AIR POLLUTION CONTROL

1. Objectives
2. Basic approach
3. Control equipments
4. Gaseous pollutant control
5. Particulate pollutant control

Air Pollution Control

Objectives:

1. Prevention of nuisance
2. Prevention of physical damage to property
3. Elimination of health hazards
4. Recovery of valuable waste products
5. Product quality improvement
6. Minimization of economical losses in the industrial maintenance

Basic Approach

Pollution control could be achieved by adopting two approaches such as:

1. Dilution of pollutants to permissible level
2. Confining the pollutants at source

Dilution of pollutants to permissible level

I. Use of tall stacks

II. Dispersion of source locations

Confining the pollutants at source

I. Process control

II. Pollutant control

Process control:

The process is modified in such a way that the pollutants do not form at all beyond the permissible concentration.

It is the most effective way of pollution control. However it is some what expensive.

It could be done by two ways as under:

i) Raw material changes

ii) Operational changes

Operational changes could be done either by more effective operation of existing machinery or by replacement of old machinery.

Pollutant control:

When process control fails to achieve the source correction the pollution can be controlled by adopting effluent gas cleaning techniques, which involves many chemical engineering unit operations.

At present it is the main pollution control technology and it is of following two types:

1. Gaseous pollution control technology
2. Particulate pollution control technology

Gaseous pollution control technology

Gaseous pollution control could be achieved by adopting any one of the following three methods depending upon the nature of pollutant (effluent) gas.

1. Combustion
2. Absorption
3. Adsorption

1. Combustion

Conditions: This technique is used when the effluent gas contains organic pollutants. Product of combustion are CO_2 & H_2O vapors (less harm)

Process: 1. Thermal (Flame) combustion

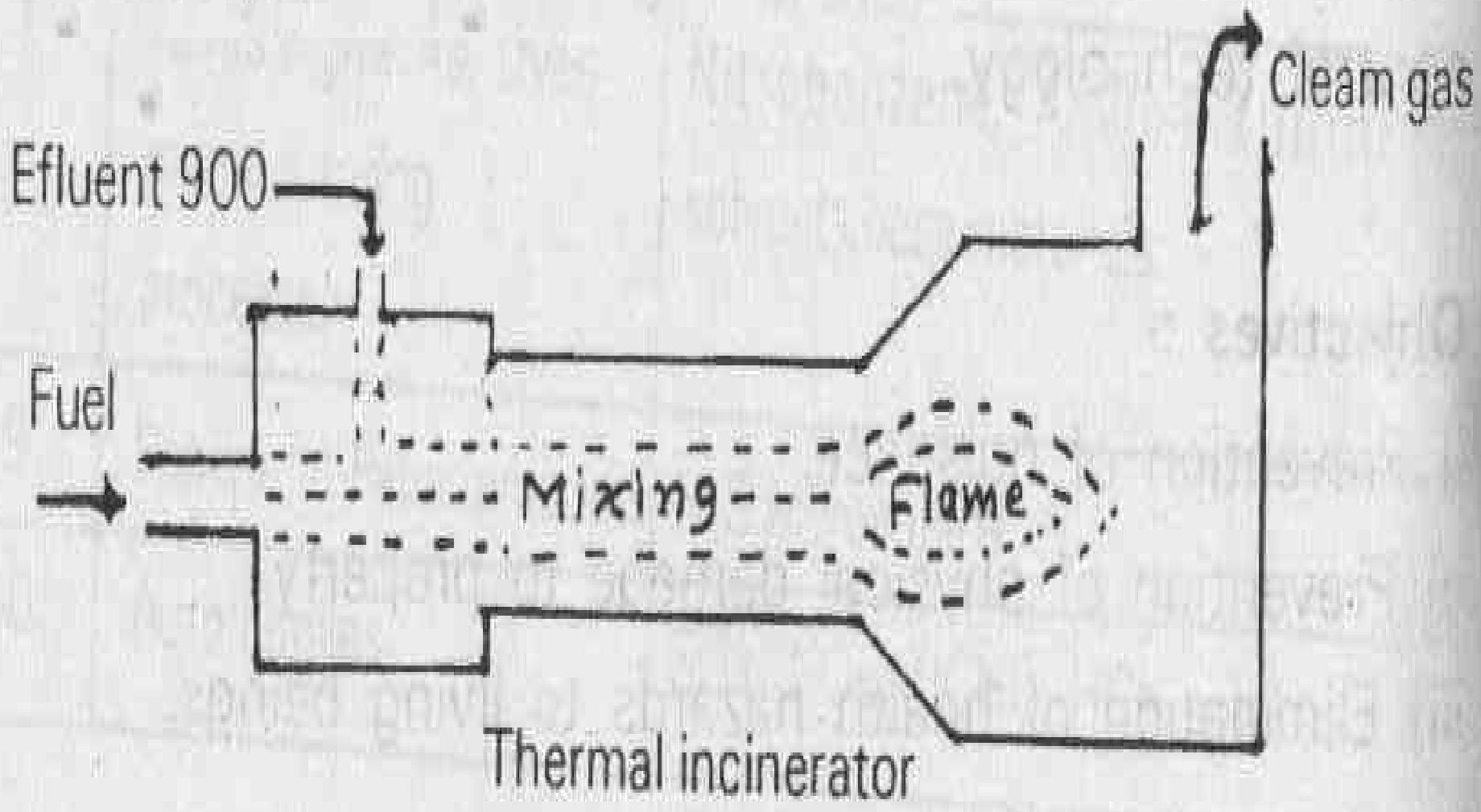
2. Catalytic combustion:-carried out when lower operating temperature is desirable. Ex- coffee roasting, enamel baking, paint fumes, waste gas

Equipments:

