Air Pollution Control Measures

Sh. S. Suresh
Zonal Officer
and
Smt. Mahima T
Environmental Engineer
Central Pollution Control Board
Bengaluru.

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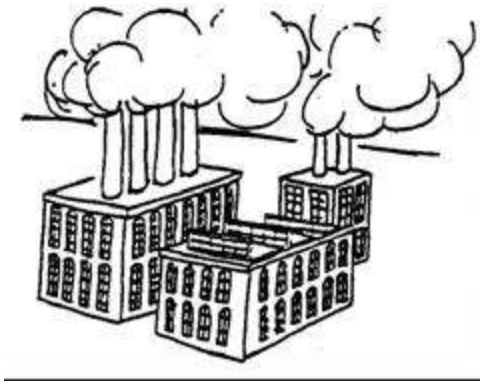
NOOOO

Burning wood was the first form of air pollution

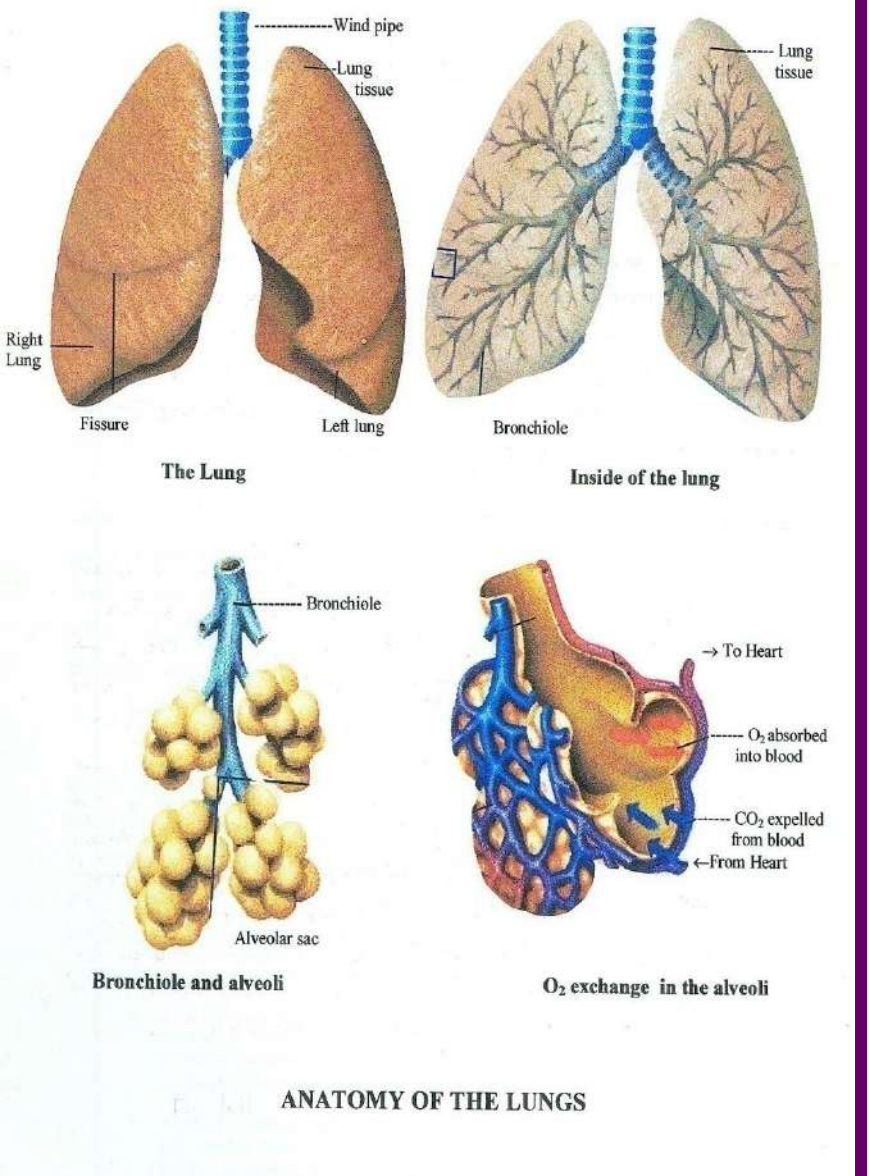
Present day air pollution from industries



Criteria pollutant	Body system	Health effects
Particulate Matter (PM2.5 and PM10)	Lower respiratory system. Particulate matter less than 10 μm in diameter gets into the lower respiratory system, particularly during exercise.	Asthma • Bronchitis • Reduced lung function • Cancer • Heavy metal poisoning
Lead (Pb)	Organs and soft tissue. Lead concentrations and accumulates in bones and soft tissue. A high concentration of lead in the body poisons the blood, nervous and renal systems.	Anemia • High blood pressure • Cancer • Neurological disorders • Intellectual function

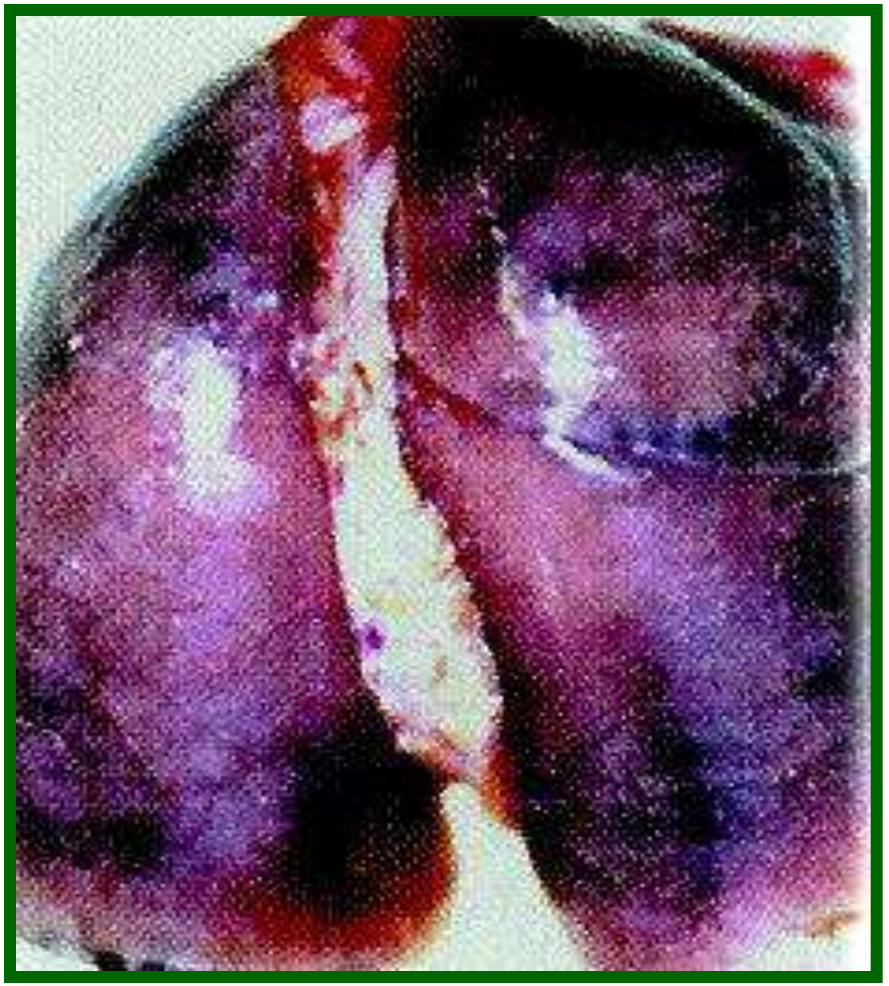
Carbon Monoxide (CO)	**Circulatory system Carbon monoxide interferes with the blood's ability to provide an adequate supply of oxygen to body tissue.**	**CO poisoning** **• Angina pectoris** **• Neurological dysfunction** **• Brain damage** **• Fetal abnormalities** **• Asphyxiation**
Ozone (O3)	Respiratory system. Tropospheric ozone results in irritation of the respiratory system	Lung inflammation • Reduced lung elasticity • Transient cough • Chest pain • Throat irritation
Nitrogen Dioxide (NO2)	Respiratory system. NO2 is very toxic at high levels.	NO2 poisoning • Asthma • Lowered resistance to infection
Sulfur Dioxide (SO2)	Respiratory system. SO2 poisoning directly affects the respiratory system and increases airway resistance adding to heartlung load.	Asthma • Bronchial constriction • SO2 poisoning • Heart attack

