A DETAILED ANALYSIS OF AIR POLLUTION EFFECTS ON ENVIRONMENT AND CONTROL TECHNIQUES

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Abstract

This paper investigates the collection efficiency of different pollution control devices used to remove particulate matters. Gravitational settlers are found to be least effective for separation of particulate matters and fabric filters are most effective since it separates particles with sizes less than 1 µm. Different classes of environmental pollution are discussed. United Nations declared Kolkata, Mumbai and Delhi the most polluted cities. Different steps taken by the government like effective use of renewable energy and replacement of CFC. Harmful effects are considered like depletion of Ozone layer and Acid rain. Health impacts of air pollution results mainly due to carbon mono oxide, which combines with haemoglobin to reduce the amount of oxygen which enters in human body. Finally removal of particulate matters from gas stream is analysed in this paper.

Keywords: Collection efficiency, cyclone separators, dust, particulates, pollution

1. Introduction

Presence of matter [gas, liquid, solid] or energy [heat, noise, radiation] whose nature, location, or quantity directly or indirectly alter characteristics of processes of any part of the environment and causes [or has the potential to cause] damage to the condition, health, safety, or welfare to animals, humans, plants, or property.

We know that, a living organism cannot live by itself. Organisms interact among themselves. Hence, all organisms, such as plant, animals and human beings, as well as the physical surrounding with whom we interact, form a part of our environment. All these constituents of the environment are dependent upon each other. Thus, they maintain a balance in nature.

1.1 Classification of environmental pollution-

Environmental pollution can be classified as air pollution, water pollution, soil pollution and noise pollution. Air pollution is the introduction into atmosphere of chemical, particulates or biological material that cause discomfort, disease or death of human , damage other living organism such as food crops ,or damage the natural environment or built environment. Water is said to be polluted when there is any physical, biological or chemical change in water quality that adversely affects living organisms or makes water unsuitable for use. Soil contamination or soil pollution is caused by the presence of anaerobic chemicals or other alteration in the nature soil environment it is typically caused by industrial activity, agriculture chemicals or improper disposal of waste. The word noise may be from the Latin word nauseas, which means disgust or discomfort the source of most outdoor or noise worldwide is mainly construction and transportation system, including motor vehicle noise, aircraft noise and rail noise.

1.2 Reason of Pollution

The ultimate cause of pollution is human action to nature. Industries for various human heeds –directly and indirectly, Agriculture for food production and industrial needs, Health care for health of human beings and animals, Transport for mobility of human beings, Dowelling for settlement in city or villages, Energy for various direct human needs and industrial needs. All of them contribute to pollution in one way or other and therefore cause miseries. A vast array of industries can cause pollution chemical to popular perception that only a chemical industry can cause pollution IN same industry pollution is out rightly visible. In others, it may be invisible, indirect.

1.3 Pollution Control Devices

Dust collection systems, scrubbers, sewage treatment, industrial wastewater treatment, vapour recovery systems are some of the pollution control devices

Electrostatic precipitator are operated at 12,000-30,000 volts applies across two spaced electrodes. At the applied voltage gas molecules ionize in between the electrodes. Suspended particulate contain in the moving air steam collide with the charged ions which in turn get charged and move toward oppositely charged electrodes [1]. At the electrodes the charged particles deposit and lose their charge. Both solid and liquid aerosols can be collected in electrostatic precipitators.

A cyclone is a vertical cylinder attached with an inverted cone at the bottom. It has no moving part. The particulate laden gas is introduced through a tangential inlet into the cylinder at high velocity which imparts a whirling motion to the gas by generating a centrifugal force. Centrifugal force acting on particle in a spinning gas steam is greater than the gravitational force. The particle laden gas undergoes a spiralling motion directed toward the cone [2]. The vortex enough centrifugal forced to throw the particle radially toward the wall of cone. At the bottom of the one the gas flow, reverse the direction to form an inner vortex spiralling upward until it exits from the cone [3].

Table-1 Pollutants Concentration.

