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# Hybrid Aerosol Filtration Systems – A Review

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***Abstract-*** *Industrial air pollution is a severe problem which has been affecting science and technology throughout the world. Various countermeasures have been taken worldwide to efficiently control the particulate matters emitted from different industries, especially submicron particles like* $PM_1$, $PM_{2.5}$ *which are more health hazardous with minimum power consumption. One of the most emerging methods to control emission efficiently with minimum power consumption is Hybrid Filtration system i.e. Pulse Jet Filtration system assisted with a static charge. This paper reviews the detail of various case studies done on hybrid filtration systems worldwide and showcasing its advantage by improved particulate collection efficiency and lower energy consumption.*

***Keywords***: ***Pulse-jet filtration system, Electrostatic Precipitator, Pre-charger, Fabric Filter, Hybrid Filter, Differential Pressure Drop.***

## 1. Introduction

Industrial pollution has a wide range of serious consequences. Industries liberate a different variety of pollutants into the atmosphere polluting both air and water; hence they are the main reason for giving off toxic matters hazardous to human health (Mukhopadhyay A.2009, Mukhopadhyay A.2010). Survey has proved that industries are responsible for 50% of the overall pollution affecting the ecosystem (Ray T.K., 2004). To control industrial pollution and its harmful effect one of the most effective technique used by various industries during present day is pulse jet filtration using fabric filter media, which has the advantage of achieving very high particulate collection efficiency up to 99.99% especially collection of extremely fine particles such as $PM_{2.5}$ i.e. aerosol particle size smaller than 2.5 micron (Mukhopadhyay A.2009, Mukhopadhyay A.2010). Another technology frequently used by various industries for capturing particles is Electrostatic Precipitator (ESP), which works on the concept of particle charging by ionic current (Neundorfer- Electrostatic Precipitator Operation, H.J. White. 1963)**,** it is capable of handling large volume of gas with an extensive variety of inlet temperatures, pressures, dust volumes, and gas conditions (Neundorfer- Electrostatic Precipitator Operation and Jaworek. A et al 2007). ESP can collect a wide range of particle sizes in both dry and wet states, the collection efficiency for ESP can go up to 99%., particle size larger than 3µm diameter are efficiently removed but fractional efficiency is minimum between the range 0.1 to 1 µm(A. Mizuno, 2000), generally less than 90% (A. Mizuno, 2000 and J. Hautanen et al, 1986). The Overall collection efficiency of ESP can be determined by following equation (H.J. White.1963 and J.C. Mycock et al 1995)

$$\eta = 1 - e^{-v \quad /V} \qquad (1)$$

Where VM the migration velocity of the aerosol flowing across the precipitator channel, A is the cross-sectional area of the channel, V is the flow rate of the gas. Alongside advantages, both Pulse Jet Filtration system and Electrostatic precipitator have distinct disadvantages that are undesirable from the economic point of view in industries. Pulse Jet Filtration gives higher pressure drop which requires high power consumption and also maintenance cost of filter media is very high, the media requires to be replaced after a certain interval which finally effects the marginal profit of industries (Tomitatsu. K.et al,2014). In Electrostatic Precipitator the collection rate is effected by aerosol composition and the equipment size is very large thus requires thus a lot of space is required (Ueda .Y et al 2014 and Neundorfer- Electrostatic Precipitator Operation) ,to counter these problems some of the countries have tried the concept of hybrid filtration i.e. E.S.P. followed by Pulse Jet Bag house or Pulse Jet System assisted with pre-charger, both the systems gave high collection efficiency at low-pressure drop (Tomitatsu. K.et al,2014, Jaworek. A and Krupa. A.2007, Li.H, Wang.Z and Ye.Y.2016, Robert. F and Kenneth. M. 2003) .

Industrial baghouses have the ability to withstand extremely high-dust densities level (i.e. more than 250 g/Nm$^3$), the differential pressure drop across the filter media increases progressively with time, thus the filter bags must be periodically cleaned, generally by pulse-jet cleaning action. Pulse Jet operation includes Injection of high-pressure back-pulse air between 3 to 7bar into the filter bags for a very short time intensity (50–150 ms), this injection of back-pulse air causes an instant expansion of bag filter which drives away the accumulated particles from the surface of filter media to dusty air stream and settle into the dust hopper. The bags are cleaned online i.e. during cleaning of a row of bags the dust-laden gas flows through other rows of bags since the back pulse is of very short duration the air filtration process is maintained continuously (Mukhopadhyay A,2009).

## 2. Pressure Drop behavior of filter media during Pulse Jet Filtration:-

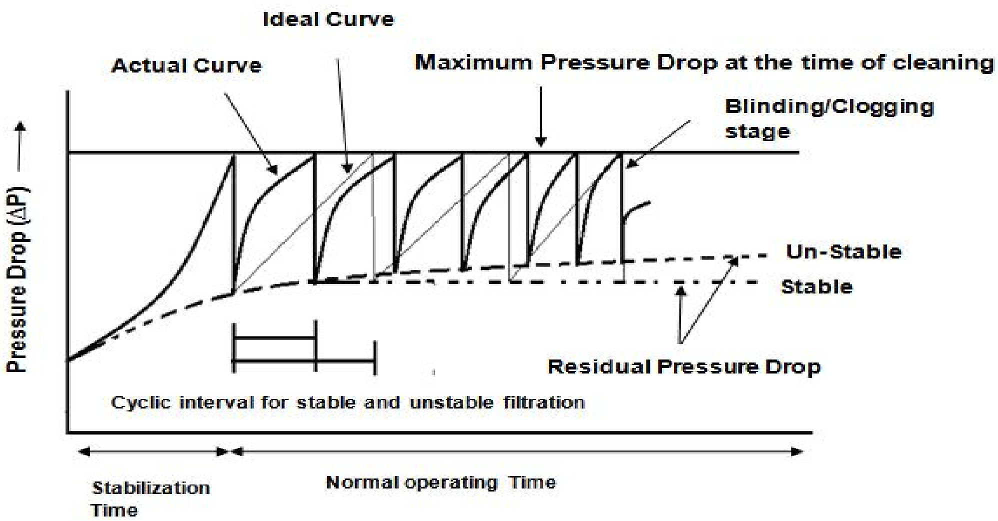


Fig. 1. Pressure behavior of filter media with respect to filtration time (Mukhopadhyay A,2009)

For any industry practicing pulse jet filtration system to cleaning aerosols, the high differential pressure drop is undesirable as it would lead to very high power consumption and large fan will be required to exhaust the gas. For ideal case during filtration the cyclic interval between the pulses should be stable throughout the process and also the residual pressure drop must be as minimum as possible all through the process, but ideal case is practically unachievable because filter media is subjected to wear and tear during successive pulsing actions and also the after every pulsing re-deposition and seepage of particles occur in the media which lowers the cyclic interval time (Mukhopadhyay A.2009). The actual trend for any filtration process is during the initial stages the cyclic interval between two pulses is very high and subsequently as the process continues the interval time keeps on decreasing and finally a stage comes where clogging or blinding occurs and residual pressure drop nears maximum pressure, this blinding or clogging indicates that the bag filter is clogged needs to be replaced. The main reason for clogging is pores of filter media getting blocked after successive pulsing as more particles seep inside the media and particles getting trapped within; hence depth filtration gets dominant due to which media gets blinded making it no longer usable. In order to prolong bag life, the maximum pressure drop must be achieved as stable as possible which will reduce the residual pressure drop (Mukhopadhyay A.2009, Schuberth.J et. al.2010 ).

## 3. Principle operation of ESP

Electrostatic precipitators (ESPs) are one of the frequently used particulate collection devices at the commercial level these days. It is capable of handling huge gas volume levels with extensive ranges of pressure, dust volumes, and temperatures. The collection efficiency can go up to 99%. ESP work on the principle of electrostatic attraction where mainly six activities take place viz. 1.Ionization, 2.Migration, 3.Collection, 4.Charge Dissipation, 5.Particle Dislodging, 6.Particle Removal. During ionization the particles get charged by high voltage, once the particles get charged they travel towards migration plate, as they reach close to the collection plate the particles start precipitating on the surface of the plate, after precipitation the charge slowly neutralizes on the collection surface. Once a particular thickness (1-2 inch) of dust accumulates on the surface of collection plate they are dislodged by hammering mechanism, finally, the dislodged dust is collected by the hopper and disposed of (Neundorfer- Electrostatic Precipitator Operation, Jaworek. A and Krupa. A,2007).

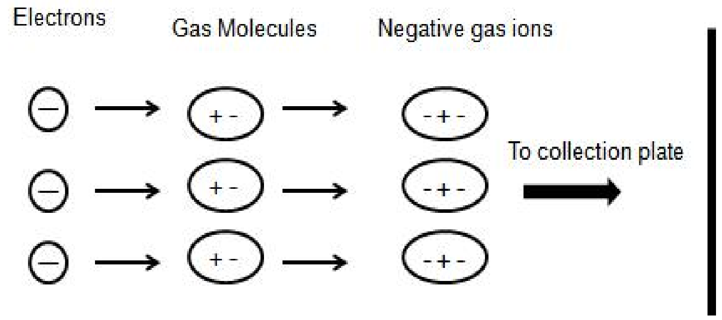


Fig. 2. Gas ionization, (Neundorfer- Electrostatic Precipitator Operation)

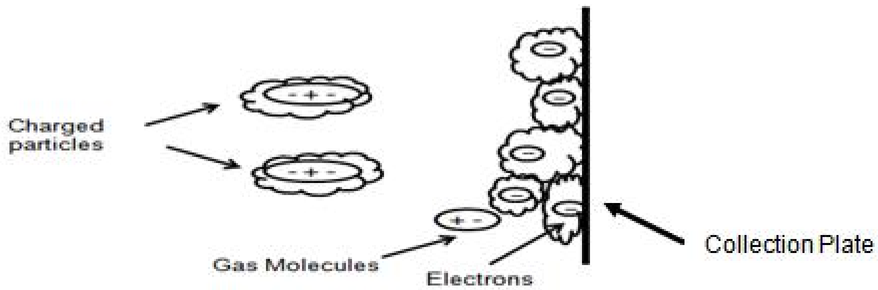


Fig. 3. Collection and removal of particles at collection plate (Neundorfer- Electrostatic Precipitator Operation)

## 4. Corona Discharge

High negative DC Voltage is applied to discharge electrode creating high-velocity electron discharge termed as corona (fig. 4). In the portion of corona nearest the electrode, the impact of high-velocity electrons with gas molecules produces positive gas ions and additional high-velocity electron chargers. The positive gas ions attach to small no. of particles near the electrode charging them positively. The positively charged particles deposit on negative discharge electrodes.