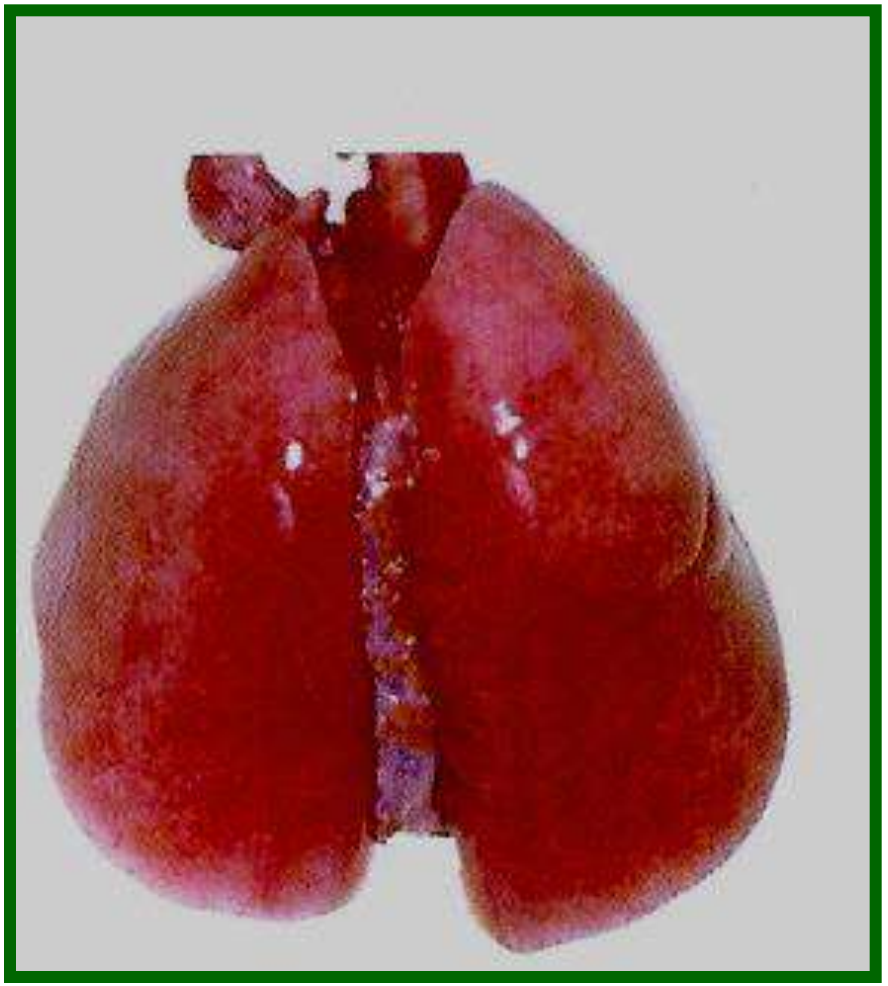
Route of invasion



- Lung - the main entry point of air pollutants, and the target organ is the alveolus. (There are 300 million alveoli in human lungs)
- 10,000 – 15,000 litres air enters every day in an adult lung.
- Increase in the concentration of pollutants cause parallel increase in the toxic intake to the lungs
- From the alveolus, pollutants travel via lymph or blood to different organs.

Health impacts





Bhopal gas tragedy

- Flare tower and venturi scrubbers were not operational which magnified the disaster

- Adequate quantity of NaoH was not present to neutralize MIC

Control strategies

- Emission taxation
- Exhaust stacks do not reduce emissions from a stationary source; rather they reduce the local effects of the pollution by elevating the exhaust stream to a point where it can be more effectively dispersed.
- High exhaust stacks were an inexpensive solution in the absence of expensive control technology.

There are more than 3-5 million Small Scale industries exists which are polluting in nature. These industries are as follows:

- Stone crusher
- Re-rolling mills
- Electroplating industries
- Brick kilns
- Foundry
- Hot Mix Plant
- Sponge iron plants
- Tannery units
- Lime kilns
- DG sets

APCD's

PARTICULATE

- Cyclones
- Electrostatic Precipitators
- Fabric Filter
- Wet Scrubbers

GASES

- Absorption
- Adsorption Towers
- Thermal Incernation
- Catalytic Combustion

Absorption

- Effluent gas passed through absorbers (scrubbers), which contain liquid absorbent.
- Efficiency depends on
    1. Amount of surface contact between gas and liquid
    2. Contact time
    3. Conc. of absorbing medium
    4. Speed of reaction between the absorbent and gases
- Absorbents used to remove SO_2, H_2S, SO_3, F and oxides of nitrogen.

Gaseous pollutants	Common absorbents used in solution form
SO_2	Dimethylaniline, ammonium sulphite, ammonium sulphate, sodium sulphide, calcium sulphite, alkaline water,
H_2S	NaOH and phenol mix (3:2), tripottasium phosphate, sodium alamine, sodium thioarsenate, soda ash
HF	Water, NaOH
NOX	Water, aqueous nitric acid

Adsorption

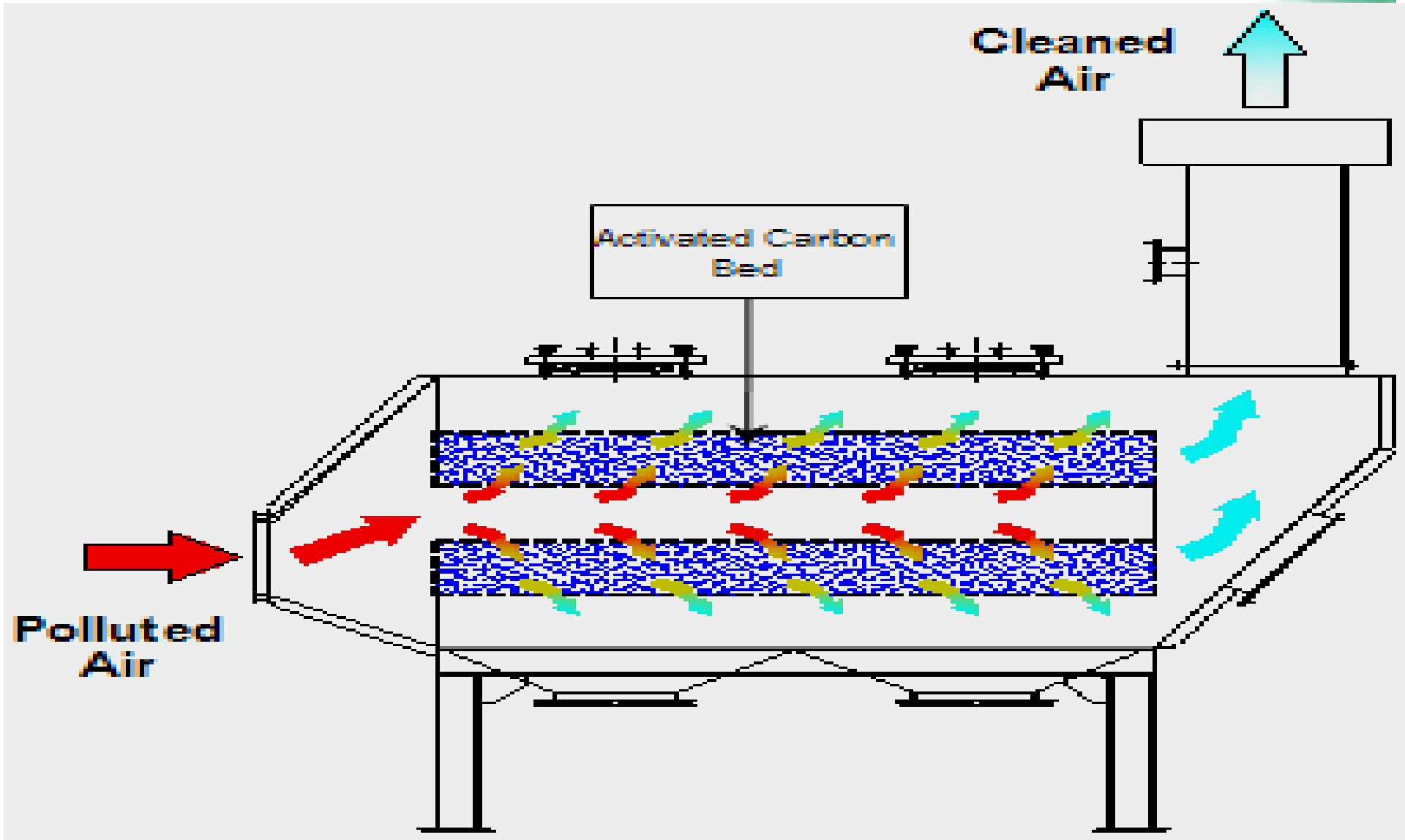
- Surface phenomenon, require large solid surface
- Adsorption towers use adsorbents to remove the impurities from the gas stream.
- The impurities bind either physically or chemically to the adsorbing material.
- The impurities can be recovered by regenerating the adsorbent.
- Adsorption towers can remove low concentrations of impurities from the flue gas stream.

Construction and Operation

- Adsorption towers consist of cylinders packed with the adsorbent.
- The adsorbent is supported on a heavy screen
- Since adsorption is temperature dependent, the flue gas is temperature conditioned.
- Vapor monitors are provided to detect for large concentrations in the effluent. Large concentrations of the pollutant in the effluent indicate that the adsorbent needs to be regenerated.

Advantages of Adsorption Towers

- Very low concentrations of pollutants can be removed.
- Energy consumption is low.
- Do not need much maintenance.
- Economically valuable material can be recovered during regeneration.


