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Design and Fabrication of Electrostatic Precipitator for Automobiles

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1. ABSTRACT

Automobiles are a necessary evil, as they have made living easy and convenient, they have also made human life more complicated and vulnerable to both toxic emissions and an increased risk of accidents. Automobiles include cars, trucks, motorcycles, and boats (anything that burns gas). They leave oil, antifreeze, grease and metals on streets and driveways. They also emit nitrogen, hydrocarbons, and other contaminants, which settle in water. Emissions of hydrocarbons, carbon monoxide and nitrogen oxides from motor vehicles, can be seen as a major source not only of climate modification but also of adverse health and other environmental effects resulting from ground level pollution.

Here comes the Idea of our project which is Electrostatic precipitator (ESP) for automobiles. ESP is the device, which is used in industries like thermal power plant, steel plant to trap the carbon content coming from the products of combustion. Such a device can be scaled down so that it can be successfully attached to the automobiles to reduce the percentage of carbon-monoxide and hydrocarbons from exhaust of automobiles.

2. INTRODUCTION

The growing cities, increasing traffic, trajectory growth, rapid economic development, and industrialization with higher levels of energy consumption have resulted in an increase in pollution load in an urban environment. Air pollution is the major environmental risk to health and according to WHO it is estimated to cause approximately 2 million premature deaths worldwide per year. Besides health effect, air pollution also contributes to tremendous economic losses, especially in the sense of financial resources that are required for giving medical assistance to the affected people. In India, the vehicle population is growing at the rate of over 5% per annum and today the vehicle population is more than 75 million. The growth rate of vehicles is the backbone of economic development and the Indian automotive industry (the second fastest growing in the world). But there is a direct relationship between road transport system and air pollution in a city. Vehicular

emissions depend on vehicle speed, age of vehicle and emission rate.

1.1) Objective

- To reduce the percentage of carbon – monoxide and hydrocarbon count in the emission 0f theexhaust from Activa3G vehicle.
- To design the Exhaust gas recirculation system for NO_x Reduction.

1.2) Problem Statement

The increasing pollution caused by automobiles poses a significant threat to the environment, public health, and overall quality of life. The emissions released by vehicles, including carbon dioxide (CO2), nitrogen oxides (NOx), particulate matter (PM), and volatile organic compounds (VOCs), contribute to air pollution and climate change, leading to severe consequences such as global warming, respiratory diseases, and ecological imbalances.

On the other side, the solution that we have proposed is Electrostatic precipitator (ESP) for automobiles. ESP is a device, which used in industries but it cab be scaled down so that it can be successfully attached to the automobile to reduce the percentage of carbon-monoxide and hydrocarbons from automobile exhauast.

