JECRC Foundation

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTER

Class – 3rd Year - V Semester: B.Tech. (Civil Engineering)
Subject –AIR & NOISE POLLUTION AND CONTROL
Ch – CONTROL OF GASEOUS POLLUTANTS
Presented by – Assistant Professor Narendra Sipani

VISSION AND MISSION OF INSTITUE

Vision-

To become a renowned centre of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission-

M1. Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.
M2. Identify, based on informed perception of Indian, regional and global needs, areas of focus and provide platform to gain knowledge and solutions.
M3. Offer opportunities for interaction between academia and industry.
M4. Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VISSION AND MISSION OF DEPARTMENT

Vision-

To become a role model in the field of Civil Engineering for the sustainable development of the society.

Mission-

M1. To provide outcome base education.

M2. To create a learning environment conducive for achieving academic excellence.

M3. To prepare civil engineers for the society with high ethical values.

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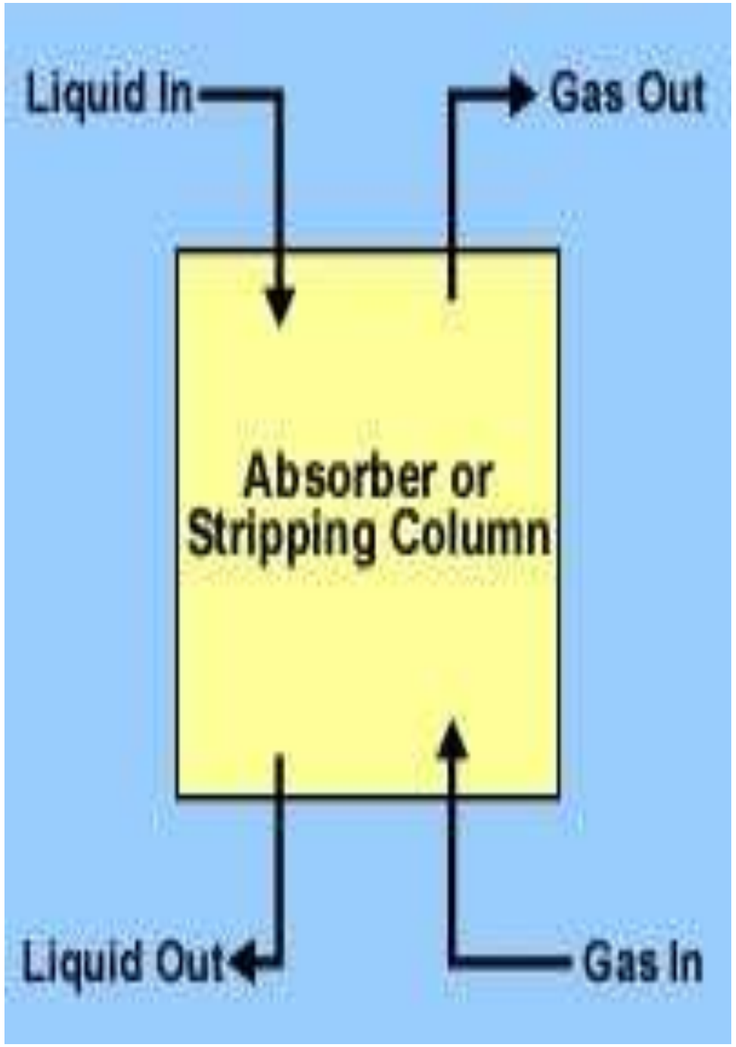
1. CONTROL OF GASEOUS POLLUTANTS
2. ABSORPTION
3. ADSORPTION
4. CONDENSATION
5. COMBUSTION
6. SOURCE CORRECTION METHOD
7. PARTICULATE CONTROL EQUIPMENT

CONTROL OF GASEOUS POLLUTANTS FROM STATIONARY SOURCES

- The most common method for controlling gaseous pollutants is the addition of add-on control devices to recover or destroy a pollutant.
- There are four commonlyused technologies for gaseous pollutants:
  - Absorption,
  - Adsorption,
  - Condensation, and
  - Incineration (combustion)

ABSORPTION

- The removal of **one or more selected components** from a gas mixture by absorption is probably the most important operation in the control of gaseous pollutant emissions.
- Absorption is a process in which a gaseous pollutant is dissolved in a liquid.
- Water is the most commonly used absorbent liquid.
- As the gas stream passes through the liquid, the liquid absorbs the gas, in much the same way that sugar is absorbed in a glass of water when stirred.



- Absorbers are often referred to as scrubbers, and there are various types of absorption equipment.

- The principal types of gas absorption equipment include spray towers, packed columns, spray chambers, and venture scrubbers.

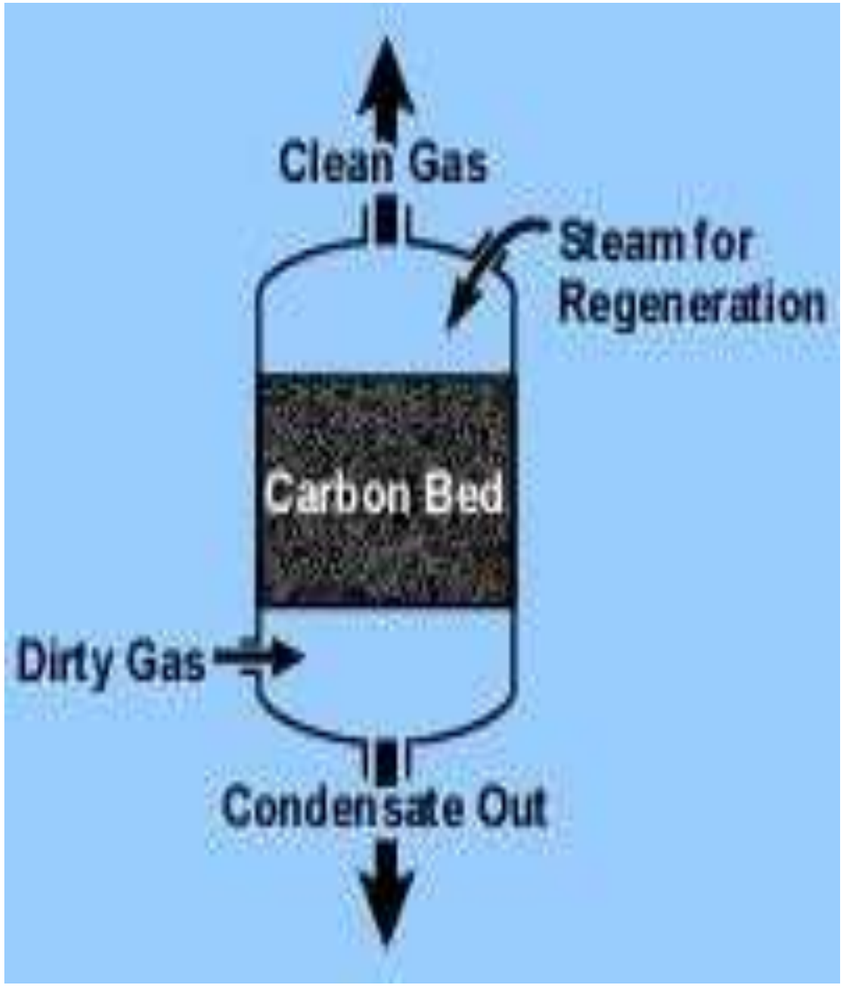
- Ingeneral, absorbers can achieve removal efficiencies grater than 95 percent.
- Absorbents used to remove SO_2, H_2S, SO_3, F and oxides of nitrogen.

