Reduction of Air Pollution in Industries

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Abstract

For normal and healthy living conducive environment is required by all living things, including humans, livestock, plants, micro-organisms and the wildlife. The favorable unpolluted environment has a specific composition. The certain substances are present in concentrations which can cause undesirable effects on this specific composition. When this composition gets changed by addition of above substances, the environment is called polluted environment and the substances polluting it is called pollutants. It includes gases, particulate matter, radioactive substances etc… keep these things in the mind, and following project is analyzed.

The rapid industrialization has disturbed the balance of natural atmosphere. In fossil fuel burning coal, oil, natural gas and gasoline are consumed by industry. Power plants and automobiles increasing the atmospheric store of carbon by 6.1Gt of carbon each year. In 1850 atmospheric carbon monoxide was about 280ppm (parts per million). In 1990's it was about 385ppm at present more than 450ppm. As like other contaminants caused by various sources also increased in the atmosphere. To control this concentration of pollutants the emission rate should be restricted to permissible levels by each and every industry. Even though, the atmosphere as several built in self cleaning process, control of contaminants at their source is a more desirable and effective method through preventive or control technologies.

In this aspect, incorporation of CNS precipitator with two different compactable models in the design of plant layout is studied. When the coal is ignited, the electrostatic force is introduced which separate the unwanted pollutants from exhausted gas based on the theory of electrolytic conductance. Additionally, the rate of liberation of oxygen to atmosphere is enhanced. The exhaustion of pollutants after passing through CNS precipitator by changing terminals analysis helps the conformation of removal of undesirable substances is explained elaborately. Finally, the ultimate aim of the project is "to control the air pollution and increase the liberation of oxygen to the atmosphere from exhausted gas".

Keywords: Air pollution, Environment, Industrialization, CNS   precipitator, Electrostatic force.

1. Introduction

The natural environment encompasses all living and non-living things occurring naturally on Earth or some region thereof. It is an environment that encompasses the interaction of all living species. The natural environment is contrasted with the built environment, which   comprises the areas and components that are strongly influenced by humans. Universal natural resources and physical phenomena that lack clear-cut boundaries, such as air, water, and climate, as well as energy, radiation, electric charge, and magnetism, not originating from human activity. But these natural resources are being misused by human and one of the major problems that the environment is facing is pollution. There are different kinds of pollutions and one among them is the air pollution which is the significant one and it causes many demerits to the whole human race and also the mother earth. Indoor air pollution and urban air quality are listed as two of the world's worst pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. So, I did this research in air pollution. Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems.

2. Literature review

Hohlfeld [1]: The first use of corona discharge to remove particles from an aerosol was by Hohlfeld in 1824. An electrostatic precipitator (ESP) or electrostatic air cleaner is a particulate collection device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge. Electrostatic precipitators are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulate matter such as dust and smoke from the air stream. In contrast to wet scrubbers which apply energy directly to the flowing fluid medium, an ESP applies energy only to the particulate matter being collected and therefore is very efficient in its consumption of energy (in the form of electricity).

Prof. Cottrell [2]: At the time of Cottrell's invention, the theoretical basis for operation was not understood. The operational theory was developed later in the 1920s, in Germany. Prof. Cottrell used proceeds from his invention to fund scientific research through the creation of a foundation called Research Corporation in 1912 to which he assigned the patents. The intent of the organization was to bring inventions made by educators (such as Cottrell) into the commercial world for the benefit of society at large. The operation of Research Corporation is perpetuated by royalties paid by commercial firms after commercialization occurs. Research Corporation has provided vital funding to many scientific projects: Goddard's rocketry experiments, Lawrence's cyclotron and the production methods for vitamins A and B_1, among many others. By a decision of the U.S. Supreme Court the Corporation had to be split into two entities, the Research Corporation and two commercial firms making the hardware: Research-Cottrell Inc. (operating east of the Mississippi River) and Western Precipitation operating in the Western states. The Research Corporation continues to be active to this day and the two companies formed to commercialize the invention for industrial and utility applications are still in business as well. Electrophoresis is the term used for migration of gas-suspended charged particles in a direct-current electrostatic field. A negative voltage of several thousand volts is applied between wire and plate. If your television set accumulates dust on the face it is because of this phenomenon (a CRT is a direct-current machine operating at about 35kV).

