# Experimental Investigation of Air Pollution from Automobile Using Electrostatic Methodology

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*Abstract*- **Air pollution is one of the main types of pollution of the environment. The most common sources of air pollution include the burning of fossil fuels and other materials in oil refineries, power plants, factories, automobiles and other forms of transportation, as well as the incinerators. Fumes from aerosols and chemicals like paint also cause air pollution. The main types of pollution gases in the air are carbon dioxide, carbon monoxide, methane, sulfur dioxide, chlorofluorocarbons (CFCs) and nitrogen oxides. Air pollution adversely affects humans by causing cardio-respiratory problems among other health problems. Our Problem Statement is to study and analyse, exhaust gases from automobiles and design a prototype model for reducing air pollution there from, by using electrostatic precipitator. The main objectives is to study air pollution, it's hazardous and Remedial methodologies air pollution data collection and its analysis, to design and develop prototype model by using Electrostatic Precipitators methodology.**

*Index Terms*- **Biomass, Methane, Electrostatic, precipitator, Gravitational Settling Chamber.**

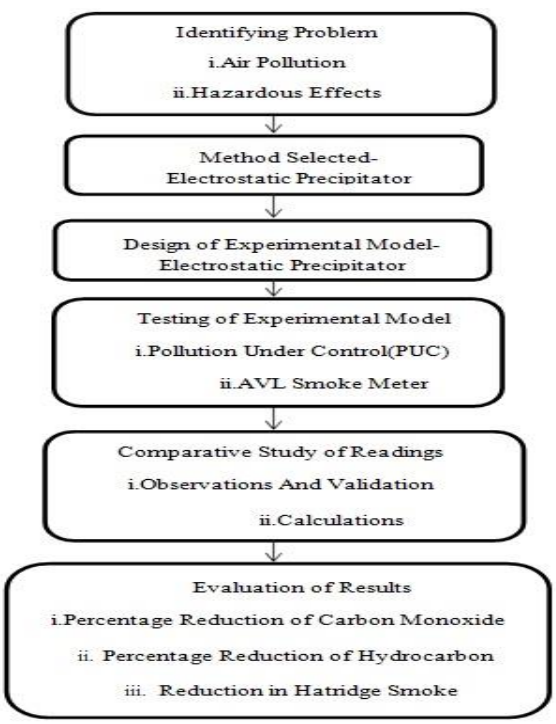
## I. INTRODUCTION

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants. According to a 1983 article in the journal science, Soot found on ceiling of prehistoric caves provides ample evidence of high level of pollution that was associated with inadequate ventilation of open fire [3]. Pollution is often classed as point source or non-point source pollution. Pollution started from prehistoric times when man created the first fire. Pollution from cars and trucks is split into primary and secondary pollution. Primary pollution is emitted directly into the atmosphere; secondary pollution results from chemical reactions between pollutants in the atmosphere. Particulate matter (PM) these particles of soot and metals give smog its murky colour. Fine particles less than one-tenth the diameter of a human hair -pose the most serious threat to human health, as they can penetrate deep into lungs. PM (Particular Matter) is a direct (primary) pollution and a secondary pollution from hydrocarbons, nitrogen oxides, and sulphur dioxides. Diesel exhaust is a major contributor to PM pollution. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking. Smoke and carbon monoxide from wildfire. Volcanic activity, which produces sulphur, chlorine, and ash particulates. Our Problem Statement is to study and analyse, exhaust gases from automobiles and design a prototype model for reducing air pollution there from, by using electrostatic precipitator. The main objectives is to study air pollution, it's hazardous and Remedial methodologies air pollution data collection and its analysis, to design and develop prototype model by using Electrostatic Precipitators methodology.

## II. LITERATURE REVIEW

Agung Sudrajada , [1] Review of electrostatic precipitator device for reduce of diesel engine particulate matter, 2nd International Conference on Sustainable Energy Engineering and Application, ICSEEA 2014 presented the research paper on "Review of electrostatic precipitator device for reduce of disel engine particulate matter" in which they describe the work that has been done in term of fundamental of ESP. W. Peukert , [2] Industrial separation of fine particles with difficult dust properties, Institute of Particle Technology, Technische UniÕersitat Munchen, Boltzmannstrasse 15, 85748 Garching, Munich, Germany Hosokawa Micron GmbH, Welserstr. 9-11, 51149 Koln, Germany, presented the research paper on "Industrial separation of fine particles with difficult dust properties" in which they describe the possibilities to separate particles with difficult dust properties from gases. Muhammad Ahmad, [3]Modelling and Simulation of an Electrostatic Precipitator, School of Computer Science, Physics and Mathematics Växjö, Sweden, presented the research paper on "Modelling and Simulation of an Electrostatic Precipitator" in which the goal of this reference paper is to model the electric field of an Electrostatic Precipitator and study the working principle of an Electrostatic Precipitator. Miros aw Dors,[4] Removal of NOx by DC and pulsed corona discharges in a wet electrostatic precipitator model, Journal of Electrostatics 45 (1998), presented the research paper on "Removal of NOx by DC and pulsed corona discharges in a wet electrostatic precipitator model. The object of this investigation was the removal of NO and NO 2 from simulated exhaust gases by DC and pulsed corona discharges in reactors simulating a segment of an electrostatic precipitator whose collecting electrodes are irrigated by water.

