A STUDY ON TOPIC

Physics Concepts To Control Or Reduce The Air Pollution In Metro City

PROJECT REPORT

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Abstract - It is clearly seen that air is polluted with a huge amount of pollutants. These pollutants consist of particles like SOx and NOx . With the help of mechanical process as combination of filters HEPA (which is mainly consist of PAN)+ activated charcoal , the pollutants can be converted into the soot particles which is again converted into the renewable energy with the help of plasma. The alternative solution of this problem is using Plasma DBD (Dielectric barrier discharge) technology to reduce the intensity of gasses (Sox and NOx) and release them into the air and this device is used at the exhaust of automobile .

Aim of Project :-

An approach to control air pollution in metro cities by using co-axial dielectric barrier discharge plasma system at atmospheric pressure.

Introduction :-

Pollution is a term which nowadays everyone is talking about and barely doing anything to reduce it .It has become so common that almost everyone acknowledges the fact that pollution is rising continuously. Pollution means the manifestation of any unsolicited foreign substance in something. When we talk about pollution on earth we refer to the contamination that is happening of the natural resources by various pollutants. Pollution affects the quality of life more than one can imagine it works in mysterious ways, sometimes which cannot be seen by naked.

Coal-burning power stations, motor vehicles and chemical industries are the primary source of urban air pollution. The combustion of fossil fuels is the principal source of fine particle emissions. Automotive exhaust contains hydrocarbons, nitrogen oxides, Sulphur dioxides, particulate matter and carbon monoxide. Other dangerous emissions from vehicles include toxic organic compounds such as formaldehyde, acetaldehyde and benzene. Chemical industries produce volatile organic contamination. Recent evidence suggests that diesel engine emissions are more dangerous that were previously considered. Pollution from natural sources occurs as a result of methane emission from paddy fields and from livestock and forest fires. Aerosols are mixtures of microscopic solid particles and liquid droplets in the air. Suspended particulate matter includes all air-borne particles in the size range from 0.5 to 100 microns. SPM less than 10 micron in size can pass through into the human respiratory system. Nitrogen dioxide and related Nitrogen oxides are produced when fuel is burned in power plants and motor vehicles. Nitrogen dioxide is a strong oxidizing agent that reacts in the air to form corrosive nitric acid as well as toxic organic nitrates. Ozone, the highly reactive form of Oxygen, is formed in the atmosphere by the action of sunlight on nitrogen oxides and reactive hydrocarbons emitted by motor vehicles and industrial sources. It also plays a major role in the production of smog. Carbon monoxide is a poisonous gas formed by incomplete combustion of coal, wood, charcoal or petroleum. In cities, automobile exhaust constitutes as much as 95 per cent of all carbon monoxide emissions. Other sources include industrial processes and fuel combustion in boilers and incinerators. Sulphur dioxide is formed when Sulphur-containing fuel, mainly coal and oil, is burned, primarily in power plants and diesel engines. Like nitrogen dioxide, sulphur dioxide can react in the atmosphere to form toxic particles.

Clean air is a delicately balanced mixture of Nitrogen and Oxygen, with small amounts of Argon, Carbon dioxide, Neon, Helium, and other gases . Pollutants such as ozone, aerosols, nitrous oxide, carbon monoxide and heavy metals poison this mixture, raising health risks to everyone who breathes them in. The effects on human beings have ranged from respiratory symptoms and illness impaired lung function, hospitalization for respiratory and cardiac diseases, increases in mortality. More people are suspected to die prematurely from lung disease every year, due to air pollution, than from automobile accidents.

HEPA (high-efficiency particulate air) filter, also known as high-efficiency particulate absorbing filter and high-efficiency particulate filter, is an efficiency standard of air filter.

Filters meeting the HEPA standard must satisfy certain levels of efficiency. Common standards require that a HEPA air filter must remove—from the air that passes through—at least 99.95% (ISO, European Standard) or 99.97% (ASME, U.S. DOE) of particles whose diameter is equal to 0.3 μm, with the filtration efficiency increasing for particle diameters both less than and greater than 0.3 μm. HEPA filters capture pollen, dirt, dust, moisture, bacteria (0.2-2.0 μm), virus (0.02-0.3 μm), and submicron liquid aerosol (0.02-0.5 μm).HEPA filters are composed of a mat of randomly arranged fibers . The fibers are typically composed of polypropylene or fiberglass with diameters between 0.5 and 2.0 micrometer . Most of the time, these filters are composed of tangled bundles of fine fibers. These fibers create a narrow convoluted pathway through which air passes. When the largest particles are passing through this pathway, the bundles of fibers behave like a kitchen sieve which physically blocks the particles from passing through. However, when smaller particles pass with the air, as the air twists and turns, the smaller particles cannot keep up with the motion of the air and thus they collide with the fibers. The smallest particles have very little inertia and they always move around the air molecules like they are bombarded by these molecules (Brownian motion). Because of their movement, they end up crashing into the fibers. Key factors affecting its functions are fiber diameter, filter thickness, and face velocity. The air space between HEPA filter fibers is typically much greater than 0.3 μm. HEPA filters in very high level for smallest particulate matter. Unlike sieves or membrane filters, where particles smaller than openings or pores can pass through, HEPA filters are designed to target a range of particle sizes.