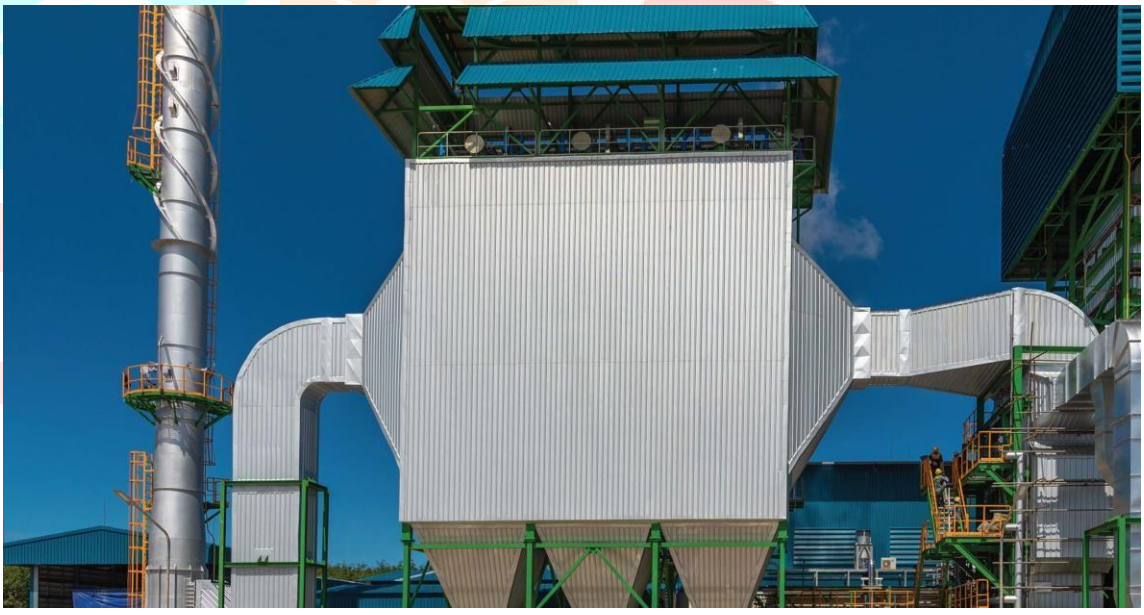


Figure 1.2.1. ESP Used in Power Plant

3. Methodology

3.1) Materials and its Specifications:

ESP (Electrostatic Precipitator) Consist of these main parts-

1. Positive plate electrode
2. Negative Electrode
3. Perforated Disc
4. Outer Casing
5. Mild steel elbow
6. Glass wool for insulation
7. Battery 6V 5Amp

8. PVC Pipe

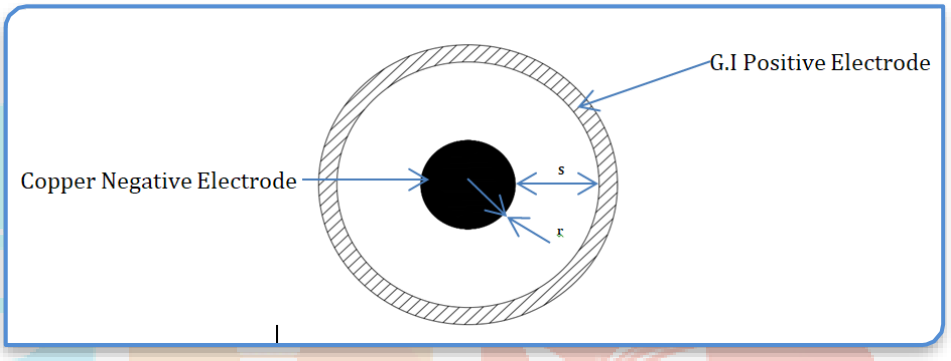
4. DESIGN CALCULATION

4.1) Theoretical Calculations for Design

Electrode Dimension Calculation:

➢ Nomenclature

- S = Spacing between Electrodes
- r = Radius of Small Electrode
- G_v = Visual critical gradient
- G_0 = Disruptive critical gradient
- d̛ = Density



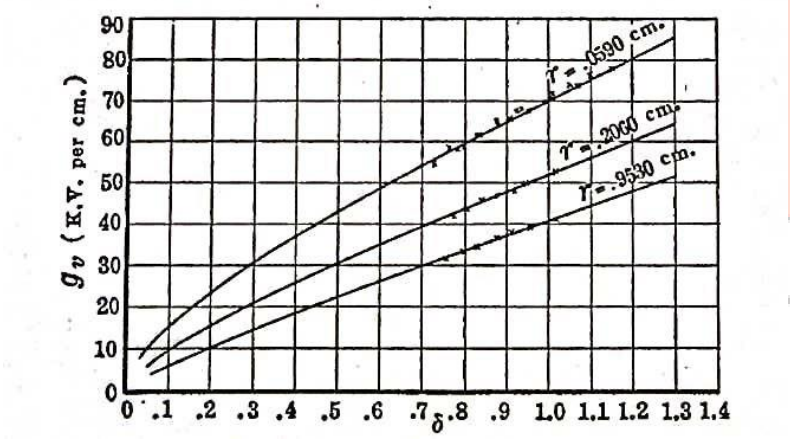


Fig. 3.2.4 Effect of Temperature on Strength of Air [4]

For Concentric Cylinders:

$$R/r < 2.718$$

R = Radius of bigger Electrode r = Radius of Smaller Electrode

We have,
Gv = Go * d̛
For,
Go = 30,
d̛= 1Therefore,
Gv = 30 kV/cm

From figure 3.2.4,

r= 0.96 cm = 96 mm

Corona effect does not form when,R/r < 2.718
R < 2.60
Therefore, R should be greater than 2.60 cm.
Thus, **Negative Electrode of 0.96cm radius.**
Positive Electrode of 3cm radius.