1. Thermal combustors-fume incinerators, steam injection(ventury)flares, after burners, etc

2.Catalytic combustors-

Combustion … cont …



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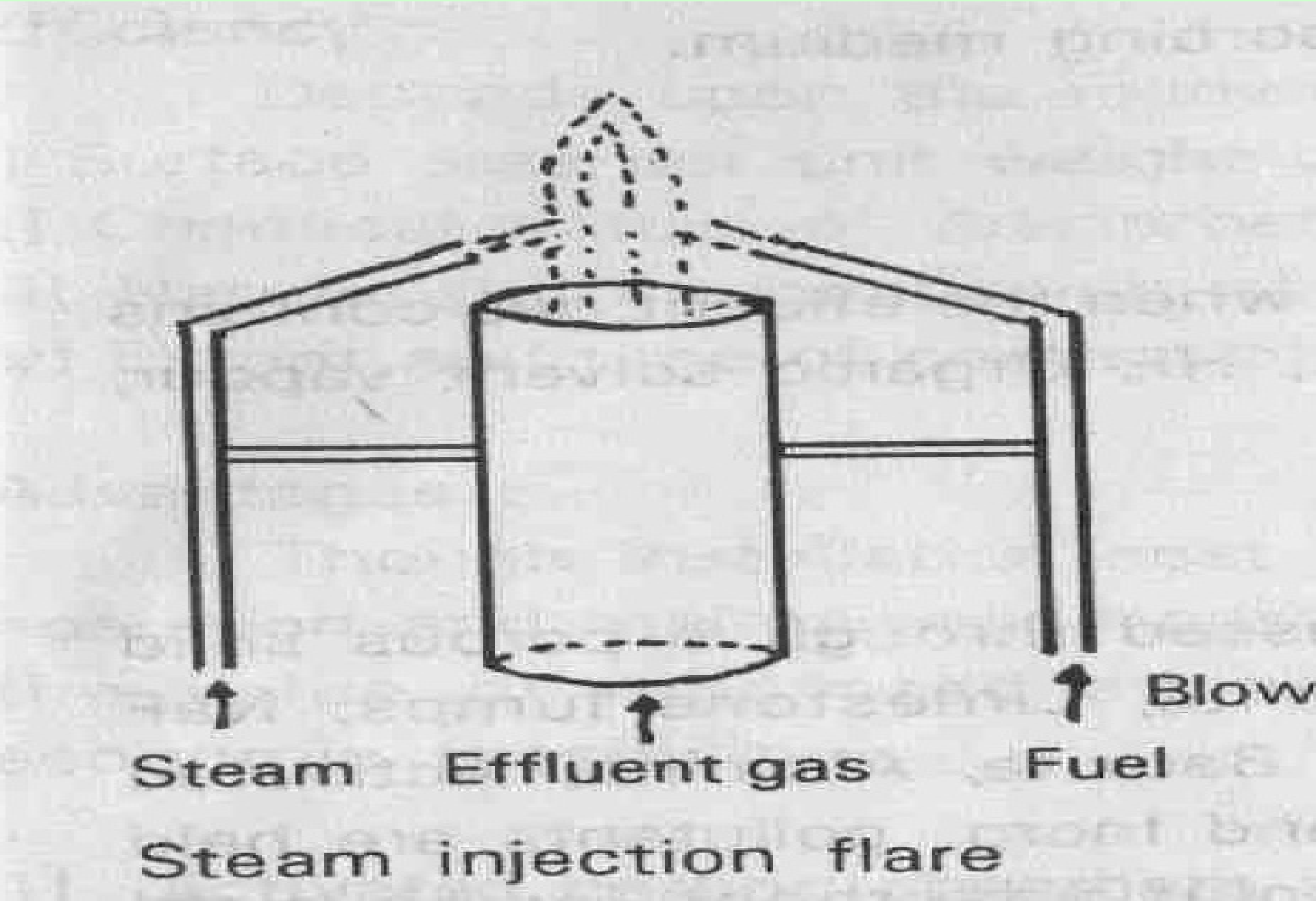

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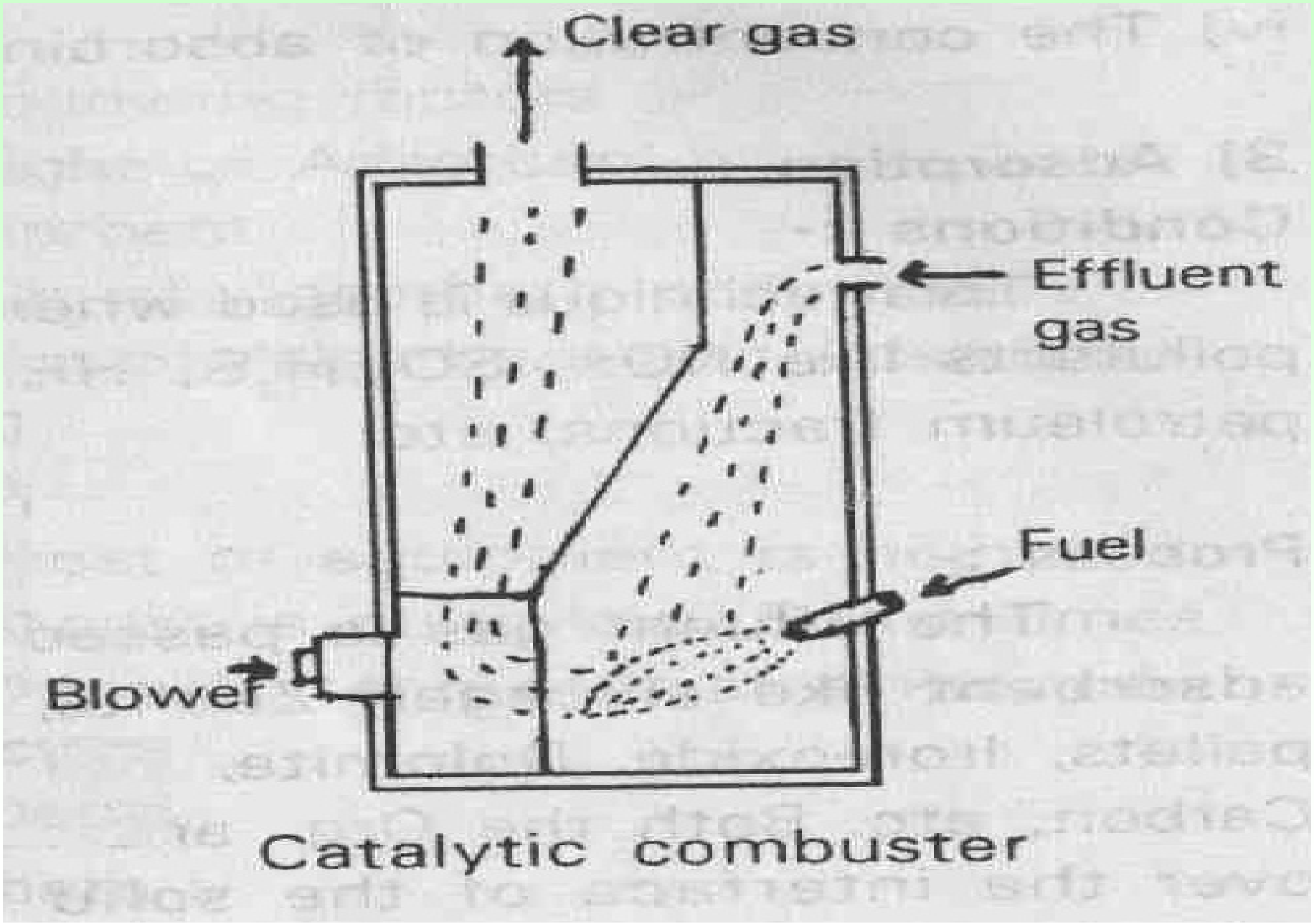