Perry, J. H. (Ed.). 1973 [3]: The term wet scrubber describes a variety of devices that remove pollutants from a furnace flue gas or from other gas streams. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants. The design of wet scrubbers or any air pollution control device depends on the industrial process conditions and the nature of the air pollutants involved. Inlet gas characteristics and dust properties (if particles are present) are of primary importance. Scrubbers can be designed to collect particulate matter and/or gaseous pollutants. Wet scrubbers remove dust particles by capturing them in liquid droplets. Wet scrubbers remove pollutant gases by dissolving or absorbing them into the liquid. Any droplets that are in the scrubber inlet gas must be separated from the outlet gas stream by means of another device referred to as a mist eliminator or entrainment separator (these terms are interchangeable). Also, the resultant scrubbing liquid must be treated prior to any ultimate discharge or being reused in the plant. There are numerous configurations of scrubbers and scrubbing systems, all designed to provide good contact between the liquid and polluted gas stream.

Rhodes M. (1998) [4]: Cyclonic separation is a method of removing particulates from an air, gas or liquid stream, without the use of filters, through vortex separation. Rotational effects and gravity are used to separate mixtures of solids and fluids. The method can also be used to separate fine droplets of liquid from a gaseous stream. A high speed rotating (air) flow is established within a cylindrical or conical container called a cyclone. Air flows in a helical pattern, beginning at the top (wide end) of the cyclone and ending at the bottom (narrow) end before exiting the cyclone in a straight stream through the center of the cyclone and out the top. Larger (denser) particles in the rotating stream have too much inertia to follow the tight curve of the stream, and strike the outside wall, then falling to the bottom of the cyclone where they can be removed. In a conical system, as the rotating flow moves towards the narrow end of the cyclone, the rotational radius of the stream is reduced, thus separating smaller and smaller particles. The cyclone geometry, together with flow rate, defines the cut point of the cyclone. This is the size of particle that will be removed from the stream with a 50% efficiency. Particles larger than the cut point will be removed with

a greater efficiency and smaller particles with a lower efficiency. Airflow diagram for Aerodyne cyclone in standard vertical position Secondary air flow is injected to reduce wall abrasion. Airflow diagram for Aerodyne cyclone in horizontal position an alternate design. Secondary air flow is injected to reduce wall abrasion, and to help move collected particulates to hopper for extraction. An alternative cyclone design uses a secondary air flow within the cyclone to keep the collected particles from striking the walls, to protect them from abrasion. The primary air flow containing the particulates enters from the bottom of the cyclone and is forced into spiral rotation by stationary spinner vanes. The secondary air flow enters from the top of the cyclone and moves downward toward the bottom, intercepting the particulate from the primary air. The secondary air flow also allows the collector to optionally be mounted horizontally, because it pushes the particulate toward the collection area, and does not rely solely on gravity to perform this function. Large scale cyclones are used in sawmills to remove sawdust from extracted air. Cyclones are also used in oil refineries to separate oils and gases and in the cement industry as components of kiln pre-heaters. Cyclones are increasingly used in the household, as the core technology in bag less types of portable vacuum cleaners and central vacuum cleaners. Cyclones are also used in industrial and professional kitchens for separating the grease from the exhaust air in extract hoods.[1] Smaller cyclones are used to separate airborne particles for analysis. Some are small enough to be worn clipped to clothing, and are used to separate repairable particles for later analysis. Analogous devices for separating particles or solids from liquids are called hydro cyclones or hydro clones. These may be used to separate solid waste from water in wastewater and sewage treatment.

Dominick DalSanto [5]: Commonly known as bag-houses, fabric collectors use filtration to separate dust particulates from dusty gases. They are one of the most efficient and cost effective types of dust collectors available and can achieve a collection efficiency of more than 75% for very fine particulates. Dust-laden gases enter the bag-house and pass through fabric bags that act as filters. The bags can be of woven or felted cotton, synthetic, or glass-fiber material in either a tube or envelope shape.

3. CNS Precipitator process
Pollution can be minimized by using CNS precipitator - Carbon, Nitrogen, Sulphur precipitator. CNS precipitator is not only arrest the carbon, nitrogen, sulphur; it also arrests the all gas molecules in exhaust gas. Since, in this precipitator reduction process is efficient, oxygen output rate is increased and pollutant output is minimized.

