust particles of different chemical precipitates that are harmful for the environment. Particulates are of serious concern to the environment and human beings, as they cause various health problems. Due to these hazards and associated federal regulations, industries have been compelled to develop techniques to capture particulates. [5]

The problem of pollutant fumes and smoke has been conventionally tackled by using mesh type filters, paper-based cartridge filters and exhausts. Out of these, exhausts just transfer polluted air from one place to another and hence are of no use. Also, exhausts prove ineffectual as the density of polluted fumes and smoke is much higher than the normal air.Mesh-type filters and paper-based cartridge filters also fail to provide a permanent solution as they consume a lot of power and need to be replaced very often, adding to energy losses, as well as recurring costs. [14]

1.1 GENERAL CONCEPT OF ELECTROSTATIC PRECIPATOR

As shown in fig ESP setup contains sharp discharge electrodes and smooth collecting electrodes. When HVDC is applied to the discharge electrode, a corona discharge takes place. Ions and electrons are produced at the corona point, and ionic current flows through the space. The ion polarity is either positive or negative. These ions attach to suspended solid particles. These charged particles are moved towards the collecting electrode by a Coulomb force, and are collected on that electrode. When the thickness of the layer of the collected solid particles reaches a predetermined level, the collecting electrode is rapped mechanically using a hammer, and the layer falls down into a hopper located below. These particles are then carried away to outside the ESP the working Principle of an Electrostatic Precipitator is best understandable by understanding six activities mentioned below [12]



Diag 1.1 Schematic diagram of an electrostatic precipitator [12]

- 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. [13]

1.2 Types of Electrostatic Precipitator
ESP is configured in several ways. Some of these configurations have been developed for Special control action and others have evolved for economic reasons. The types that will be described here are [11]

1. The Plate-Wire Precipitator
2. The Flat Plate Precipitator
3. The Tubular Precipitator
4. The Wet Precipitator
5. The Two-Stage Precipitator

1.2.1 Plate-Wire Precipitators

Plate-wire ESPs are used in a wide variety of industrial applications, including coal-fired boilers, cement kilns, solid waste incinerators, paper mill recovery boilers, petroleum refining catalytic cracking units, sinter plants, basic oxygen furnaces, open hearth furnaces, electric arc furnaces, coke oven batteries, and glass furnaces. [11]

In a plate-wire ESP, gas flows between parallel plates of sheet metal and high-voltage electrodes. These electrodes are long wires weighted and hanging between the plates or are supported there by mast-like structures (rigid frames). Within each flow path, gas flow must pass each wire in sequence as flows through the unit. [11]

1.2.2 Flat Plate Precipitators

A significant number of smaller precipitators (100,000 to 200,000 acfm) use flat plates instead of wires for the high-voltage electrodes. The flat plates (United McGill Corporation patents) increase the average electric field that can be used to collect the particles, and they provide an increased surface area for the collection of particles. A flat plate ESP operates with little or no corona current flowing through the collected dust, except directly under the corona needles or wires. This has two consequences. The first is that the unit is somewhat less susceptible to back corona than conventional units are because no back corona is generated in the collected dust, and particles charged with both polarities of ions have large collection surfaces available. The second consequence is that the lack of current in the collected layer causes an electrical force that tends to remove the layer from the collecting surface; this can lead to high rapping losses. [11]

1.2.3 Tubular Precipitators

The original ESPs were tubular like the smokestacks they were placed on, with the high-voltage electrode running along the axis of the tube. Tubular precipitators have typical applications in sulphuric add plants, coke oven by-product gas cleaning (tar removal), and, recently, iron and steel sinter plants. Such tubular units are still used for some applications, with many tubes operating in parallel to handle increased gas flows. The tubes may be formed as a circular, square, or hexagonal honeycomb with gas flowing upwards or downwards. The length of the tubes can be selected to fit conditions. A tubular ESP can be tightly sealed to prevent leaks of material, especially valuable or hazardous material. [11]

1.2.4 Wet Precipitators

Any of the precipitator configurations discussed above may be operated with wet walls instead of dry. The water flow may be applied intermittently or continuously to wash the collected particles into a sump for disposal. The advantage of the wet wall precipitator is that it has no problems with rapping re-entrainment or with back coronas. The disadvantage is the increased complexity of the wash and the fact that the collected slurry must be handled more carefully than a dry product, adding to the expense of disposal. [11]