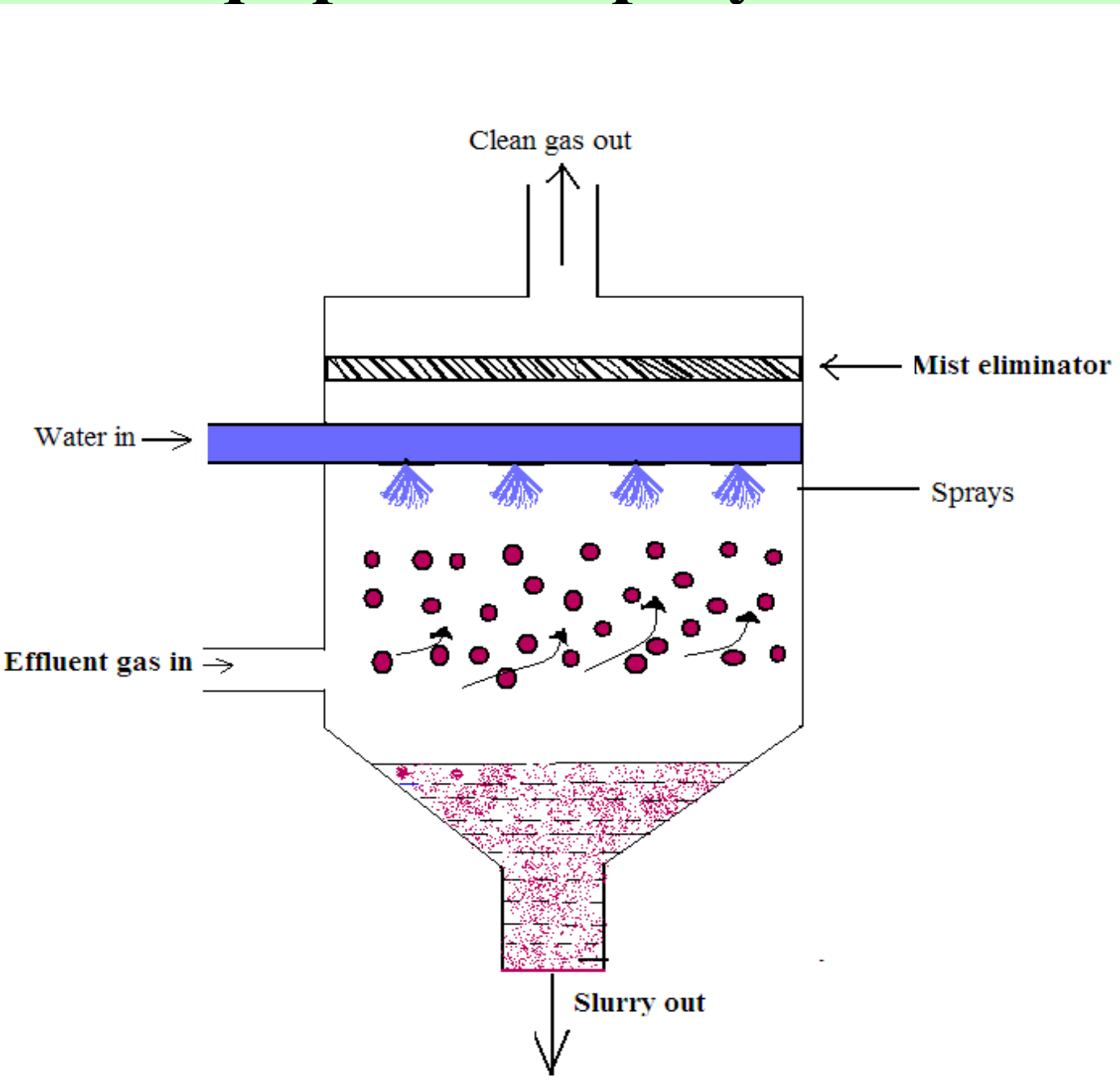
2. Absorption

Conditions: This technique is widely used when the effluent gas contains hazardous pollutants like NOx, SOx, H_2S, Fluorides, etc