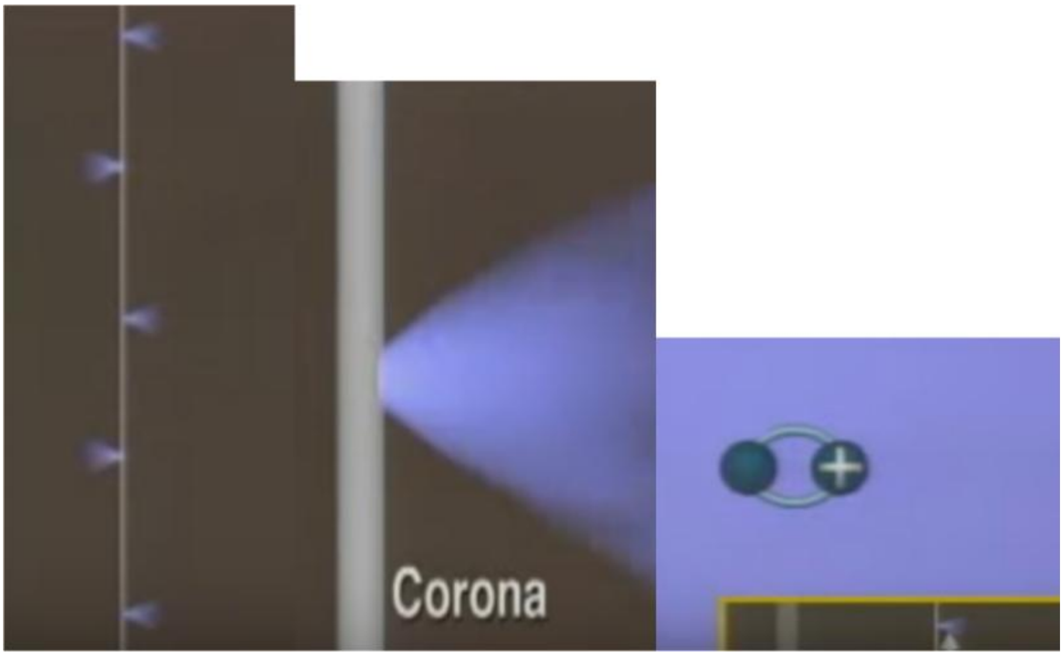


Fig. 4. Mechanism of Corona Discharge

## 5. Different types of ESP

One of the major concerns of industries using ESP is to overcome the problem of the back corona. Back corona is initiated when dust of higher resistivity forms a tight barrier on the electrodes, as the accumulated charge could not lead to the surface of the electrode, which results in increase in potential difference across the dust layer causing dust breakdown creating positive ions which collide with negatively charged particles thus decreasing their charge, these particles cannot be removed by precipitator and are exhausted into the atmosphere, thus in order to overcome this problem various designs of ESP have been practiced by industries. One the most frequently used design of ESP in the industry is set of sharp discharge electrodes placed between parallel collection plates (fig 5).Another type of design which is practiced is tubular shaped ESP in which a thin wire is stretched along the axis of the cylinder (fig 6).

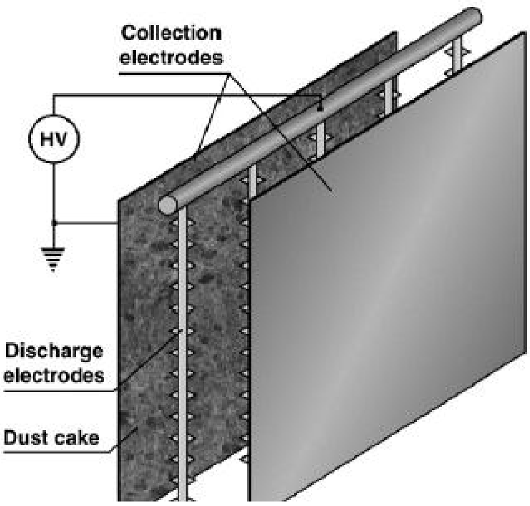


Fig.5 Parallel-plate ESP (Jaworek. A and Krupa. A,2006)

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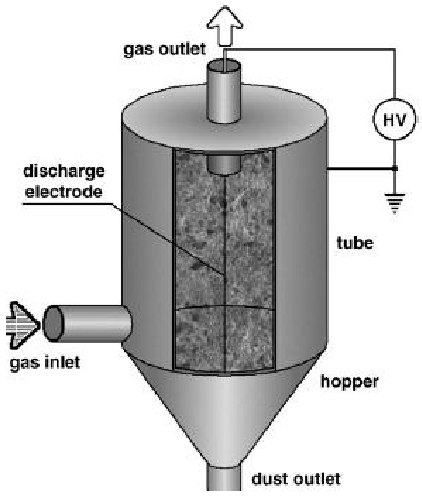


Fig.6 Tubular ESP (Jaworek. A and Krupa. A,2006)

The electrical discharge is maintained at a high negative potential in these types of electrodes, gaseous ions are produced by attachment of free electrons to gas molecules. Particles are charged by colliding with gaseous molecules. The rate of particle charging is given by the following differential equation:

$$\frac{d}{d} = 3\pi n E \mu r^{2} \frac{€_r}{€_r + 2}\left(1 - \frac{Q}{12\pi€\ r^{2}E}\frac{€_r + 2}{€_r}\right)^{2} + \pi n r^{2} v \qquad (2)$$

n= Space charge density in charging zone
μ= ion mobility
r= aerosol radius
v= mean velocity of the gaseous ion.

There are two main mechanisms through which particles are charged by ionic current :

1. Field charging, in which ions are driven to the particle by the electrostatic forces caused by an external electric field. A repulsive force imparted on the charge balances these electrostatic forces.

2. Diffusion charging occurring due to the kinetic energy of gaseous ions that bombard the particle independently of the electric field.

For particle size larger than 1 mm, field charging is the dominant mechanism and ion diffusion is responsible for particle charging where for particles are smaller than 0.1 mm

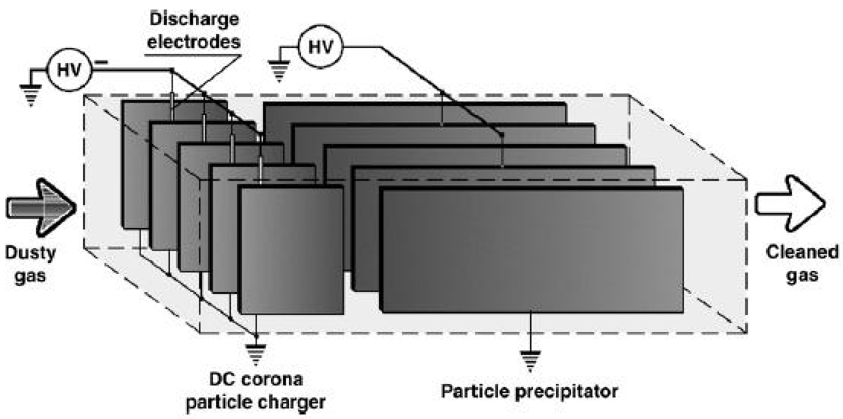


Fig.7 Two-stage electrostatic precipitator with dc corona discharge pre-charger (Jaworek. A and Krupa. A,2006)

To avoid difficulties with an aerosol of high resistivity, another design which has become popular is two-stage ESP (fig.7) in which the charging and collection processes have been separated and accomplished in two different stages. The charging stage is similar to conventional ESPs and the collection stage is formed by a set of parallel plates with every second plate being maintained at high potential and the remaining plates are grounded. The charging section was developed with boxer charger (fig.8). It is an energization system in which monopole ions (either positive or negative), with plasma generated source creating creeping discharge on the respective surface of two electrode groups, are discharged alternately (left and right) to the aerosol particles, using the alternate electrical field. The system is different from the direct current system, boxer charger discharges always only negative (or only positive) ions come and go alternately in the space, electric charge is provided from both sides of the electrodes just like two boxers are confronting each other, enabling the particles to be charged effectively.