1.2.5 Two-Stage Precipitators

The previously described precipitators are all parallel in nature, i.e., the discharge and collecting electrodes are side by side. The two-stage precipitator invented by Penney is a series device with the discharge electrode, or ionizer, preceding the collector electrodes. For indoor applications, the unit is operated with positive polarity to limit ozone generation. Advantages of this configuration include more time for particle charging, less propensity for back corona, and economical construction for small sizes. This type of precipitator is generally used for gas flow volumes of 50,000 acfm and less and is applied to submicrometer sources emitting oil mists, smokes, fumes, or other sticky particulates because there is little electrical force to hold the collected particulates on the plates. Modules consisting of a mechanical pre-filter, ionizer, collecting-plate cell, after-filter, and power pack may be placed in parallel or series-parallel arrangements. Preconditioning of gases is normally part of the system. Cleaning may be by water wash of modules removed from the system up to automatic, in-place detergent spraying of the collector followed by air-blow drying. Two-stage precipitators are considered to be separate and distinct types of devices compared to large, high-gas-volume, single-stage ESPs. The smaller devices are usually sold as pre-engineered, package systems. [11]

1.3 components of electrostatic precipitator –

1. Positive/ Negative plate
2. Common Plate
3. Tray
4. Pre/After Filter
5. Blower

1. Positive/ Negative plate –

Positive/Negative plate act as electrodes in precipator filter, to reduce the overall weight of precipator we use aluminum sheet for precipator and they are easily available in market.

- Material - 22G Aluminum
- Thickness – 0.9 mm
- Operation - laser cutting
- Number of Total Plates - 61

2. Common Plate –

Common plate is acts as larger electrode in precipator & maintains the electrical conductivity in all positive/negative plate.

- Material – 22G Aluminum
- Thickness – 0.9 mm
- Manufacturing Operation - laser cutting
- Number of Total Plates – 7

3. Tray -

Tray acts as a support to all Plates, Rod & Bush in electrostatic precipator, there are 2 trays are used from both side of precipator. It gives better handling of stack.

- Material – 16G Aluminum
- Thickness – 1.6 mm
- Manufacturing Operation - laser cutting
- Number of Total Plates – 2

4. Pre/After Filter

A pre-filter is an essential feature on a precipator because it prolongs the life of the Precipator & blower .If the pre-filter was not on the device, precipator would take too much large size particles and gap between electrodes will fill out faster & then current jumping problem cause in precipator causes more repetitive maintenance.

- Material – GI Wire Mesh media in MS powder coated channel frame
- Manufacturing Operation - laser cutting
- NOS – 2

5. Blower –

A centrifugal fan is a mechanical device for moving air or other gases in a direction at an angle to the incoming fluid. Centrifugal fans often contain a housing direct outgoing air in a specific direction such a fan is also called a blower fan.DIDW centrifugal backward curved impeller with external rotor type motor is used in this filter having 2600 RPM.

II. Working

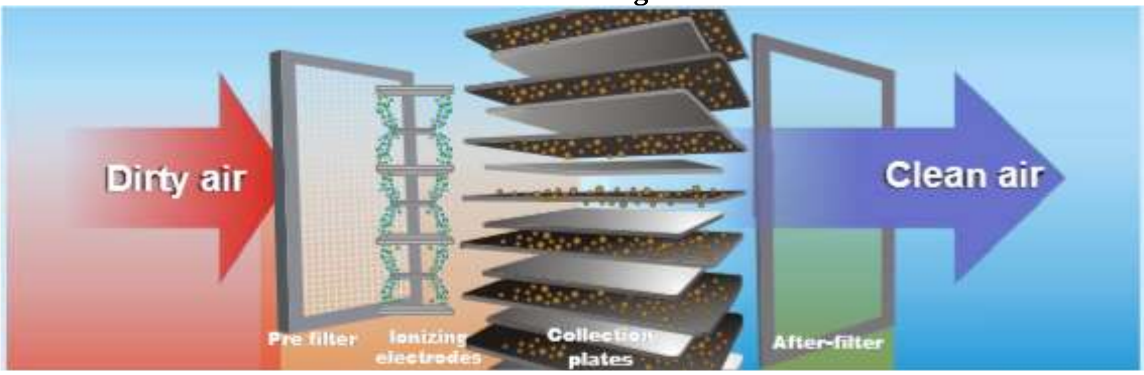


Fig 2.1 Working of ESP [13]

As shown in fig 3.2. ESP system works on the principle of two stage electrostatic precipitation. The extracted air which is mixed with fumes /mist / fine dust particles is passed through parallel electrode plates (Ionization section).High voltage is applied across these plates, because of which, the particles in air are charged with positive charge.These charged particles are then passed through another setoff parallel electrode plates (Collection section).Here the positive particle is attracted and held on the negatively charged electrode plate and thus gets separated from the air flow. Likewise, the air flow becomes free of particles and we get clean and unpolluted air at the outlet.