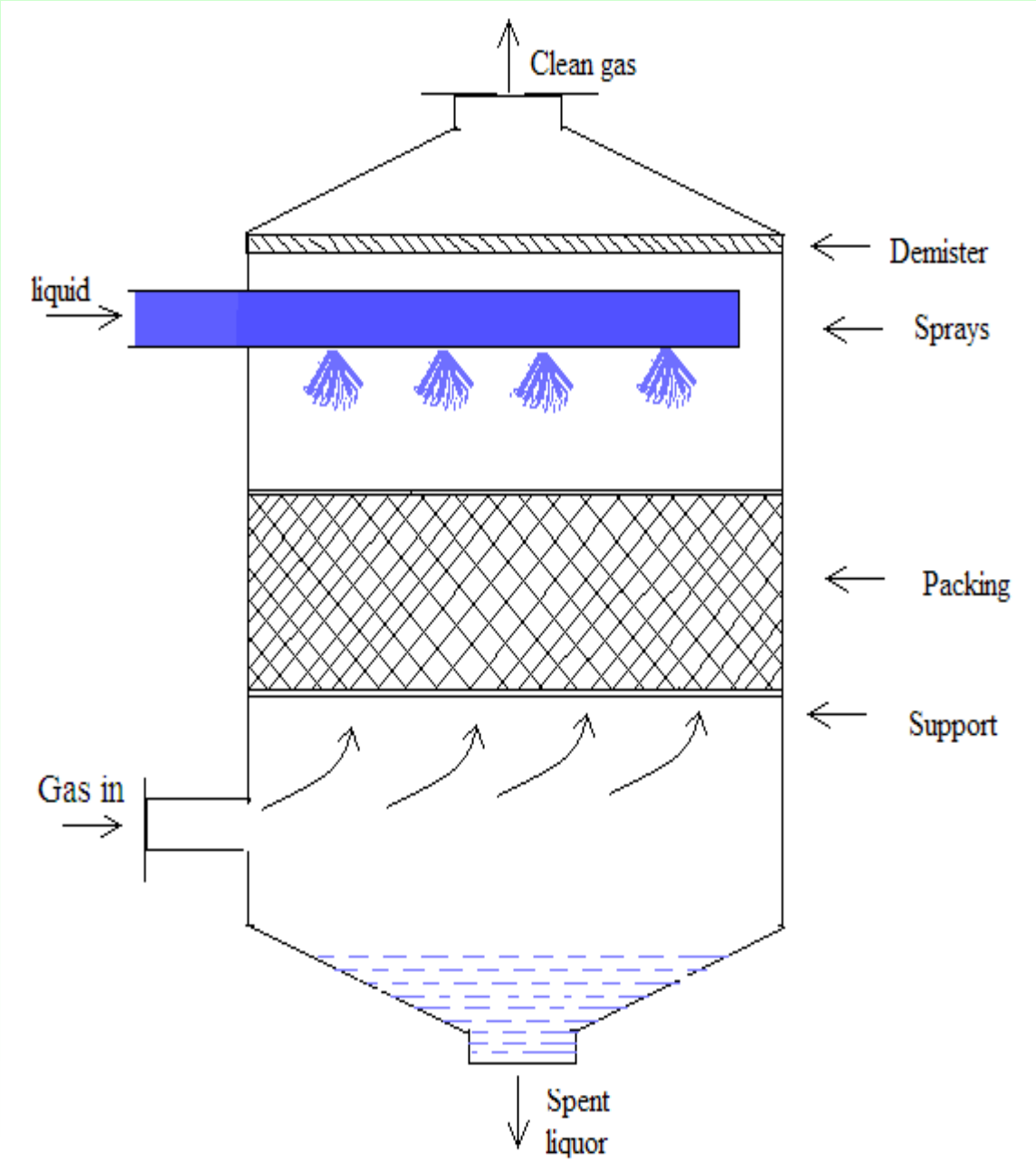
Process: The effluent gas is passed through a suitable liquid adsorbent like aq. NaOH, aq. HNO3, liquor NH3, NaOH+Phenol, Ethanolamine di Me Aniline, etc. One or more pollutants get absorbed / modified.

Equipments: Plate towers, packed towers, spray towers, bubble cap towers, scrubber towers, etc