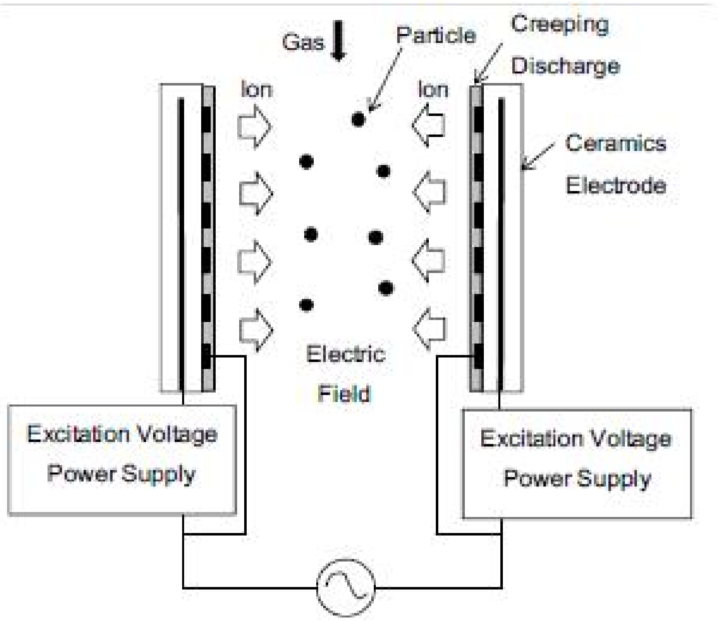


Fig.8 Boxer Charger (Tomitatsu. K.et al,2014)

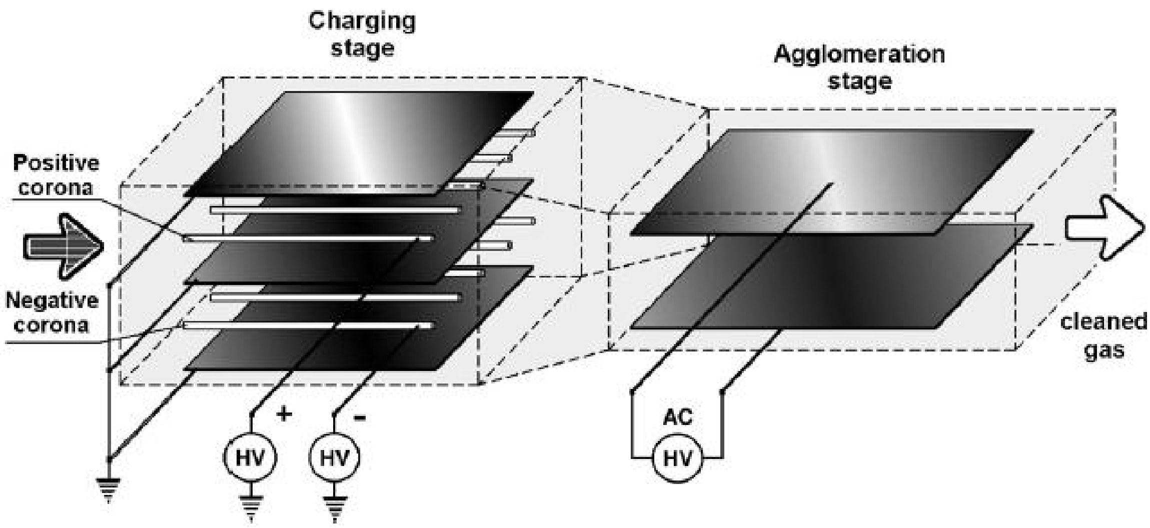


Fig.9 Electrostatic precipitator with agglomeration section (Jaworek. A and Krupa. A,2006)

ESP with agglomeration section is another type of design (Fig.9) which is practiced by various industries, during the first section, the particles are charged to opposite polarities, and in the second, they are subjected to the alternating electric field, which causes the particles to collide called agglomeration. Agglomeration is a process in which small particles come together to adhere a larger one, as sub-micrometer particles are most difficult to capture the agglomerators are basically proposed to coagulate sub-micrometer particles to form larger one in order to achieve higher energy efficiency. Aerosol particles smaller than 1 mm are generally difficult to agglomerate, by charging them to opposite polarities (positive and negative corona) the coagulation can be accomplished more conveniently.

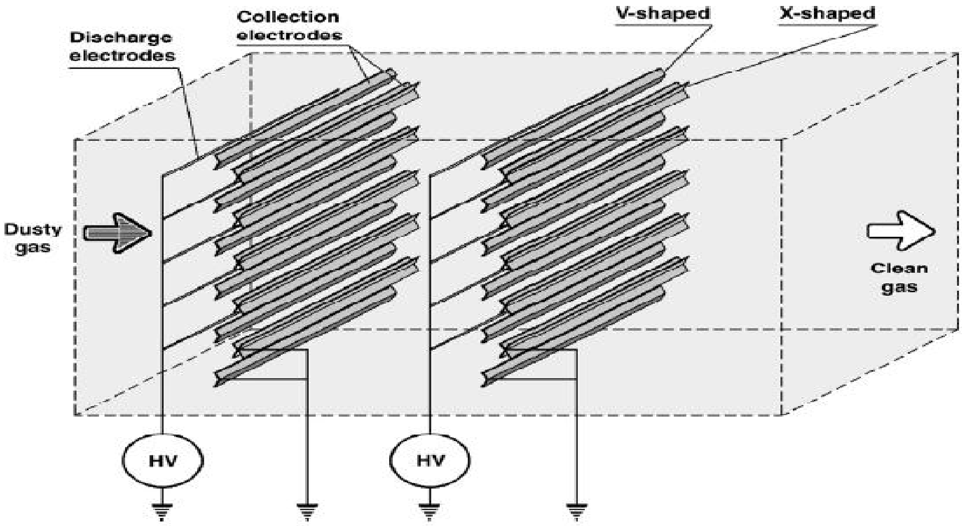


Fig. 10 Co-flow electrostatic precipitator with V- and X-shaped collection electrodes (Jaworek. A and Krupa. A,2006)

In V and X shaped ESP (fig. 10) the electrodes are arranged in an alternating pattern and positioned traverse to aerosol flow, this arrangement is done to overcome back corona. Back-corona is avoided as the ions and electrons flow along the field lines to the edges of the electrodes, while dust particles having lower mobility, are driven by inertial force to the inner surface of the electrodes.

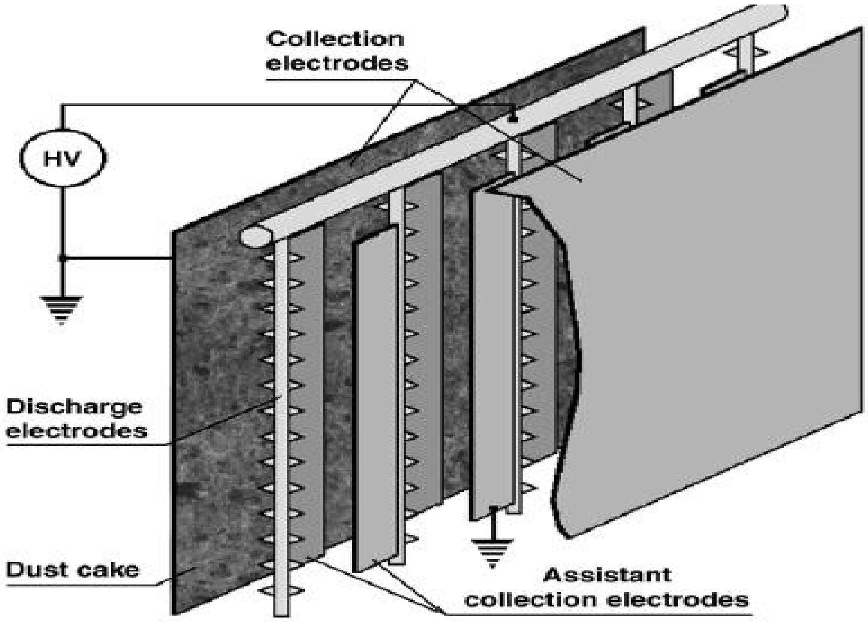


Fig.11 Electrostatic precipitator with assistant collecting plates (Jaworek. A and Krupa. A,2006)

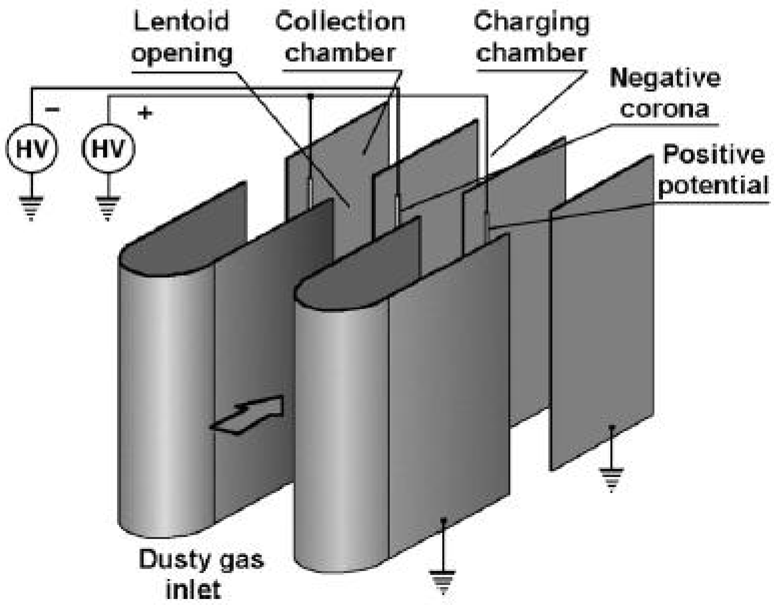


Fig.12 Lentoid type electrostatic precipitator (Jaworek. A and Krupa. A,2006)

In lentoid type electrostatic precipitator (fig.12) the collection electrodes have longitudinal slots facing the discharge electrode, the slot operates like a lens which focuses negative ion trajectories onto positive electrode in the hollow chamber, the particles are not re-entrained and remain in the hollow chamber where there is no gas flow, the particles get agglomerated due to Coulomb force and turbulent motion, and precipitate on the positive electrode.