Cleaned
Air
Activated Carbon
Bed
Polluted
Air

Gaseous pollutants	Adsorbents used in solid form
SO_2	Pulverized limestone or dolomite, alkalized alumina
H_2S	Iron oxide
HF	Lump limestone, porous sodium fluoride pellets
NOX	Silica gel
Organic solvent vapours	Activated carbon

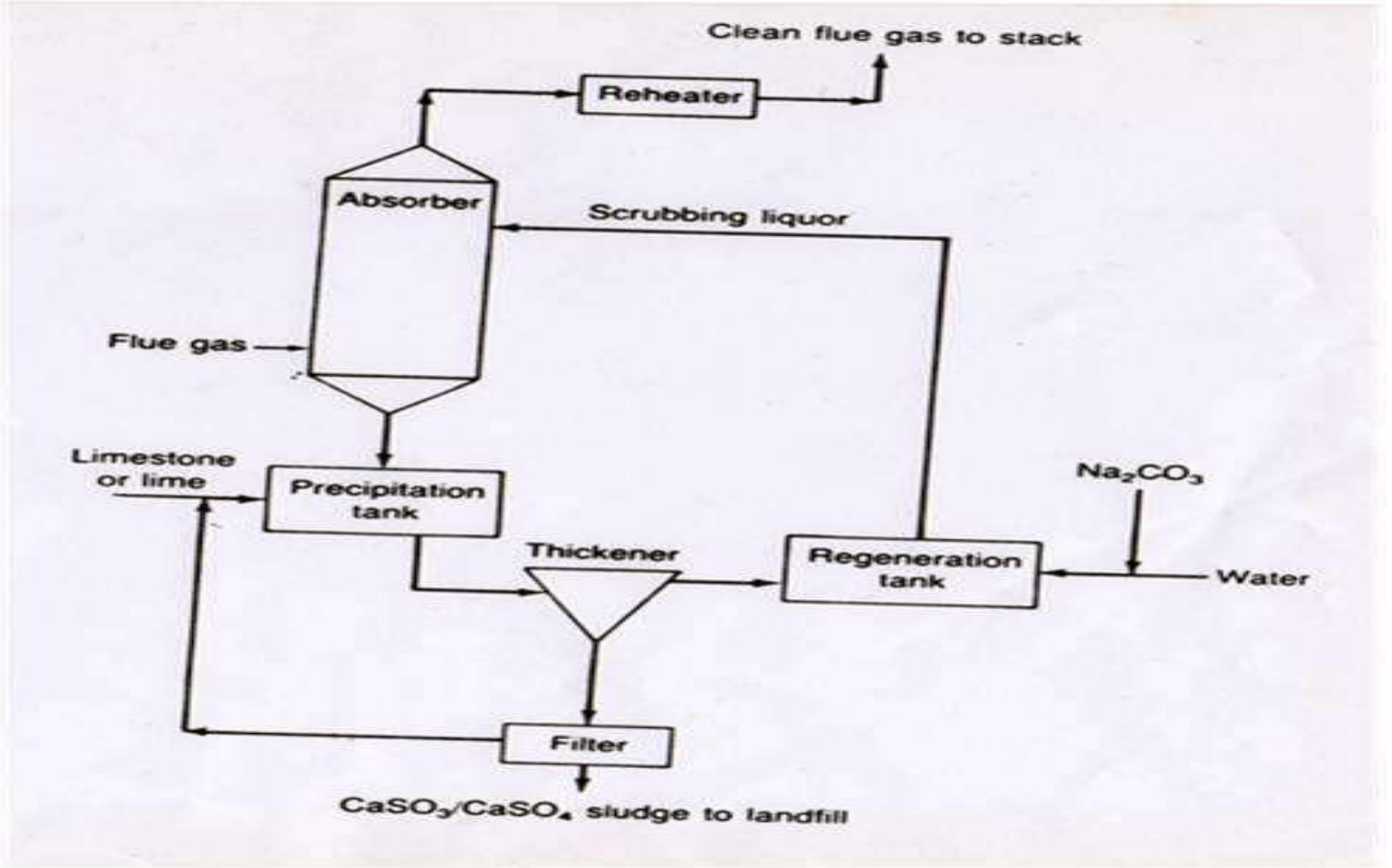
SOx Control

- General
  - Use of Desulphurized coal & oil
  - Increase effective stack height

- Flue gas desulphurization
  - Limestone Scrubbing
  - Lime Scrubbing
  - Dual Alkali Processes
  - Lime Spray Drying
  - Wellman-Lord Process

Flue Gas Desulfurization System

Limestone Scrubbing

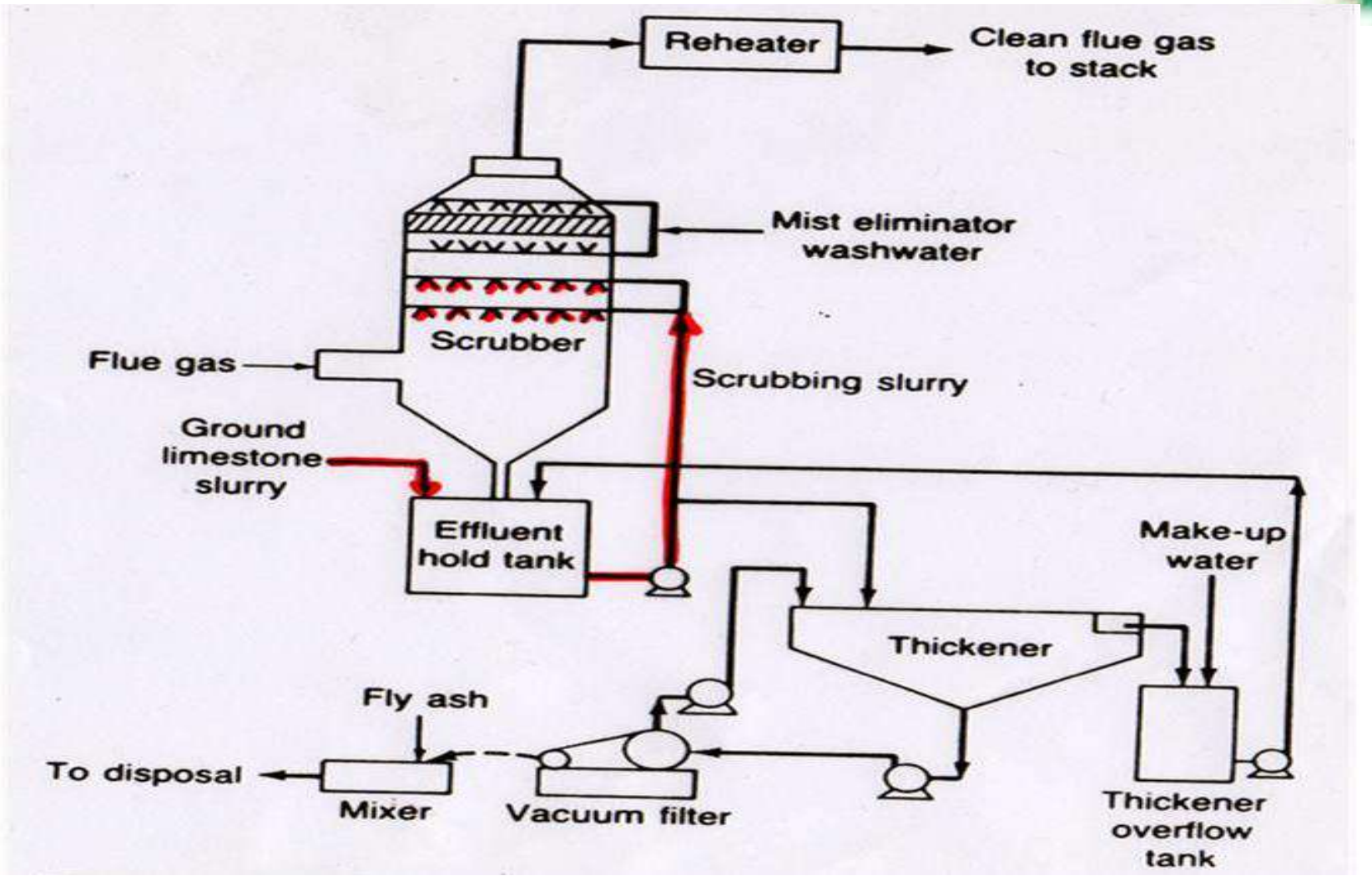


Limestone slurry is sprayed on the incoming flue gas. The sulfur dioxide gets absorbed The limestone and the sulfur dioxide react as follows :

$$CaCO_3 + H_2O + 2SO_2 \longrightarrow Ca^{+2} + 2HSO_3^- + CO_2$$

$$CaCO_3 + 2HSO_3^- + Ca^{+2} \longrightarrow 2CaSO_3 + CO_2 + H_2O$$

Lime Scrubbing



The equipment and the processes are similar to those in limestone scrubbing Lime Scrubbing offers better utilization of the reagent. The operation is more flexible. The major disadvantage is the high cost of lime compared to limestone.