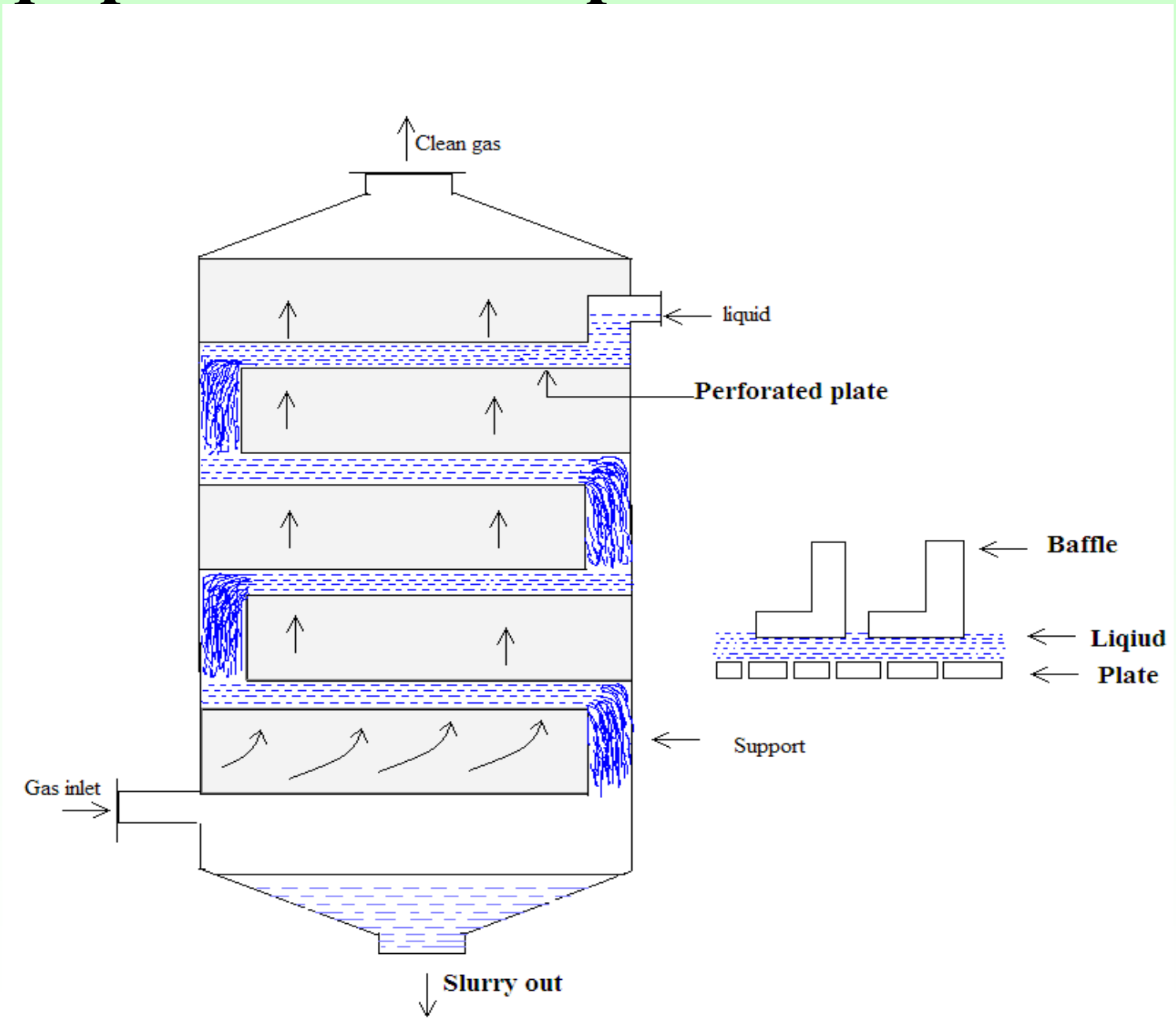
Equipment: Spray tower



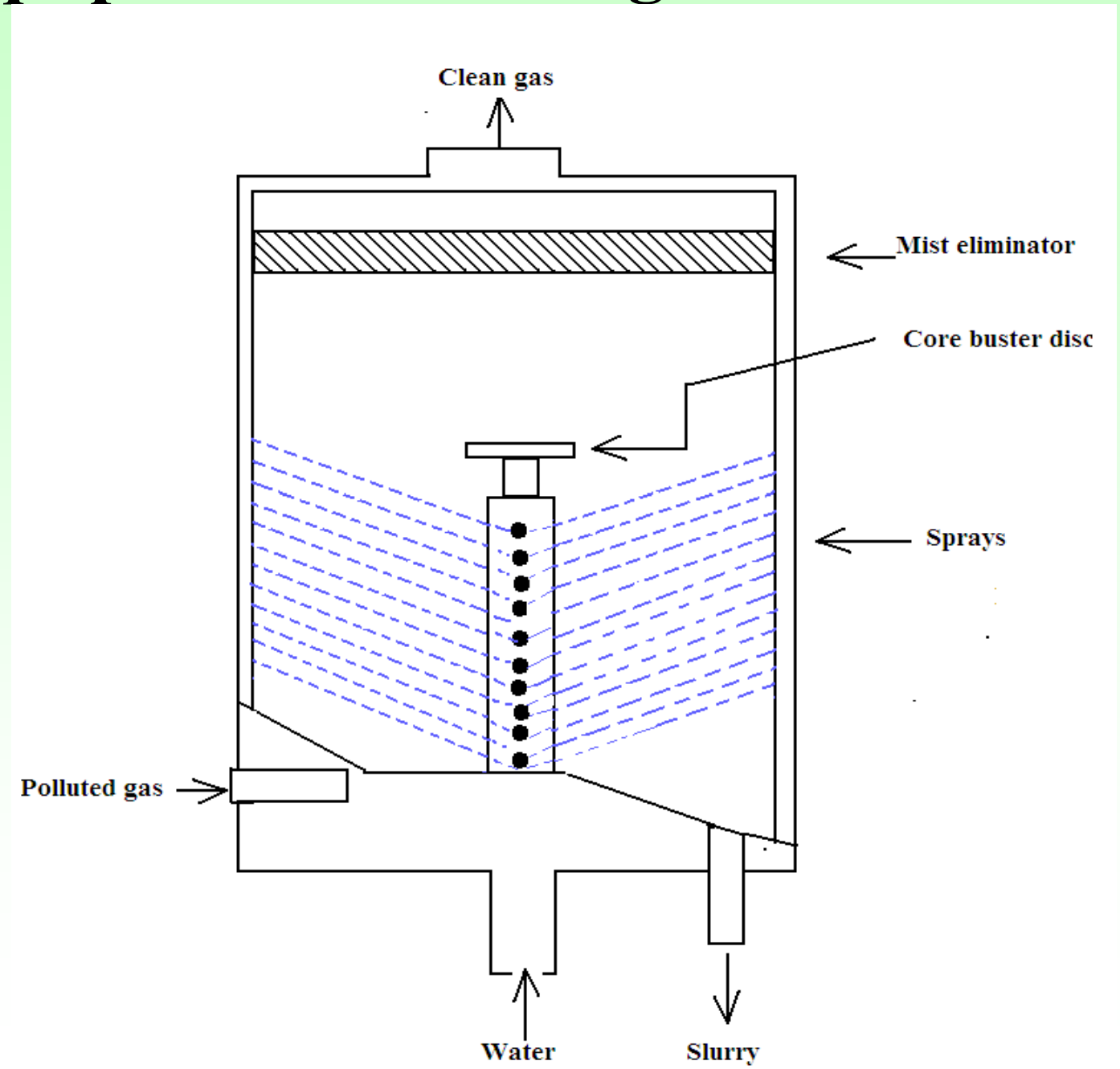
Equipment: Packed tower



Equipment: Baffle-plate scrubber tower



Equipment: Centrifugal scrubber tower



Absorption *... cont ...*

Efficiency:

Depends upon following factors-

1. Chemical reactivity of the pollutants in liquid phase
2. Extent of surface contact between gas & liqid
3. Time of contact
4. Concentration of absorbing medium

3. Adsorption

Conditions: This technique is used when the effluent gas contains pollutants like NOx, SOx, HF,Org.solvent vapors, Petroleum fractions, etc

Process: The effluent gas is passed through a porous solid adsorbent like Silicagel, Zeolite, Dolomite, Bauxite, Alumina, Limestone lumps, NaF pallets, Iron oxide, Activated Carbon, etc.