These particles are trapped (they stick to a fiber) through a combination of the following three mechanisms: diffusion, interception, impaction . HEPA filters are designed to target a range of particle sizes.

Carbon air filters are the filters most commonly used to remove gases. They are designed to filter gases through a bed of activated carbon (also called activated charcoal) and are usually used to combat volatile organic compounds (VOCs) released from common household products. They are also often used to remove odors from the air, such as the smell of tobacco smoke. They cannot remove fine particles like mold, dust, or pollen from the air.
Activated carbon air filters remove pollutants from the air with a process known as adsorption. In absorption, the substance you want to remove (let's say water) is absorbed into the structure of the absorbent (like a sponge), but it doesn't become a part of the absorbent on a molecular level. Therefore, when you absorb water with a sponge, the water does not become chemically bonded to the sponge. It just fills in the spaces inside it.

Carbon filters on the other hand use ad-sorption, not ab-sorption. The key difference here is that during adsorption the pollutants stick to the outside of the carbon. Whereas with absorption, the pollutants are absorbed inside the structure itself–as with the sponge.

Carbon is a lattice of carbon atoms connected to each other. The activation process is so important because the increase in surface area gives gases a greater area to stick to. When a molecule of some gaseous substance comes through the carbon, it can stick to the surface of the bed, provided there is an open adsorption site.

The process of adsorption allows carbon air filters to filter organic chemicals (gases) from the air. The problem with the activated carbon bed is that over time, the gaseous pollutants increasingly fill up the adsorption sites of the activated carbon. Once the bed is saturated, the filter can no longer trap pollutants. In fact, chemicals with a greater affinity for an adsorption site can displace those with lesser affinity, and the affinity of a given chemical for the sorbent is highly dependent on ambient conditions such as temperature and relative humidity. So, as conditions change, different chemicals may be released from the filter. When a carbon air filter is saturated, you might notice it giving off a strange odor. This is a strong indicator that it's time to change your carbon filter.

So with the help of a mechanical process we can combine HEPA and activated charcoal filter to increase the efficiency of the filter which can also help in the cost cutting. HEPA has the efficiency upto 99% but it is very expensive. HEPA can only filter micron range and bigger particles but it is unable to filter small particulates. This is achieved with the use of activated Charcoal filter. The activated charcoal filter has the great efficiency for filtering gas particles but it is not heat resistant. Also it has negligible making cost (as made by coconut shell). The combination of HEPA and Charcoal filter is an approach to solve the problem of gas filtration with increased efficiency of the device. However, fabrication of such device is complicated and require a lot of mechanical processing. As an alternative approach, one can also use non-thermal plasma technology. Earlier the plasma technology is proposed for pollution control application at different laboratories. The plasma process also supports in conversion of decomposed particles into a renewable energy. We are proposing to use a dielectric barrier discharge device operated at atmospheric pressure for decomposition of polluting gases and to generate useful renewable energy.