4. Principle of process
This process work on the principle of: "theory of electrolytic conductance". Arrhenius Theory says "In water solution, the neutral electrolytic molecule is split up into two types of charged particles. This particle was called as ions & the process is known as ionization". This theory is used in air gas molecule.

$$A\ B \rightarrow A^+ + B^-$$
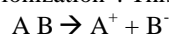
Example:
In water solution, NaCl exists as Na^+Cl^-, In air, HCl gas exists as H^+Cl^-.
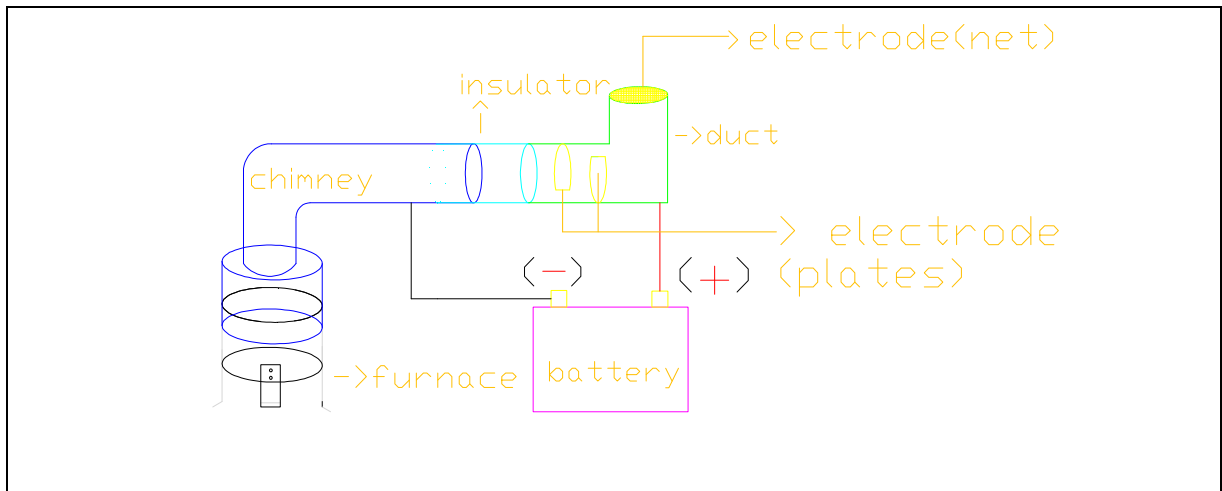
5. Experimental setup

Figure 1. Experimental setup

The main parts of CNS precipitator is

- Furnace,
- chimneys,
- Duct,
- Electrode,
- Battery (15v).

The chimney is fitted over the furnace. All sides of duct is covered by insulator, one end of the duct is fitted into chimneys and another end covered by net. In duct, the plates are fixed. Each plate cut in one side and cutting side of plate is placed opposite to each other that are shown in figure. The net, plates is act as an electrode. Finally, the positive terminal of 15v battery is connected to the net & negative terminal of 15v battery is connected to chimneys. Insulator is used to separate the duct & chimney.

6. Working of process

6.1 When positive charge given to the electrodes
The same charges particles are repelled. Both carbon & electrode carries positive charge, if the voltage of positive electrode is greater than standard voltage of positive molecules in exhaust. Therefore, the exhaust gas molecule bond will break and forced to strike the wall and settled on the surface of the duct.

6.2 When negative charge given to the electrodes
Always opposite charges are attracted. When dust air is passed through the electrode (15v) of positive ions of gas molecules are attracted by negative ions. If the voltage of negative electrode is greater than standard voltage of positive molecules in exhaust gas, the positive molecules in exhaust gas loses the voltage to negative electrode. The voltage lost molecule fall down in duct. The carbon molecule loses the charge, and converted into dust molecules.

7. Reduction process involve in the cns
Table 1. Reduction process involve in the CNS

parameters	Reduction
Carbon dioxide	$CO_2 \rightarrow C + O_2$
Carbon monoxide	$2CO \rightarrow 2C + O_2$
Oxides of Nitrogen	$NO_X \rightarrow N + O_X$
Oxides of Sulphur	$SO_X \rightarrow S + O_X$

The carbon dioxide is reducing into carbon and oxygen. The carbon monoxide is reducing into carbon and oxygen. The oxides of nitrogen are reducing into nitrogen and oxygen. The oxides of sulphur is reducing into sulphur and oxygen.