Both the Organic & Inorganic pollutants are held over the interface of the solid adsorbent by physical adsorption or chemo sorption.

Adsorption *... cont ...*

Equipment:-

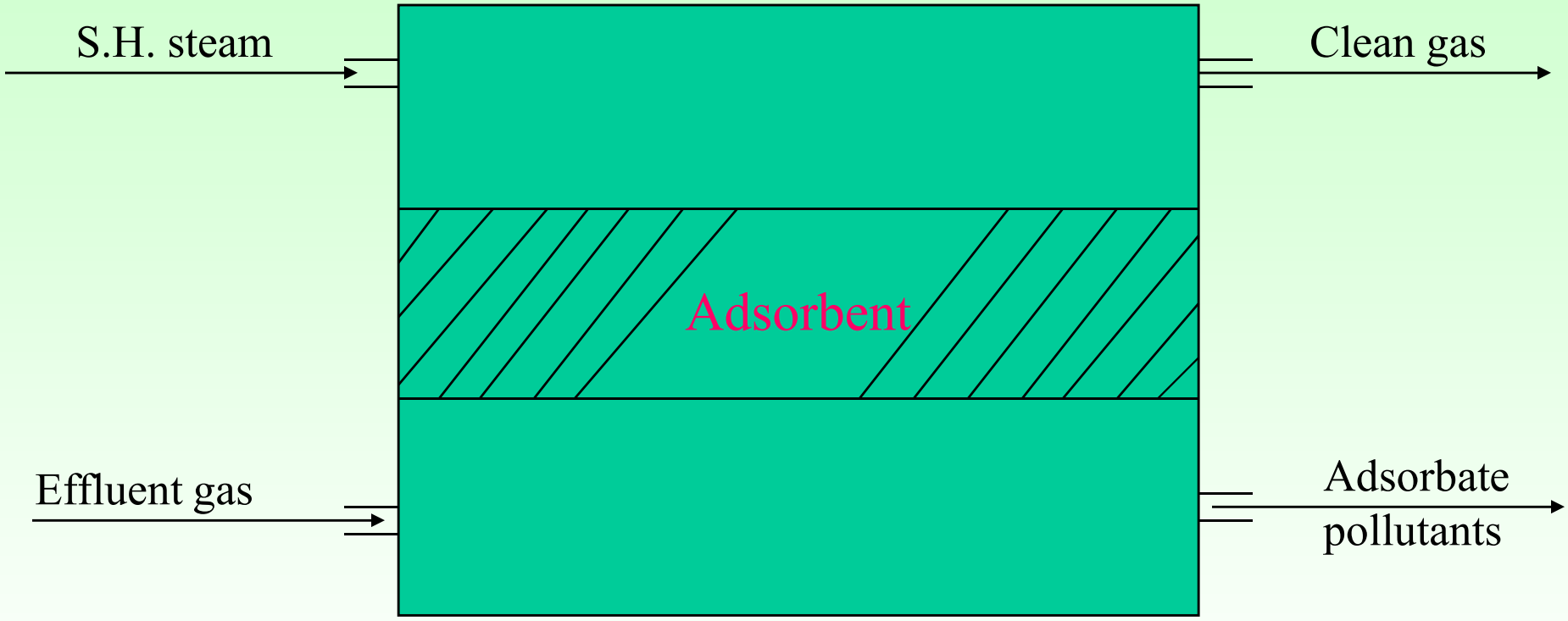
Consists of a packed adsorbent in the middle region.

It has one inlet for effluent gas below the bed.

Regenerative System:-

The equipment is also provided with a regenerative system, which causes disorption of the Adsorbate pollutants on raising temperature by injecting super heated steam or reducing pressure.

Adsorption ... *cont* ...



Adsorber

Adsorption *... cont ...*

Efficiency:- Depends upon the following factors

1. Surface area per unit weight of adsorbent.
2. Chemical nature of adsorbent.
3. Nature & concentration of adsorbate pollutant
4. Extent and time of contact of adsorbent & adsorbate

Advantages:-

1. Though installation cost of equipment is high, the operation & maintenance cost is quit low.
2. Some time the value of recovered adsorbate material enhances economic feasibility.

Activated Carbon Adsorber

Adsorption Capacity: Activated Carbon acts as a very good adsorbent because it is a highly porous solid & provides a very large surface area for adsorption (surface area of 1cubic inch activated carbon is above 20,000 sq. meters). This surface area is far greater than the volume of the adsorbate to be adsorbed.

Adsorption Selectivity: i) The adsorption by activated C is primarily a physical phenomenon

ii) Most suitable for Org. solvent vapours (HCs)

iii) Only adsorbent that adsorbs toxic & odorous materials (other methods are impossible/hazardous/uneconomical)

Particulate pollution control technology

Particulate matter emitted in effluent gases are minute suspended particles of 0.1 to 100 μm diameter.

These are originated from stationary as well as mobile sources.

Depending on their characteristics such as:- i) size & shape ii) physical & chemical nature iii) concentration iv) hygroscopic property v) electrical properties and vi) toxicity

the choice of devices to be used is based.

Particulate pollution control tech ...cont...

