Electrostatic Precipitator

Ankit Sharma[1],Ravi Prakash Choubey[2],Akshay Gnyanamothe[3],Kumar Manju[4]
Ballari Institute of Technology and Management

Abstract- *Electrostatic precipitators have been used widely in industry, and play an important role in environmental protection. Electrostatic precipitator (ESP) can be operated with a high collection efficiency and a low pressure drop. Recently, ESP also has been used for cleaning indoor air. Performance of ESP deteriorates by abnormal phenomenon, including back corona for treating high resistivity dust, abnormal re-entrainment for low resistivity dust, and corona quenching for fine dusts. To cope with these phenomena, new technologies have been developed. Pulsed energization is a technique to cope with high resistivity dusts, and this results in lower power consumption. Using pulsed energization, non-thermal plasma can be generated and chemical reactions can be promoted for treating gaseous pollutants such as NO and volatile organic compounds. Wet ESP can also remove dusts and gaseous pollutants simultaneously. These new advancements will widen the field of application of electrostatic precipitation.*

I. INTRODUCTION

Many industrial, power generation and chemical processes produce unwanted fine particulate material as a consequence of their operation. Electrostatic precipitation (ESP) is a highly efficient method of removing entrained particulate contaminants from exhaust gases and is extensively used in these industries to limit particulate emissions. Electrostatic precipitator (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. ESP can be operated with a high collection efficiency and a low pressure drop. The collection efficiency is usually >99%. Micrometer particles also can be collected effectively. The pressure drop is normally less than 1000 Pa. This is an important advantage of ESP, resulting in low operation cost.

II. OBJECTIVES:

- To design and develop an electrostatic precipitator.
- To reduce the concentration of the suspended particles in the exhaust of combustion engine.
- To increase the voltage using a transformer.
- To control global warming and other environmental hazards.
- To provide simple design and portable machine.

III. LITERATURE SURVEY:

- B. Sung, A. Aly, S. Lee, K. Takashima, S. Kastura, A. Mizuno,

It is known that fine particles suspended in the atmosphere can cause serious health hazards because of heavy metals and toxic compounds adsorbed on their surfaces and their high probability of deposition in deeper parts of the respiratory tract. As a result, it is highly important to control and remove the fine particles from the air to improve the air quality. Many Electrostatic Precipitators are utilized to collect fine particles. However, these precipitators collect fine particles in the range 0.1 – 1 µm with relatively low efficiency (~ 85%) compared to HEPA (High Efficiency Particulate air) filters, which collect 99.9%. On the other hand, HEPA filters are expensive and a large amount of power is needed to force air through them. There is, therefore, a motivation to improve the collection efficiency of electrostatic precipitators.

- Niewulis, J. Podlinski, M. Kocik, R. Barbucha, J. Mizeraczyk, A. Mizuno

Another technique used to improve the collection efficiency was also introduced. This technique involved the use of flocking plane electrodes as the collecting electrodes instead of smooth-plates, and the efficiency can increased from 80% to 94%. These flocking plane electrodes were made by depositing dielectric nylon fibers on a metal wire mesh. A three-dimensional (3D) Particle Image Velocity (PIV) was used to measure the electrohydrodynamic flow in the narrow electrostatic precipitator. It was suggested that laminar flow can increase the particle collection. Therefore, slowing the air inflow velocity can improve the fine particle collection efficiency.

- J. Dunn, X. Jia, J. McLaughlin

The GEP contains a blower which drives air from the bottom to the inlet of the GEP. An Accutrac sensor is used to test the air inflow velocity at the inlet, and connects to the computer to illustrate the velocity chart. A pre-charge section pre ionize the particles to facilitate the agglomeration of particles before they enter the main section of the GEP. The pre-charged air is recharged by the saw blades when it enters the lower part of the GEP, which contains two grounded grid electrostatic plates for particles deposition. Then, the charged particles pass through the upper grid electrodes, with one charged grid plate and one grounded plate, and the particles migrate to the collection electrodes.

- B. Liu, F. Romay, W. Dick, K. Woo, M. Chiruta

A Wide-range Particle Spectrometer was used in the lab to measure the total particles counts in the size range of 0.01µm to 10 µm. This advanced instrument contains three parts: laser light scattering (LLS), differential mobility analysis (DMA) and condensation particle counting (CPC). The LLS senses individual particles by light scattering and measures the scattered light amplitude to determine particle size. The DMA classifies the aerosol particles by electrical mobility while the CPC counts the classified particles. This design of combination of multiple instruments is beneficial in obtaining accurate measurements over a broad range of particles sizes and ensuring that all flow rates are controlled.

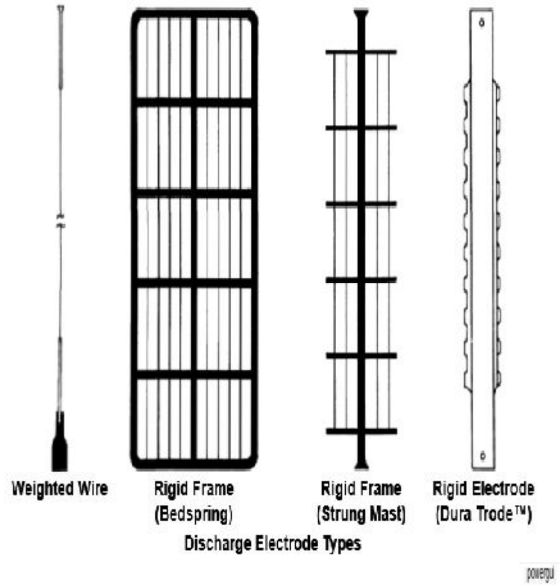
- Ozone Water Treatment – UV Ozone Destruct Website

