**DESIGN AND FABRICATION OF MODIFIED ELECTRO-STATIC PRECIPITATOR**

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**ABSTRACT**

*Energy conversion and equipment are closely related due to industrialization and increase in population due to which our environment is polluted vigorously. Many of the industries and fossil fuel power plant emits CO2, CO, particulate matter, heat and other poisonous gases to the atmosphere, resulting in many problems like global warming, health hazards, environmental degrading.  
 Various alternatives are being examined and studied about the employment of different pollution control equipment by National Environmental protection agency and environmentalist. One of the Instrument which control the quantity of particulate matter is Electro-static precipitator. An electrostatic precipitator or air cleaner is a particulate collection device that removes particles from a flowing gas Electrostatic precipitators are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulate matter such as dust and smoke from the air stream. The Project aims at designing a system which is capable of reducing wastage of power utilized by the electro-static precipitator in order to remove the dust particles from the gas stream and it can be done by modifying the existing electro-static precipitator. In existing ESP, all the charging plates remain always energized due to which there is a continuous wastage of energy. In order to remove this drawback, we are modifying existing ESP with the help of sensor.*

**1 INTRODUCTION**

An electrostatic precipitator is a large industrial emission-control unit. It is designed to trap and remove dust particles from the exhaust

gas stream of an industrial process. Precipitators are used in these industries:

1. Power/Electric

2. Cement

3. Chemicals

4. Metals

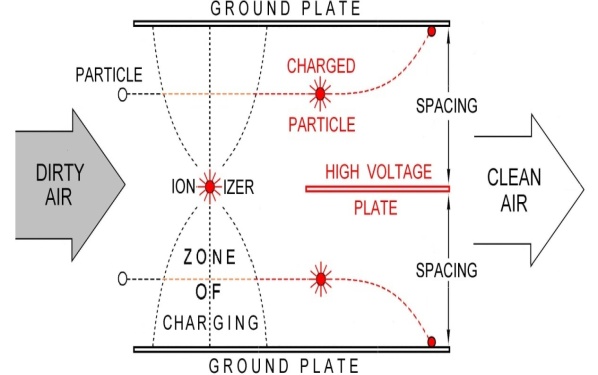
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**1.1 BASIC PRINCIPLE**

Electrostatic precipitator removes particles from the exhaust gas stream of an industrial process. Often the process involves combustion, but it can be any industrial process that would otherwise emits particles to the atmosphere

Six activities typically take place:

1. Ionization- Charging of particles.
2. Migration -Transporting the charged particles to the collecting surfaces.
3. Collection - Precipitation of the charged particles on to the collecting surfaces.
4. Charge Dissipation -Neutralizing the charged particles on the collecting surfaces.
5. Particle Dislodging – Removing the particles from the collecting surface to the hopper
6. Removal - Conveying the particles from the hopper to a disposal point. [5]



**Fig 1.1 Operational Diagram** [6]

**1.2 WORKING**

Fig. 1.1 shows the operational diagram of ESP. It is a device for removing small particles, as of smoke, dust, or oil, from a gas, as air, by passing the gas first through an electrically charged screen that gives a charge to the particles, then between two charged plates where the particles are attracted to one surface.

In high- voltage electrostatic field, affected by the electric field force, gas ionization takes place. There are tremendous amount of electrons and ions existing in the ionized gas. After the dust particles are combined with these electrons and ions, they will be polarized most of them are negatively polarized. Under the action of the field force, negatively charged particles migrates towards the positive electrode and in turn release electrons and attach to the positive electrode.

When the particles agglomerate and the layers reaches a certain thickness on the plate, rapping system will start to work and the particles will be dislodged from the collecting plate by vibration and falling into the hopper. That ends the collection process .[6]

**1.3 BACKGROUND**

In many industrial plants, particulate matter created in the industrial process is carried as dust in the hot exhaust gases. These dust gases pass through an electrostatic precipitator that collects most of the dust, cleaned gas then passes out of the precipitator and through a stack to the atmosphere. Precipitators typically collect 99.9% or more of the dust from the gas stream.

Precipitators function by electro statically charging the dust particles in the gas stream. The charged particles are then attracted and deposited on plates or other collection devices. When enough dust has accumulated, the collectors are shaken to dislodge the dust, causing it to fall with the force of gravity to hoppers below. The dust is then removed by a conveyor system for disposal or recycling.

Depending upon dust characteristics and the gas volume to be treated, there are many different sizes, types and designs of electrostatic precipitators. Very large power plants may actually have multiple precipitators for each unit. [7]

**2 RELATED WORK**

Electrostatic precipitator works like a magnet by pulling charged particles of pollutant out of air stream. With this method energy is applied directly to the particle to be removed. In mechanical filtration, the entire air flow is squeeze through the filter. That is why energy-wise electrostatic precipitation is far more efficient than any other method. In our modification, if the ash density of dust particle increases, the sensor senses it. Thus, relay gets turn on which increases the current carrying capacity of charging plates .Also the backward plates which are initially off , gets activated. [3].