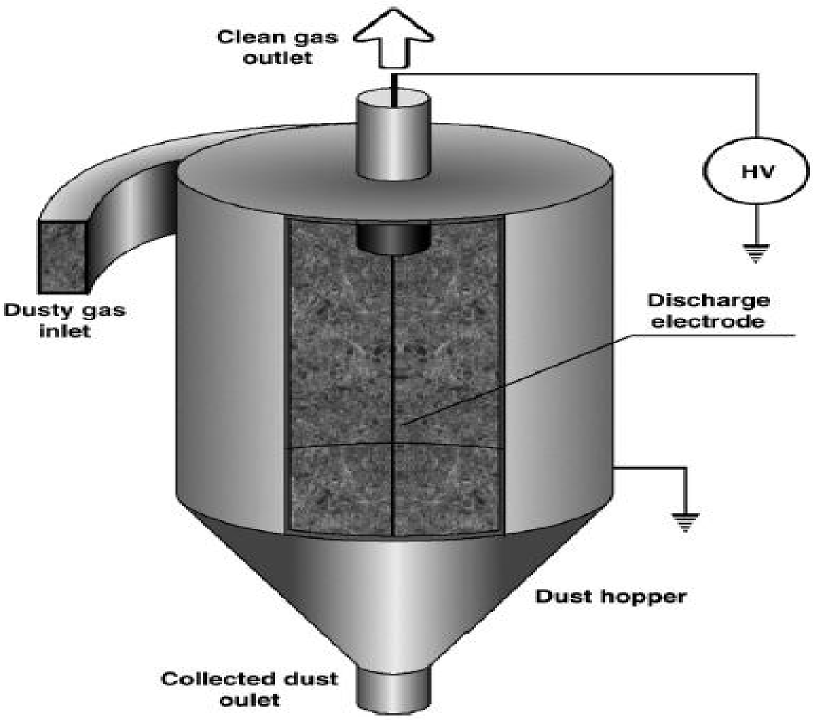


Fig.13 Electrically energized cyclone (electro-cyclone) (Jaworek. A and Krupa. A,2006)

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Many industries use electrically energized cyclone (fig.13) which utilizes centrifugal acceleration of dust particles to precipitate them on the walls of the chamber. The acceleration level ranges from 5 g to 2500 g for small cyclones, for fine particles the centrifugal is kept lower than the drag force to achieve higher collection efficiency. Primary particles of the size range 10–30nm can form aggregates of a few microns in diameter and dendrites on the walls ( Peukert.W,2001).The diameter of electro-cyclones is usually limited to about 1.8 m, and the dust loading is limited to 4.5 g/m$^3$ because of corona quenching at larger dimensions and loading (Henry.R.F. et.al, 1985).

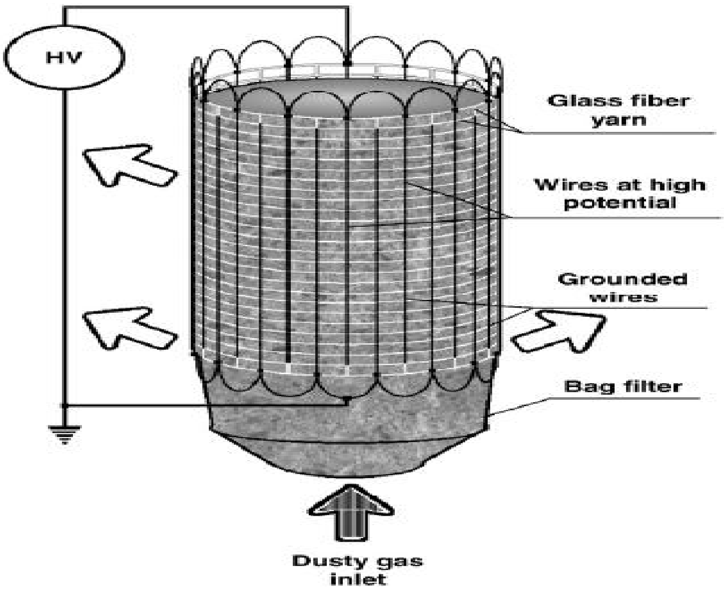



Fig.14 Bag filter with assistive electric field without particle charging (Jaworek. A and Krupa. A,2006)

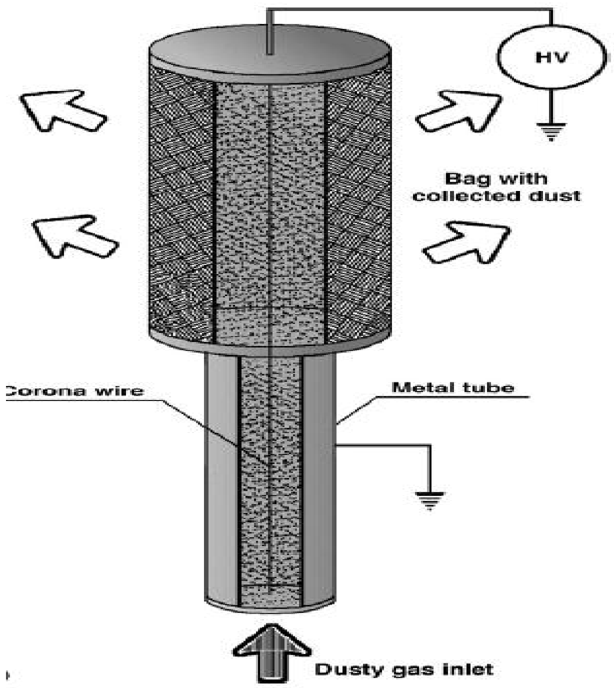



Fig.15 With particle charging and filtration in an electric field (Jaworek. A and Krupa. A,2006)

Filter bags embedded with an electric field (fig.14, fig.15) set up produces an electric field to charge the particles, Particle penetration through a fabric or tissue filter decreases exponentially with the filter thickness h ( Mermelstein.J. et.al, 2002) according to the formula

$$\lambda = \exp(-\gamma h) \quad (3)$$

Electrostatic effects on fabric filters were investigated by Bhutra and Payatakes (Bhutra and Payatakes,1979), (Frederick.E.R.,1961), (Lathrache et al., 1986), and (Lundgren and Whitby, 1965). (Frederick.E.R.,1961) studied that triboelectric charging is of larger significance infiltration process facilitating to improve filtration efficiency. Bhutra and Payatakes (Bhutra and Payatakes,1979) and (Oak and Saville, 1980) found out that the particles are captured in the form of long and thin dendrites on the bag surface, the dust is deposited on the surface of the media ( Penney and Uber,1985). The electric results in the formation of bridges between the fibers, with free gaps between them (Frederick, 1980). In the absence of an electric field, the dendrites formed are shorter and multi-branched which form a tight layer. The dendrite-like structure helps in reducing the differential pressure drop and penetration by an order of magnitude compared to conventional fabric filters.

In some cases the particles are charged before filtration process in a corona-free electric field (Luckner.H.J.et.al,1998, Lundgren andWhitby,1965 Lee.J.K. et.al,2001, Pogo´rski.A.et.al,1998), or they are simultaneously charged and precipitated during the same stage in the lower part of the filter is charged with concentrically arranged corona wire. Larger particles are collected on tubular ESP, particles with lower mobility flow upwards to the bag filter where they get deposited.

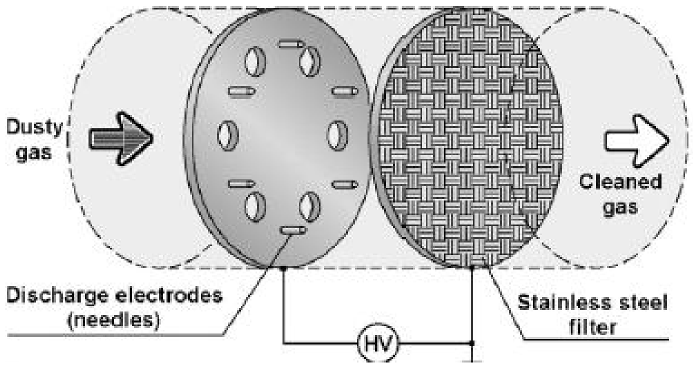



Fig.16 Stainless-steel-fiber co-flow electrostatic precipitator (Jaworek. A and Krupa. A,2006)

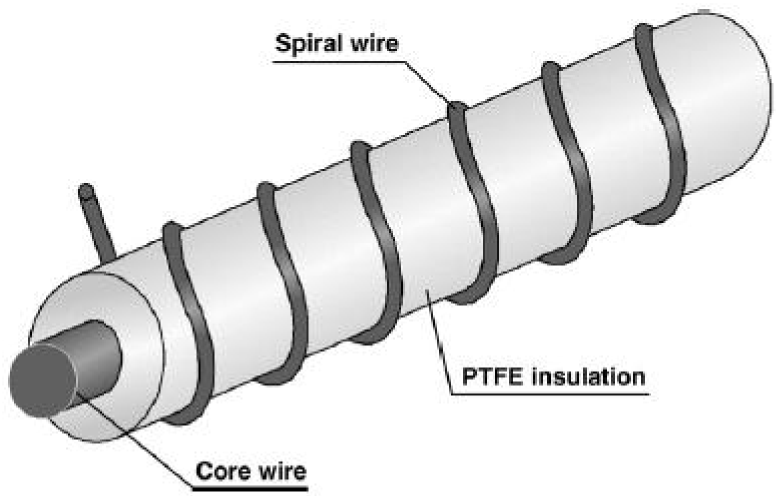
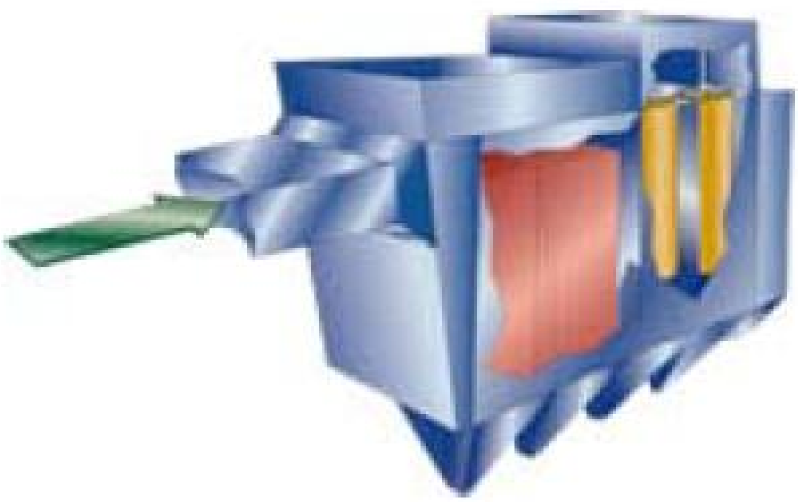