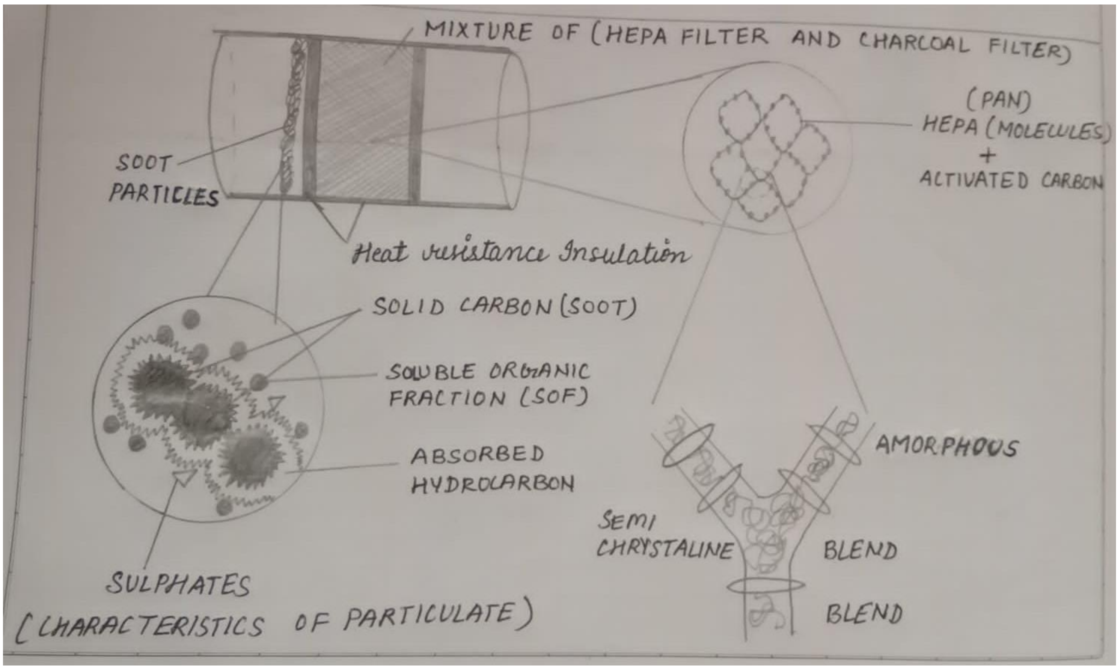

Figure: COMBINATION OF HEPA AND ACTIVATED CARBON

What is Plasma?

Plasma is the fourth state of matter.

We are using plasma for the decomposition of harmful gases like SOx and NOx.

In non-equilibrium plasmas, electrons have an energy distribution different from, and not in equilibrium with, that of the heavy particles. Thus, the electron gas can be assigned a temperature substantially higher than that of the heavy neutrals or ions. The high energy of the electrons is then preferentially directed to produce excitation, dissociation and ionisation by electron impact to produce radicals that, in turn, decompose the toxic molecules. Plasma chemical reactions can be targeted to transform specific species. Energetically, this is a far more efficient way of using the plasma properties for the required transformation, in contrast to the use of thermal energy of the plasma to break up the molecules by thermal dissociation. This is especially true in many practical applications where the toxic molecules form a dilute concentration. This has to be contrasted with the sledgehammer and fly approach of incineration.

A characteristic of the silent discharge is that a dielectric layer covers at least one of the electrodes, sometimes both. For this reason the silent discharge is also referred to as the "dielectric-barrier discharge," or simply, "barrier discharge." The dielectric is the key for the proper functioning of the discharge. Once ionization occurs at a location in the discharge gap the transported charge accumulates on the di-electric. Atthe maximum and minimum of the applied voltage the displacement current is zero (dU/dt = 0) and the micro discharge activity stops, only to start again when the breakdown field is reached in the gap during the next half-wave.

TOOLS AND TECHNIQUES

Dielectric(insulation),barrier discharge , electrodes , supply ac , supply of oxygen ,semi bounded coil(high AC voltage Supply(kilovolts), high frequency(Khz),distance between two electrodes (0.5 to 1 cm).