Pollution Control Equipments:

1. Mechanical devices-cyclone collector, gravity separator, etc
2. Absorption devices- wet scrubbers
3. Filtration devices- fabric filers
4. Electrical devices- electrostatic precipitators

Generally the spm of bigger dimension(< 50μm) are removed by Cyclone separators & Wet scrubbers where as fine spm (>0.1μm) are removed by fabric filers & ectrostatic precipitators

1. Cyclone Separators

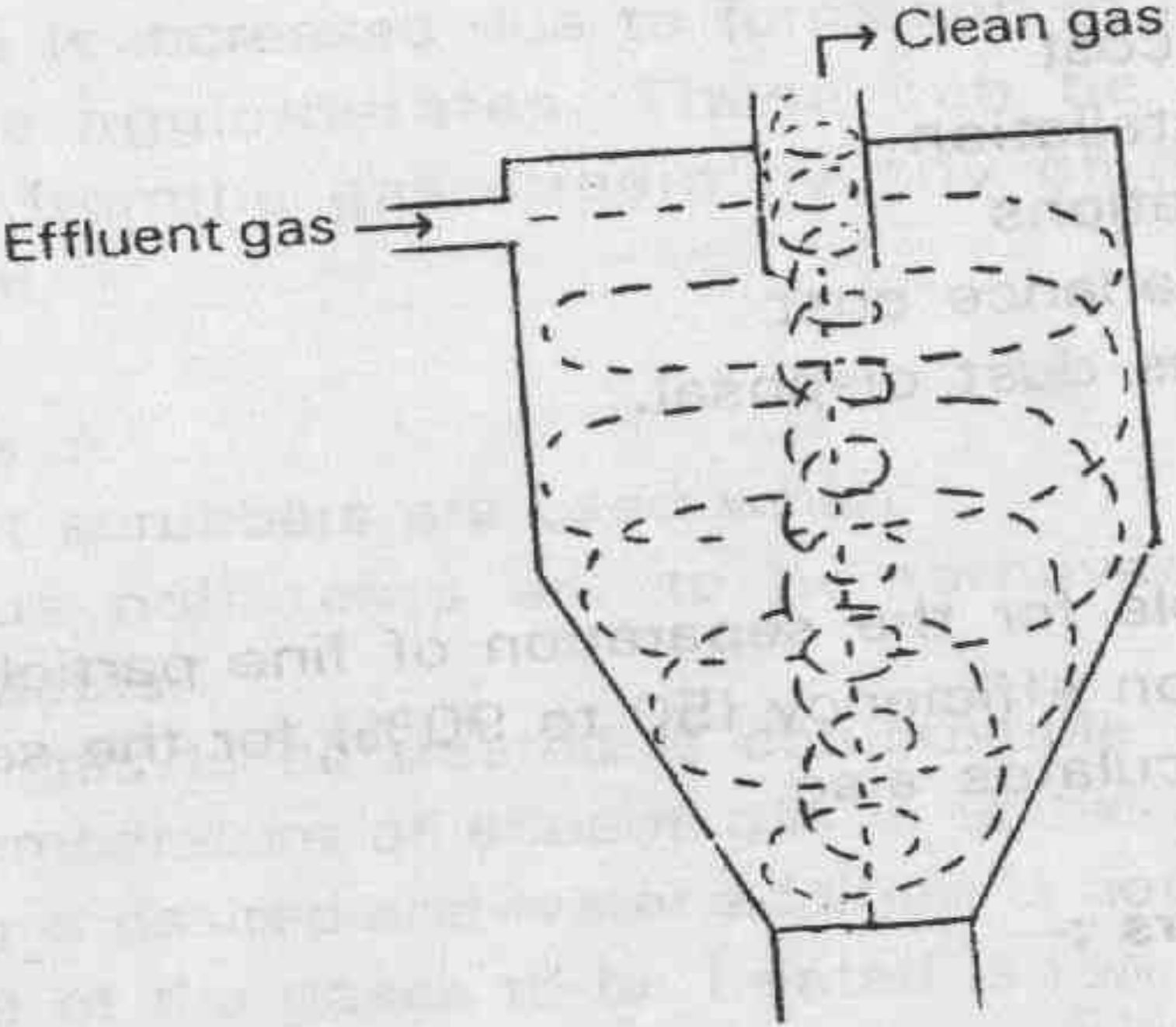
Principle: Utilizes a centrifugal force generated by spinning gas stream which separates the spm from the career gas.

Equipment: Consists of a vertical cylinder with a conical bottom.

Near the top a tangential inlet for effluent gas is located and at the bottom of the cone an outlet for spm is provided.

An outlet pipe for clean gas is extended in to cylinder to prevent short circuiting of gas from inlet to outlet.

Cyclone Separators ... cont ...



Cyclone Separators ... cont ...

Operation:

The effluent gas upon entering the cyclone cylinder, receives a rotating motion.

The vortex so formed, develops a centrifugal force, which acts through the spm radically towards the cylinder wall.

The gas spirals down wards to the bottom of the cone and at the bottom, the gas flow reverses to form an inner vortex, which leaves through the outlet pipe.

Cyclone Separators ... cont ...

Applications:

Used to remove the bigger spm from

1. Rock product industries- cement, mining, mineral processing, power plant fly ash, etc
2. Iron & Steel plants
3. Metallurgical industries
4. Food processing
5. Textile & paper industries
6. Petroleum refineries- recovery of catalyst

Cyclone Separators ... cont ...

Advantages:

1. Low initial cost
2. Simple installation
3. Easy operations
4. Low maintenance cost
5. Continuous dust disposal

Limitations:

1. Not applicable for separation of fine spm
2. Low collection efficiency (50 to 90%) for the separation of bigger spm too.