Pollutants	Average time	Concentra tion
Sulpher dioxide [So2]	Annual average 24 hours	60 μg\m^3
Oxide of nitrogen [No2]	A.A.24 hours	60 μg\m^3
Suspended particulate matter	A.A 24 hrs	140 μg\m^3 200ug 1m^3
Carbon monoxide	A.A 24 hrs	o.75μ g\m^3
Carbon monoxide	A.A 24 hrs	2. μg\m^3 4.o μg\m

1.4 Present Pollution Status of Indian Metropolitan Cities

The United Nations reported in 1994 that Kolkata, Mumbai and Delhi were among the most polluted [air pollution] cities in the world. WHO (world health organization) also reported that out of the 7 cities in the world with serious air pollution, 5 were located in Asia-Kolkata, Mumbai, Delhi. Kolkata core, with an area of 104 sq. km. and a population of 4 million has a record of severe air pollution during winter season. The cities are comparatively clean during rainy season (July to October) due to heavy rainfall and also during summer (April to June) when high winds blow away the pollutants. Ambient air quality monitoring in major Indian cities has been conducted cities has been conducted since 1978 by National Environmental Engineering Research Institute (NEERI), Nagpur and central pollution Control Boards (CPCB) under National Ambient Air Quality Monitoring (NAAQM) Programmes [4]. The database has been generated since 1978 for the cities – Ahmadabad, Chennai, Delhi, Hyderabad, Jaipur, Kanpur, Kochi, Kolkata, Mumbai and Nagpur. The urban environmental issues arise from failure to provide the basic amenities to urban population. Accumulation of huge solid wastes [1000 tonnes per day at Kolkata] enhance the water pollution hazards – this along with air pollution and noise pollution pose severe health hazards for the urban population. Industries produce environment hazards everywhere .they consume 37 % of the world's energy and emit 50% of the world's CO_2 ,90% of SOx and almost all the chemicals now threatening O3 layer with depletion. In developed country, energy is being used more efficiently and expected rate of increase of energy consumption is only 1.3 % a year the energy needed to produce a single unit of Gross Domestic Product (GDP) has declined by 29% since 1970 [5]. Natural gas is being used as fuel in cars in several countries in reducing Italy where 3lakh cars run on compressed natural gas (CNG). Major efforts have been made in developed countries in reducing petrol consumption by 50% of the amount used two decades ago. Auto emissions have also been cleaned up. Use of lead free petrol has curtailed lead emission lead emission by 87% during 1976-1978 [6].

1.5 Pollutants Present in Atmosphere

Pollutants present in atmosphere are Carbon Monoxides, Nitrogen Oxides, Hydrocarbons and Photochemical Smog, Sulphur dioxide and Particulates [7].

1.5.1 Carbon Monoxides [CO]

It is a colourless, odourless, and tasteless gas. It is 96.5% as heavy as air and is not soluble in water. The basic chemical reaction yielding CO are

Incomplete combustion of fuel or carbon-containing compounds –

$$2C + O_2 = 2CO$$

$$CO_2 + C = 2CO$$

$$CO_2 = CO + O$$

1.5.2 Nitrogen Oxides [NOx]

Nox represents composites atmospheric gases, nitric oxide and nitrogen dioxide. Which are primarily involved in air pollution. NO is a colourless gas, odourless gas, but NO2 has a reddish – brown colour and pungent suffocating odour.

$$N2 + O2 = 2NO$$

$$2NO+ O2 = 2NO2$$

1.5.3 Hydrocarbons and Photochemical Smog

Natural sources, particularly trees, emit large quantities of hydrocarbons in the atmosphere [8]. CH_4 is the major naturally occurring hydrocarbons emitted into the atmosphere. It is produced in considerable quantities by bacteria in the anaerobic decomposition of organic matter in water, sediments and soil. It has been estimated that anthropogenic sources [human activities] contribute about 15% of the hydrocarbons emitted to the atmosphere each year. An approximate break-up of global hydrocarbons is given as Petroleum -55%, Coal-3.3%, Wood -2.2%, Incinerators and refuse burning- 28.3%, Solvent evaporation -11.3% [9].

1.5.4 Sulphur dioxide [SO2]–

It is colourless gas with a pungent odour.it is produced from the combustion of any sulphur bearing material. SO2 is always accompanied by a little SO_3. The mixture is denoted by –

$$S + O2 = SO_2$$

$$2SO_2 + O\,2 = 2SO_3$$

Under normal humid condition of the atmosphere, SO3 invariably reacts with water vapour to from droplets of H2SO4.