The reactions occurring during lime scrubbing are :

$$CaO + H_2O \text{ -----> } Ca(OH)_2$$

$$SO_2 + H_2O \text{ <----> } H_2SO_3$$

$$H_2SO_3 + Ca(OH)_2 \text{ -----> } CaSO_3.2\ H_2O$$

$$CaSO_3.2\ H_2O + (1/2)O_2 \text{ -----> } CaSO_4.2\ H_2O$$

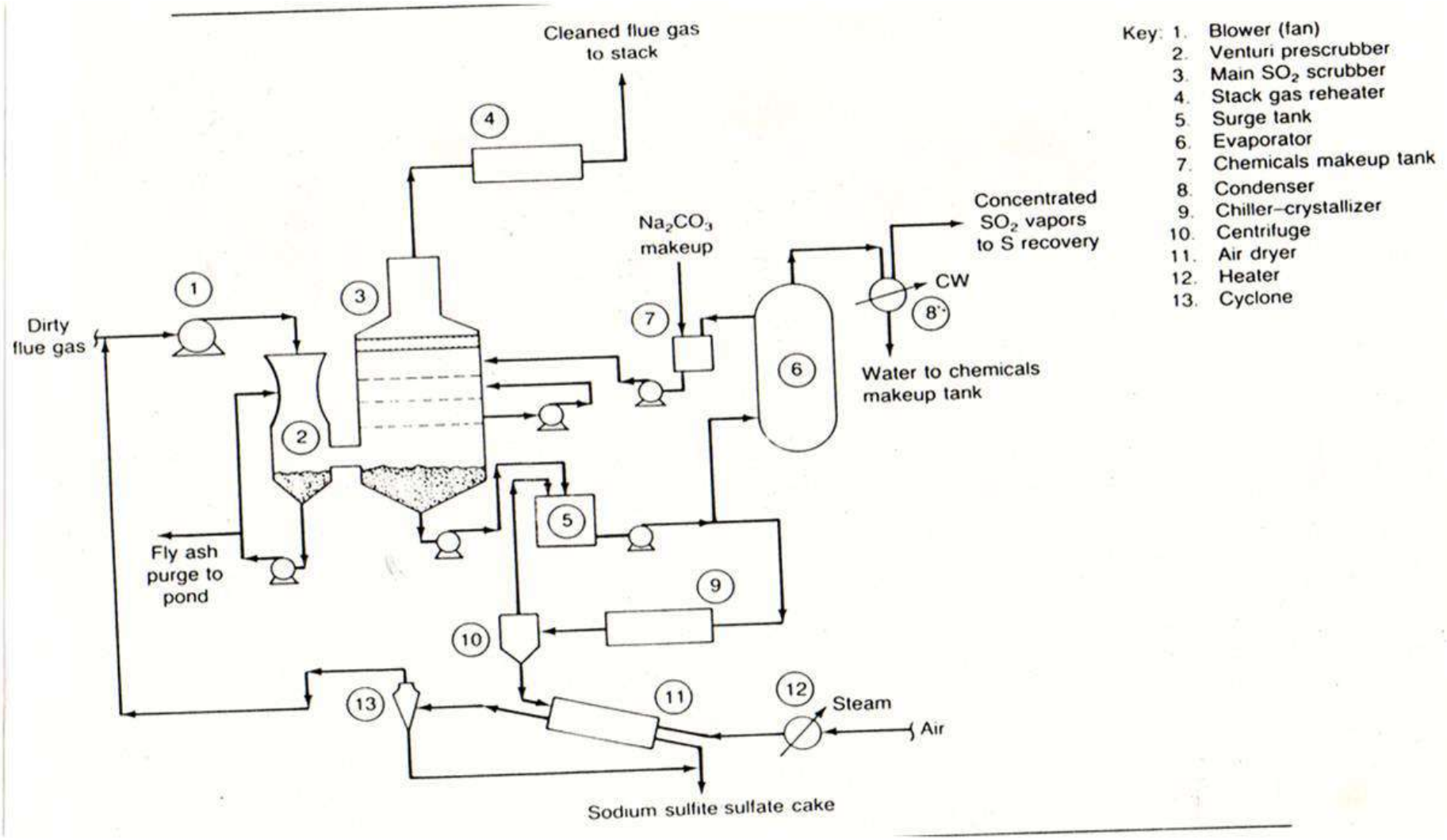
Dual Alkali System

- Lime and Limestone scrubbing lead to deposits inside spray tower.
- The deposits can lead to plugging of the nozzles through which the scrubbing slurry is sprayed.
- The Dual Alkali system uses two regents to remove the sulfur dioxide.
- Sodium sulfite / Sodium hydroxide are used for the absorption of sulfur dioxide inside the spray chamber.
- The resulting sodium salts are soluble in water, so no deposits are formed.
- The spray water is treated with lime or limestone, along with make-up sodium hydroxide or sodium carbonate.
- The sulfite / sulfate ions are precipitated, and the sodium hydroxide is regenerated.

Lime – Spray Drying

- Lime Slurry is sprayed into the chamber
- The sulfur dioxide is absorbed by the slurry
- The liquid-to-gas ratio is maintained such that the spray dries before it reaches the bottom of the chamber
- The dry solids are carried out with the gas, and are collected in fabric filtration unit
- This system needs lower maintenance, lower capital costs, and lower energy usage

Wellman – Lord Process



This process consists of the following sub processes:

- Flue gas pre-treatment.
- Sulfur dioxide absorption by sodium sulfite
- Purge treatment
- Sodium sulfite regeneration.
- The concentrated sulfur dioxide stream is processed to a marketable product.

The flue gas is pre - treated to remove the particulate. The sodium sulfite

neutralizes the sulfur dioxide :

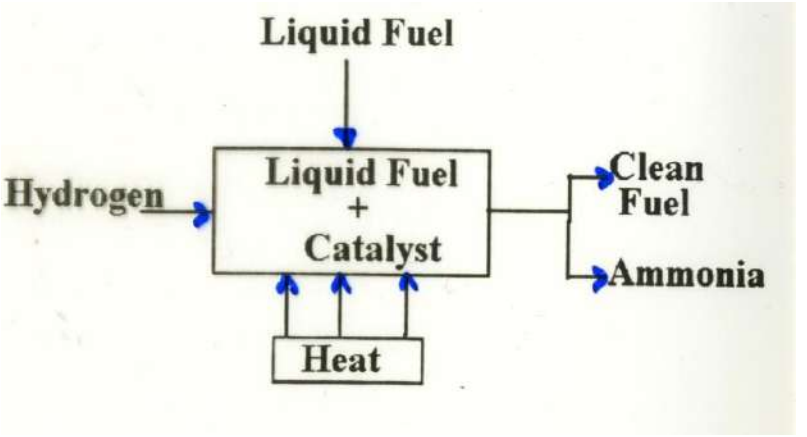
$$Na_2SO_3 + SO_2 + H_2O \text{ -----> } 2NaHSO_3$$

- Some of the Na_2SO_3 reacts with O_2 and the SO_3 present in the flue gas to form Na_2SO_4 and $NaHSO_3$.

- Sodium sulfate does not help in the removal of sulfur dioxide, and is removed. Part of the bisulfate stream is chilled to precipitate the remaining bisulfate. The remaining bisulfate stream is evaporated to release the sulfur dioxide, and regenerate the bisulfite.

Nox Control

Fuel De-nitrogenation

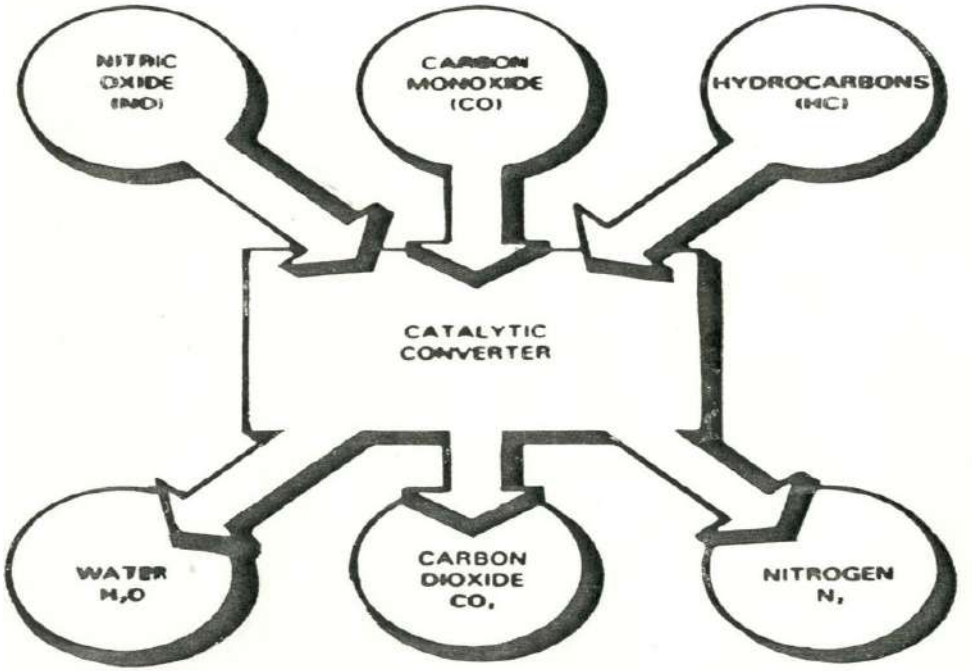


One approach of fuel denitrogenation is to remove a large part of the nitrogen contained in the fuels. Nitrogen is removed from liquid fuels by mixing the fuels with hydrogen gas, heating the mixture and using a catalyst to cause nitrogen in the fuel and gaseous hydrogen to unite. This produces ammonia and cleaner fuel.

This technology can reduce the nitrogen contained in both naturally occurring and synthetic fuels.