4.2) 3D Model Design in Fusion 360 Software

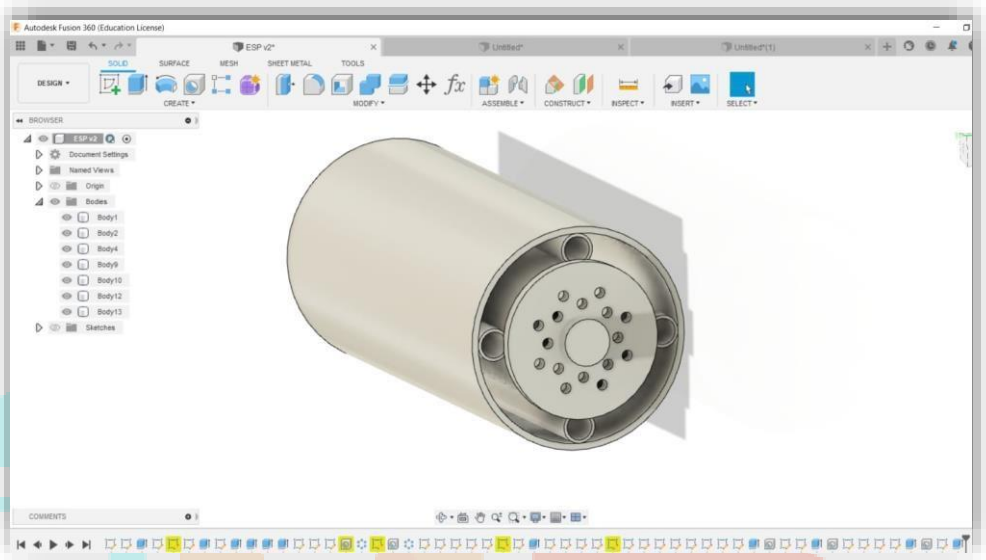


Fig.4.3.1. Cad Model of ESP

5. TESTING AND RESULTS

Testing without ESP

Testing with ESP

5.1. Final Result table using ESP on Activa3G

Operatingconditions	Carbon-Monoxide (Percentage %)	Hydrocarbon(ppm)
Idle speed (Without ESP)	1.71	351
Idle speed (With ESP)	0.87	100
Maximum speed(Without ESP)	2	380
Maximum speed(With ESP)	0.91	192

6. CONCLUSION

✓ From the conducted experiment it can be concluded that the Electrostatic precipitators which are typically used in industries like thermal power plant and steel plants operating under higher voltage can be reduced into the smaller configurations such that it can be attached to the vehicles to trap HC and CO in the exhaust of automobiles.

✓ By maintaining the voltage between two electrode 30 kV and conducting the test on Activa 3G the retrofitted ESP device will work to trap the HC and CO in exhaust gases.

✓ Carbon-monoxide can be trapped at an efficiency of 49.2 % at idle running speed and at 54.5 % at maximum speed whereas Hydrocarbon is trapped at an efficiency of 71.50 %. At idle running speed and at 49.47 % at maximum running speed.

7. FUTURE SCOPE

The Electrostatic precipitator can be extremely useful for the automobile engines to control the emission of HC and CO to reduce the pollution.

Not only for automobile engines but for remote engines, generators, three wheelers, where there is combustion of fuel and the exhaust is directly expelled out into an environment, we can use the ESP at the end of exhaust system so that the HC and COcan be trapped within it.

By attaching the suitable mechanism for removing the deposited carbon on a positive electrode we can use the device continuously.

Adding the exhaust gas recirculation system along with ESP will make the system much more efficient, as EGR system will recirculate the exhaust coming from the ESP to the engine again which will help to reduce NO_x emission.

According to 2021 report 2.5 Crores of units of active 3G are sold out in single year. Which will result in emission of 877.5 Cr PPM of hydrocarbon. Considering efficiency of our ESP device we can reduce this up to 263.25 PPM.

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