## III. METHODOLOGY




Pollution is the introduction of contaminants into the natural environment that cause adverse change. [1] Pollution can take the form of chemical substances or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants. Pollution is often classed as point source or nonpoint source pollution.

### A. *Pollution Control Equipment's*

Sometimes pollution control at source is not possible by preventing the emission of pollutants. Then it becomes necessary to install pollution control equipment to remove the gaseous pollutants from the main gas stream.

Pollution control equipment's are generally classified into two types:

i. Control devices for particulate contaminants.
ii. Control devices for gaseous contaminants.

## IV. DESIGN OF ELECTROSTATIC PRECIPITATORS

### A. *Construction*

Precipitators function by electrostatic ally charging particles in the gas stream. The charged particles are attracted to and deposited on plates or other collection devices. The treated air then passes out of the precipitator and through a stack to the atmosphere. When enough particles have accumulated on the collection devices, they are shaken off the collectors by mechanical rappers [11].The particulates, which can be either wet or dry, fall into a hopper at the bottom of the unit, and a conveyor system transports them away for disposal or recycling. Precipitators are often deployed with denitrification units that remove nitrogen oxides and scrubbers or other devices that remove sulphur dioxide. The most basic precipitator design consists of a row of thin vertical wires and a stack of large flat vertical metal plates. The plates are spaced from less than 0.5 inch (1.3 cm) to about 7 inches (about 17.8 cm) apart, depending on the application. The gas stream flows horizontally between the wires and through the stack of plates. A negative charge of several thousand volts is applied between the wires and plates to remove impurities from the gas stream. Although the actual design of ESP systems is typically done by the manufacturer, a basic understanding of the design process is helpful for making an informed selection [10].

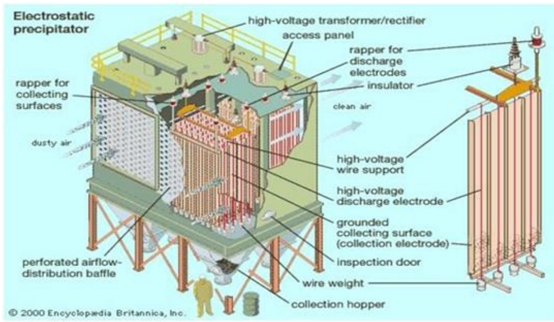



Fig.I ESP at Fossil Fuel Power generating plant [6]

*B. Design factors that determine an ESP's performance include:*

i. Precipitator size - the size of the precipitator affects its collection efficiency, footprint, and gas flow capacity. The sizing process is complex and often involves the use of computer models to aid in accounting for the numerous associated variables.

ii. Power input - the power supplied to the system to induce the electric field. Increasing power input improves collection efficiency under normal conditions.

*C. Electrostatic Precipitators Working*

Electrostatic precipitators use electrostatic charges to separate particles from a dirty gas stream as shown in fig 3.7 High voltage, direct current electrodes are used to establish a strong electric field. This field (known as a corona) delivers a (usually) negative charge to particles as they pass through the device. This charge forces the particles onto the walls of collection plates or tubes. These collection surfaces (or collection electrodes) are then rapped, vibrated, or washed with water to dislodge the particles, which fall into a hopper to be disposed.

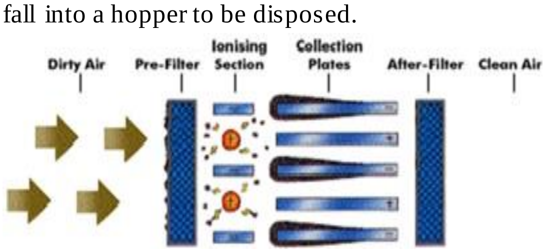



Fig.II. Schematic ESP Working [5]

The major components of a precipitator include:

i. Precipitator Casing-It is an all-welded steel construction, assembled from prefabricated wall and roof panels using panel construction. The precipitator casing is designed for horizontal gas flow. The casing is thermally insulated by insulation.

ii. Hoppers -The hoppers are of pyramidal construction type with dry or wet conveying system. The valley angle of the hoppers (angle between hopper corner and horizontal) is never less than 55° and offer more to ensure easy dust flow down to the feed out flange. To ensure free flow of ash into the disposal system lower portions of the hoppers are provided with electrical heaters with thermostatic control.

iii. Gas Distribution System-The gas velocity in the precipitator is approximately 1/10th of the velocity in the ducting before the precipitator. It is therefore essential that the precipitator have arrangements to give an even distribution over its entire cross sectional area. Special gas distribution screens are therefore located at the inlet of the precipitator. The screens are of modular design and hang within a framework in the precipitator-casing inlet.

iv. Collecting Electrode System-The collecting plates are made of 1.6-mm steel plate and shaped in one piece by roll forming. The 'G' profiled collecting electrode is provided. The upper edge of the connecting plates are provided with hooks, which are hung from support angles welded to the roof structure. The lower edge of each plate has a shock receiving plate, which is securely guided by the shock bar arrangement. This results in a stable collecting system similar to the emitting system.

v. Emitting Electrode System-Wire type/pipe type electrodes are used for emitting electrode. Wire type electrodes give the best current distribution. Therefore they are the ones best suited for difficult dusts with high electric resistivity.