Stoichiometric combustion: reduce excess air

Catalytic reduction using ammonia–catalyst is a combination of titanium and vanadium oxides



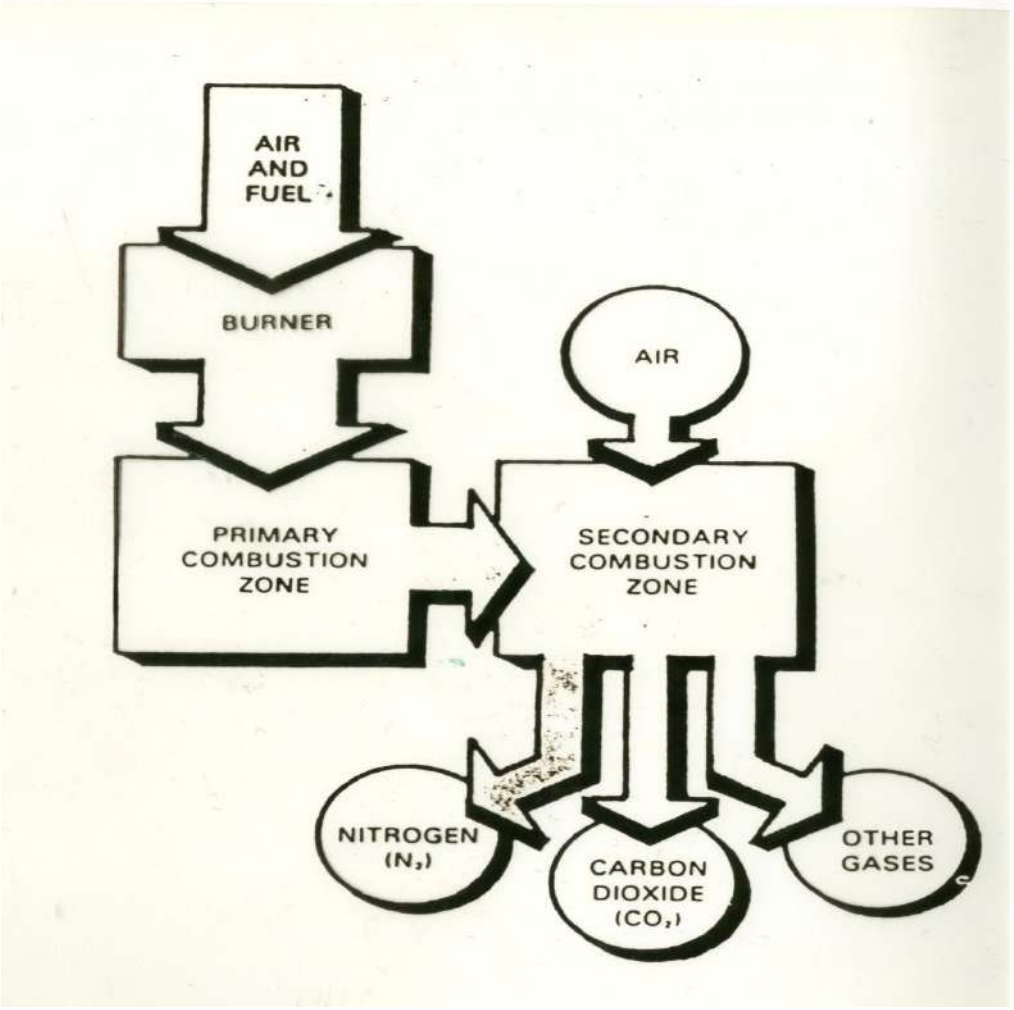
At higher temperatures (900–1000°C), NH_3 will reduce NO_X to nitrogen without a catalyst.

Staged combustion

Initially, less air is supplied to bring about incomplete combustion

- Nitrogen is not oxidized. Carbon particles and CO are released.
- In the second stage, more air is supplied to complete the combustion of carbon and carbon monoxide.

30% to 50% reductions in NOx emissions are achieved



CO & NOx control strategies are in conflict

General Methods For Control of CO_2 Emissions

- Reducing energy consumption, increasing the efficiency of energy conversion
- Switching to less carbon intensive fuels
- Increasing the use of renewable sources
- Sequestering CO_2 through biological, chemical, or physical processes

Control of Mercury Emissions

Currently installed control devices for SO_2, NO_X, and particulates, in a power plant, remove some of the mercury before releasing from the stack

Activated Carbon Injection:

Particles of activated carbon are injected into the exit gas flow, downstream of the boiler. The mercury attaches to the carbon particles and is removed in a particle control device

Particulate Control

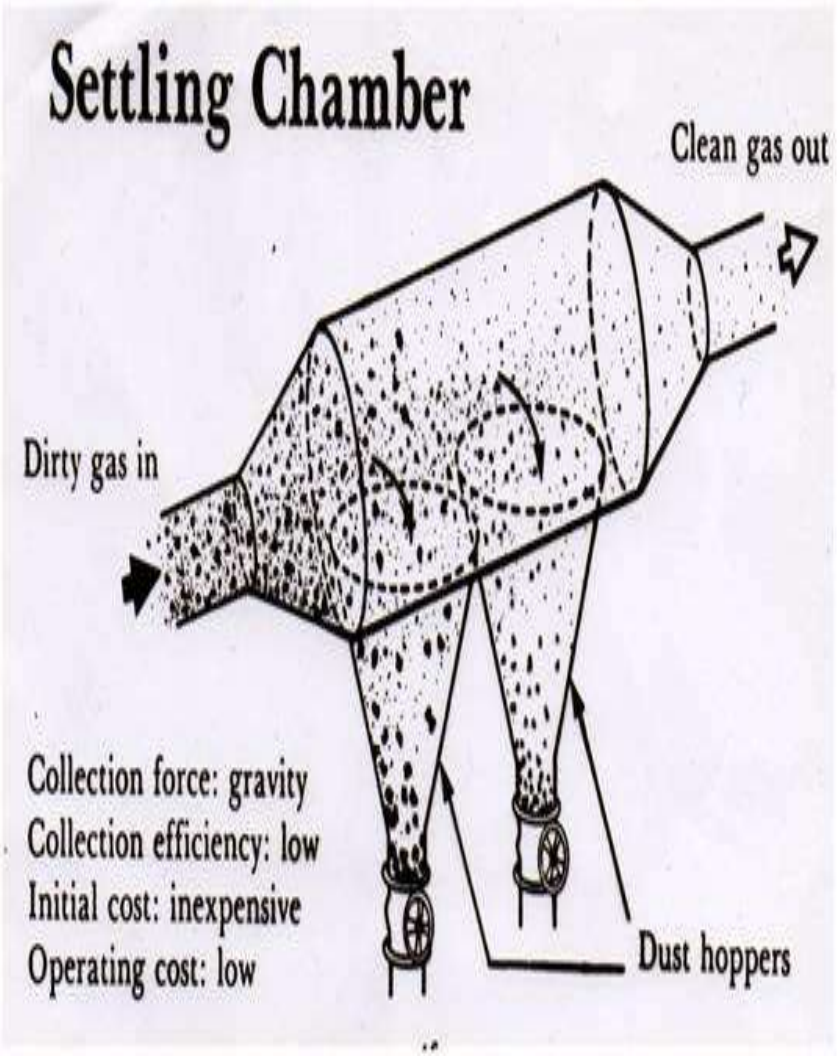
- Particulate matter is the general term used for a mixture of solid particles and liquid droplets found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can hardly be detected with an electron microscope.

- PM2.5 describes the "fine" particles that are less than or equal to 2.5 micrometers in diameter. "Coarse" particles refers to particles greater than 2.5, but less than or equal to 10 micrometers in diameter. PM10 refers to all particles less than or equal to 10 micrometers in diameter. Just to put this in perspective, ten micrometers are about one-seventh the diameter of human hair.

Particulate Collection Mechanism

- Gravity Settling
- Centrifugal Impaction
- Inertial Impaction
- Direct Interception
- Diffusion
- Electrostatic Effects

- Removes particles greater than 50µm size
- Velocity of fluegas reduced in large chamber
- Particles settle under gravitational force
- Industrial application is limited, used as pre-cleaners

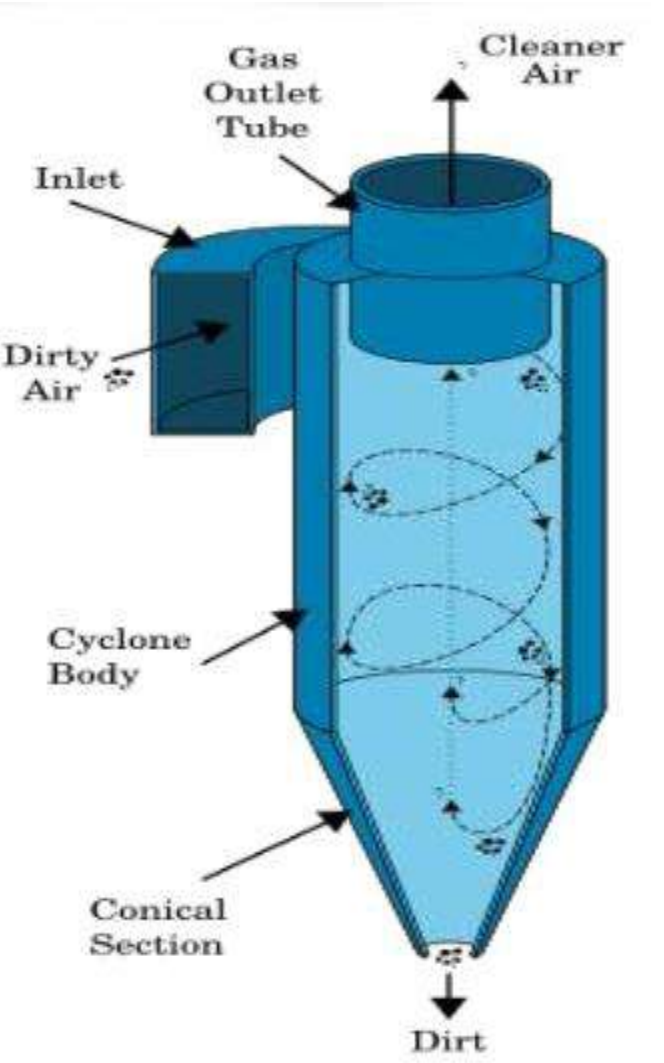


- Low initial cost
- Easy to design
- Low maintenance cost
- Dry & continuous disposal of particles