1.5.5 Particulates

Small solid particulates and liquid droplets are collectively termed particulates. These are present in the atmosphere in fairly large numbers and sometimes pose a serious air-pollution problem. The most important physical property is size. Particulates range in size from a diameter of 0.0002 micron to a diameter of 500 micron with lifetimes varying from a few seconds to several months.

1.6 Pollution due to Thermal Power Plants

Natural gas is frequently combusted in gas turbine as well as boiler. The waste heat from a gas turbine can be used to raise steam, in a combined cycle plant that improves overall efficiency. Power plants burning coal, fuel, oil or natural gas are often called fossil-fuel power plants. Some biomass – fuelled thermal power plants have appeared also. Non – nuclear thermal power plants, particularly fossil fuel plants, which do not use co –

generation are sometimes referred to as conventional power plants.

The warm temperature reduces the level of dissolved oxygen in water. The decrease in DO can create suffocation of plants and animals such as fish, amphibians, copepods, which give rise to anaerobic conditions. With the constant flow of high temperature discharge from industries, there is a huge increase in TOXINS that are being regurgitated into the natural body of water. These toxins may contain chemical and radiation that may have harsh impact on the local ecology and make them susceptible to various diseases. A dent in a biological activity in water may cause significant loss of biodiversity. Changes in the environment causes certain species of organisms to shift their base to some other place while there, could be a significant number of species that may shift in because of warmer waters. Organisms that can adapt easily may have an advantage over organisms that are not used to the warmer temperature. A sudden thermal shock can result in mass killing of fish, insects, plants or amphibians. Hotter water many prove favourable for some species while it could be lethal for other species. Small water temperature increases the level of activity while higher temperature decreases the level of activity. A significant halt in the reproduction of marine wildlife can happen due to increasing temperature as reproduction can happen within certain range of temperature. Excessive temperature can causes the release of immature eggs or can prevent normal development of certain eggs. The warm water can also causes particular species of organisms to migrate to suitable environment that would cater to its requirement for survival. This can result in loss for those species that depends on them for their daily food as their food chain is interrupted.

1.7 Steps Taken by Government to Control Pollution

The government Committed to halve the number of people without access to safe drinking water and sanitation by 2015. Effectively increase of the use of renewable energy without setting any targets. Shift from coal-fired thermal power stations to more efficient gas-fired ones. Use maximum solar and wind energies. Impose heavy penalties for motors vehicles exceeding emission levels in metropolitan cities. Introduce CFC substitutes [such as butane and propane] in all air – conditioners and refrigerators. Minimise deforestation and maintain the bio reserves. Reduce population growth by 30% in the next 5 years. Reduce livestock population [source of methane, greenhouse gas emission]. 1974-Water [prevention and control pollution] act for restoration and maintenance of wholesomeness and cleanliness in our national aquatic resources by prevention and control of pollution. Central and state pollution control boards established to advise the central GOVT. On water pollution issues, coordinate the activities of the state pollution control board, and control of water pollution. 1981-Air [prevention and control of pollution] act of prevention, control and abatement of air pollution and preserving the air quality in the country. The Environment Protection Act [EPA] for protection and improvement of the human environment and prevention of hazards of human beings, plants, animals and property [Act introduced in the wake of the BHOPAL disaster]. Environment Impact Assessment [EIA] is to identify, predict and evaluate the likely economic, environmental and social impact of development activities and taking necessary steps as a remedy as a part of overall environmental management plan [EPM].

2 Problem identification

2.1 Harmful Effect of Pollution

It affects respiratory system of organisms and causes pneumonia etc. carbon monoxide emitted from motor vehicles and cigarette smoke effect nervous system. Due to depletion of ozone layer, radiation reaches earth UV radiation causes skin cancer, damage to eyes and system of body. Acid rain also results of air pollution. Some rain of also result of air pollution also causes air pollution. The greenhouse gases, such as carbon dioxide [co_2] and methane [CH_4] trap the heat radiated from earth. This leads to an increase in earth temperature. Some toxic metals and pesticides also cause air pollution. Human beings become victims of various water home diseases, such as typhoid, cholera, dysentery, jaundice etc. The presence of acids/alkalizes in water destroys the microorganisms, there by hindering the self – purification process in the rivers or water bodies. Agriculture is affected badly due to polluted water; marine eco-systems are affected adversely. The sewage waste promotes growth of phytoplankton in water bodies, causing reduction of dissolved oxygen. Poisonous industrial wastes present in water bodies affect the fish population and deprives us of one of our sources of food. It also kills other animals living in fresh water.