- One potential problem with absorption is the generation of waste-water, which converts an air pollution problem to a water pollution problem.

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

- When a gas or vapor is brought into contact with a solid, part of it is taken up by the solid.
- The molecules that disappear from the gas either enter the inside of the solid (Absorption), or remain on the outside attached to the surface (Adsorption).
- The most common industrial adsorbents are activated carbon, silica gel, and alumina, because they have enormous surface areas per unit weight.
- Activated carbon is the universal standard for purification and removal of trace organic contaminants from liquid and vapor streams



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

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.

CONDENSATION

- Condensation is the process of converting a gas or vapor to liquid. Any gas can be reduced to a liquid by lowering its temperature and/or increasing its pressure. Condensers are typically used as pretreatment devices.

- They can be used ahead of absorbers, absorbers, and incinerators to reduce the total gas volume to be treated by more expensive control equipment.

- Removal efficiencies of condensers typically range from 50 percent to more than 95 percent, depending on design and applications.

DIRECT COMBUSTOR

- **Direct combustor** is a device in which air and all the combustible waste gases react at the burner. Complete combustion must occur instantaneously since there is no residence chamber.
- A flare can be used to control almost any emission stream containing volatile organic compounds. Studies conducted by EPA have shown that the destruction efficiency of a flare is about 98 percent.

COMBUSTION

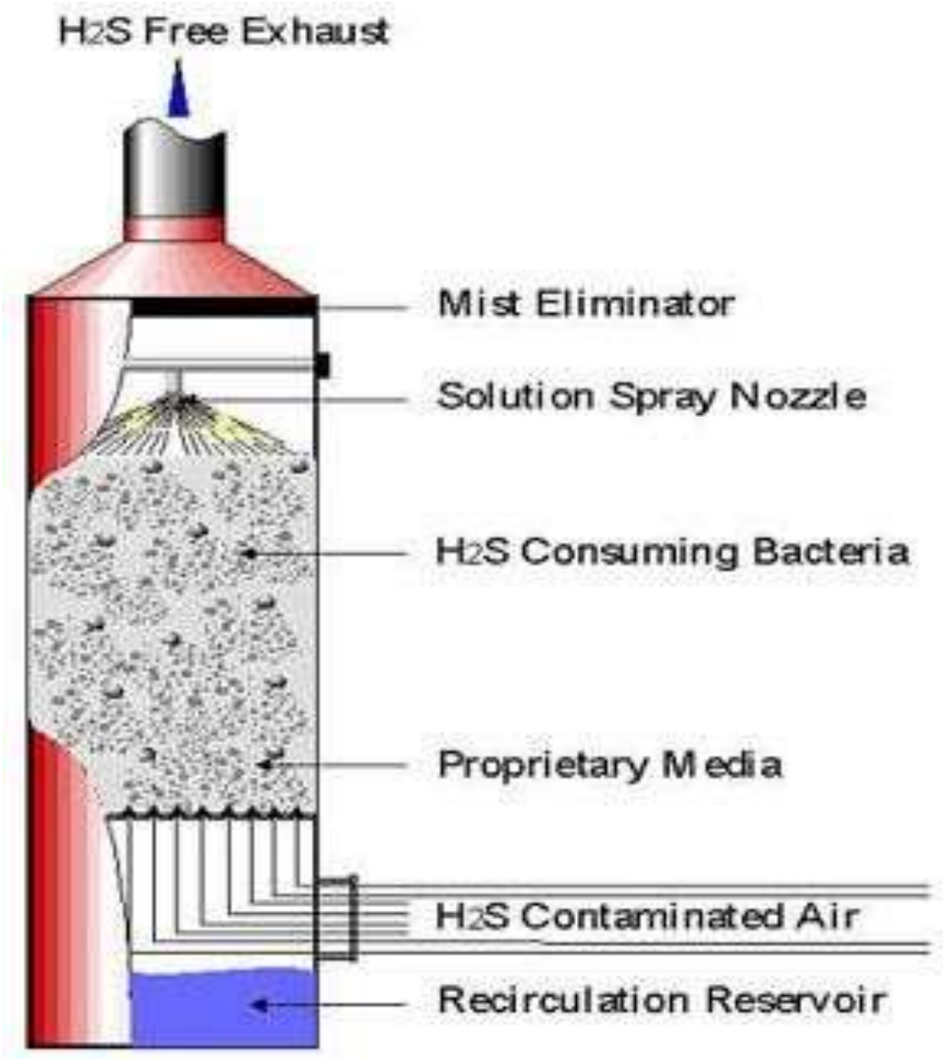
- In **thermal incinerators** the combustible waste gases pass over or around a burner flame into a residence chamber where oxidation of the waste gases is completed.
- Thermal incinerators can destroy gaseous pollutants at efficiencies of greater than 99 percent when operated correctly.

SECONDARY COMBUSTION

- Flame or catalytic combustion can be utilized when gases or vapors to be controlled.
- Fume and vapor incinerators
- After burners
- Flares, either with steam injection or venturi flare

BIOSCRUBBERS

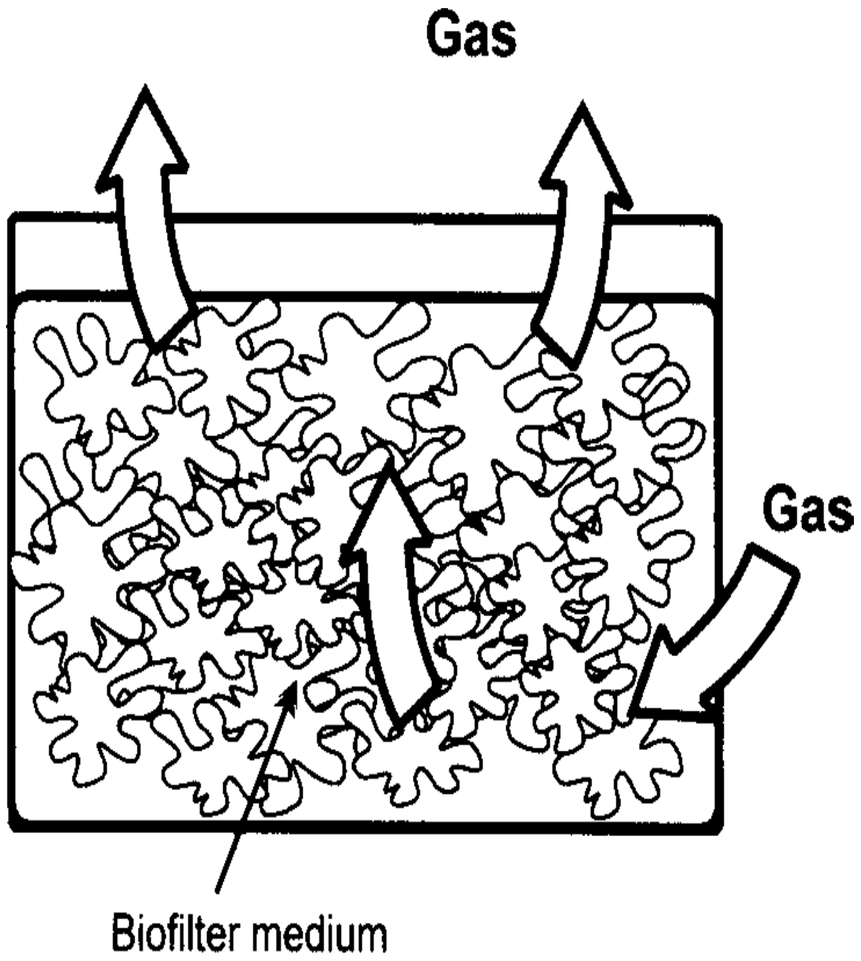
- **Design**: It consists of an absorption column and one or more bioreactors.
- **Operation**: The reaction tanks are aerated and supplied with nutrient solution. The microbial mass remains in the circulating liquor which passes through the absorption column. Waster air to be aerated is first brought to a temperature range of 10-43^{o}C suitable for microorganisms. Dust in air, if any, should be removed by the filter in the line.