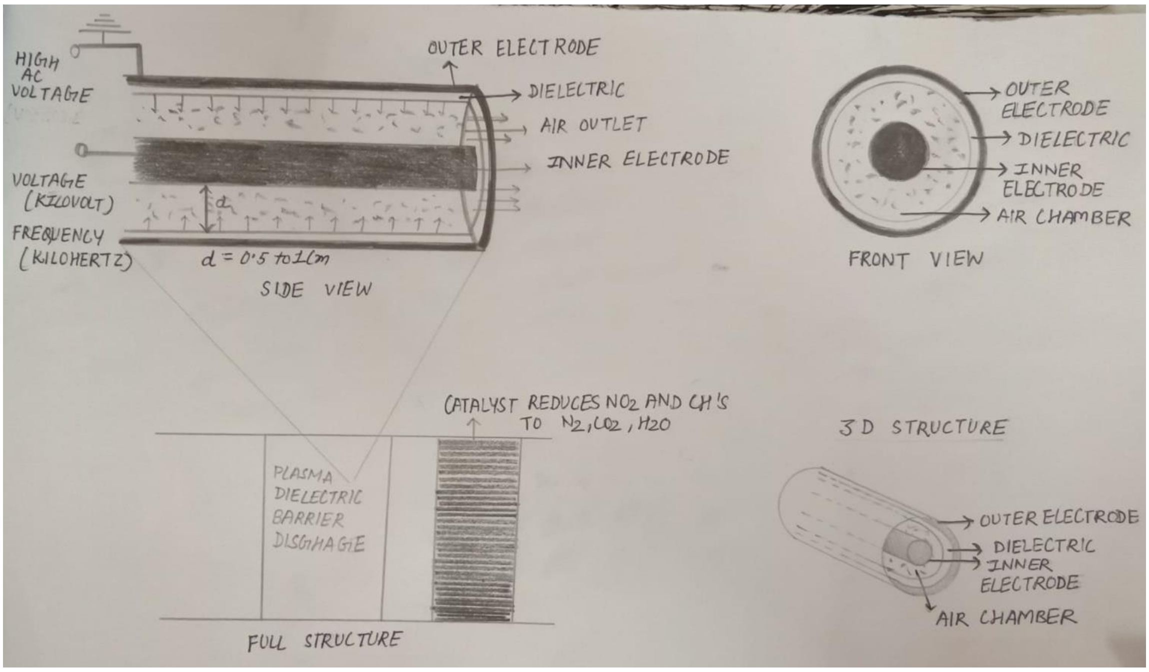

Figure : Cylindrical plasma dielectric barrier discharge filter(setup)

Plasma application to pollution control will be meaningful and widely applicable only with the availability of devices to produce non-equilibrium plasmas at atmospheric pressures. This is because of the high throughput requirements of the process to match the effluent flow rates in typical systems like a power station. Such plasma sources are based either on high energy electron-beam irradiation or electrical discharge methods. The latter category consists of pulsed corona, dielectric barrier, surface and packed-bed corona discharges. All atmospheric pressure non-equilibrium plasms discharges are based on techniques which prevent the transition of glow discharge into an arc discharge. Electrical energy deposited into the discharge produces electrons with a typical energy of less than 5 eV [Penctrante,1995], which gives them much higher average kinetic energies than the surrounding gas-phase ions and molecules. These energetic electrons can interact with the background gas to produce highly reactive species like radicals, anions, cations and secondary electrons) that will preferentially destroy pollutants.

METHODOLOGY

Barrier discharges or silent discharges are characterized by the presence of at least one dielectric layer between the electrodes (Kogelschatz, 2004; Wagner et al., 2003). Typical materials for dielectric barriers are glass, quartz and ceramics. The discharge gap is usually in the range of 1 mm. There is a planar surface barrier discharge, i.e. both electrodes (metal meshes) are in direct contact with the dielectric plates. Another type of DBD is the so-called coplanar discharge where both electrodes are embedded in the dielectric material. Due to the capacitive coupling of the insulating material to the gas gap DBDs can only be driven by alternating feeding voltage or pulsed DC voltages. When a sufficient voltage is applied to the electrodes, electrical breakdown occurs most commonly as number of individual discharge filaments or micro discharges (Kogelschatz, 2002). Micro discharges have a small duration (tens of nanoseconds in air), small size (diameter about 100 µm) (Brandenburg, 2005) and are distributed over the whole surface area. Due to the local charging of the dielectric surface after micro discharge inception the local electric field is weakened leading to the extinction of the micro discharge after several ten nanoseconds. Thus the barrier prevents the formation of a spark or arc discharge, keeping the plasma in the non-thermal regime. Despite the numerous applications of DBDs the knowledge on micro discharge development and thus plasma parameters and elementary processes within these micro plasmas is not sufficient, although the multitude of subsequent micro discharges determines the efficiency and selectivity of the exhaust gas treatment.

Chemical processes in non-thermal plasmas are based on non-thermal activation of particles via collisions. The quality and quantity of collisions is determined by the density and the kinetic parameters (e.g. mean velocity, collision frequency) . In general three different phases has to be distinguished. The first phase is characterized by the electrical breakdown of the gas (e.g. in form of short-lived micro discharges as described above) where free electrons with high kinetic energies are produced via ionising collisions.

1.	Ionisation:	$AB + e^- \rightarrow AB^+ + 2e^-$
2.	Dissociation:	$AB + e^- \rightarrow A + B + e^-$

3.	Dissociative Ionisation:	$AB + e^- \rightarrow A^+ + B + 2e^-$
4.	Excitation:	$AB + e^- \rightarrow AB^* + e^-$
5.	Penning-Ionisation:	$M^* + A_2 \rightarrow A_2^+ + M$
6.	Penning-Dissociation:	$M^* + A_2 \rightarrow 2A + M$
7.	Attachment:	$AB + e^- \rightarrow AB^-$ $AB + e^- \rightarrow A^- + B$
8.	Charge transfer:	$AB^+ + C \rightarrow AB + C^+$
9.	Recombination:	$AB^+ + e^- \rightarrow AB$ $A^+ + B^- \rightarrow AB$
10.	Ion-Molecule reaction:	$I^+ + AB \rightarrow$ products
11.	Dissociate recombination:	$AB^+ + e^- \rightarrow$ products
12.	Detachment:	$AB^- \rightarrow A + B + e^-$