2.2 Health impacts of air pollution

Air pollution is a major environmental health problem affecting the developing and the developed countries alike. The effects of air pollution on health are very complex as there are many different sources and their individual effects vary from one to the other. It is not only the ambient air quality in the cities but also the indoor air quality in the rural and the urban areas that are causing concern. In fact in the developing world the highest air pollution exposures occur in the indoor environment

Carbon monoxide combines with hemoglobin to decrease the amount of oxygen that enters our blood through our lungs. The binding with other hemo proteins causes changes in the function of the affected organs such as the brain and the cardiovascular system, and also the developing foetus. It can impair our concentration, slow our reflexes, and make us confused and sleepy. Sulphur dioxide in the air is caused due to the rise in combustion of fossil fuels. It can oxidize and form sulphuric acid mist. SO_2 in the air leads to diseases of the lung and other lung disorders such as wheezing and shortness of breath.

2.3 Diseases Caused by Air Pollution

While the most visible consequences of air pollution smog, the effects of this environmental problem are more devastating than what simply meets the eye. Breathing in these chemicals daily is damaging the body causing serious health problems. Below read about some diseases caused by air pollution

2.3.1 Asthma

Although asthma may not be directly caused by air pollution, asthma attacks can be triggered by high levels of air pollution. The health condition asthma can also be caused by air pollution. A pollutant such as sulphur dioxide causes the constriction of smaller airways in the lungs and makes breathing harder even for healthy people. With someone prone to asthma attacks, this constriction can set off a serious and life-threatening attack. In fact, asthma attacks set off by pollutants are one of the largest causes of air pollution related death in Europe and in North America.

2.3.2 COPD

Chronic Obstructive Pulmonary Disease [COPD] is a disease spreading quickly due to increases in levels of air pollution.Basically, Chronic Obstructive Pulmonary Disease [COPD] refers to recurring episodes of respiratory problems, such as bronchitis.

2.4 Environmental Problem

2.4.1 SMOG

Smog is a type of air pollutant. The word "smog" was made in the early 20th century as a portmanteau of the words smoke and fog to refer to smoky fog. The word was then intended to refer to what was sometimes known as pea soup fog, a familiar and serious problem in London from the 19th century to the middle 20th century. This kind of smog is caused by the burning of large amounts of coal within a city; this smog contains soot particulates from smoke, sulfur dioxide and other components.

2.4.2 Coal

Coal fires, used to heat individual buildings or in a power-producing plant, can emit significant clouds of smoke that contributes to smog.

2.4.3 Transportation emissions

Traffic emissions – such as from trucks, buses, and automobiles – also contribute. Airborne by-products from vehicle exhaust systems cause air pollution and are a major ingredient in the creation of smog in some large cities. The major culprits are from transportation sources are carbon monoxide [CO], nitrogen oxides NO and NO_x volatile organic compounds, sulphur dioxide and hydrocarbons.

2.4.4 Photochemical smog

Photochemical smog was first described in the 1950s. It is the chemical reaction of sunlight, nitrogen oxides and volatile organic compounds in the atmosphere, which leaves airborne particles and ground-level ozone. This noxious mixture of air pollutants can include the following aldehydes, nitrogen oxides, such as nitrogen dioxide. peroxyacyl nitrates, tropospheric ozone, volatile organic compounds. All of these harsh chemicals are usually highly reactive and oxidizing. Photochemical smog is therefore considered to be a problem of modern industrialization. It is present in all modern cities, but it is more common in cities with sunny, warm, dry climates and a large number of motor vehicles.[15] Because it travels with the wind, it can affect sparsely populated areas as well.

2.4.5 Natural causes

An erupting volcano can also emit high levels of sulphur dioxide along with a large quantity of particulate matter; two key components to the creation of smog. However, the smog created as a result of a volcanic eruption is often known as vogue to distinguish it as a natural occurrence. The radiocarbon content of some plant life has been linked to the distribution of smog in some areas.