**3 TYPES OF DUST COLLECTOR**

Five types of industrial dust collectors are:

1. Inertial separators
2. Fabric filters
3. Wet scrubbers
4. Electrostatic precipitators
5. Unit collectors

Inertial Seperator-

They separate dust from gas streams using combination of forces such as centrifugal ,gravitational and inertial. These forces move the dust to an area where the force exerted by the gas stream are minimal. The separated dust is temporarily moved to hopper by gravity. They are used in mineral processing industry.

Fabric Filters-

The fabric filters are inherently large structures , resulting in a large pressure drop, which reduces the plant efficiency. Electrostatic precipitators have collection efficiency of 99%, but do not work for fly ash with a high electrical resistivity (as commonly results from combustion of low-sulfur coal). The bag is made up of woven or felted-cotton , synthetic or glass fiber material .

Wet Scrubbers-

Dust particles that uses a liquid are known as wet scrubbers .In these system water comes in contact with a gas stream containing dust particles .Greater contact of the gas and liquid streams yields higher dust removal efficiency .

Unit Collector-

They are small and self contained consisting of a fan and some form of dust collectors. They are suitable for isolated ,portable or frequently moved dust producing operations such as bins and silos or remote belt conveyors or transfers points . [6]

**3.1ADVANTAGES OF ESP**

1.This is more effective to remove very small particles like smoke, mist and fly ash. Its range of dust removal is sufficiently large (0.01 micron to 1.00 micron). The small dust particles below 10 microns cannot removed with the help of mechanical separators and wet scrubbers cannot be used if sufficient water is now available. Under these circumstances, this type is very effective.

2.This is also most effective for high dust loaded gas (as high as 100 grams per cu. Meter).

3.The draught loss of this system is the least of all

forms(1 cm of water).

4.It provides ease of operation.

5.The dust is collected in dry form and can be removed either dry or we t.[3]

**3.2DISADVANTAGES OF ESP**

1.The direct current is not available with the modern plants, therefore considerable electrical equipment is necessary to convert low voltage (400 V) A.C to high voltage (60000 V) D.C. This increases the capital cost of the equipment as high as 40 to 60 cents per 1000 kg of rated installed steam generating capacity.

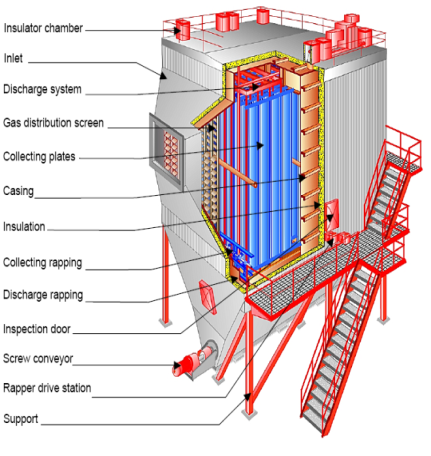
2.The running charges are also considerably high as the amount of power required for charging is considerably large.

3.The space required is larger than the wet system.

4.The efficiency of the collector is not maintained if the gas velocity exceeds that for which the plant is designed. The dust carried with the gases increases with an increase of gas velocity.

5.Because of closeness of the charged plates and high potential used, it is necessary to protect the entire collector from sparking by providing a fine mesh before the ionizing chamber. This is necessary because even a smallest piece of paper might cause sparking when it would be carried across adjacent plates or wires. [3]

**4 COMPONENTS OF ESP**



**Fig 4.1 Constructional Diagram**

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

1. Discharge electrodes
2. Collection electrodes
3. High voltage electrical systems
4. Rappers
5. Hoppers
6. Shell

1. Discharge electrodesare 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.
2. Collection electrodescollect charged particles. Collection electrodes are either flat plates or tubes with a charge opposite that of the discharge electrodes.
3. High voltage equipmentprovides the electric field between the discharge and collection electrodes used to charge particles in the ESP.
4. Rappersimpart 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.
5. Hoppersare located at the bottom of the precipitator. Hoppers are used to collect and temporarily store the dust removed during the rapping process.
6. The shellprovides the base to support the ESP components and to enclose the unit. [5]

**4.1 DESIGN AND PERFORMANCE REQUIREMENT**

Designing a precipitator for optimum performance requires proper sizing of the precipitator in addition to optimizing precipitator efficiency. While some users rely on the precipitator manufacturer to determine proper sizing and design parameters, others choose to either take a more active role in this process or hire outside engineering firms. Precipitator performance depends on its size and collecting efficiency. Important parameters include the collecting area and the gas volume to be treated. Other key factors in precipitator performance include the electrical power input and dust chemistry.

The sizing process is complex as each precipitator manufacturer has a unique method of sizing, often involving the use of computer models and always involving a good dose of judgment. No computer model on its own can assess all the variables that affect precipitator performance.  
 Based on specific gas volume and dust load, calculations are used to predict the required size of a precipitator to achieve a desired collecting efficiency.