- **Use**: Applied in the food industry, in rendering plants, livestock farming, foundries.
- **Advantages**: it is suitable for water soluble hydrocarbons. Use of activated carbon in the absorber improves mass transfer, buffer capacity and immobilization of microorganisms.
- **Disadvantages**: require a lot of skilled attention. Emission of microorganisms is considered to be the risk involved.
- **Status**: considered to be of concern by the food industry and pharmaceutical industry.

BIOFILTERS

- **Design**: Biofilteration uses microorganisms fixed to a porous medium to break down pollutants present in an air stream. The microorganisms grow in a biofilm on the surface of a medium or are suspended in the water phase surrounding the medium particle. The filter bed medium consists of relatively inert substances (compost, peat, etc.) which ensure large surface attachment areas and additional nutrient supply.



Operation: Contaminated air ishumidified and passed through a packed bed and pollutant transfers into a thin biofilm and degrade the pollutant. They are systems that use a combination of processes: absorption, adsorption, degradation and desorption of gas phase contaminants.

- **Conditions**: Microorganisms used are mesophilic, Temperature 15-40^{0}C, moisture 40-60% and gas contact time 10-30 sec
- **Use**: used in treating malodorous compounds and water soluble Volatile organic compounds (VOCs) Industries employing this technology include food and animal products, pharmaceuticals, wood products, paint and coating applications, resin manufacturing. Compounds treated are typically mixed VOCs and sulfur compounds, including hydrogen sulfide.

SOURCE CORRECTION METHOD

- Raw material changes
- Process changes
- Equipment modification & replacement

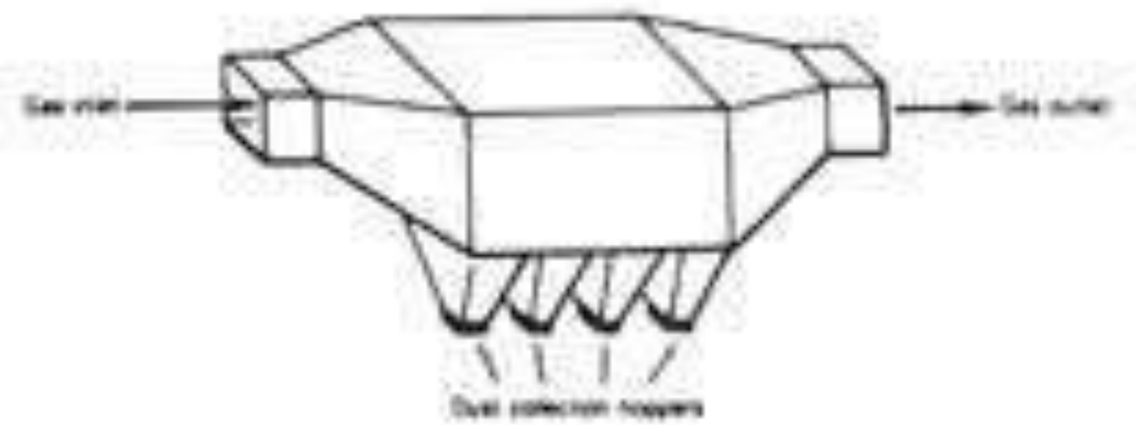
Objectives of control equipment

- Prevention of nuisance
- Prevention of physical damage to property
- Elimination of health hazards to plant personnel
- Recovery of valuable waste product
- Minimization of economic losses

PARTICULATE CONTROL EQUIPMENT

- Gravitational settling chambers
- Fabric filters
- Scrubbers
- Cyclone separator
- Electrostatic precipitators

GRAVITATIONAL SETTLING CHAMBER



Settling Chamber

- Used to remove particles with size greater than 50 μm.
- Velocity of flue gas reduced in large chamber.
- Particles settle under gravitational force.

$$Vs = hV / L \quad \text{---------- (i)}$$

L= length of chamber

V= horizontal velocity of carrier gas Vs=

settling velocity of particulates

h= height through which particulates travel before settling down

From eq- i and ii

$$\mathbf{D= [18Vh\mu/ Lg (\rho_p- \rho)]^{1/2}}$$

D = is minimum size of particle that can be removed in a settling chamber

Advantages

- Low initial cost.
- Easy to design.
- Low pressure drop.
- Low maintenance cost.
- Dry and continuous disposal of solid particulates.

Disadvantages

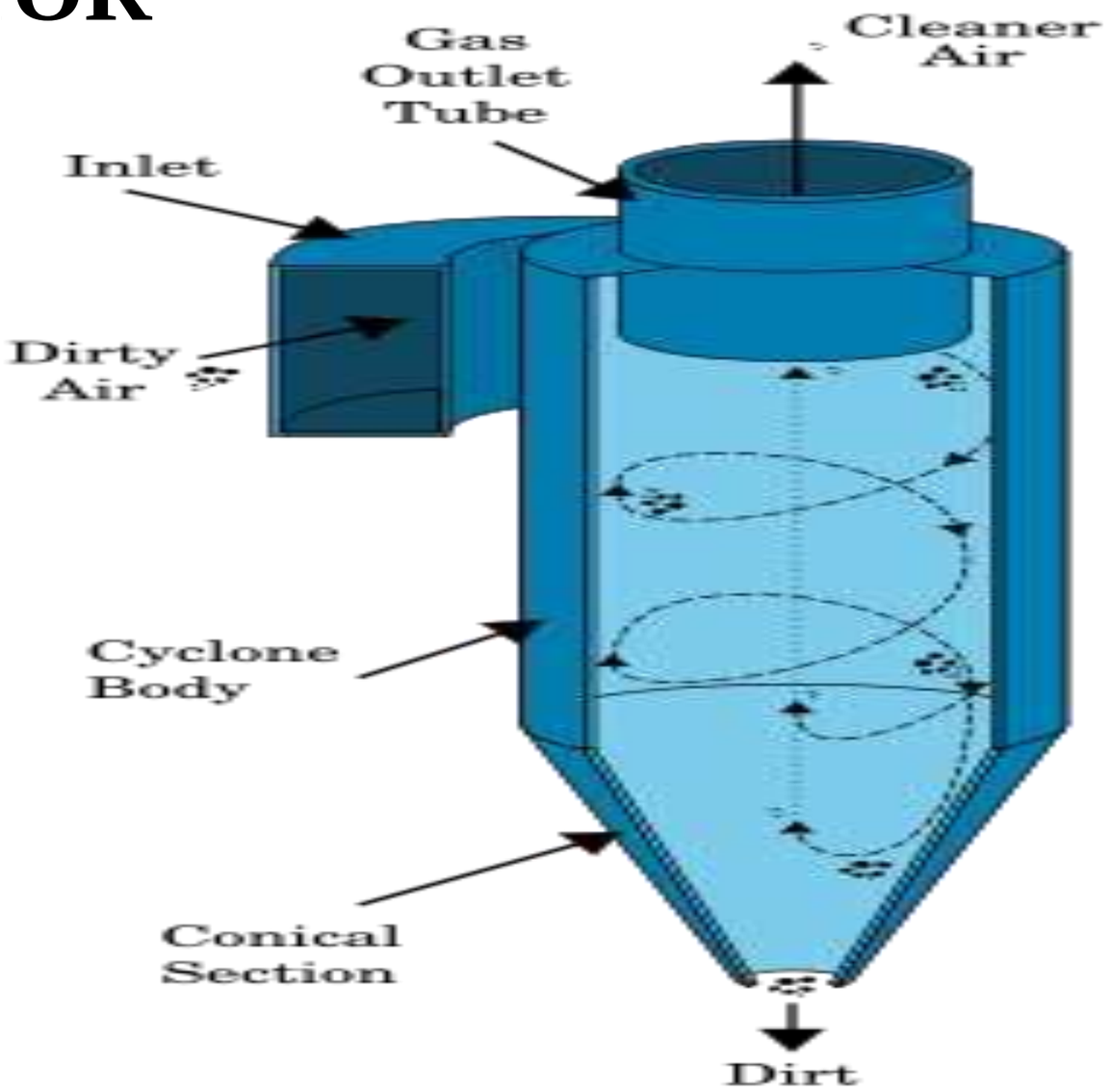
- Require large space.
- Less collection efficiency.

