**IOSR Journal of Engineering (IOSR JEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 20-23

# Electrostatic Precipitator Using Van de Graaff Generator

Kavan Raval[1], Ashwini Khedekar[2], Rushikesh Shinde[3], Saurabh Warekar[4], Prof. Priyanka Sharma[5]

[1]*(Department of Electrical Engineering, Atharva College of Engineering, Mumbai University, India)*
[2]*(Department of Electrical Engineering, Atharva College of Engineering, Mumbai University, India)*
[3]*(Department of Electrical Engineering, Atharva College of Engineering, Mumbai University, India)*
[4]*(Department of Electrical Engineering, Atharva College of Engineering, Mumbai University, India)*
[5]*(Department of Electrical Engineering, Atharva College of Engineering, Mumbai University, India)*

***Abstract :*** *The particulate matter created in the manufacturing process by the industrial plants is released as dust in the hot exhaust gases. If such matter is released into the atmosphere, the particulates reduce visibility and it contributes to climate change as well as serious health problems in humans. Fine particles that are smaller than 2.5 microns in diameter can be especially dangerous because they are drawn deep into the lungs and can trigger inflammatory reactions. The aim of the paper is to present an electrostatic precipitator which uses an electric charge that is provided by a Van de Graaff generator. The pumped charge from the generator will remove such impurities from air or other gases in smokestacks and other flues.*

***Keywords:*** *Electrostatics, Electrostatic Precipitator, Triboelectric Effect, Van de Graaff generator.*

## I. Introduction

The electric charge is used in electrostatic precipitator to remove certain impurities that are either solid particles or liquid droplets from air or other gases in smokestacks and other flues. During its early stage it was operated for recovery of processed materials, where such units were used to remove sulfuric acid mist and lead oxide fumes emitted from acid-making and smelting activities. Nowadays it's used for controlling release of particulate matter from waste gases at industrial facilities and power generating station. For the proposed working model of an electrostatic precipitator, the working charge is provided by Van de Graaff generator which is an Electrostatic device that pumps charges.

.

## II. Types of Electrostatic Precipitators

### 2.1. Dry Electrostatic Precipitator

This type of precipitator collects pollutants from a stream of gas that is in dry state. The precipitator operates by initially ionizing the entered particle, so it becomes electrically charged. The ionized particle is then made to flow through oppositely charged electrodes where the particles are collected by the electrodes. Such particulate matter is later removed from such electrodes.

### 2.2. Wet Electrostatic Precipitator

This type of precipitator collects particles from the stream that is not dry in state which includes paint, oil, tar, acid. The operation is similar to Dry Electrostatic precipitator wherein the particulates are first ionized and later collected at electrode of opposite polarity. The particles collected from sludge are treated separately.

## III. Working and System Implementation

### 3.1. Van de Graaff generator's working

A Van de Graaff generator is made of a belt whose material is selected according to the triboelectric table, is made to run over two rollers of material as per triboelectric table. Upper roller is surrounded by a hollow metal sphere. Electrodes, in the form of brush of sharp metal points, used to carry charge are placed at bottom of the lower roller and inside the sphere, over the upper roller. Upper Comb is connected to the sphere and lower comb to the ground. The charging takes place according to triboelectric effect, wherein simple contact of dissimilar materials causes the transfer of some electrons from one material to the other. The upper roller of the belt will become positively charged while the bottom roller will become negative charged. The upper roller is positively charged due to the selection of roller's material and belt carries positive ions. The strong electric field surrounding the positive upper roller induces a very high electric field near the points of the comb. The strong field ionizes air molecules which attracts the electrons to the outside of the belt while positive ions go to the comb. The positive ions are then neutralized by electrons present on comb leaving the comb and the outer shell with fewer net electrons. The excess positive charge inside the dome is accumulated on the outer surface of

the outer shell by Faraday's ice pail experiment, leaving no field inside the shell. The process keeps building up very large amounts of charge on the shell till the contact and its removal is maintained for flow of charge.

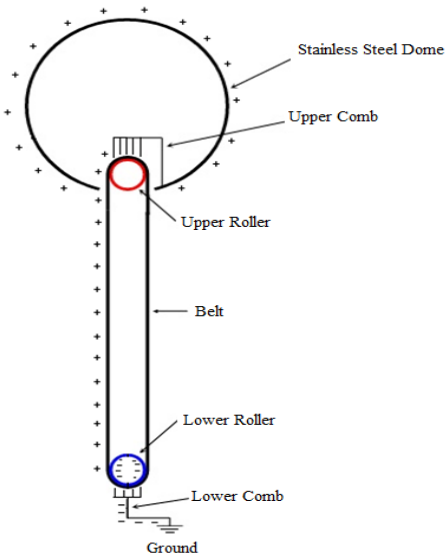


**Figure 1:** Flow of positive charge on the Dome

### 3.1.1. Triboelectric Effect

The triboelectric effect is a method of making and removing the contact, leading to the materials getting electrically charged after they are separated. There is increase in contact between two materials when they are rubbed, producing tribo-electricity and thus the triboelectric effect. Static electricity that is produced almost every day is an example of such triboelectric effect. Different material with different characteristic of matter collects charge of different polarity. The charge induced on the material depends upon the factors like the material's surface roughness, temperature, strain, and other properties. Following table shows the materials that are placed in order of acquiring a positive charge from top to bottom due to make and break contact.