- Requires large space
- Less collection efficiency
- Only large particles are removed

Cyclone Separator

- Centrifugal force is utilized to separate particulate matter
- Removes particles of 10-50 µm
- Smaller dia, higher efficiency- centrifugal action increases with decreasing radius of rotation

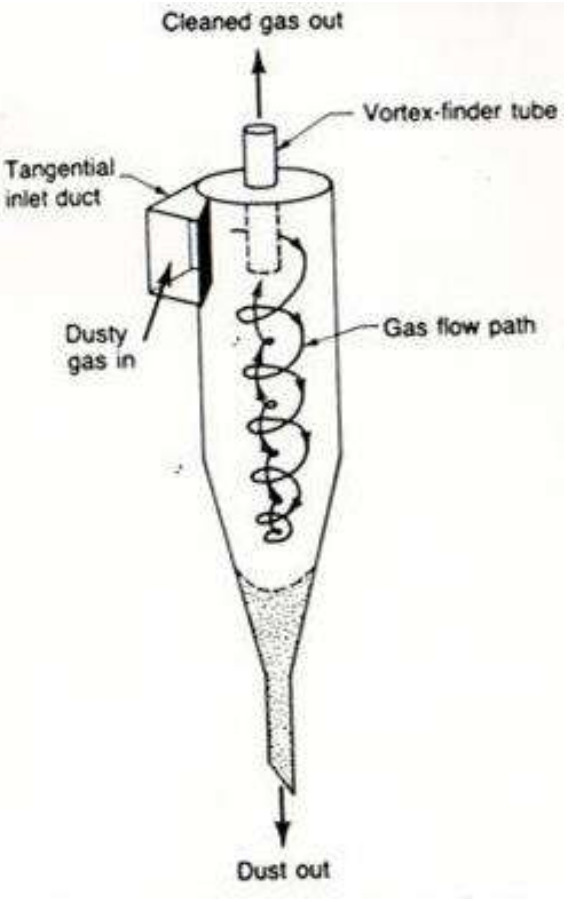


- The particles are removed by the application of a centrifugal force. The polluted gas stream is forced into a vortex. the motion of the gas exerts a centrifugal force on the particles, and they get deposited on the inner surface of the cyclones

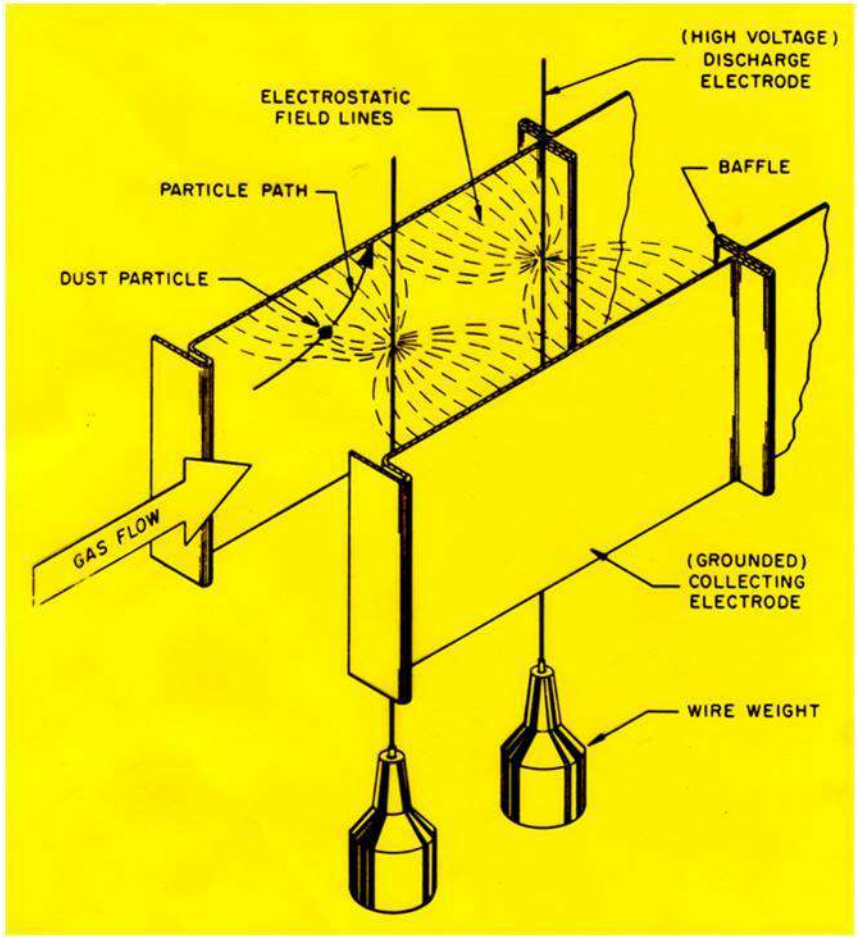
The gas enters through the inlet, and is forced into a spiral.

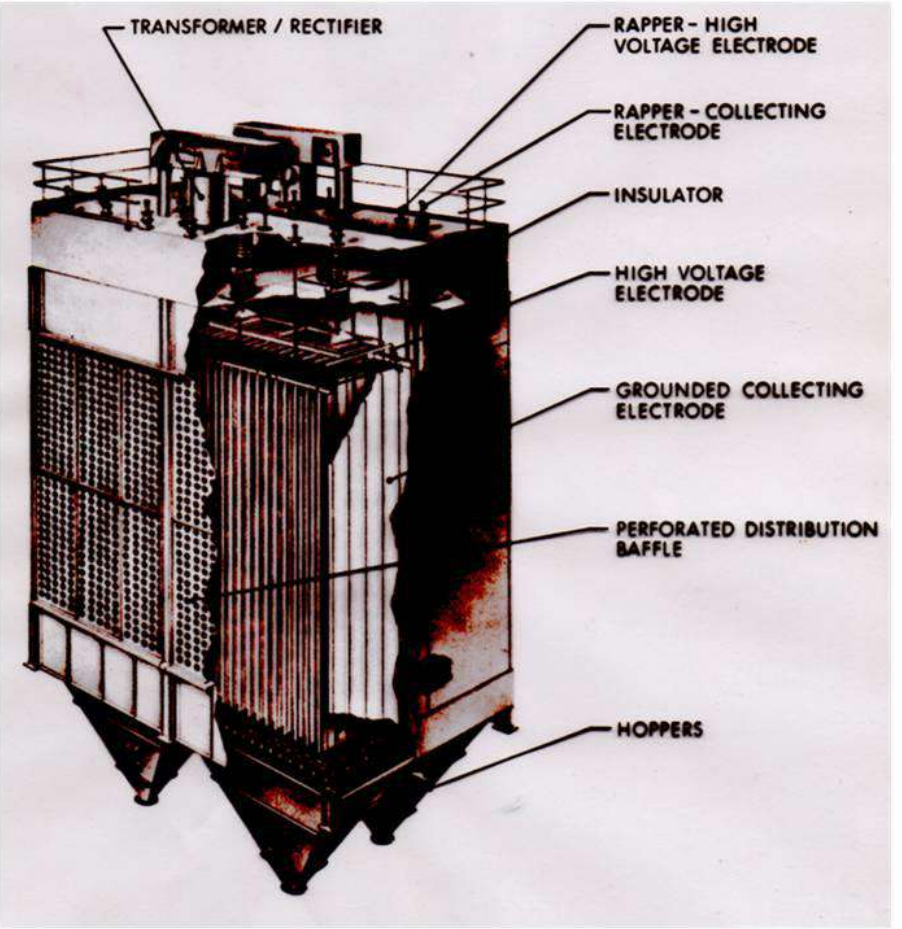
  - At the bottom, the gas reverses direction and flows upwards.

  - To prevent particles in the incoming stream from contaminating the clean gas, a vortex finder is provided to separate them. the cleaned gas flows out through the vortex finder.