Application

- Industrial application is limited.
- Used widely for removal of large solid particulates from draft furnace, kilns.
- Sometimes used in process industry, food and metallurgical industry.
- Used as pre-cleaners for high efficiency collectors

CYCLONE SEPERATOR

- Centrifugal force is utilized to separate the particulate matter.
- It can remove 10 to 50 μm particle size.
- Used mostly in industries.



$Dp, min = [9 \mu B / \pi V Nt(\rho_p - \rho)] ½$

Dp, min= dia of smallest particles that can be removed cm

μ = viscosity of the fluid

B= width of cyclone inlet duct V= avg. inlet velocity

Nt= no of turns made by gas stream in cyclone

ρ_p = density of particles

Q= Density of fluid

- Design factor having greatest effect on collection efficiency is cyclone diameter.
- Smaller dia, higher is efficiency, because centrifugal action increase with decreasing radius of rotation.
- Cyclone efficiencies > 90 % with particle dia of 10 μ
- > 95 % with particle dia 20 μ.

Efficiency

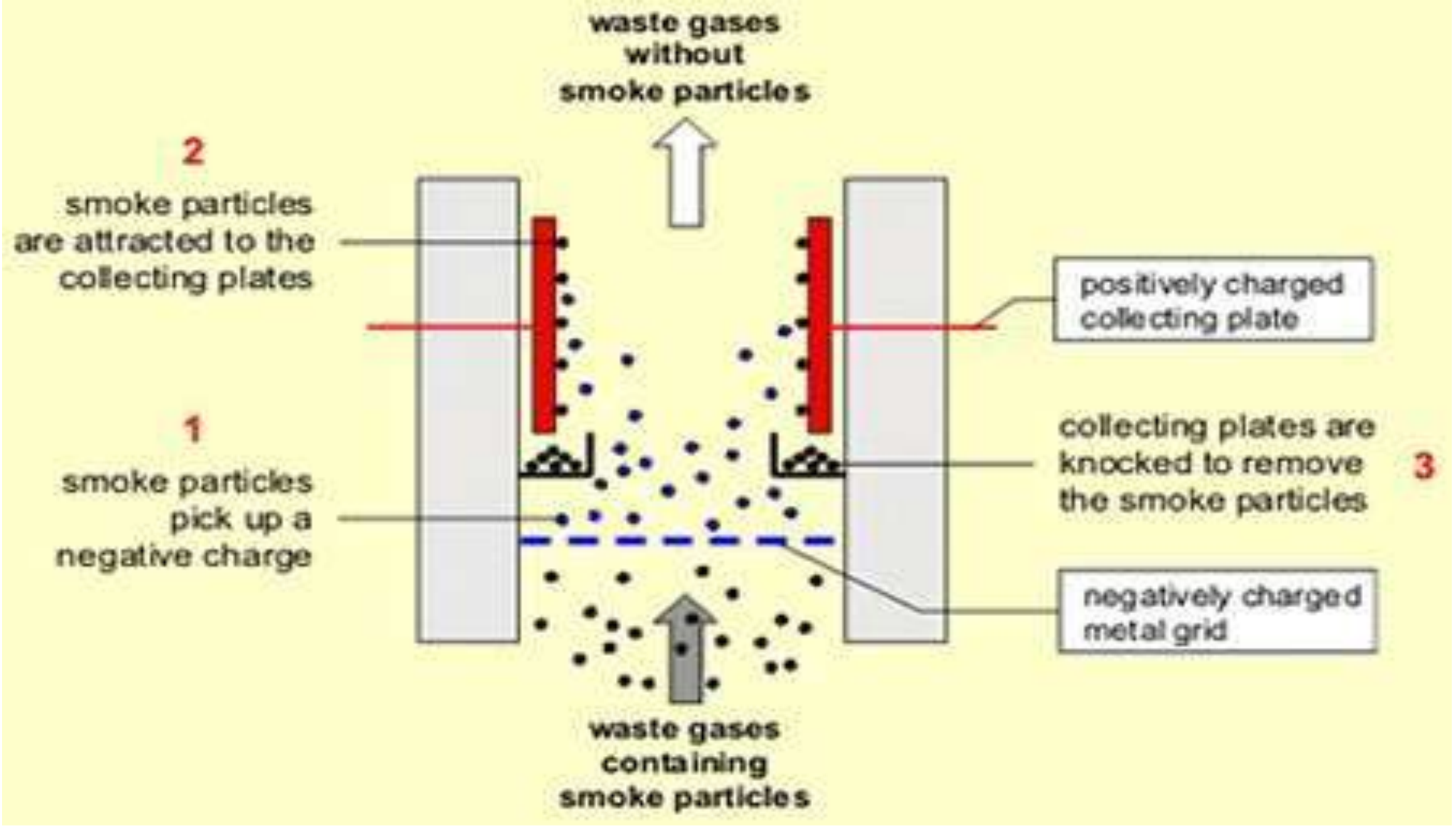
- Conventional efficiency
- High efficiency- smaller body dia to create greater separating force.
- Increase collection efficiency, if increase in dust particle size, dust particle density, gas inlet velocity, inlet dust loading, cyclone body length (no of gas revolutions)
- Decrease collection efficiency due to increase in gas viscosity, cyclone dia, gas outlet dia, inlet width, and inlet area.