8. Selection of voltage for electrode

Standard potential: The maximum or minimum voltage accepts by the substance, without any disturbance in the substance that is called as standard voltage. The standard potential means the potential of a redox reaction, when it is at equilibrium, in relation to zero. When the standard potential exceeds zero, we are dealing with an oxidation reaction. When the standard potential is below zero, we are dealing with a reduction reaction. The standard potential of electrons is expressed in volt (V), by the symbol V^0.

Table 2. Selection of voltage for electrode

Parameters	Standard voltage
Carbon	11.26v
Sulphur	10.36v
Nitrogen	14.53v

When voltage given to the electrode should be greater than std. voltage of C, N, S. So, the 15v is given.

9. Testing of CNS process

9.1 Chemical test

9.1.1 Carbon dioxide & carbon monoxide

The dissolved calcium hydroxide is taken in 100ml beaker. Air is allowed to pass through it. The formation of white turbidity indicates the presence of Carbon dioxide & carbon monoxide.

9.1.2 Oxides of sulphur

The barium oxide is taken 100ml beaker. Air is allowed to pass through it. Formation of barium sulphate (milky colour) indicates the presence of oxides of sulphur.

9.1.3 Oxides of nitrogen

Elemental analysis gives amount of nitrogen content.

9.2 Actual reading test

Table 3. Actual reading test

parameters	Actual reading			
	Without fitting duct	Fitting the duct (electrostatic precipitator)	Given current to duct	Given current to duct
No. of electrode	No	Two	Two	Two
charge	No	No	Positive	Negative
CO (%)	1.44	1.09	0.28	0.1
Hydrocarbons (ppm)	1167	480	130	87
CO_2 (%)	10	5.3	1.2	0.5
O_2 (%)	8.29	14.08	18.90	20.4

This test will be approved by the **"Tamilnadu pollution control board"** on the date of **31 august 2011.**

10. Result and discussion

10.1 Efficiency calculation

 The pollutant molecules are carbon monoxide, hydrocarbon to compare each test to calculate the efficiency as follows below:

10.1.1 Efficiency of electrostatic precipitator
Table 4. Efficiency of electrostatic precipitator

parameters	Actual reading		Efficiency = $\frac{\text{initial process- final process}}{\text{initial process}}$ *100 (%)
	Without fitting electrode	Fitting the electrode (electrostatic precipitator)	
No. of electrode	**No**	**Two**	-
charge	**No**	**No**	-
CO (%)	**1.44**	**1.09**	**24.31**
Hydrocarbons (ppm)	**1167**	**480**	**58.87**
CO_2 (%)	**10**	**5.3**	Average = 41.59%
O_2 (%)	**8.29**	**14.08**	

 The net efficiency of electrostatic precipitator is **41.59%**

10.1.2 Efficiency of CNS precipitator (positive charge given to electrode)
Table 5. Efficiency of positive charge given to electrode

parameters	Actual reading		Efficiency = $\frac{\text{initial process- final process}}{\text{initial process}}$ *100 (%)
	Without fitting electrode	Given current to electrode	
No. of electrode	**No**	**Two**	-
charge	**No**	**Positive**	-
CO (%)	**1.44**	**0.28**	**80.56**
Hydrocarbons (ppm)	**1167**	**130**	**88.86**
CO_2 (%)	**10**	**1.2**	**Average = 84.71%**
O_2 (%)	**8.29**	**18.90**	

The net efficiency of CNS precipitator (positive charge given to electrode) is 84.71%

10.1.3 Efficiency of CNS precipitator (negative charge given to electrode)
Table 6. Efficiency of negative charge given to electrode

parameters	Actual reading		Efficiency = $\frac{\text{initial process- final process}}{\text{initial process}}$ *100 (%)
	Without fitting electrode	Given current to electrode	
No. of electrode	**No**	**Two**	**-**
charge	**No**	**Negative**	**-**
CO (%)	**1.44**	**0.1**	**93.06**
Hydrocarbons (ppm)	**1167**	**87**	**92.54**
CO_2 (%)	**10**	**0.5**	Average = 92.80%
O_2 (%)	**8.29**	**20.4**	