2.4.6 Smog and low birth weight

According to a study published in The Lancet, even a very small (5 µg) change in PM2.5 exposure was associated with an increase (18%) in risk of a low birth weight at delivery, and this relationship held even below the current accepted safe levels.

2.4.7 Ozone depletion

The Earth's ozone layer is mainly found in the lower portion of the stratosphere from approximately 20 to 30 kilometers above Earth. Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in Earth's stratosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone over Earth's polar region. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar troposphere ozone depletion events. The details of polar ozone hole formation differ from that of mid-latitude thinning but the most important process in both is catalytic destruction of ozone by atomic halogens. The main source of these halogen atoms in the stratosphere is photo dissociation of man-made halocarbon refrigerants, solvents, propellants, and foam-blowing agents [CFCs, HCFCs, freons, halons].

3 Methodology

3.1 Removal of particles from gas streams

Particulate removal devices operate basically on the principle that a gas stream containing particles is passed through a region where the particles are acted on by external forces or caused to intercept obstacles, thereby separating them from the gas stream. When acted upon by external forces, the particles acquire a velocity component in a direction different from that of the gas stream. In order to design a separation device based on particulate separation by external forces, one must be able to compute the motion of a particle under such circumstances. A preliminary selection of suitable particulate emission control systems is generally based on knowledge of four items: particulate concentration in the stream to be cleaned, the size distribution of the particles to be removed, the gas flow rate, and the final allowable particulate emission rate. Once the systems that are capable of providing the required efficiencies at the given flow rates have been chosen, the ultimate selection is generally made on the basis of the total cost of construction and operation. The size of a collector, and therefore its cost, is directly proportional to the volumetric flow rate of gas that must be cleaned. The operating factors that influence the cost of a device are the pressure drop through the unit, the power required, and the quantity of liquid needed[if a wet scrubbing system]. In this chapter we concentrate on the design equations that are generally used for calculating efficiencies of various types of particulate emission control equipment. We shall not consider the estimation of capital or operating costs.

3.2 Collection Efficiency

We define the collection efficiency η[Dp] of a device for particles of diameter Dp as

$$\eta[Dp] = 1 - \frac{\text{number of particles of diameter Dp per m3 of gas out}}{\text{number of particles of diameter Dp per m3 of gas in}}$$

The overall efficiency of the device based on particle number is

$$\eta = 1 - \frac{\text{number of particles per m3 of gas out}}{\text{number of particles per m3 of gas in}}$$

These efficiencies can be expressed in terms of the particle size distribution functions at the inlet and outlet sides of the device,

$$\eta[Dp] = 1 - \frac{\eta \text{ out Dp}}{\eta \text{ in Dp}}$$

Let us consider relationship between collection efficiency and particle size simply the collection efficiency. Other terms that are used for this quantity are the grade efficiency or the fractional efficiency. An important point on the collection efficiency curve is the size for which η = 0.5. The particle size at this point is called the cut size or the cut diameter.

3.3 Settling Chambers

Gravitational settling is perhaps the most obvious means of separating particles from allowing gas stream. A settling chamber is, in principle, simply a large box through which the effluent gas stream flows and in which particles in the stream settle to the floor by gravity. Gas velocities through a settling chamber must be kept low enough so that settling particles are not retained. The gas velocity is usually reduced by expanding the ducting into a chamber large enough so that sufficiently low velocities result. Although in principle settling chambers could be used to remove even the smallest paI1ides, practical limitations in the length of such chambers restrict their applicability to the removal of particles larger than about 50 µm. Thus settling chambers are normally used as precleaners to remove large and possibly abrasive particles, prior to passing the gas stream through other collection devices.