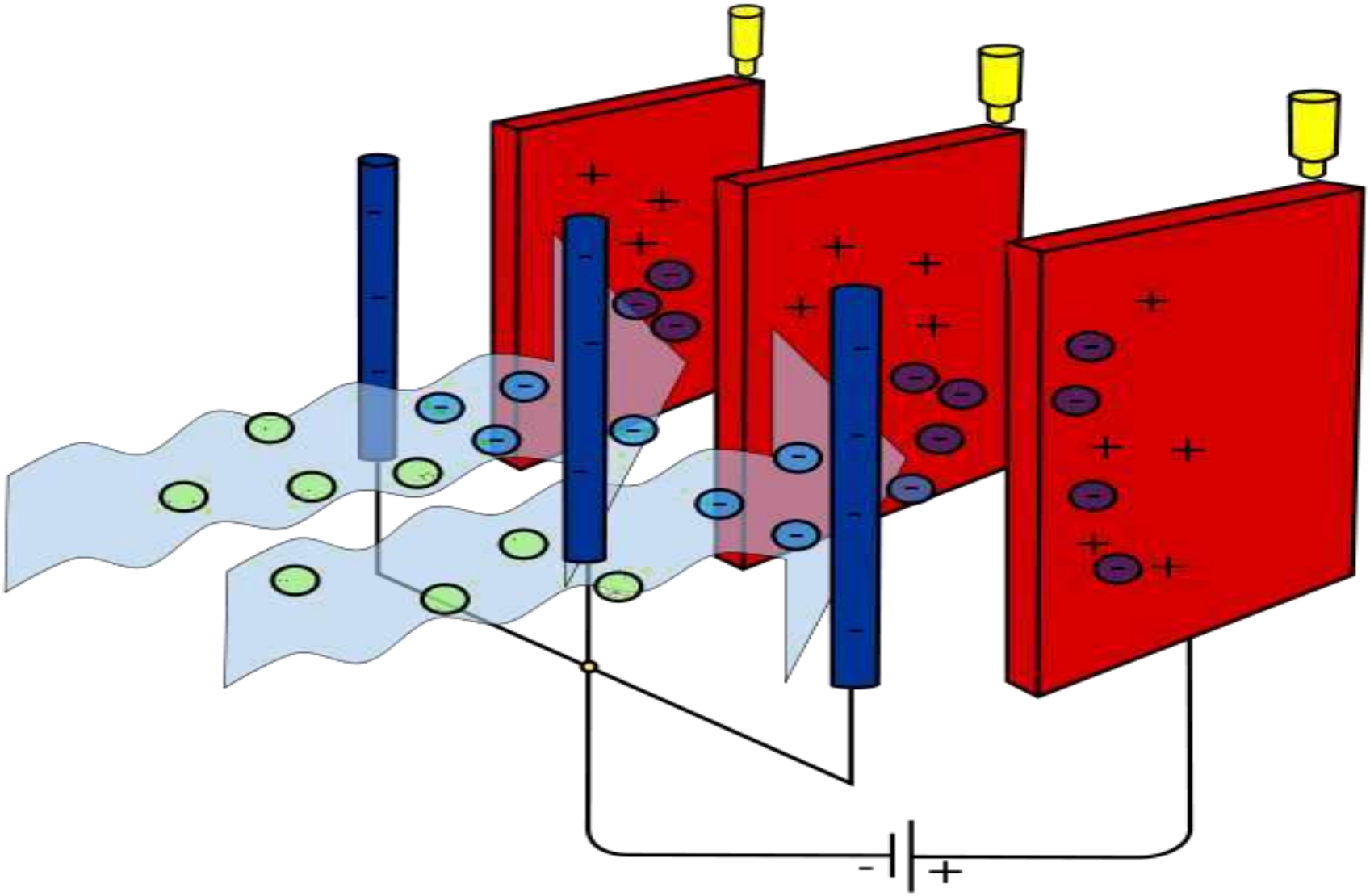
ELECTROSTATIC PRECIPITATORS

- Works on the principle of electrical charging of particulate Matter (-ve) and collecting it in a (+ve) charged surface.
- 99% efficiency.
- Can remove particle size range of 0.1 μm to 1 μm.

Six major components

- A source of high voltage
- Discharge electrodes and collecting electrodes
- Inlet and outlet for gas
- A hopper for disposal of collected material
- An electronic cleaning system
- An outer casing to form an enclosure around electrodes


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



Principles

- Gas stream passed two electrodes.
- High potential difference is maintained.
- Out of two electrodes, one is discharging other collecting.
- Potentials of 100 kv are used.
- Ionization creates active glow zone called “corona”.
- Gas ionization is dissociation of gas molecules into free ions.
- As particulates pass through field, they get charged and migrate to oppositely charged electrode.
- Particles deposited on collecting electrodes, lose charge and removed mechanically by rapping., vibration or washing to a hopper.

Single stage and two stage precipitators

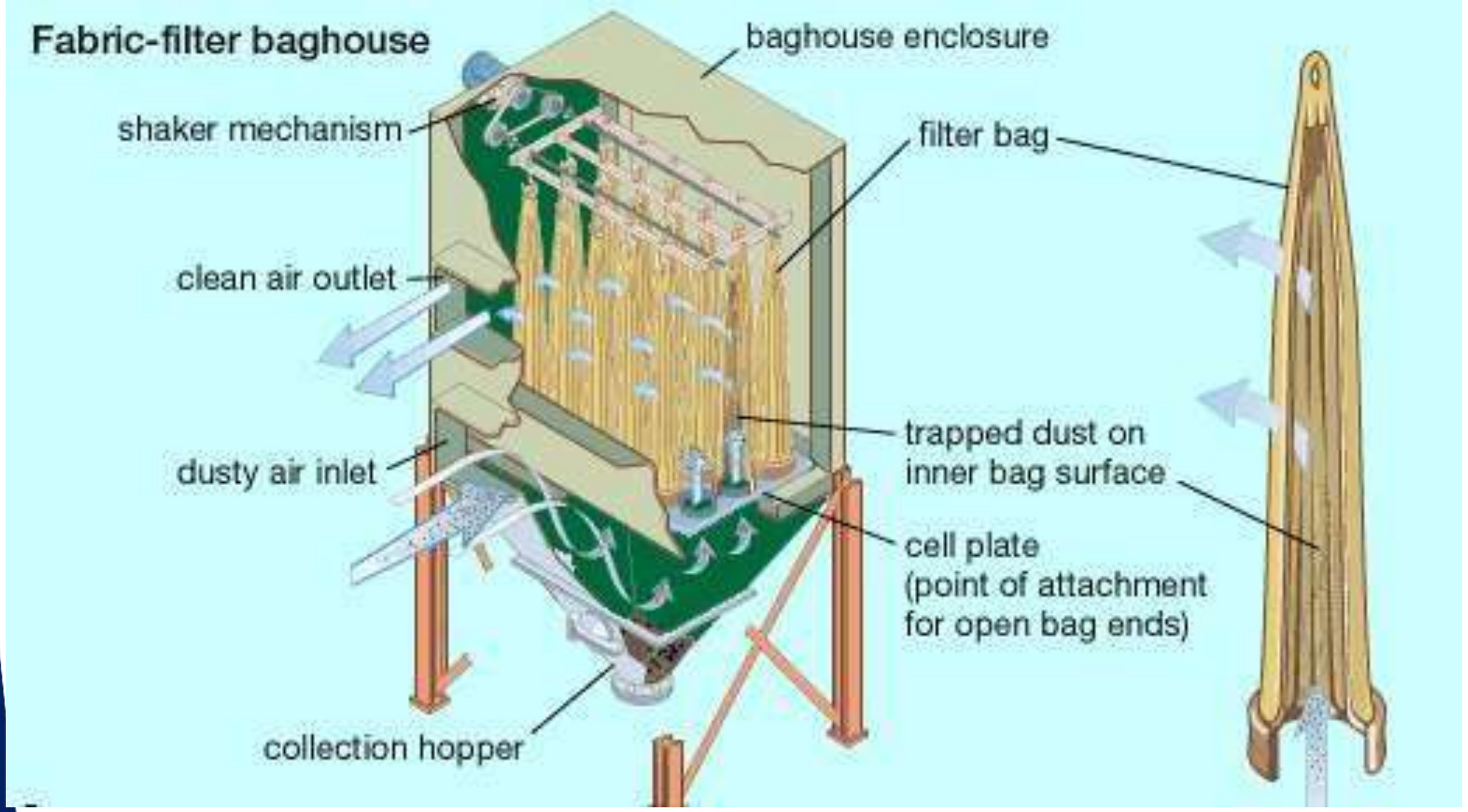
- Single stage gas ionization and particulate collection in a single stage.
- Two stage, particle ionized in first chamber and collected in second chamber.
- Industrial precipitators single stage design.
- Two stage used for lightly loaded gases.
- Single stage for more heavily loaded gas streams