Fig.17 Pseudo-electret fiber (Jaworek. A and Krupa. A,2006)

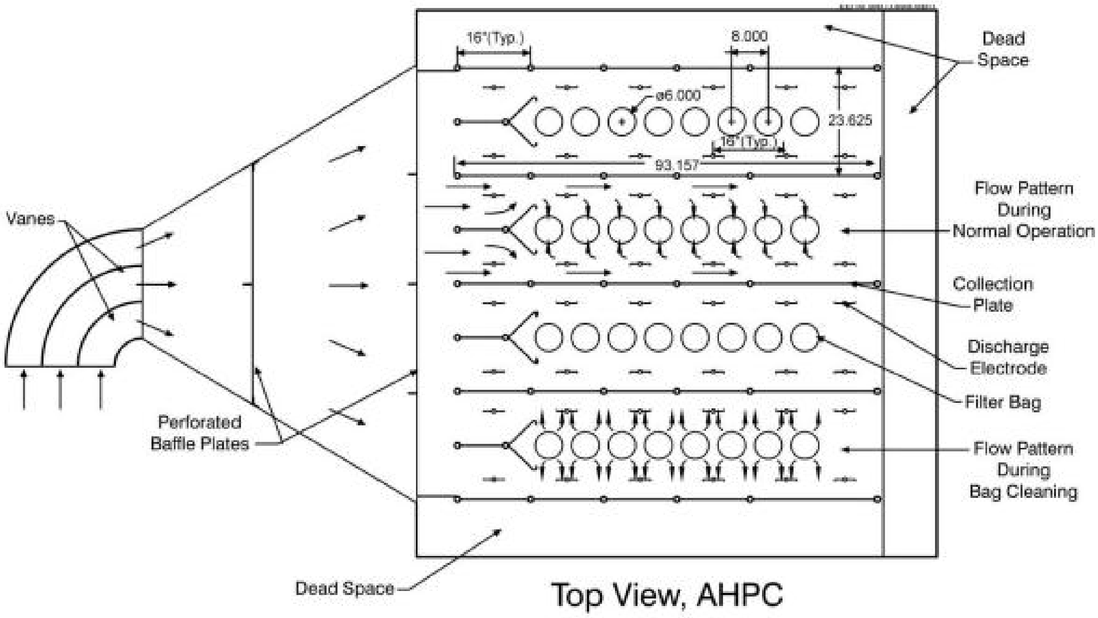
An electret is a dielectric material (fig.17) producing permanent electric field without any externally applied voltage which is fabricated from polymer fibers that are permanently charged during production. Electrets are frequently used in cleaning devices where high efficiency is mandatory such as indoor air filters, cabin air filters and respiratory filters Electret filters are fabricated from polymer fibers, which are permanently charged during production. Electret produces strong electrostatic fields close to the fiber surface remove very fine particles with higher efficiency compared to conventional fibrous filters ( Nifuku.M et.al.2001, Tsai.P.P. et.al 2002, Ji.J.H. et.al. 2003). These are produced either by the polarization of dielectric material in an electric field or by the charge**.** Through triboelectric charging, corona discharge, or by the electrospinning. Tribocharging occurs as a result of carding with two different materials of dissimilar electronegativity (Tsai.P.P. et.al 2002). Corona discharge is appropriate for charging polymer fibers whereas polypropylene is used as electret material (Tsai.P.P. et.al 2002, Łowkis and Motyl 2001, Tsai.P.P. et.al. 1998 ).

**5. Types of hybrid Hybrid Filtration System**

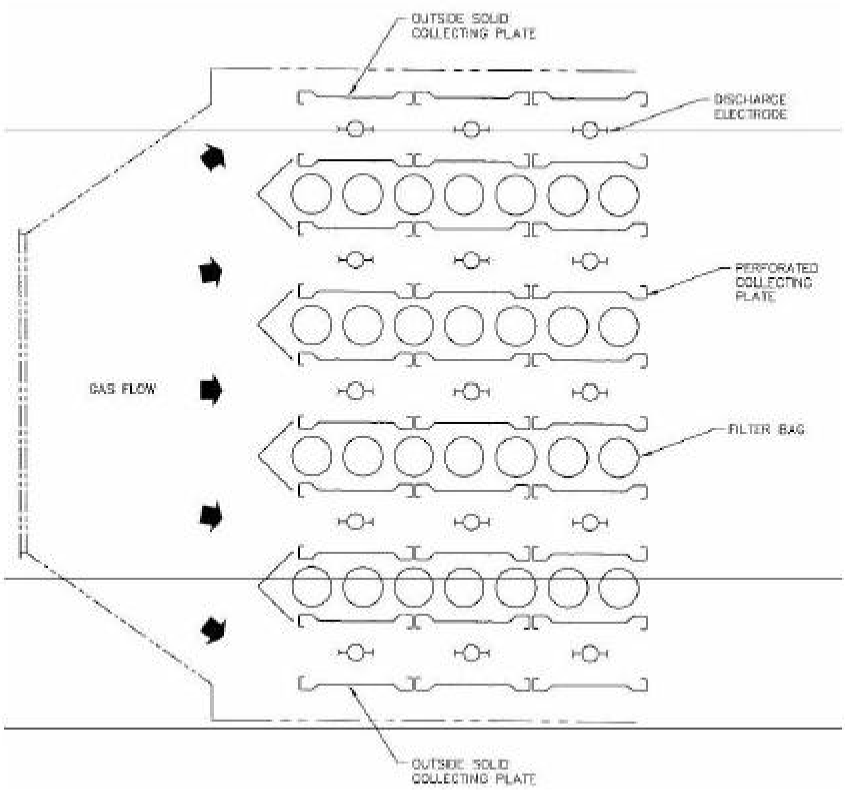
**COHPAC I**



**COHPAC II**




**Advanced Hybrid - Original Concept**




**Advanced Hybrid - Modified Concept**

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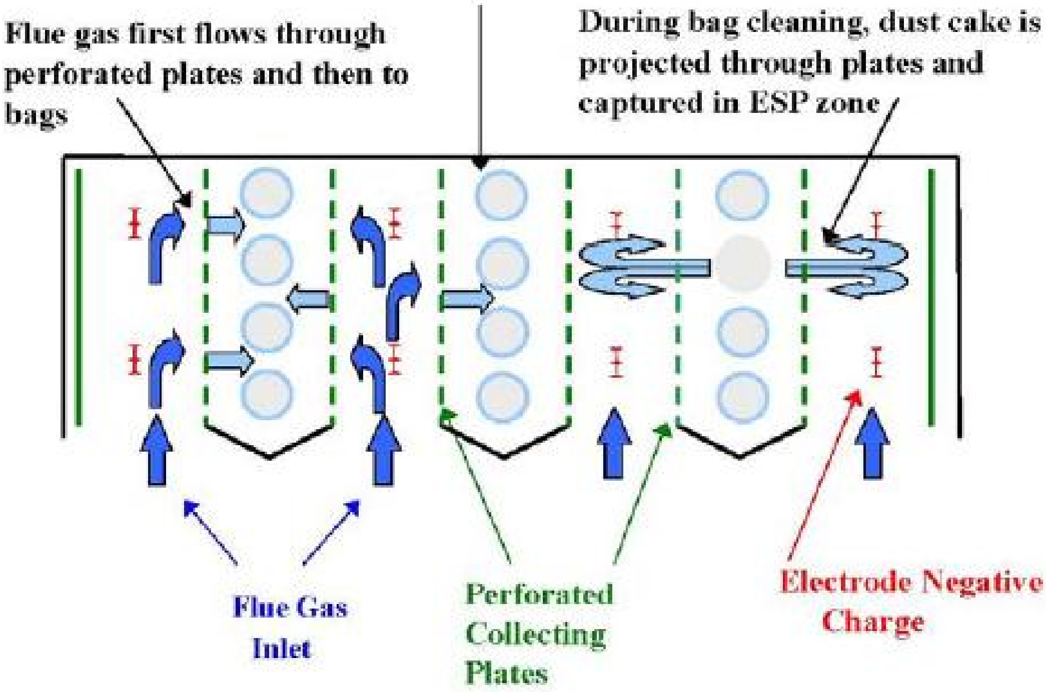
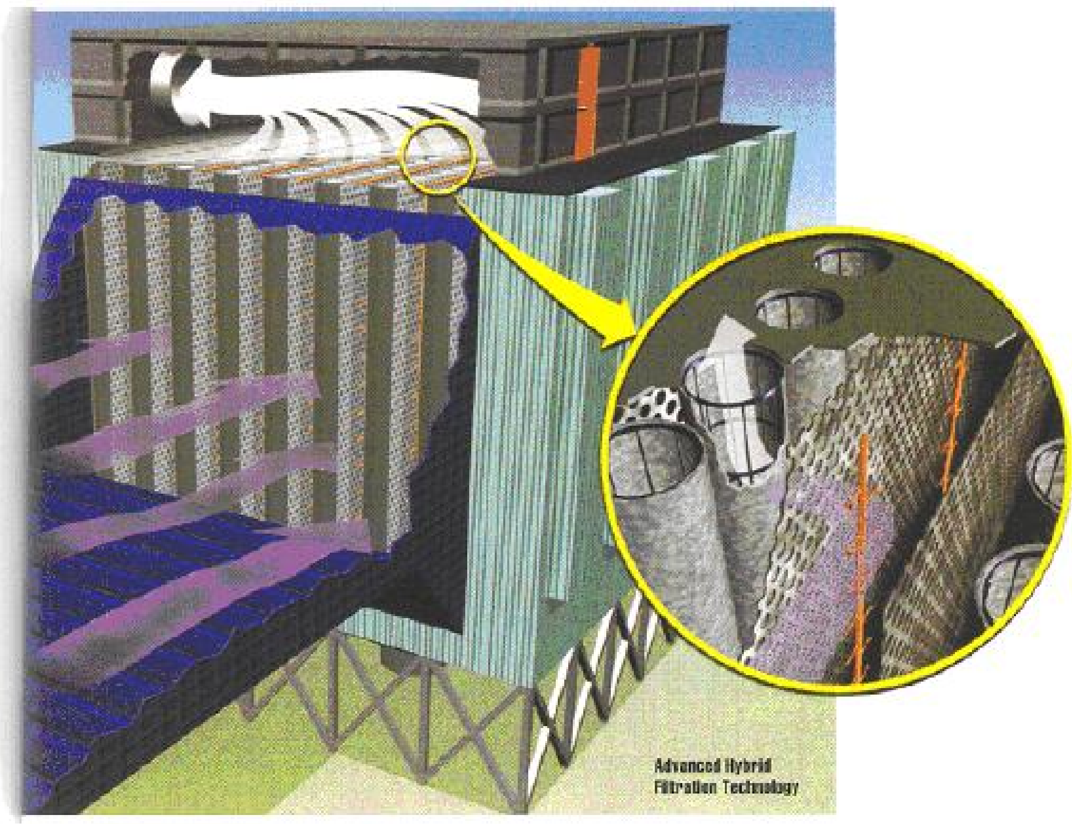