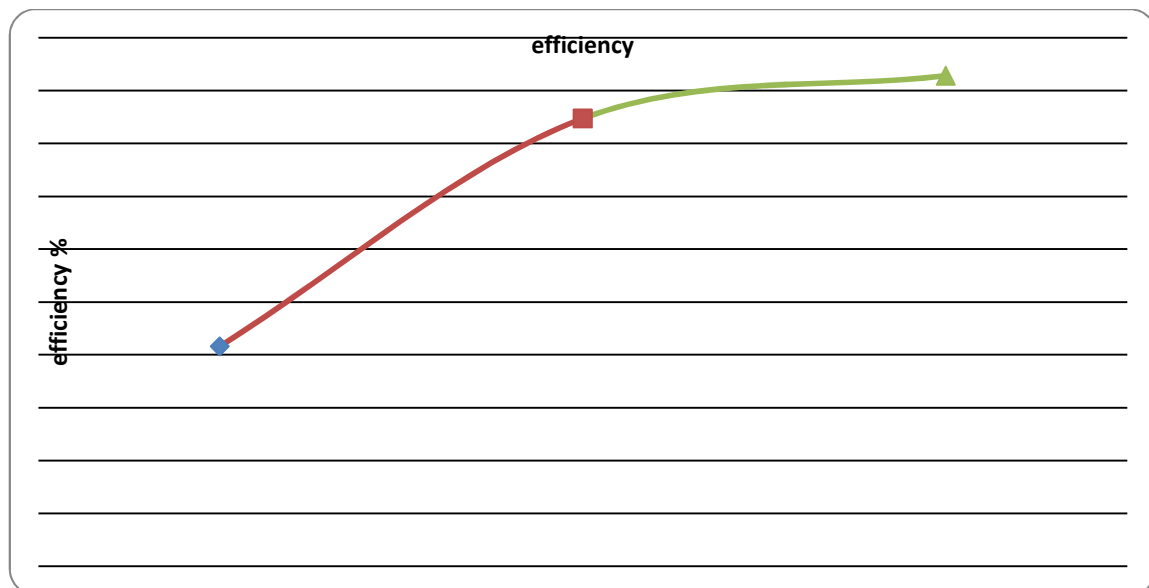The net efficiency of CNS precipitator (negative charge given to electrode) is 92.80%

Figure 2. Efficiency

10.2 Result of efficiency calculation

The calculation of efficiency proves that pollution rate. Those are following below:

Efficiency between initial process and negative charge given to electrode is greater than Efficiency between initial process and positive charge given to electrode is greater than Efficiency between initial process and electrostatic precipitator. This proves that the negative charge is given to the electrode is the best process to reduce the pollution.

10.3 Comparison of electrode

Table 7. Comparison of electrode

parameters	Actual reading			
	Given current to duct	**electrostatic precipitator**	**Given current to duct**	**Given current to duct**
No. of electrode	one	two	two	two
charge	Positive	No	Positive	negative
CO (%)	1.13	1.09	0.28	0.1
Hydrocarbons (ppm)	2100	480	130	87
CO_2 (%)	8.3	5.3	1.2	0.5
O_2 (%)	10.21	14.08	18.90	20.4

10.4 Result of comparison of single and double electrode

The calculation proves them the number of electrode is inversely proportional to pollution rate. When number of electrode increases, pollution rate will be decreases. When number of electrode decreases, pollution rate will be increases.
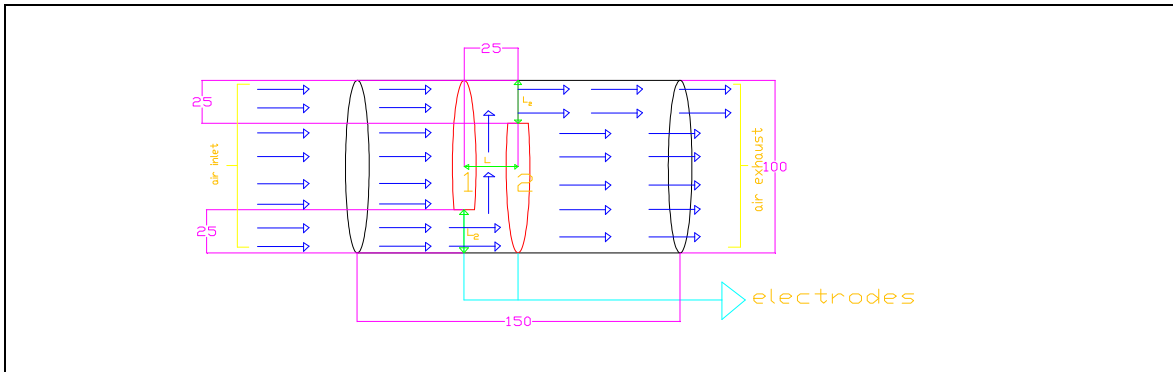
10.5 Calculation of electrode placed in duct