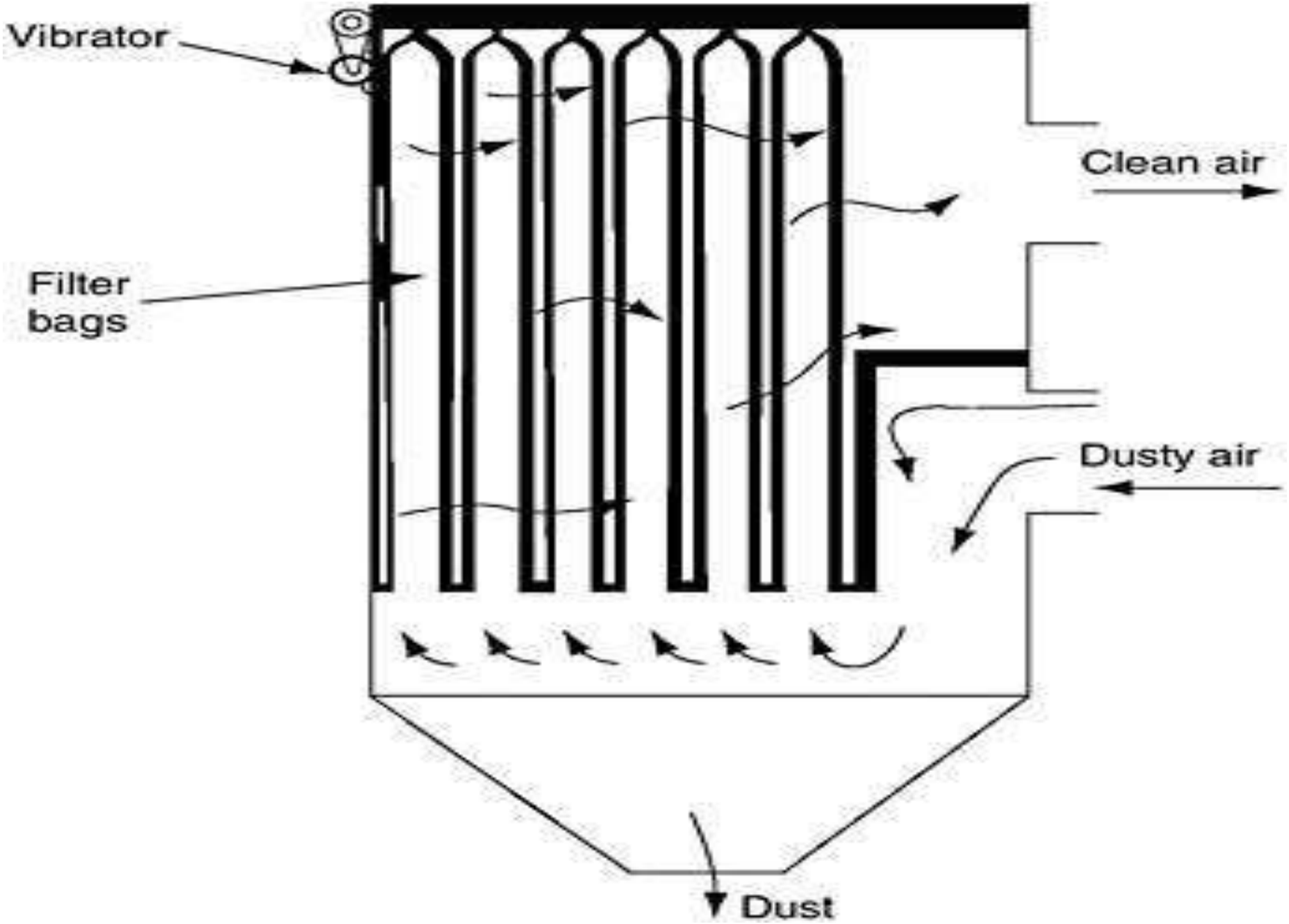
Efficiency

- General collection efficiency is high, nearly 100%
- Installations operate 98 and 99% efficiency.
- Acid mist and catalyst recovery efficiencies in excess of 99%.
- Carbon black, because of agglomeration tendency collection efficiency less than 35%.

FABRIC FILTERS OR CLOTH FILTERS

- Flue gas is allowed to pass through a woven fabric, which filters out particulate matter.
- Small particles are retained on the fabric.
- Consists of numerous vertical bags 120-400 mm dia and 2-10 m long.
- Remove particles up to 1 μm.
- Its efficiency up to 99%.


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


Vibrator
Clean air
Filter
bags
Dusty air
Dust

Factors affecting efficiency

Efficiency decrease due to

- Excessive filter ratio:- ratio of carrier gas vs gross filter area

- Improper selection of filter media:- temp. resistance, resistance to chemical attack and abrasion resistance taken into consideration

Operating problems

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

Fabric	Max. operatin g temp. (˚ C)	Acid resistance	Alkali resistance	Abrasion resistance	Tensile strength Kg/cm^2
Cotton	82	Poor	Good	Very good	4920
Wool	93	Very good	Poor	Fair to good	1755
Nylon	93	Poor to fair	Excellent	Excellent	5625
Dacron	135	Good	Good	Very good	5625
Polypropyl ene	93	Excellent	Excellent	Excellent	7730
Fiber glass	290	Fair to good	Fair to good	Fair	14,060

Advantages

- Higher collection efficiency for smaller than 10 μm particle size.
- Performance decrease becomes visible, giving prewarning.
- Normal power consumption.

Disadvantages

- High temp. gases need to be cooled.
- High maintenance and fabric replacement cost.
- Large size equipment.
- Fabric is liable to chemical attack.

SCRUBBERS OR WET COLLECTORS

- Particulate matters are incorporated into liquid droplets and removed from the gas stream.
- Flue gas made to push up against a down falling water current.
- Particulate matter mix up with water thus falls down and gets removed.