**Gas Flow Direction in the Advanced Hybrid Collector**




**Advanced Hybrid – Artist's Rendition**

## 6. The advantage of using Hybrid Filtration System

Use of hybrid filtration system can help in countering the demerits faced while using ESP and Fabric Filter systems individually. Following table gives the detail of the reason why hybrid filter should be used

Table No. 1 Hybrid filters give a combined advantage (Tomitatsu. K.et al,2014)

| | ESP | Fabric Filter | | |
|---|---|---|---|---|
| Merits | Less Pressure Drop<br><br>Less maintenance Cost | Dust collection rate remains unaffected by aerosol composition.<br><br>Extremely high collection efficiency can be achieved i.e. up to 99.99% | ➡ | Hybrid Filters have been designed to get combined benefit ESP and Fabric Filter |
| De-Merits | Dust collection rate is affected by the aerosol composition<br><br>Larger space is required to get high dust collection rate. | Higher Differential Pressure Drop<br><br>High maintenance cost as the bags needs to replaced frequently | | |

### 6.1. Reason for reduced pressure drop in Hybrid systems

During Hybrid Filtration aerosol particles are charged during the preliminary phase, the fine particles are agglomerated thereby preventing the particles to penetrate into the inner layer hence negating depth filtration, as a result the particles get deposited on the surface of the filter media fabric facilitating proper dust cake formation (fig.18) therefore resulting in easy dislodging of dust during pulsing action with lower differential pressure drop (Tomitatsu. K.et al,2014) .

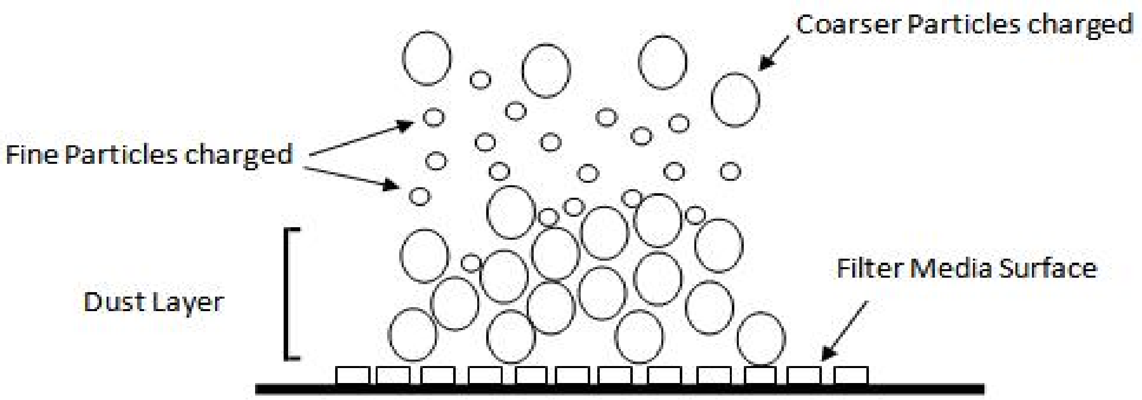



Fig. 18 Particles collecting on the surface of filter media (Tomitatsu. K.et al,2014)

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## 7. Case studies were done on Hybrid Filtration:-

Most of the countries have tried hybrid filters in the form of ESP followed by fabric filter on commercial basis in industries such as coal-fired power plant where performance improvements were noticed but the problem which was noticed with the set-up was it consumed large space as the equipment size was too large which was undesirable considering the economical aspect (K. M. Cushing.2008, W. Huang. 2008, Zhao and S. Luo. 2008, K. Zheng, Z. Zhu and W. Yuen. 2011), to overcome this Fabric Filters assisted with pre-charger was tried. Pre-charger was attached followed by fabric filter (Ueda .Y, 2014), Pre-charger is a small box in which aerosol particles are charged by providing high-velocity DC voltage (Fig. 19), the charged particles further flow towards fabric filter and gets deposited on its surface. Pressure Drop was found comparatively 30% less in case of particle charging (Ueda .Y. 2014, Jaworek. A and Krupa. A.2007, Li.H et al 2016, Robert. F and Kenneth. M. 2003).

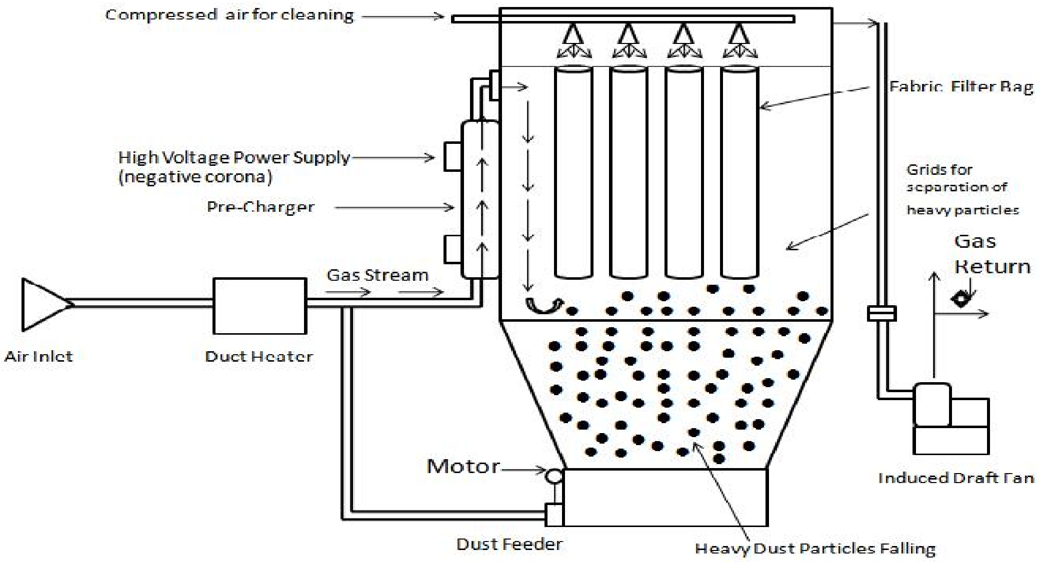


Fig.19 Filter Fabric set-up assisted with pre-charger (Tomitatsu. K.et al,2014)

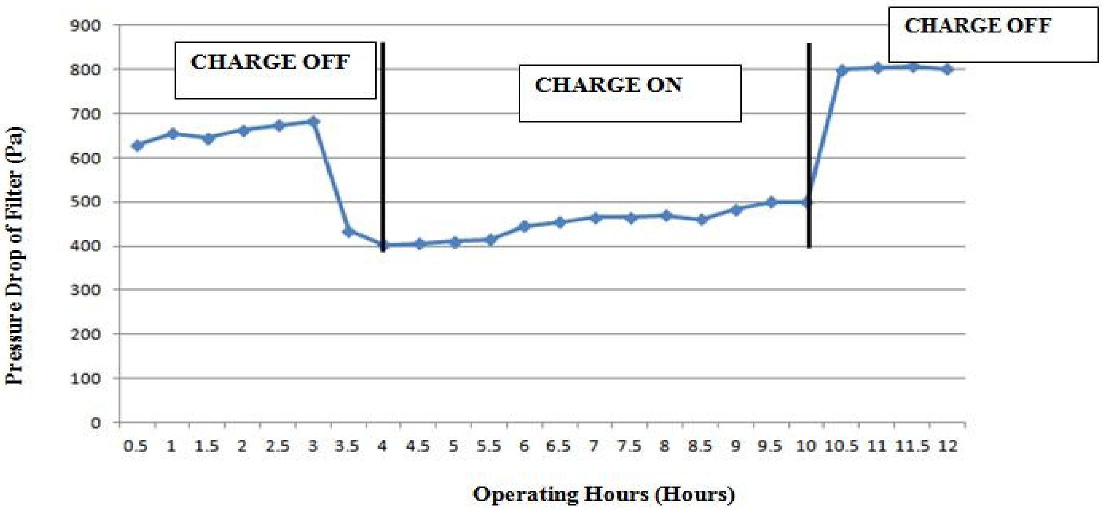


Fig.20 Reduced Pressure Drop after charging aerosol (Tomitatsu. K.et al,2014)