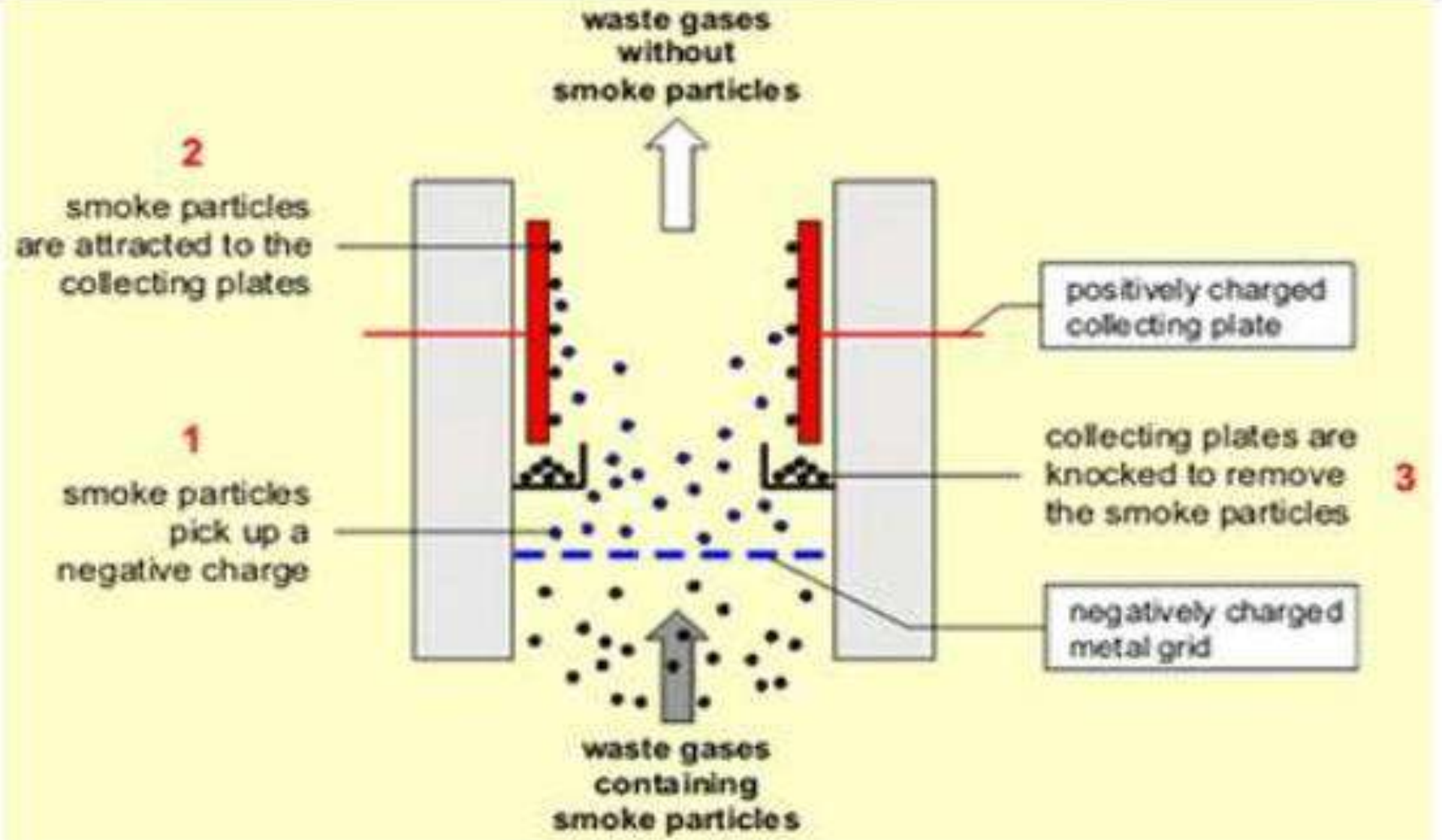


Electrostatic Precipitators





- The particles in a polluted gas stream are charged by passing them through an electric field
- The charged particles migrate to oppositely charged electrode
- Particles deposited on collecting electrode, lose charge and removed from gas stream.
- Particles from collecting plates are removed mechanically by rapping, vibration or washing to a hopper


waste gases without smoke particles
2
smoke particles are attracted to the collecting plates
positively charged collecting plate
1
smoke particles pick up a negative charge
collecting plates are knocked to remove the smoke particles
3
negatively charged metal grid
waste gases containing smoke particles

High efficiency, generally of the order of 99.5-99.9%.

Can handle higher loads with lower pressure drops.

Can operate at higher temperatures.

O & M costs are normal/generally low

Particles can collected dry or wet

High initial capital costs

Although they can be designed for a variety of operating conditions, they are not very flexible to changes in the operating conditions, once installed.

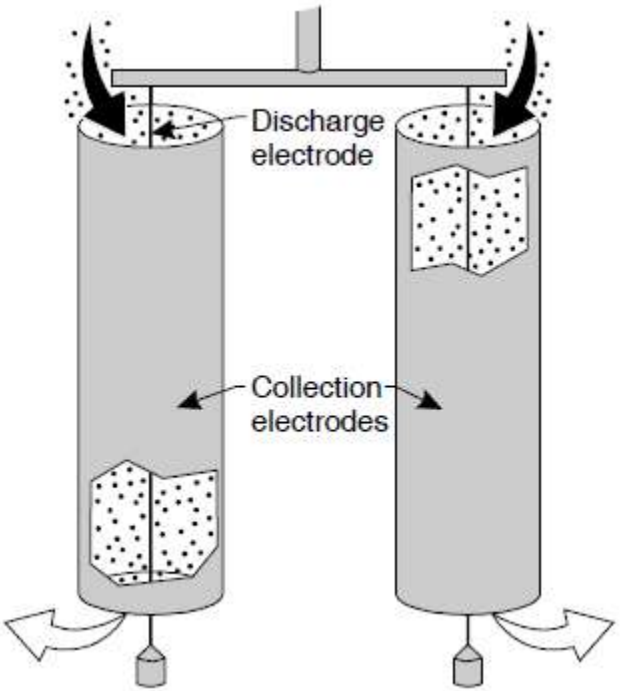
Particulate with high resistivity may go uncollected.

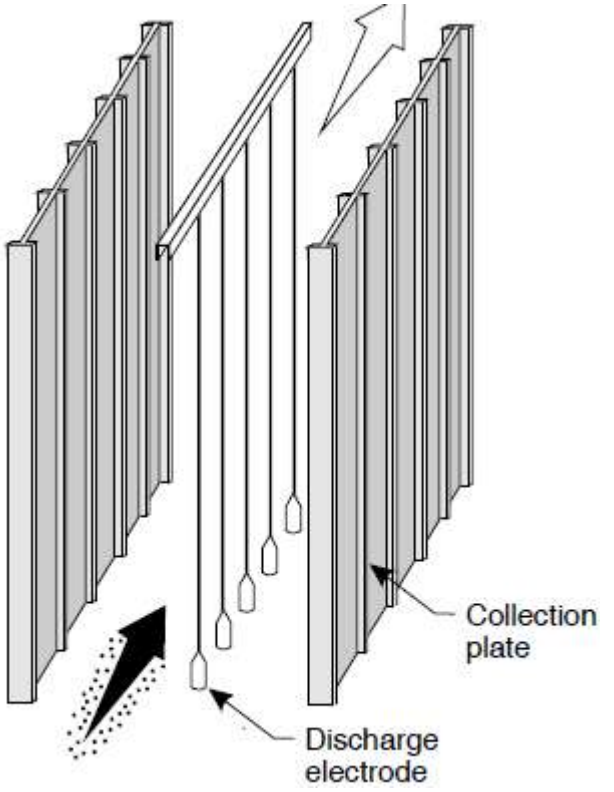
Requires high voltage

Single stage and two stage precipitators

- Single stage gas ionization and particulate collection in a single stage.
- Two stage, particle ionized in first chamber and collected in second chamber.
- Industrial precipitators single stage design.
- Two stage used for lightly loaded gases.
- Single stage for more heavily loaded gas streams.

- Collection electrodes are either tubes or plates





Cleaning

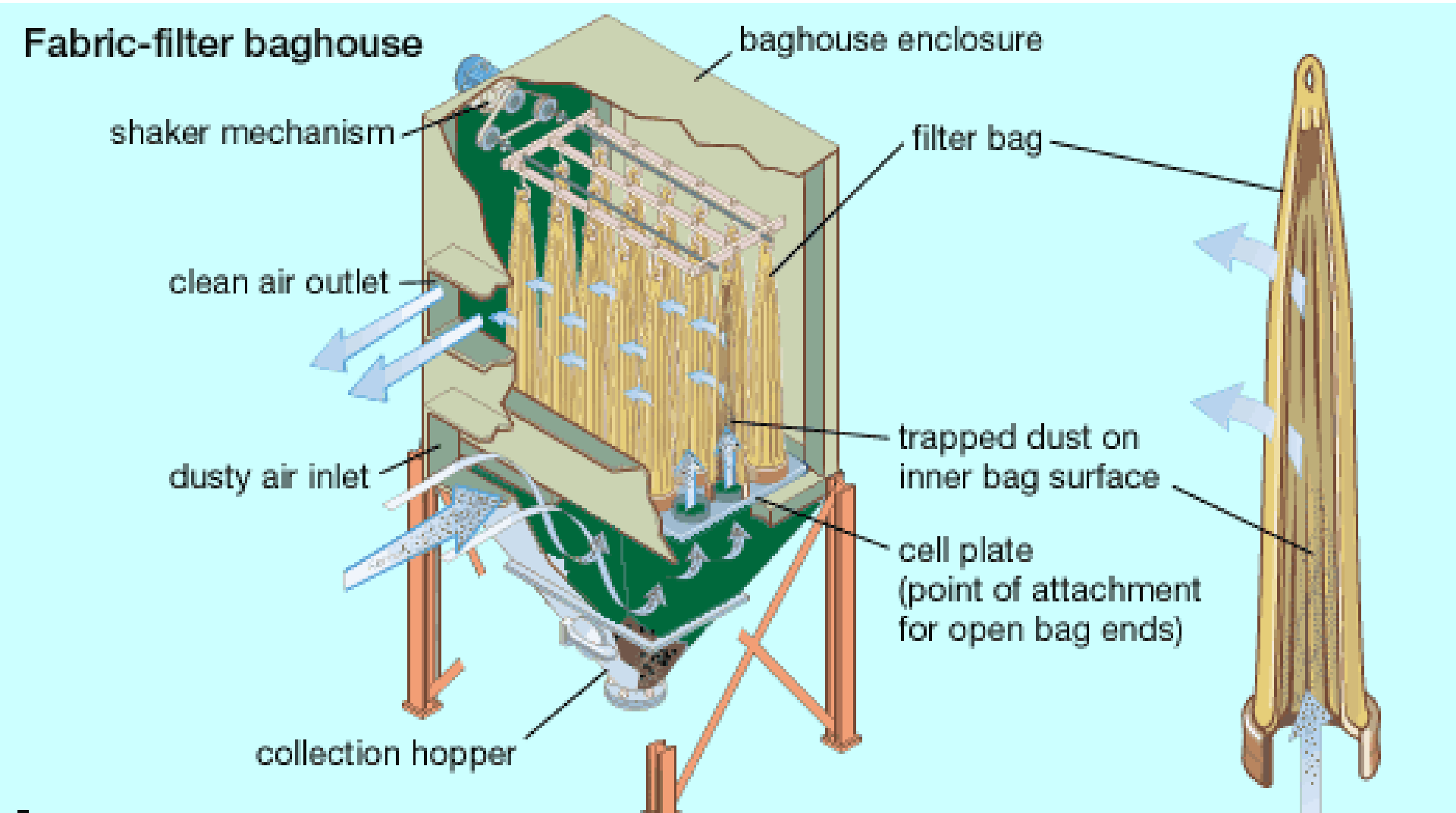
- Plates are rapped/ vibrated periodically while ESP is on-line when (0.08 to 1.27 cm or 0.03 to 0.5 in.). Dislodged dust falls from the plates into the **hopper**