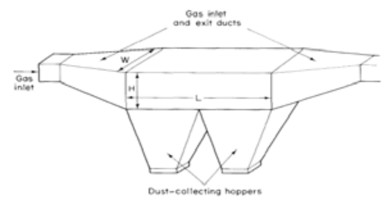

Fig. 1 Settling Chamber

3.4 Cyclone Separators

Cyclone separators are gas cleaning devices that utilize the centrifugal force created by a spinning gas stream to separate particles from a gas. A standard tangential inlet vertical reverse flow cyclone separator is shown in fig (2). The gas flow is forced to follow the curved geometry of the cyclone while the inertia of particles in the flow causes them to move toward the outer wall, where they collide and are collected. A particle of mass m_p moving in a circular path of radius r with a tangential velocity $v_o$is acted on by centrifugal force of $m_p v_o^2$ / r.. At a typical value of Vo= 10 m s $^{-1}$, r = 0.5 m, this force is 20.4 times that of gravity on the same particle. Thus we see the substantially enhanced in a cyclone the particles in the spinning gas stream move progressively closer to the outer wall as they flow through the device. There are a variety of designs of cyclone separators, differing in the manner in which the rotating motion is imparted to the gas stream. Conventional cyclones can be placed in the following categories:

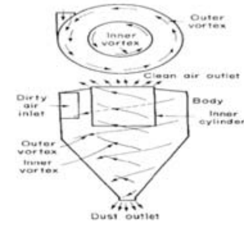

Fig. 2 Tangential inlet vertical reverse flow cyclone

3.5 Electrostatic Precipitation

Electrostatic precipitators are one of the most widely used particulate control devices, ranging in size from those installed to clean the flue gases from the largest power plants to those used as small household air cleaners. The basic principle of operation of the electrostatic precipitator is that particles are charged, an electric field is then imposed on the region through which the particle-laden gas is flowing, exerting an attractive force on the particles and causing them to migrate to the oppositely charged electrode at right angles to the direction of gas flow. If the particles collected are liquid, then the liquid flows down the electrode by gravity and is removed at the bottom of the device. If the particles are solid, the collected layer on the electrode is removed periodically by rapping the electrode. Particle charging is achieved by generating ions by means of a corona established surrounding a highly charged electrode like a wire. The electric field is applied between that electrode and the collecting electrode. If the same pair of electrodes serves for particle charging and collecting, the device is called a single-stage electrostatic precipitator. Fig. (3) shows a cylindrical single stage electrostatic precipitator.

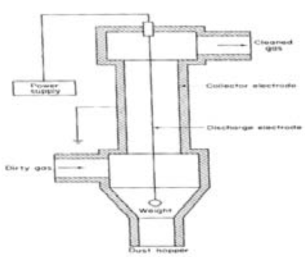

Fig. 3 Cylindrical single-stage electrostatic precipitator

3.6 Collection Efficiency of a Fibrous Filter Bed

A fibrous filter bed is viewed as a loosely packed assemblage of single cylinders. Even though the fibres are oriented in all directions in the bed, from a theoretical point of view the bed is treated as if every fibre is normal to the gas flow through the bed. Since, as we have noted, the solid fraction of the filter, ∝, is generally the order of only 10%,we assume, in addition, that each fibre acts more or less independently as a collector. Thus, to compute the particle removal by a filter bed, we basically need to determine the number of fibres per unit volume of the bed and then multiply that quantity by the efficiency of a single fibre.

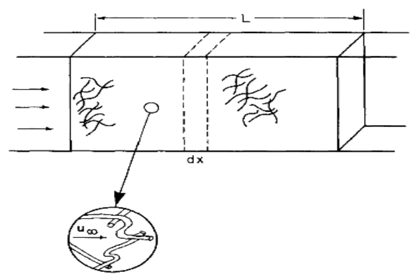

Fig. 4 Filter bed composed of an assemblage of single fibers

3.7 Wet Collectors

Wet collectors, or scrubbers, employ water washing to remove particles directly from gas stream.

4. Result and discussion

4.1 Cyclone Collection Efficiency

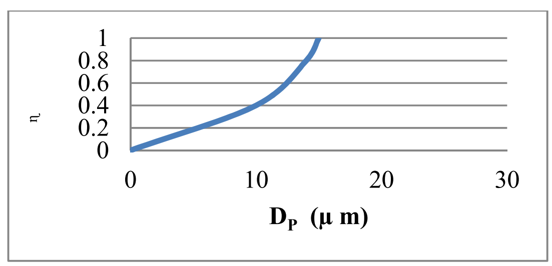

Fig. 5 Cyclone efficiency of laminar flow particle as the particle size increases the efficiency also increases so it can be said that efficiency is a function of particle size