The technology is based on the principle of two stage electrostatic air filtration. Fine sub-micron suspended particles are electrostatically charged using high-voltage electric field, which then get attracted and precipitated on opposite charged electrode plates Filter On Electrostatic Filtration Systems offer high efficiency even for small submicron particles which form the maximum percentage of floating and suspended particles in air. The efficiency of ESP is equivalent to EU9 grade filters.Lowest pressure drop As compared to any type of filter having EU9 equivalent filtration efficiency, ESP offers very low pressure drop i.e. only 3-6 mm WG Permanent filter Since ESP is made of Aluminum plate electrodes, it never requires any replacement over the lifetime (15-20 years). It only requires periodic cleaning. So, no replacement costs at all. [14]

2.1 ESP Design Parameter
• Specific collection area
• Collection plate area
• Collection height and length
• Gas velocity
•Number of fields in series
• Number of discharge electrodes
• Type of discharge electrodes
• Discharge electrode-to-collection plate spacing

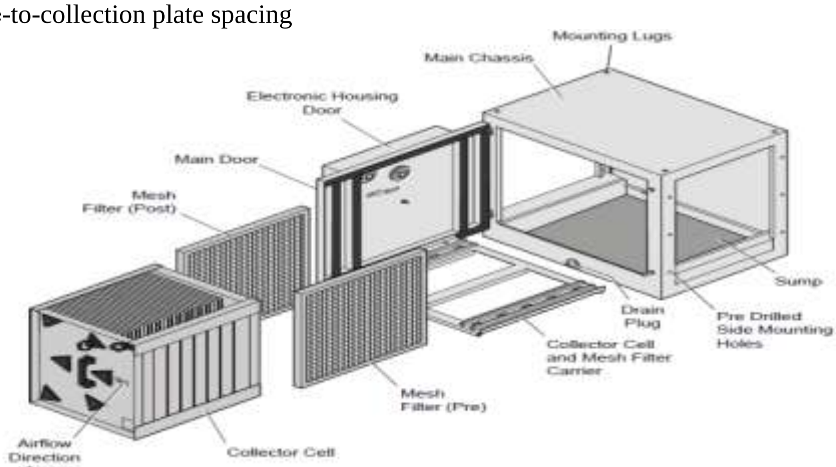


Fig 2.2 Electrostatic Precipitator Unit

2.2 Filtration efficiency of filters

There are various different filtration efficiency tests recommended as per different standards for various differentgrades of filters. The Electrostatic filters have the ability totrap very fine particles even up to

0.1 micron size. Efficiency measured as per ASHRAE gravimetric test basis on standard test rig is 95+/-2% for 0.5 micron and aboveparticles. In this test the sample of air is taken at inlet and outlet of the filter. The concentration of the dust in the samples iscalculated in mg/m^3. Then these values of inlet and outlet are compared. The filter paper used in the sample probes is of 0.5 micron porosity. On the EU grades of filters, thisefficiency is better than EU9 Grade filters.The efficiency is defined as the percentage of removal. We find it to be

$$\eta = \frac{C\ input\ - Coutput}{Cinput}$$

- Sample calculation

• C_{input}=27 mg/m^3 C_{output}= 6 mg/m^3 $=\frac{27-6}{27}$ • η = 77.77 %	V = 19.3 m/sec Dia = 195 mm Area = 0.029 m^2 Discharge = A X V = 2075 CMH

III. Conclusion

Electrostaticprecipitator (ESP) has been used widely in various industries such as utility boilers, cement kilns etc. and also has been applied in cleaning of indoor air in houses, offices, hospitals, and factories for food processing An electrostatic precipitator (ESP) is a particle control device that uses electrical forces to move the particles out of the flowing gas stream and onto collector plates. The particles are given an electrical charge by forcing them to pass through a corona, a region in which gaseous ions flow. The electrical field that forces the charged particles to the walls comes from electrodes maintained at high voltage in the centre of the flow lane. Once the particles are collected on the plates, they must be removed from the plates without restraining them into the gas stream. By optimizing certain parameter such as collection plate area, size of electrode, applied voltage, current, gap between electrode and other design parameter. Analysing obtained results for improve collection efficiency of electrostatic preceptor filter.

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