Figure 3. Calculation of electrode placed in duct

The electrode is not placed easily in duct. The calculation is used to use to place the electrode in duct. This calculation is follows below:

Consider the duct at 100 cm diameter and taken the two electrode have the same 100cm diameter of the duct and height of duct is 150cm that are shown in figure.

When taken two electrodes his diameter is 100cm. when electrode is cut into same distance. When electrode 1 is considered as L1 and cutting distance is 75cm. when electrode 2 is considered as L2 and the distance is 75cm. the in between distance of electrode is taken as L that have 25cm. when electrode is cut from any end through centre.

$$L = L1 = L2 = 25cm$$

When electrode 1 cutting face is face downward placed in duct. When electrode 2 cutting face is face upward placed in duct. The in between distance of electrodes is same as cutting face of two electrode. This is the correct method to fit the electrode in duct. If we change the fitting of electrode, the pollution is reduced into minimum rate.

10.6 Analysis of fuel

Fuel: charcoal

'Carbon' is derived from the Latin word 'carbo,' meaning charcoal. Carbon has been known since ancient times in the form of soot, charcoal, graphite and diamonds. So, carbon is called as charcoal.

Table 9. properties of fuel

General properties	
Name	Carbon (charcoal)
Type	Non-Metal, Carbon group
Symbol	C
Atomic weight	12.011
Atomic volume	5.3 cc/mol
State	solid
Melting point	3823 K (3550 ^{o}C)
Boiling point	4300 K (4027 ^{o}C)
Energies	
Specific heat capacity	At 300K. 709 J/(kg.K)
Heat of fusion	117 kJ mol^{-1} (graphite)
1st ionization energy	1086.5 kJ mol^{-1}
3rd ionization energy	4620.5 kJ mol^{-1}
Heat of atomization	717 kJ mol^{-1}
Heat of vaporization	710.9 kJ mol^{-1}
2nd ionization energy	2352.6 kJ mol^{-1}

Electron affinity	121.55 kJ mol^{-1}
Oxidation & Electrons	
Shells	2, 4
Minimum oxidation number	-4
Min. common oxidation no.	-4
Electro negativity (Pauling Scale)	2.55
Electron configuration	$1s^2\ 2s^2\ 2p^2$
Maximum oxidation number	4
Max. Common oxidation no.	4
Polarizability volumes	1.8 Å^3
Reactions & Compounds	
Oxide(s)	CO , CO_2, SO_X, NO_X
Hydride(s)	CH_4 and many C_xH_y
Reaction with 6 M HCl, Reaction with 6 M NaOH	None
Chloride(s)	CCl_4
Reaction with HNO$_3$	$C_6(CO_2H)_6$
Radius	
Atomic radius	70 pm
Ionic radius (2+ ion)	pm
Ionic radius (2- ion)	pm
Ionic radius (1+ ion)	pm
Ionic radius (3+ ion)	pm
Ionic radius (1- ion)	pm
Conductivity	
Thermal conductivity	1.7W/(m.K)
Electrical conductivity	0.07×10^6 S cm^{-1}