- Spraying occurs while the ESP is on-line and is done intermittently to remove the collected particles. Water is generally used as the spraying liquid although other liquids could be used if absorption of gaseous pollutants is also being accomplished.

- Sludge is collected in holding basin and sent for disposal

Fabric Filters

- The filters retain particles larger than the mesh size
- Air and most of the smaller particles flow through some of the smaller particles are retained due to interception and diffusion.
- The retained particles cause a reduction in the mesh size.
- The primary collection is on the layer of previously deposited particles.
- Filters are made of fibre glass, nylon etc
- Inspecting and changing bags takes a long time and are the highest maintenance costs in a baghouse.


Fabric-filter baghouse
baghouse enclosure
shaker mechanism
filter bag
clean air outlet
trapped dust on
inner bag surface
dusty air inlet
cell plate
(point of attachment
for open bag ends)
collection hopper

Operating problems

- Cleaning
- Rupture of cloth
- Temperature
- Bleeding
- Humidity
- Chemical attack

Cleaning

- Rapping
- Shaking
- Pulse jet
- Backwash

Very high collection efficiency

They can operate over a wide range of volumetric flow rates

The pressure drops are reasonably low.

Fabric Filter houses are modular in design, and can be pre-assembled at the factory

Fabric Filters require a large floor area.

The fabric is damaged at high temperature.

Ordinary fabrics cannot handle corrosive gases.

Fabric Filters cannot handle moist gas streams

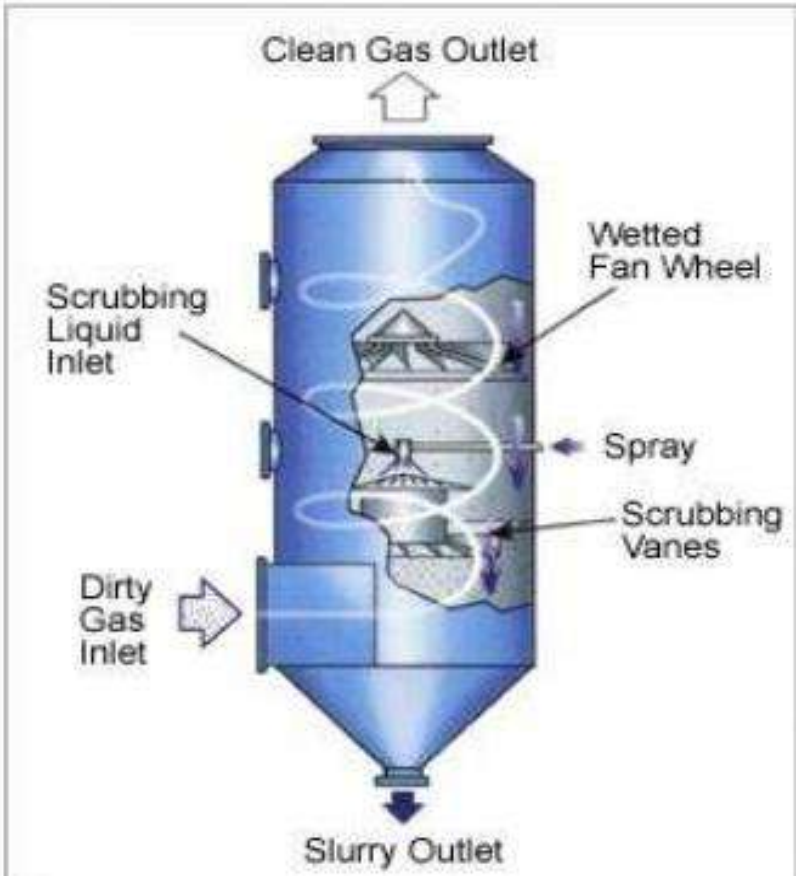
A fabric filtration unit is a potential fire hazard

Scrubbers/ Wet Collectors

- Wet scrubbers are used for removal of particles which have a diameter of the order of 0.2 mm or higher.
- Flue gas is made to push up against down falling water current.
- The droplets capture the particles
- The liquid is subsequently removed for treatment.
- A wet scrubber consists of a rectangular or circular chamber in which nozzles are mounted.
- The nozzles spray a stream of droplets on the incoming gas stream
- The droplets contact the particulate matter, and the particles get sorbed.
- The droplet size has to be optimized.
- Wet scrubbers are also used for the removal of gases from the air streams.

Cyclone scrubber

- These scrubbers combine a cyclone with a spray nozzle.
- The added centrifugal force permits good separation of the droplets, hence a smaller droplet size can be used.
- Cyclone spray chambers provide up to 95% removal of particles > 5 micron.



Simultaneously removes particulates and gaseous pollutants

Wet Scrubbers can handle incoming streams at high temperature, thus removing the need for temperature control equipment.

handle high particle loading.

Loading fluctuations do not affect the removal efficiency.

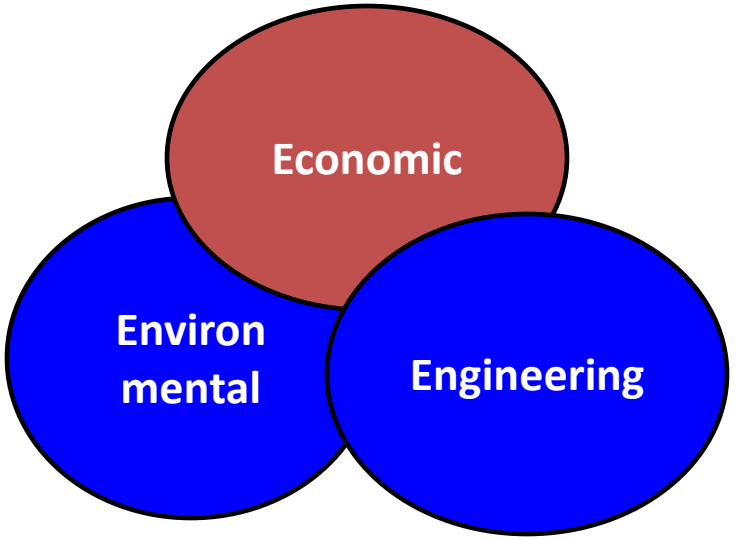
They can handle explosive gases with little risk. Corrosive gases and dusts are neutralized

Maintenance problems are high when corrosive materials are collected

Effluent scrubbing liquid poses a water pollution problem

Choice Of Equipment

EEE



Environmental factors

Equipment location

Available space

Ambient conditions

Availability of adequate utilities (i.e., power, water, etc.) and ancillary system facilities (i.e., waste treatment and disposal, etc.)

Maximum allowable emissions (air regulations)

Aesthetic considerations

Contribution of air pollution control system to wastewater and solid waste

Contribution of air pollution control system to plant noise levels

Engineering

Contaminant characteristics (i.e., physical and chemical properties, concentration, particulate shape and size)

Gas stream characteristics (i.e., volume flow rate, temperature, pressure, humidity, composition, viscosity, density, reactivity, combustibility, corrosivity, toxicity, etc.)

Design and performance characteristics of the particular control system(i.e., size and weight, fractional efficiency curves, etc)

Economic

- Capital cost (equipment, installation, engineering, etc.)
- Operating cost (utilities, maintenance, etc.)
- Expected equipment lifetime and salvage value

Economical aspects

1. Cyclones:- cheap to install, power consumption moderate, maintenance cost normal.
2. Filters:- expensive to install, power consumption moderate. Maintenance cost high.
3. Electrostatic precipitators:- most expensive regarding installation, power consumption moderate to low as pressure drops. Maintenance cost moderate
4. Scrubbers :- installation cost moderate, maintenance cost not high, high rate of power consumption.

Electroplating

- 90% of the solvent is emitted to air

- Exhaust hoods and good ventilation systems protect the working environment
- The exhaust streams from sucction hoods must be treated using carbon filters to remove VOC's and heavy metals
- Acid mists and vapors should be
- scrubbed with water before venting

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DONT LET
OUR FUTURE
GO UP IN
SMOKE


THANKS ALOT.