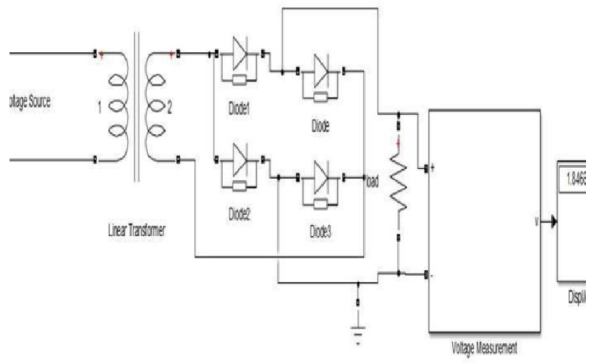
The efficiency of catalytic methods at removing ozone created by the corona discharge will also be evaluated in the experiments. One of the methods is to use UV light with 254nm wave length to destroy the ozone molecules. As a result, each ozone molecule is converted into one oxygen atom and one oxygen molecule. Free oxygen atoms will combine with each other to form oxygen molecules.

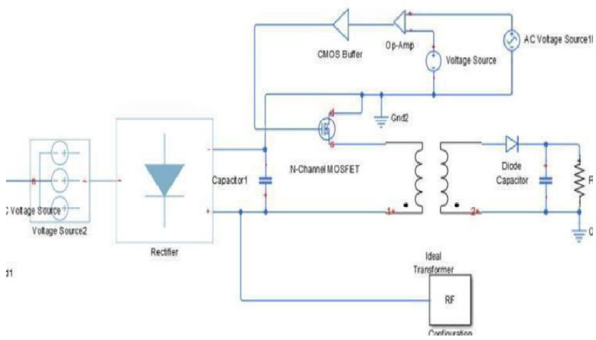
IV. METHODOLOGY:

Design of ESP was done taking into consideration the tubular ionizing and collecting cartridge adapted from the working and design features of Diesel particulate filter and Catalytic convertor ceramic monolith packing efficiency. In this design the ionizing is done by multiple perforated (3mm holes) conducting tube of diameter 8mm enclosed in conducting stainless steel tube with phase perforation of 8mm holes to hold the tubes. Collection of emission particle is done by aluminium perforated tube cluster of the same dimensions as that of the ionizing cartridge. Casing is design to accommodate both the ionizing and the collecting cartridge is within the safe limits of spark
jumping between the same.

V. COMPONENTS:







VI. ADVANTAGES:

Energy requirements and operating costs tend to be low.

- They are capable of very high efficiencies, even for very small particles.
- They can be designed for a wide range of gas temperatures, and can handle high temperatures, up to 700°C (1300°F).
- Dry collection and disposal allows for easier handling.
- Operating costs are relatively low.
- ESPs are capable of operating under high pressure or vacuum conditions
- Relatively large gas flow rates can be effectively handled.

VII. DISADVANTAGES:

- ESPs generally have high capital costs
- Certain particulates are difficult to collect due to extremely high or low resistivity characteristics.
- There can be an explosion hazard when treating combustible gases and/or collecting combustible particulates.
- Relatively sophisticated maintenance personnel are required, as well as special precautions to safeguard personnel from the high voltage.
- Dry ESPs are not recommended for removing sticky or moist particles.
- Ozone is produced by the negatively charged electrode during gas ionization.

VIII. APPLICATIONS:

- It is used in coal fired power station
- It is used to purify the exhaust smoke
- It is used to remove particulate matter from combustion gasses
- It is used in glass furnace and electric arc furnace
- It is used in solid waste incinerators
- It is used in ash handling unit in steam thermal power stations.

IX. POSSIBLE OUTCOMES:

- The concentration of suspended particles is reduced
- They can be designed for a wide range of gas temperatures, and can handle high temperatures
- It is used to remove particulate matter from combustion gasses
- Environmental hazards are reduced

X.WORK DONE TILL NOW:

- We have made the precipitator and the frame as shown in the picture
- The power supply connection is yet to be given
- We have to install the transformer to increase the voltage

REFERENCES

[1] B. Sung, A. Aly, S. Lee, K. Takashima, S. Kastura, A. Mizuno, Fine-Particle Collection Using an Electrostatic Precipitator Equipped With an Electrostatic Flocking Filter as the Collecting Electrode, in Plasma Process and Polymers. (2006) 661-667

[2] A.Niewulis, J. Podlinski, M. Kocik, R. Barbucha, J. Mizeraczyk, A. Mizuno, EHD Flow Measured by 3D PIV in a Narrow Electrostatic Precipitator With Longitudinal-to-flow Wire Electrode and Smooth or Flocking Grounded Plane Electrode, in ELSEVIER Journal of Electrostatics, (2007) 728-734

[3] J. Dunn, X. Jia, J. McLaughlin, Development and Commercilization of a Grid Electrostatic Precipitator, in Center For Advanced Materials Processing Newsletter, (2010)

[4] B. Liu, F. Romay, W. Dick, K. Woo, M. Chiruta, A Wide-Range Particle Spectrometer for Aerosol Measurement from 0.010µm to 10 µm, in Aerosol and Air Quality Research, (2010) 125-139

[5] Ozone Water Treatment – UV Ozone Destruct Website