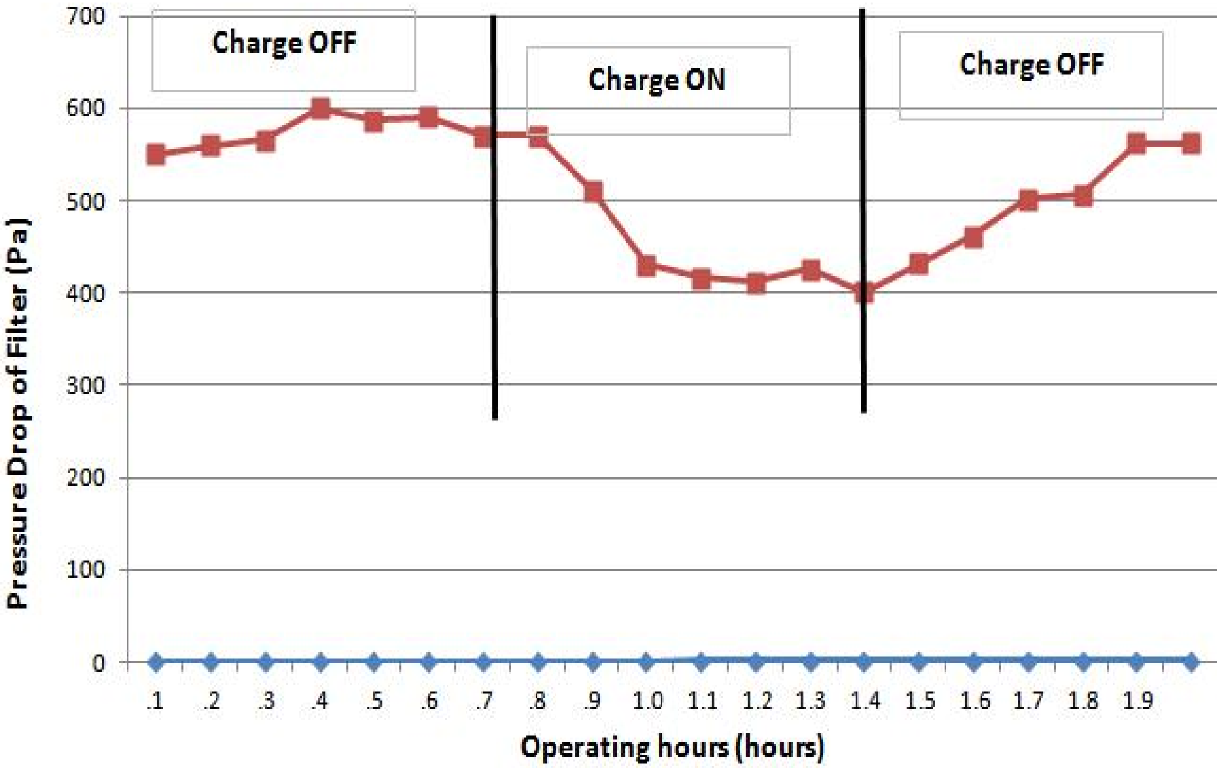


Fig.21 Reduced Pressure Drop after charging aerosol (Tomitatsu. K.et al,2014)

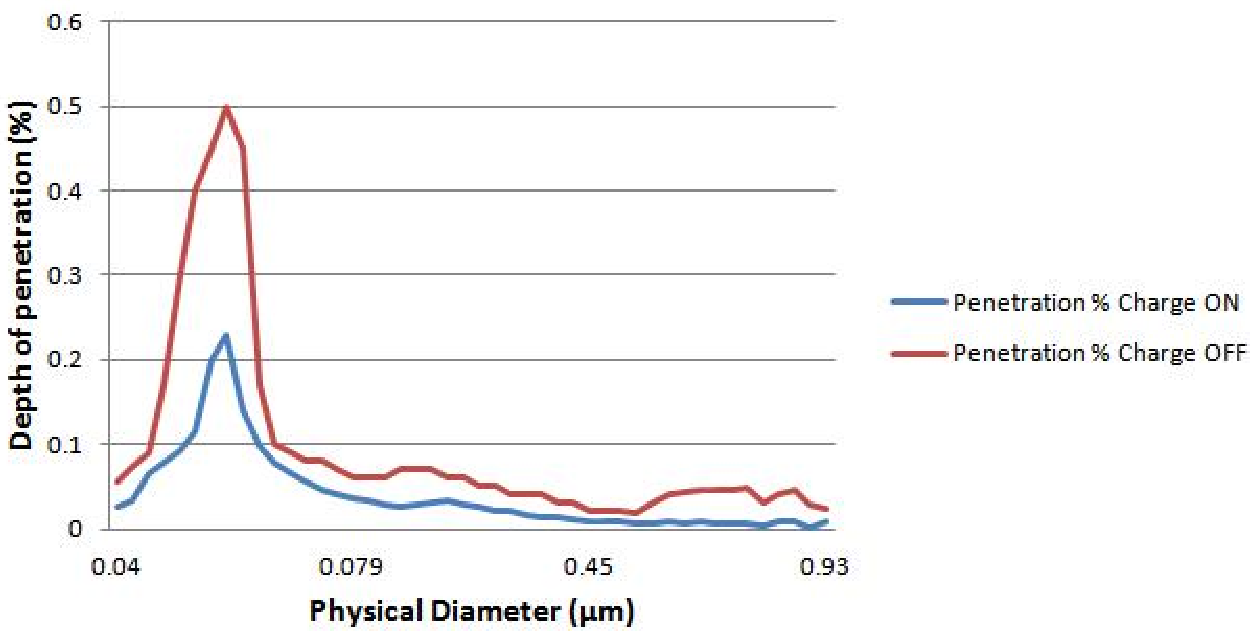


Fig.22 Depth of penetration with a charge on and charge off (Zhao.X and Luo.S, 2008)

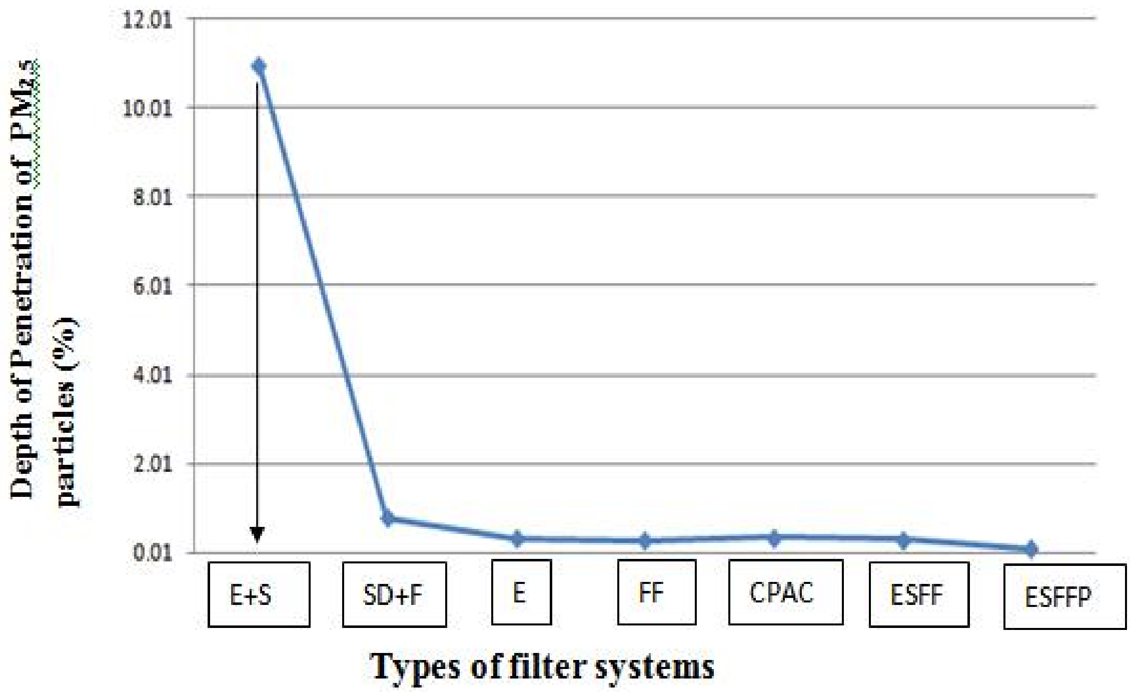


Fig.23 $PM_{2.5}$ penetration levels and different set-ups (Zhao.X and Luo.S, 2008)