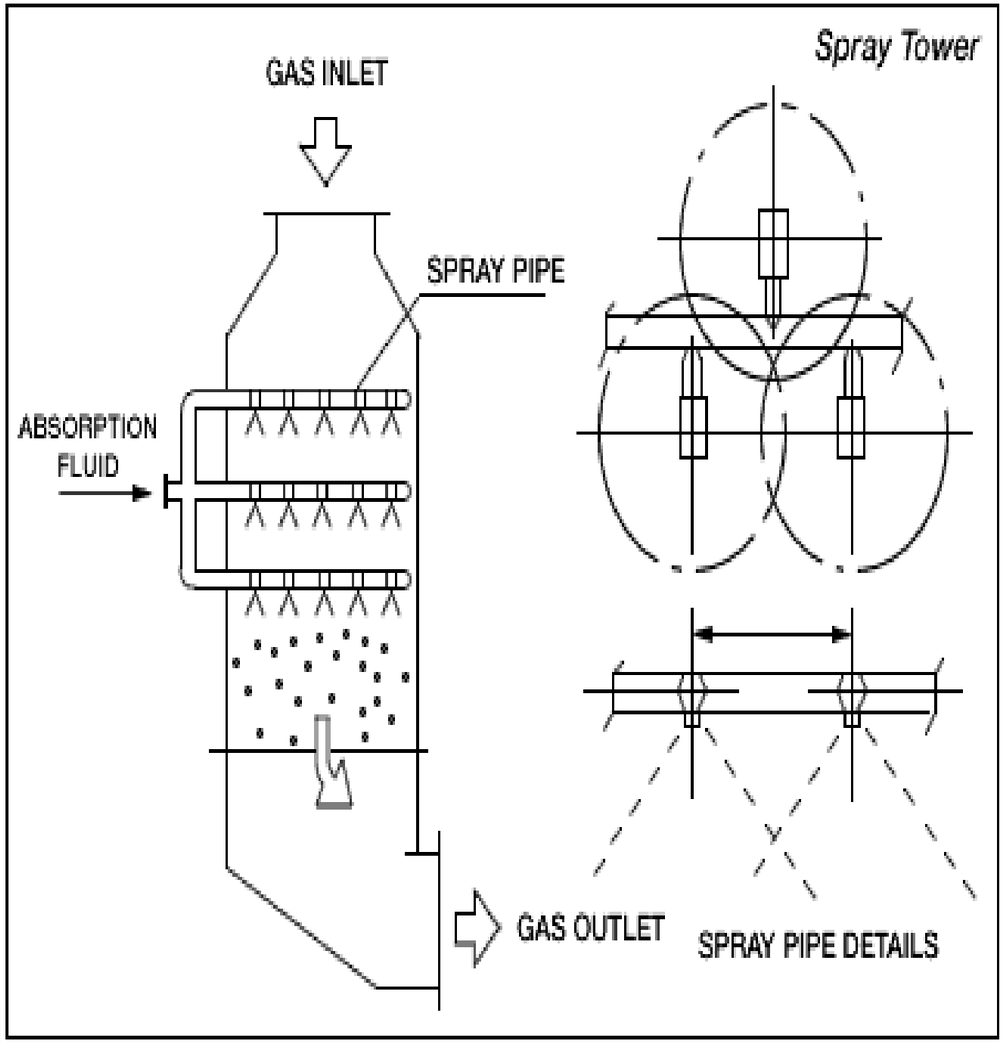
Collection mechanism

- Impingement
- Interception
- Diffusion
- Condensation

Types of scrubbers

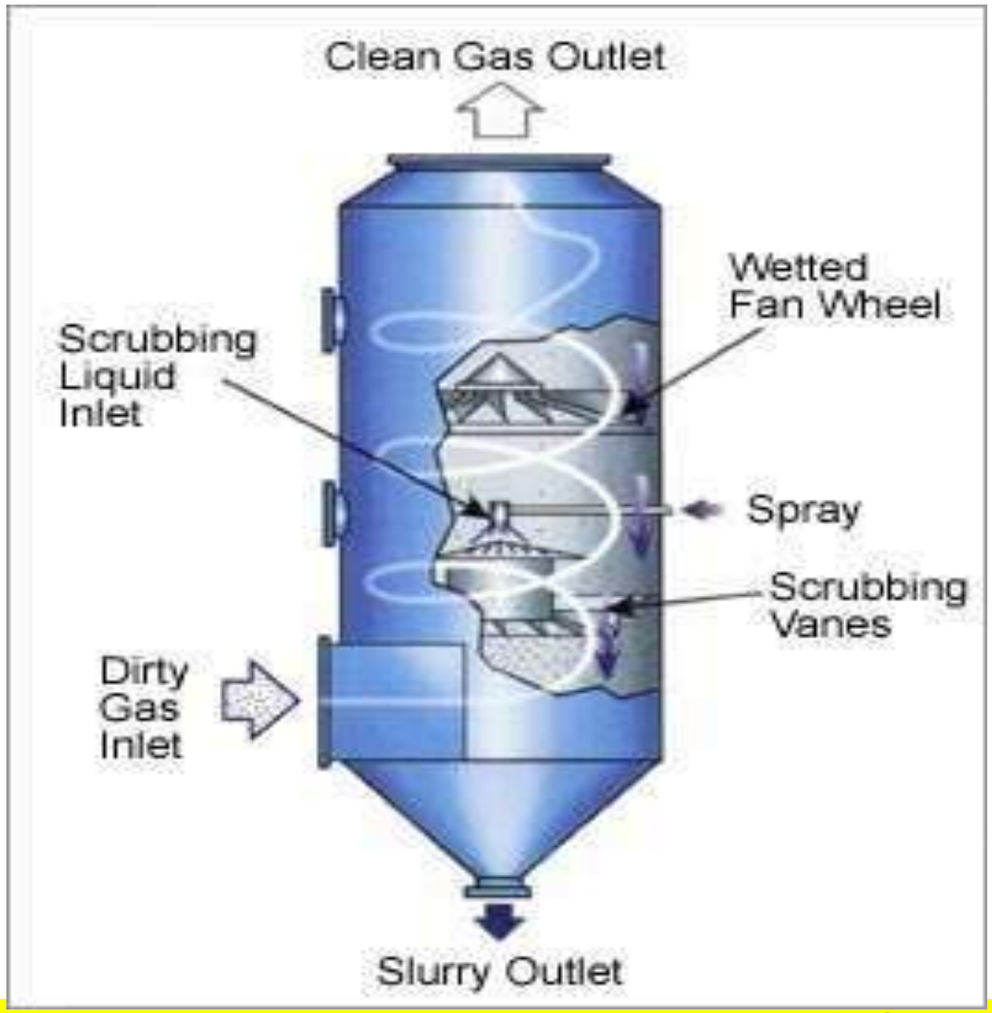
- Spray towers
- Venturi scrubbers
- Cyclone scrubbers
- Packed scrubbers
- Mechanical scrubbers