Power input is comprised of the voltage and current in an electrical field. Increasing the power input improves precipitator collecting efficiency under normal conditions. [1]

**4.2 ESP INSTALLATION**

Depending on the electrostatic precipitator chosen, production, installation and operation startup may take from a few months to one or two years. In any case, proper installation procedures will save time and money, and will also help in future operation and maintenance.

Good coordination between the ESP designer (vendor) and the installation and maintenance crews will help keep the ESP running smoothly for years. Occasionally this coordination is overlooked. Because they are so large, ESPs are usually installed by skilled craftsmen who do not work for the ESP vendor, and, therefore, may not be informed of specific installation instructions. Since all design tolerances are critical (especially those affecting discharge and collection electrode alignment), it is imperative that information about the proper installation procedures be transferred from designers to installers.[2]

**4.3 SOME KEY CONSIDERATIOM DURING INSTALLATION**

1.Uniform flue gas distribution across the entire unit. Ductwork, turning vanes, baffle plates, and inlets with perforated diffuser plates all affect flue gas distribution. These items are usually installed in the field and should be checked visually. If improperly installed, they induce high airflow regions that decrease collection efficiency and cause entrainment of collected dust, especially during rapping cycles.

2.Complete seal of ESP system from dust pickup to stack outlet. Air in leakage or out leakage at flanges or collector access points either adds additional airflow to be processed or forces the process gases to bypass the collector. In leakage to a high-temperature system (hot-side ESP) is extremely damaging, as it creates cold spots which can lead to moisture or acid condensation and possible corrosion. If severe, it can cause then tire process gas temperature to fall below the gas dew point, causing moisture or acid to condense on the hopper walls, the discharge electrode, or collection plates. In addition, air in leakage and moisture condensation can cause caking of fly ash in the hopper, making normal dust removal by the discharge device very difficult. The best way to check for leaks is an inspection of the walls from inside the system during daylight. Light penetration from outside help to isolate the problem areas.

3.Proper installation of discharge electrodes and collection plates. Collection electrodes are usually installed first, and the discharge wires or rigid frames are positioned relative to them. Check each section of electrodes to ensure that the electrodes are plumb, level, and properly aligned.

4**.** Proper installation of rappers. Collection-plate rappers and discharge-electrode rappers should   
be installed and aligned according to vendor specifications. Check hammer and anvil rappers   
 to see if the hammers strike the anvils squarely. Check vibrator rappers installed on discharge wires to make sure they operate when activated. Rapper frequency and intensity can be adjusted later when the unit is brought on-line.

5.Proper insulation. Most ESPs use some type of insulation to keep the flue gas temperature   
 high. This prevents any moisture or acids present in the flue gas from condensing on the hoppers, electrodes, or duct surfaces. Because most ESPs are installed in the field, check that all surfaces and areas of potential heat loss are adequately covered.

6. Proper installation and operation of discharge devices. It is important to check the operation of   
 the discharge devices before bringing the ESP on-line to see if they are properly installed. Make sure that the discharge devices are moving in the right direction so they can remove the dust freely from the hopper. A backward-moving screw conveyor can pack dust so tightly that it can bend the screw. Overfilled hoppers are common operating problems that can be avoided   
 by proper installation and maintenance of discharge devices. Installed as maintenance tools,   
dust-level detectors in the hoppers can help alert ESP operators that hoppers are nearly full.

7. Smoothly running fans. Check fans for proper rotation, drive component alignments, and   
vibration. Fans should be securely mounted to a component of sufficient mass to eliminate   
excessive vibration. In addition to the above items, each ESP installation should have its own   
checklist reflecting the unique construction features of that unit. The installation crew should   
prepare a checklist before beginning final inspection and initial startup. [4]

5 BLOCK DIAGRAM

**Fig 5 Modified Block Diagram**

Working-

Fig. 5 shows the modified block diagram of ESP. Here E1 and E2 are the forward electrodes and the backward electrodes respectively. From the control power supply, a supply is given to a vibrator which is use for hammering process. Also supply is given to a forced draught fan which is basically used for blowing the ash from the inlet section .Before giving supply to a extra high tension kit , a value is set which is equal to the maximum increase in speed ash density at the electrode 2. Here E1 is always remains activated at the same time E2 remains de-activated .When the supply is given to a high tension kit ,it makes the e1 activated ,when the ash density is less ( that is when dust to be captured is less in quantity ).But as there is increase in the speed of ash density ( when ash density is more ) , which will be sense by the sensor and it will give signal to a electronic control unit . When the value which we have set is equal to the set value, it makes the relay on which will further activate the E2. And the dust particles to be capture will be collected at E2. After sometime the supply is switched off, and all the dust particles will be collected at the hopper which will be placed at the bottom with the help of hammering process.

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