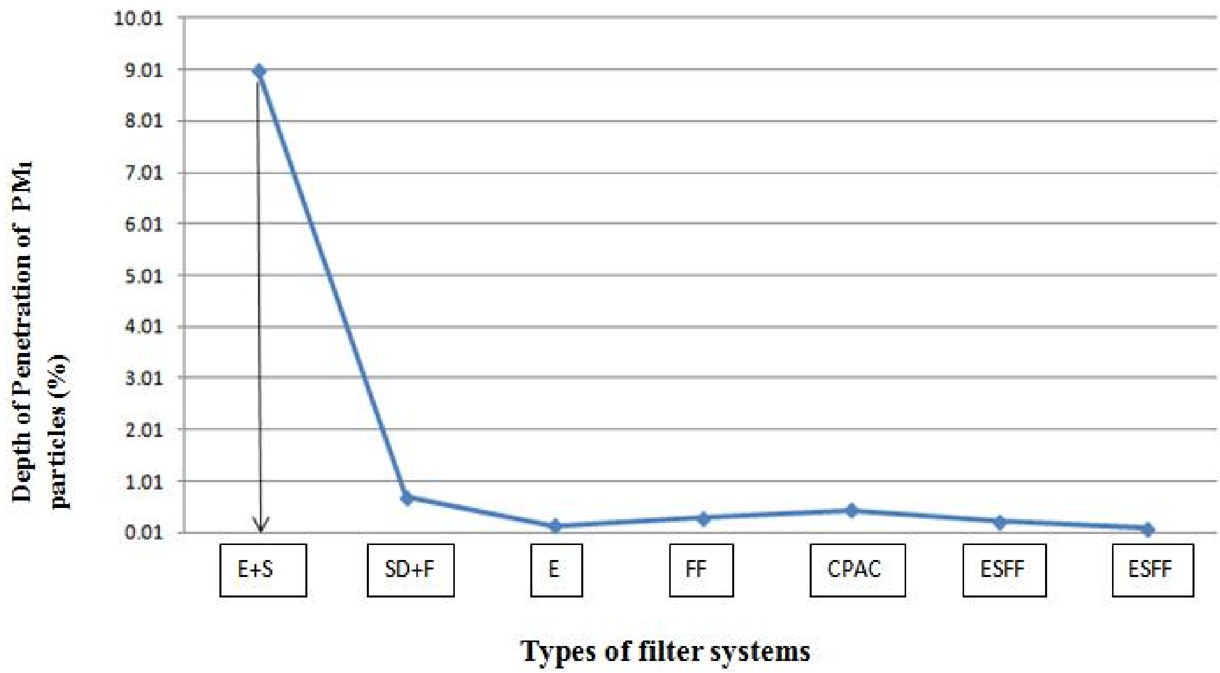


Fig.24 $PM_1$ penetration levels and different set-ups (Zhao.X and Luo.S, 2008)

Table No.2 System Label Keys for systems (Zhao.X and Luo.S, 2008)

| Label | Description |
|---|---|
| E+S | High-efficiency ESP+Wet Limestone Scrubber |
| SD+FF | Spray Dryer+Reverse Gas Cleaned Fabric Filter |
| E | Large SCA* High-Efficiency ESP |
| FF | Reverse Gas Cleaned Fabric Filter |
| COHPAC | Pilot Compact Hybrid Particle Collector |
| ESFF | ESFF Without Electrode Energization |
| ESFFP | ESFF With Electrode Energization |

During another study, evaluation of electrostatically stimulated fabric filtration system with conventional fabric filtration using Polyphenylene sulfide fiber bags with silicon micro-powder was done (Li.H, Wang.Z, Ye.Y,2016) and results were found somewhat comparable as the previous case (Ueda .Y et al, 2014 ) i.e. charging of particles viz. electrostatically stimulated fabric filtration system offered performance at Lower Pressure Drop (Fig.20, 21) and depth of penetration (Fig.23, 24) than conventional Fabric Filter and also the Drag Coefficient was found to be one-third of conventional Fabric Filter, the collection efficiency can go as high as 99.99% in case of conventional fabric filter assisted with static charge (Heaphy.R.F. et al, 2003). For electro-statically stimulated fabric filtration system the main problem is uneven static pressure distribution on filter media surface (Yan.C.P.2013, Turner.J.H. et al 1998, Simon.X et al 2010), further the electrical properties while applying electrostatic field such as applied voltage, current etc effects the attachment of particles on the filter surface caused pressure variation in cake porosity (Koehler.J.L. and Leith.D,1983). The filter performance in terms of differential pressure drop was explained as per following Koehler and Leith model (Gebert.R, 2003)

$$\Delta P = \frac{1}{2}\left[P_S + k_1 v_f - \sqrt{(P_S + k_1 v_f)^2 - 4W\frac{k_2}{k_3}}\right] + k_v v^2 f \qquad (4)$$

Pressure Reduction Factor (PRF) = $k_2/k_3$

Table No.3 System Label Keys for equation 2 (Li.H et al 2016)

| Label | Description |
|---|---|
| ΔP | Differential Pressure Drop |
| $P_s$ | The residual static pressure in Pa |
| $k_1$ | Clean fabric resistant coefficient(Pa.min.m/g) |
| $k_2$ | Specific drag coefficient with the electrostatically stimulated fabric filtration system. |
| $k_3$ | Specific drag coefficient without the electrostatically stimulated fabric filtration system. |
| W | The areal density of dust cake |
| $o_f$ | Flow velocity |

Pressure drop was found one-third lower for electrostatically stimulated fabric filtration system and also the cleaning cycle was found higher for high-pressure reduction factor (PRF) and differential pressure drop was

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found to be lower (Li.H et al 2016), hence it was proved that pressure reduction factor (PRF) evaluates cleaning performance as well as quantifies the cleaning cycle.

In another relevant study filtration performances of electrostatically stimulated fabric filter with conventional fabric filter was investigated (Robert. F and Kenneth. M, 2003). The emission was found 75% to 80% less for electrostatically stimulated fabric filter and also penetration of submicron particles exponentially decreased, in addition, the pressure drop was one-third less for fabric filter assisted with a static charge.(Tomitatsu. K.et al,2014, Li.H et al2016, Robert. F and Kenneth. M 2003). The electrostatically stimulated system was found to be more flexible and occupied lesser space comparatively. Also in the study (Robert. F and Kenneth. M, 2003) comparative analysis of 7denier fiber filer media and 2.7 denier fiber filter media was done and it was found that pressure drop was much lower for 7 denier filter media due to high air permeability but for the same denier the emission was found to be higher as the chances of particles going across the filter media straight through were more (Robert. F and Kenneth. M 2003, Mukhopadhyay A and Choudhary A.K. 2012, Mukhopadhyay A.2009, Mukhopadhyay A.2010) In another incidence during a symposium it was presented that, using gypsum dust this time the cake resistance or pressure drop reduced substantially with increase in electrostatic charge (fig. 25) of particles and the results were same for subsequent industrial dust samples also (Tomitatsu. K.et al,2014, Li.H et al 2016, Robert. F and Kenneth. M 2003, Edward R. F.1980).

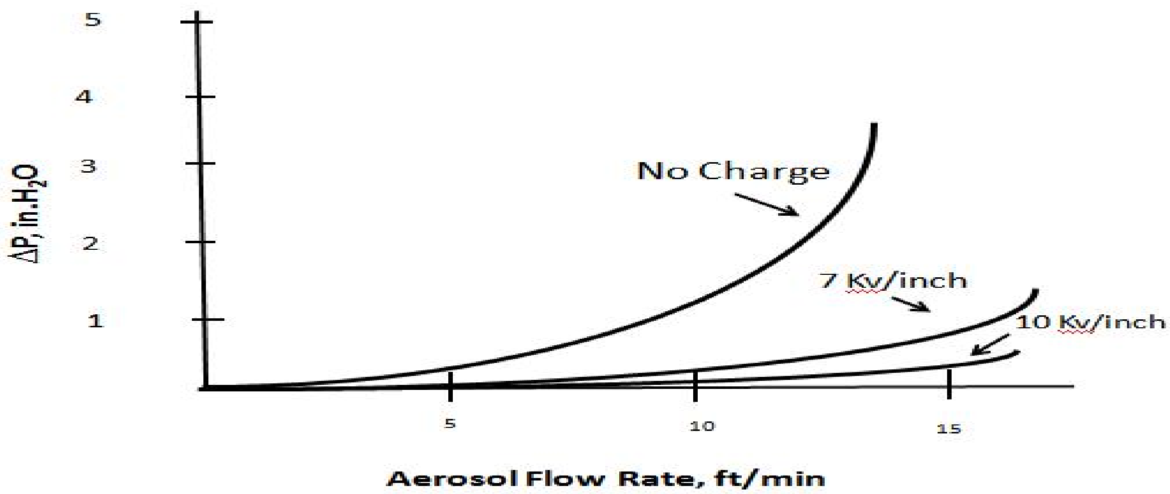


Fig. 25 Advantage of aerosol charging (Edward R. F.,1980)

## 8. Conclusion

It can be summarized from each case study that fabric filter assisted with electrostatic charge is economically beneficial in terms of achieving lower pressure drop (Tomitatsu. K.et al,2014, Li.H et al 2016, Robert. F and Kenneth. M 2003, Edward R. F.1980). Lower pressure drop meant that energy required to clean the filter media is less which will result in lower power consumption. It has also been noticed that by charging the aerosol particles, size of the setup can be reduced by a factor of four with better collection efficiency (Edward R. F.1980**).** Charging of aerosol particles facilitates surface filtration providing better cake formation of dust on the surface of media which can easily be dislodged during pulsing, easier the removal of dust lesser will be the load on filter media which can subsequently improve the filter media life (Tomitatsu. K.et al,2014).

To make hybrid filtration system more frequently available and for future actualization, different types of conductive filter media can be tried in the system which can contribute to higher collection efficiency with more reduced power consumption as the filter media will also act as collecting electrode and can dissipate the static charge.

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