SPRAY TOWERS

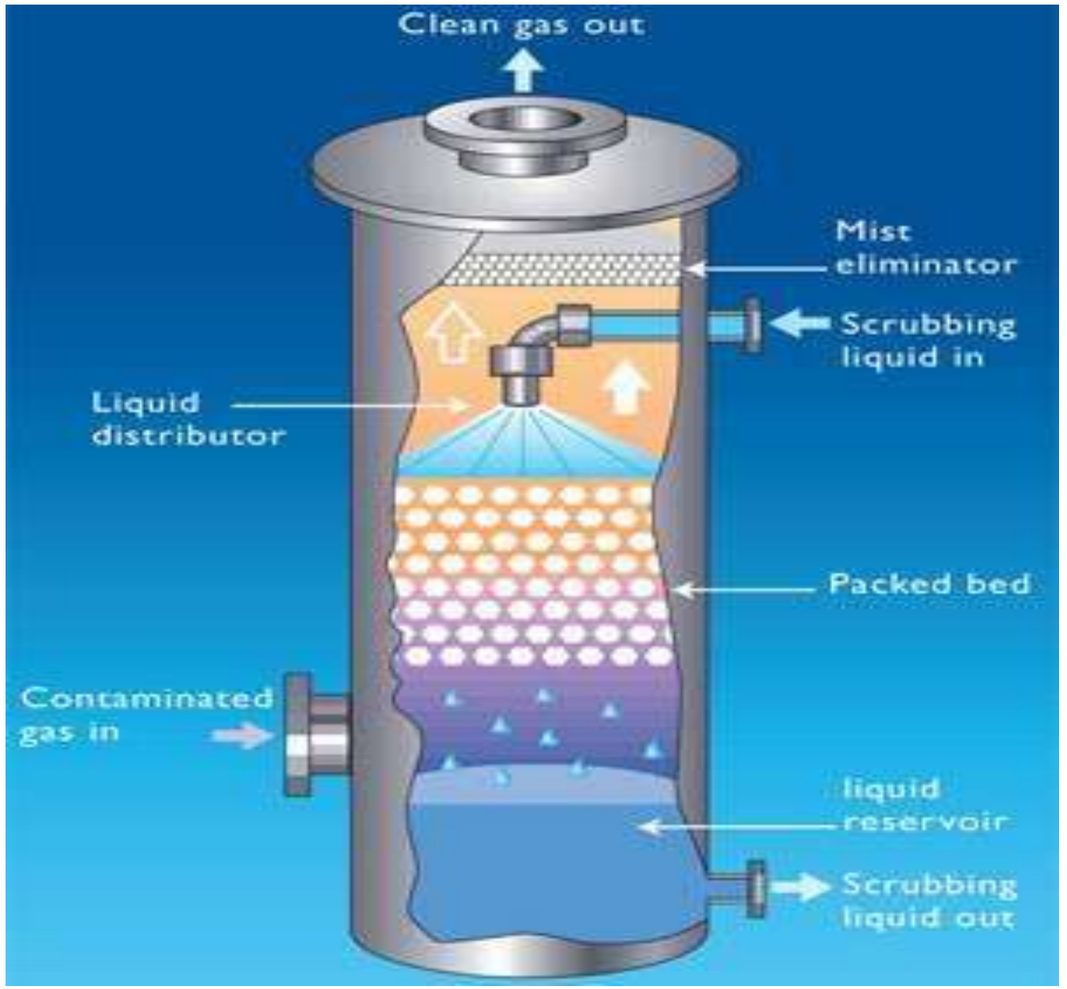


VENTURI SCRUBBER

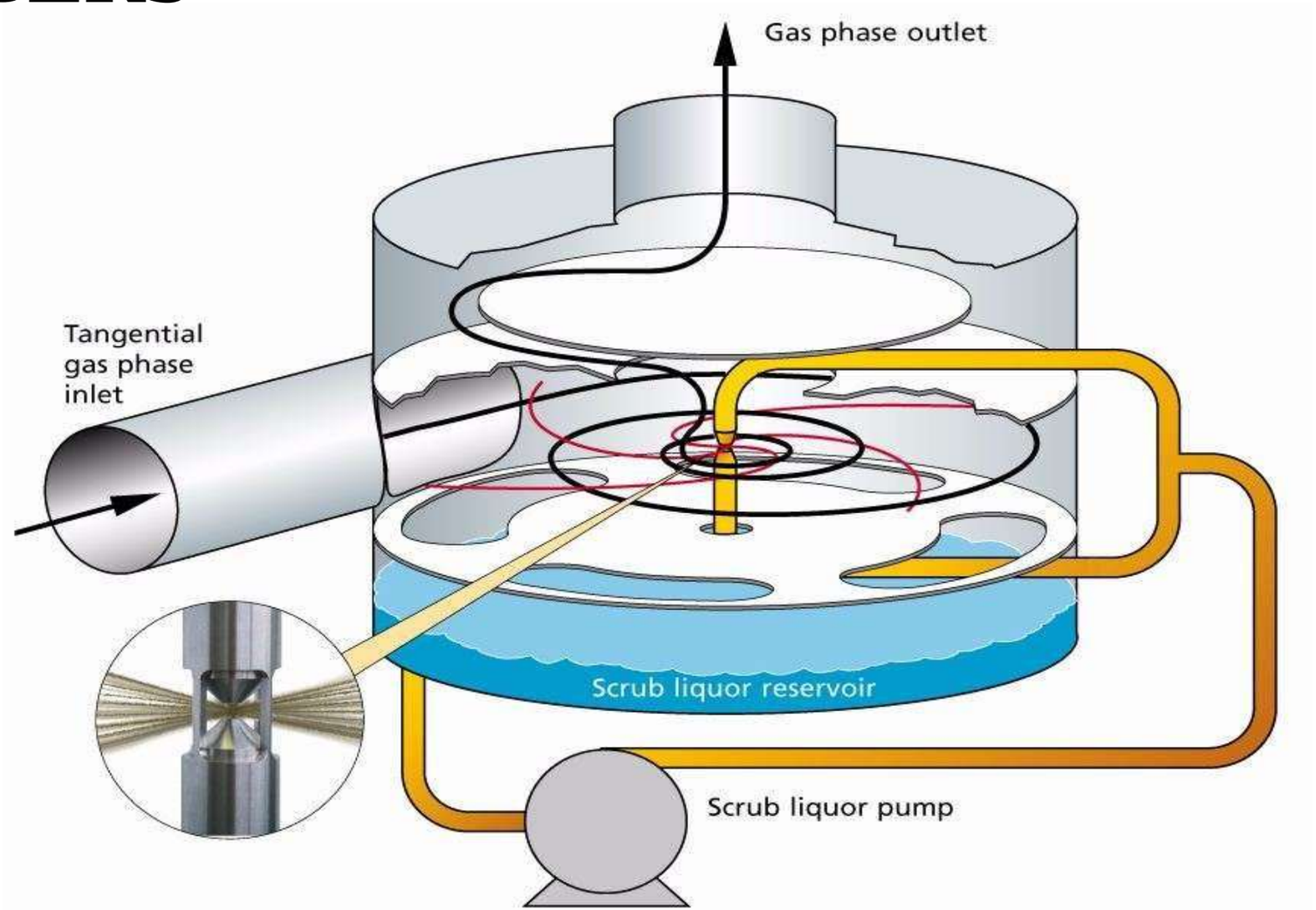
CYCLONE SCRUBBER



PACKED SCRUBBERS



MECHANICAL SCRUBBERS



Advantages

- Simultaneously remove particulates and gaseous pollutants.
- Hot gases can be cooled down.
- Corrosive gases can be recovered and neutralize.

Disadvantages

- Lot of waste waters produced.
- Poses freezing problem in cold countries.
- Maintenance cost is high when corrosive materials are collected.

ECONOMIC 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.

LECTURE CONTENTS WITH A BLEND OF NPTEL CONTENTS

REFERENCES/BIBLOGRAPHY

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Thank you!

STAY HOME, STAY SAFE