**Table no 1**: Triboelectric series

| | |
|---|---|
| POSITIVE CHARGE (+) | Asbestos |
| | Glass |
| | Mica |
| | Nylon |
| | Wool |
| | Lead |
| | Silk |
| | Aluminum |
| NEUTRAL | Paper |
| | Cotton |
| | Steel |
| | Wood |
| | Amber |
| NEGATIVE CHARGE (-) | Hard Rubber |
| | Nickel |
| | Copper |
| | Brass |
| | Polyester |
| | Polyvinylchloride |
| | Silicon |
| | Teflon |

### 3.2. Electrostatic Precipitator's working

The electrostatic precipitator has two sets of electrodes, one is positive and another is negative. The negative electrodes at the inlets can be wire mesh or of rod structure. Positive electrodes are in the form of plates. At the inlet, negative electrode is placed followed by a positive electrode. The distance between electrodes depends upon its collection efficiency.

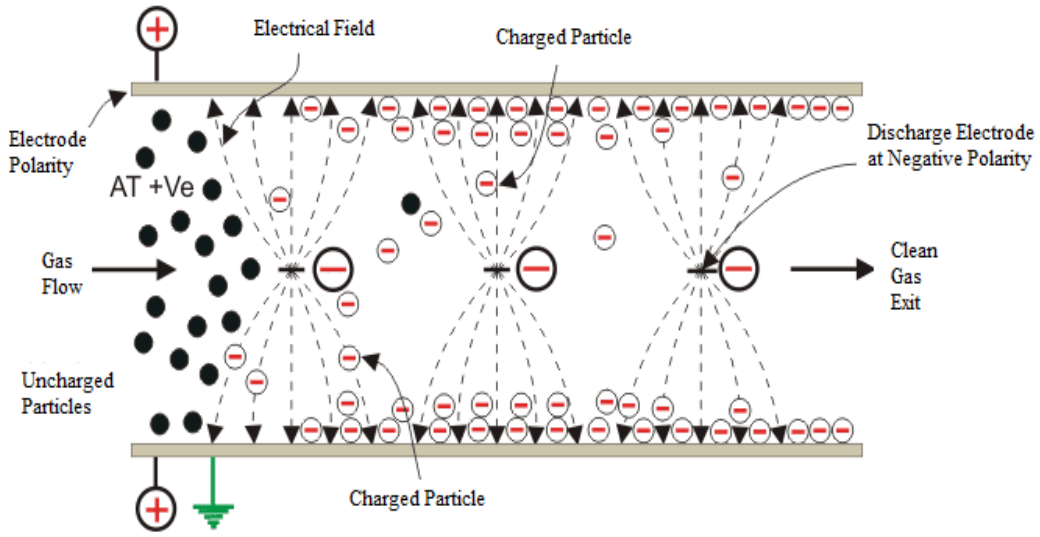


**Figure 2:** Flow of particles in Electrostatic Precipitator

The positive and negative electrode is charged by the High Voltage DC source with respective terminals for each polarity of an electrode. The electrodes are adjusted such that due to DC voltage applied across electrode leads to voltage gradient between them which are enough to ionize the medium passing through. The precipitator is enclosed by a specific material as it's exposed to flue gas as well as charge on electrodes. This enclosure is provided with an inlet for medium to enter and an outlet for collection of processed medium. Through the inlet, medium enters in the precipitator, collision takes place between medium and free electron which leads to free electron attached to the medium. This leads to inlet medium with negative charged. The positive charge on plates attracts such negative medium. Subsequently the medium gets deposited on positive plates. The processed medium after travelling through the electrostatic precipitator is free from particulates and the discharged medium is treated accordingly.

## IV. Conclusion

Conventional electrostatic precipitator uses a High Voltage DC source to charge the electrodes of the precipitator which makes addition in expenses to industry in which it is installed. In addition, the space required for such setup is larger. The value proposition for small-scale industries gets reduced as they prove costly as well as a lot of space is required to set up. The paper proposes in using a Van de Graaff generator for supplying the charge as to reduce the initial cost. Also the charge produced by Van de Graaff generator can be stored using high voltage capacitors.

## Acknowledgment

Authors please to acknowledge Atharva College of Engineering, Mumbai for every support to write the paper. Authors also acknowledge other contributors for their contribution in preparing such paper.

## References

[1]. Aditya Pathak and et.al, "Van De graaff Generator for High Voltage DC Source and it's Applications" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 6, Issue 3, March 2017
[2]. P.G.Mahajan et.al, " Basic Operation & Applications of Van de Graaff Generator" International Journal of Scientific Research and Education, Vol.5, Issue 5, May 2017
[3]. Toshiaki Yamamoto et.al, " Electro -hydro dynamically Assisted Electrostatic Precipitator for the Collection of Low-Resistivity Dust" IEEE Transaction on Industry Applications, Vol. 45, Issue 6, Nov.-Dec. 2009
[4]. F.A. Furfari, "A history of the Van de Graaff generator" IEEE Industry Applications Magazine, Vol.11, Issue 1, Jan.-Feb. 2005
[5]. Hossein Rezaei et.al, "Effect of relative humidity and materials on triboelectric charging of USB cables" IEEE International Symposium on Electromagnetic Compatibility & Signal/Power Integrity (EMCSI), Oct. 2017

[6]. M. W. Williams, " Triboelectric Charging of Insulators - Evidence for Electrons versus Ions" 2010 , IEEE Industry Applications Society Annual Meeting, Oct.2010
[7]. M. S. Naidu and V. Kamaraju, High Voltage Engineering, Tata McGraw-Hill, 2004
[8]. J.H. Cloete and J. van der Merwe, "The breakdown electric field between two conductiong spheres by the method of images," IEEE Transactions on Education, Vol 41,no.2, pp.141-145,1998