The dirty gas enters at the top of the cyclone and is given a spinning motion because of its tangential entry. Particles are forced to the wall by centrifugal force and then fall down the wall due to gravity. At the bottom of the cyclone the gas flow reverses to form an inner core that leaves at the top of the unit. In a reverse-flow axial-inlet cyclone, the inlet gas is introduced down the axis of the cyclone, with centrifugal motion being imparted by permanent vanes at the top. In straight-through-flow cyclones the inner vortex of air leaves at the bottom [rather than reversing direction], with initial centrifugal motion being imparted by vanes at the top. This type is used frequently as a precleaner to remove fly ash and large particles. The chief advantages of this unit are low pressure drop and high volumetric flow rates

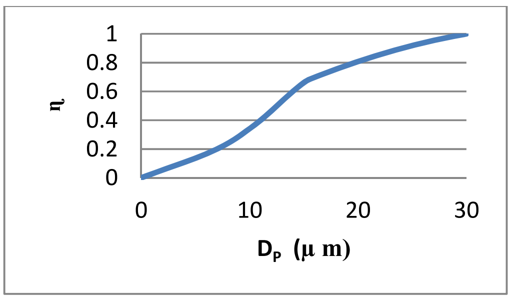

Fig. 6 Cyclone efficiency of turbulent flow particle

4.2 Efficiency of electrostatic precipitator

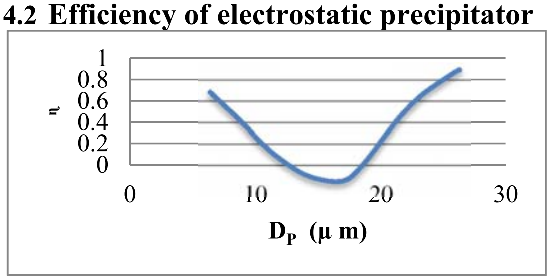

Fig. 7 Overall efficiency of the electrostatic precipitator

Overall efficiency of the electrostatic precipitator as a function of precipitator particle when particle size is kept constant and graph is drawn efficiency increases with increase in particle size .hence it can be concluded that the efficiency of ESP increases in particle size, and also Overall efficiency of the electrostatic precipitator as a function of precipitator length. When particle length is kept constant and graph is drawn efficiency increases with increase in particle length .hence it can be concluded that the efficiency of ESP increases with increase in particle length.

4.3 Efficiency Comparison

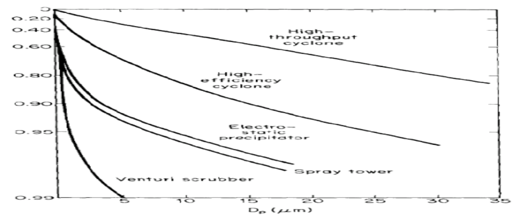

Fig. 8 Comparison of efficiencies

Collection efficiencies for gas cleaning devices hence form graph it is clear that venture scrubber has highest efficiency of all due to high relative velocity of particle collect on the electrode. If the particles collected are liquid, then the liquid flows down the electrode by gravity and is removed at the bottom of the device. If the particles are solid, the collected layer on the electrode is removed periodically by rapping the electrode. Particle charging is achieved by generating ions by means of a corona established surrounding a highly charged electrode like a wire. The electric field is applied between that electrode and the collecting electrode this is the reason why the ESP's higher efficiency as shown in fig. (8).

5. Conclusions

In this paper it is observed that cyclone separator gives maximum efficiency with increasing particle size. For laminar flow the collection efficiency is found to be maximum with a particle size about 20 μm whereas for turbulent flow the maximum efficiency observed at 30 μm particle sizes. Gravitational settler can be used to separate the particles size greater than 50 μm with efficiency more than 50%. It offers low pressure loss but requires much space. Cyclone separators are used with particle size in between 5-25 μm with efficiency in between 50-90%. Wet collectors, spray towers are used to separate particles sizes varying in between 2.5-10 μm with efficiency in between 80-99%. Electrostatic precipitator can be used to separate particles sizes less than 1 μm with efficiency in between 95-99%. Fabric filtration are found to be most effective which can be used separate particles sizes less than 1 μm with efficiency more than 99%.

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