10.7 Specification of electrode

Table 8. Analysis of electrode

Grey cast iron ASTM 40			
Chemical composition: C=2.7-4%, Mn=0.8%, Si=1.8-3%, S=0.07% max, P=0.2% max			
Property	**Value in metric unit**		**Value in US unit**
Density	7.06×10^3- 7.34×10^3	kg/m³	441-458	lb/ft³
Modulus of elasticity	124	GPa	18000	ksi
Thermal expansion (20 ºC)	9.0×10^{-6}	ºC⁻¹	5.0×10^{-6}	in/(in* ºF)
Specific heat capacity (25 ºC)	490	J/(kg*K)	0.117	BTU/(lb*ºF)
Thermal conductivity	53.3	W/(m*K)	370	BTU*in/(hr*ft²*ºF)
Electric resistivity	1.1×10^{-7}	Ohm*m	1.1×10^{-5}	Ohm*cm
Tensile strength	276	MPa	40000	psi
Elongation	1	%	1	%
Shear strength	400	MPa	58000	psi
Compressive yield strength	Min. 827	MPa	Min. 120000	psi
Fatigue strength	138	MPa	20000	psi
Hardness (Brinell)	180-302	HB	180-302	HB

Wear resistance	Low
Corrosion resistance	Low
Weldability	Low
Machinability	Good
Castability	High

10.8 Analysis of temperature and pressure

10.7.1 Temperature
Inlet temperature (before electrode): 104^oC
Exhaust temperature (after electrode): 58^oC

10.7.2 Pressure
Inlet pressure (before electrode): 0.5 mg/mm^2
Backup pressure (after electrode): 0.2 mg/mm^2

10.8 Resist the corrosion in electrode
The corrosion does not take place in electrode. All pollutant molecules are converted into dust particles. So, no chemical reaction takes place in electrode.

11. Advantages

11.1 Basic advantages
- It's very cheapest method,
- Cost of the process is very low,
- Construction is simple,
- Efficiency is very high,
- It increases the liberation of O_2 content, reduces the librations of CO, CO_2, Hydrocarbons.
- It is a compactable method for automobiles,
- Maintenance cost is low.

11.2 Advantages according to Human
- Asthma disease is reduced. due to, increases the liberation of O_2 content,
- Respiratory problem, lung and throat irritation is reduced,
- Death of human according to pollution is reduced.

11.3 Advantages according to Environment
- Reduction of global warming. Due to, increases the liberation of O_2 content, reduces the librations of CO, CO_2, Hydrocarbons,
- Climatic changes are changes into normal and Global temperature is reduced. Due to, Reduction of global warming,
- Ozone hole is closed. Due to, dead of pollutant molecules in atmosphere,
- Glaciers should not change into liquid. Due to, Ozone hole is closed,
- Sea level changes into normal. Due to, Glaciers should not change into liquid.

12. Limitations
Battery should be periodically checked, to confirm the minimum voltage supply.

13. Cost estimate

13.1 Capital investment
Table 9. Capital investment

Apparatus required	Quantity (Nos.)	Cost (Rupees)
Furnace	1	200
Chimney	1	100
Duct	1	100
Electrode	2	80
Battery (1.5V)	10	150
Wire	1 meter	10
testing	6	300
TOTAL		Rs.1030/-

13.2 Running cost
Initial Weight of duct: 0.44kg
After, run the prototype for 15 minutes.
Final weight of duct: 0.448kg
Total weight of pollutant deposited in the duct within 15minutes = final weight of duct – initial weight of duct.
= 0.448 – 0.44
Total weight of pollutant deposited in the duct within 15minutes = 0.008kg.
Table 10. Running cost

Apparatus required	Quantity (Nos.)	Cost (Rupees)
Battery (1.5V)	10	150
Electrode	2	80
TOTAL		Rs.230/-

13.3 Maintenance cost

Table 11. Maintenance cost

Apparatus required	Quantity (Nos.)	Cost (Rupees)
Voltmeter	1	100
Brush	1	50
TOTAL		Rs.150/-

Voltmeter is used to periodically check the battery, to confirm the minimum voltage supply. Brush is used to clean the electrode for weekly ones. Because, pollutant density is low and only 0.008kg is deposited in 15minutes. So, for one day 0.768kg of pollutant is deposited. 5.376kg is deposited per week.

14. Conclusions
The paper has discussed various precautionary measures in pollution control. This process will be used in both industries and automobiles to minimize the pollutant in exhaust. If the process is implemented in industries and automobiles, the green house gases will be reduced at minimum rate and oxygen rate will be increased in atmosphere. Global warming is reduced due to reducing of green house effect. Climatic change and global temperature are changes into normal. Ozone hole will be closed due to reducing of green house effect. The sea level changes into normal. Living organisms are not affected by air pollution. Finally, the globe, environment and living organisms are saving by this process.

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