In air plasmas reactive oxygen species are generated by direct electron collisions (13-16), via Penning-processes (17-19) and charge exchange (20) with subsequent ion-molecule reaction 238 Monitoring, Control and Effects of Air Pollution (21) from O_2 and H_2O. Furthermore in non-thermal plasmas generated in oxygen containing atmospheres at low gas temperatures ozone, and other a strong oxidizing agents like O, •OH and $HO•_2$ will be formed.

13.	$e^- + O_2 \rightarrow 2\,O(^3P) + e^-$
14.	$e^- + O_2 \rightarrow O(^3P) + O(^1D) + e^-$
15.	$e^- + O_2 \rightarrow O_2(^1\Delta) + e^-$
16.	$e^- + H_2O \rightarrow O• + •OH + e^-$
17.	$N(^2D) + H_2O \rightarrow •OH + NH$

18.	$O(1D) + H_2O \rightarrow 2 \bullet OH$
19.	$N_2(A) + H_2O \rightarrow \bullet OH + H + N_2$
20.	$H_2O^+ + H_2O \rightarrow \bullet OH + H_3O^+$

IMPLEMENTATION OF IDEA:-

Plasma dielectric barrier discharge (DBD) filter is used in filtration of exhaust gases releases during in complete combustion of fuel like SOx and NOx for purifying the gases or making the intensity of harmful gases at a very low level. These type of DBD filters can be used in the automobile industries in the form of a cylindrical valve which can be inserted in the fuel exhaust pipe of the motor vehicles , other smoke creating manufacturing industries and other emission creating motors like generators , chimneys , and other things where intensity of harmful gases like SOx NOx can be decreased. Its efficiency can be increased by using of hydrocarbons in particular.

OUTCOME AND SCOPE :-

New pathways for NO oxidation are introduced most of which primarily result in the formation of NO;. Briefly, when the O_2 concentration is higher than 5% the plasma gas phase chemistry is initiated mainly by the production of oxygen radicals via electron induced dissociation of Oz. The dissociation of O_2 promotes the gas-phase oxidation of NO NO to NO_2. In the absence of hydrocarbons, the efficiency of NO_2 production via three body reaction of NO with O will be reduced as a result of the reverse reaction of NO_2 with O and also by conversion of NO to acid in the presence of NO water vapour in the gas exhaust. It is well known that when hydrocarbon is added to the gas mixture. NO to NO_2 oxidation is enhanced to a large extent as the amount of hydrocarbon increases. The hydrocarbon acts as a getter of O and OH radicals. with the resulting products reacting with O_2 to yield per-oxy radicals (HO_2) which efficiently convert NO to NO_2 at high energy density in order to show how the hydrocarbon (propene in our case) affect the non-thermal plasma treatment respectively, for plasma processing at room temperature. In the of NO, in oxygen-rich exhausts. Then, experimental results absence of hydrocarbons, the oxygen radicals are responsible at lower energy density are presented.

Increasing environmental awareness and regulatory pressures are the drivers for finding energy efficient methods to remove nitrogen oxides and particulates from diesel exhaust. The air-fuel ratio in the internal combustion engine has a marked effect on the emission of hydrocarbons, as the ratio becomes leaner with stoichiometrically less fuel, the emission decreases. Improvement in diesel engine performance, however, appears to have reached a plarcau and some other form of after treatment seems to have become necessary. Diesel particulate traps suffer from the requirement of continuous regeneration to avoid uncontrolled burn of the accumulated particulates. With conventional catalyst technology ineffective under the lean burn conditions, the emerging technology is to combine plasma techniques with catalysts without the use of additives. In contrast to power plant applications, non-thermal plasma techniques used in treating vehicular emissions have to initiate NO, reduction to avoid the need for scrubbing the process products. This is not trivial since the engine exhaust is a highly oxidising environment.

In the hot environment of the engine exhaust, at typically 300° C, it has been shown that only 10 per cent of the NO is oxidised in a stream of 500 ppm NO in 10 per cent O, and balance N, However, in the present of 1,000 ppm C,H, the conversion efficiency increases to more than 80 Per cent. This is attributed to the consumption of Oxygen radicals during reactions with hydrocarbon molecules. Thus, the presence of hydrocarbons appears to be critical to plasma oxidation of NO in hot engine exhausts.

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