## V. PERFORMANCE SPECIFICATION

The most important performance specifications to consider when selecting an ESP are the airflow rating and the minimum particle size. Airflow or volumetric flow rate is the acceptable flow rate or range of flow rates of the gas stream through the ESP, measured in cubic feet per minute (cfm). It describes the acceptable flow rate(s) that the ESP is designed to support. Minimum particle size indicates the minimum diameter of particulate matter that the ESP is capable of capturing, measured in micrometers (µm). This rating effectively defines the range of capability of the precipitator [12].

## VI. EXPERIMENTAL SETUP

### *A. Components*

*i. DC Electric Supply*
*ii. Aluminium Mesh*
*iii. Aluminium Foil*

### *B. Construction*

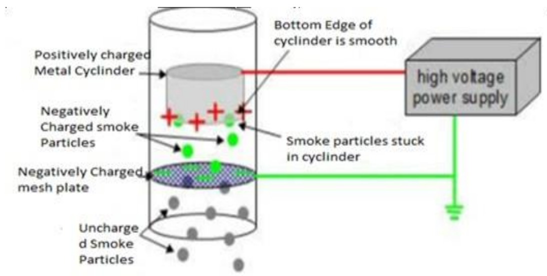



Fig.III Schematic Experimental Setup Working [6]

The model consist of the two vertical pipes of assumed length are combined together. The exhaust channel of the vehicle is connected through a long elongated elastic pipe, the model consist of the two vertical pipes of assumed length are combined together. The exhaust channel of the vehicle is connected through a long elongated elastic pipe, of which one end is connected to exhaust of vehicle and another is connected to the opening of the vertical pipe. The lower vertical pipe acts as a negatively charged terminal and the upper pipe acts as a positively charged terminal. Thus the lower vertical pipe acts as a cathode and the upper vertical pipe acts as anode. The power supply required for the experimental model is of 15KV DC supply. The inner portion of upper vertical pipe is surrounded by the aluminium foil which helps to trap the negatively charged particles of gases and allows the positively charged gaseous particles to flow. In order to trap negatively charged particles effectively ,there is aluminium plate is placed in between the two pipes which attracts most of the negatively charged particles and remaining particles are supplied further to the upper end of the pipe where aluminium foil is placed. The Pollution Control Method is used for testing the gases from the setup. The knob of the PUC is attached to exist of the pipe and the emissions are tested for identifying the amount of pollutants trapped by experimental model. Thus the results are displayed on the PUC machine screen which is being compared with the standard PUC values and the result is estimated. Instead of elastic pipe the use of blower can be effective to trap the emissions from the exhaust of vehicles.

## VII. RESULT & CALCULATIONS

Following are the parameters available from experimental setup:

- Distance= 300mm
- Plate width= 4mm
- Time= 7sec
- Voltage= 15KV
- Input Current= 230V

$$\text{Flow Velocity} = \frac{\text{Distance}}{\text{Time}} = \frac{300}{7} = 42.86 \text{ mm/s}$$

$$\text{Area} = \frac{\pi}{4} * d^2 = 4417.86 \text{mm}^2$$

$$\text{Volume} = \text{Area} * \text{length} = 4417.86*300 = 1.325*10^6 \text{mm}^3$$

$$\text{Volumetric Flow Rate} = \text{Volume} * \text{Area} = 1.325*10^6*4417.86 = 189.34*10^3 \text{mm}^3/\text{s}$$

$$\text{Electric Field Strength} = \frac{\text{Voltage}}{\text{Length}} = \frac{15*1000}{\frac{2gr}{4}} = 254.64 \text{V/mm}$$

$$\text{Specific Collection Area} = \frac{\text{Plate Area}}{\text{Gas Flow Rate}} = \frac{4417.86*10^{-6}}{186.34*60*10^{-6}} = 0.388 \text{mm}^2$$

$$\text{Efficiency} = 1 - e\,(W*Q/A)$$

$$= 1\text{-}e* \frac{4*10^{-3}*4417.86*10^{-6}}{189.34*10^{-6}}$$

$$= 89\%$$

## VIII. CONCLUSION

*A.* From the evidence shows that the ultra-fine particles can cause health effect and can penetrate the cell membranes, enter the blood and even reach in the brain. Therefore, ESP

(Electrostatic Precipitator) is one of the methods to reduce the Particulate Matter in the diesel and petrol engines.

*B.* From the experimental result it is concluded that for the petrol vehicles 36% of the exhaust pollutants can be captured with the help of the proposed model.

*C.* From the experimental result it is concluded that for the diesel vehicles 40% of the exhaust pollutants can be captured with the help of the proposed model.

The calculated theoretical efficiency of the experimental setup is 89%.

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