2. Wet Scrubbers

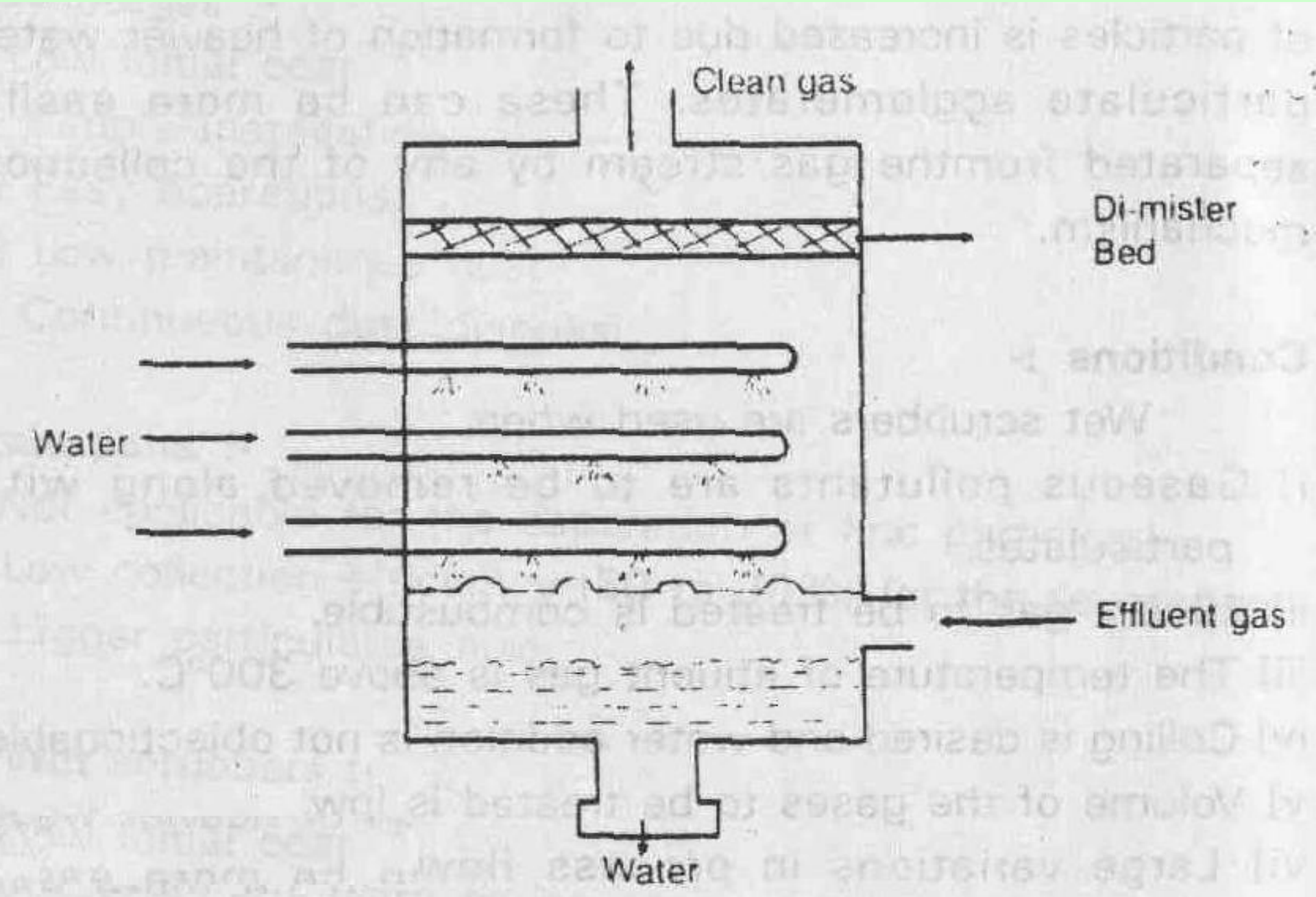
Principle:The spm laden gas is passed through a fine spray of water that very effectively removes spm as well as some gaseous matter.

Equipment: Gravity spray scrubbers, Cyclone spray scrubbers, Wet centrifugal scrubbers, wet impriger scrubbers, Ventury scrubbers, etc

System: spm collection could be done by-

1. Liquid carriage type method:- The spm laden gas stream is allowed to strike a liquid surface within the collector and the liquid carrying the trapped gas / spm move to a location outside the collector for ultimate disposal.

Wet Scrubber



Wet Scrubbers ... cont ...

2.Particle conditioning type :- spm in gas stream are brought in to intimate contact with water so that effective size of spm is increased due to formation of heavier water spm agglomerates that can be more easily separated from the gas stream by any of the collection mechanism.

Conditions: Wet scrubbers are used when-

1. Gaseous pollutants are to be removed along with the spm
2. Effluent gas to be treated is combustible
3. Temperature of effluent gas is above 300 ^{o}c

Wet Scrubbers ... cont ...

4. Cooling is desired and water addition is not objectionable.
5. Volume of the treated gas is low.
6. Large variations in process flow rates have to be accommodated.

Applications:

1. Chemical industries- H_2SO_4 manufacture
2. Mining & metallurgical industries
3. Craft mill furnaces
4. Petroleum refineries

Wet Scrubbers ... cont ...

Advantages:

1. Low initial cost
2. High collection efficiency
3. Applicable for hot effluent gases (> 300 ^{o}c)
4. Along with spm gaseous pollutants such as NH3, SOx, Metal fluons, etc are also removed

Limitations:

1. High power consumption
2. High maintenance cost(due to corrosion & abrasion)
3. Water & soil pollution (due to wet disposal)

3. Fabric Filters

Principle: spm laden gases are forced through a porous medium such as woven / felted fabrics. The spm are trapped due to different physical mechanism such as inertial impaction, direct interception, diffusion, etc. The clean gas is discharged out.

Filtration System: Filtration is the oldest, one of the most versatile & efficient methods for removing spm from the industrial gases.

Fabric filters may be woven fabrics or felt cloth. Wovenfabrics have definite long range repeating

Fabric Filters ...cont...

Pattern and considerable porosity in the direction of gas flow. Felted cloth consists of randomly oriented fibers compressed in to a mat on a loosely woven backing material.

Conditions: The choice of fabric filter is based primarily on the:- I. Operating temperature

II. Corrosiveness/abrasiveness of the spm

At low temp (80-90^{O}c)- Cotton & Nylon

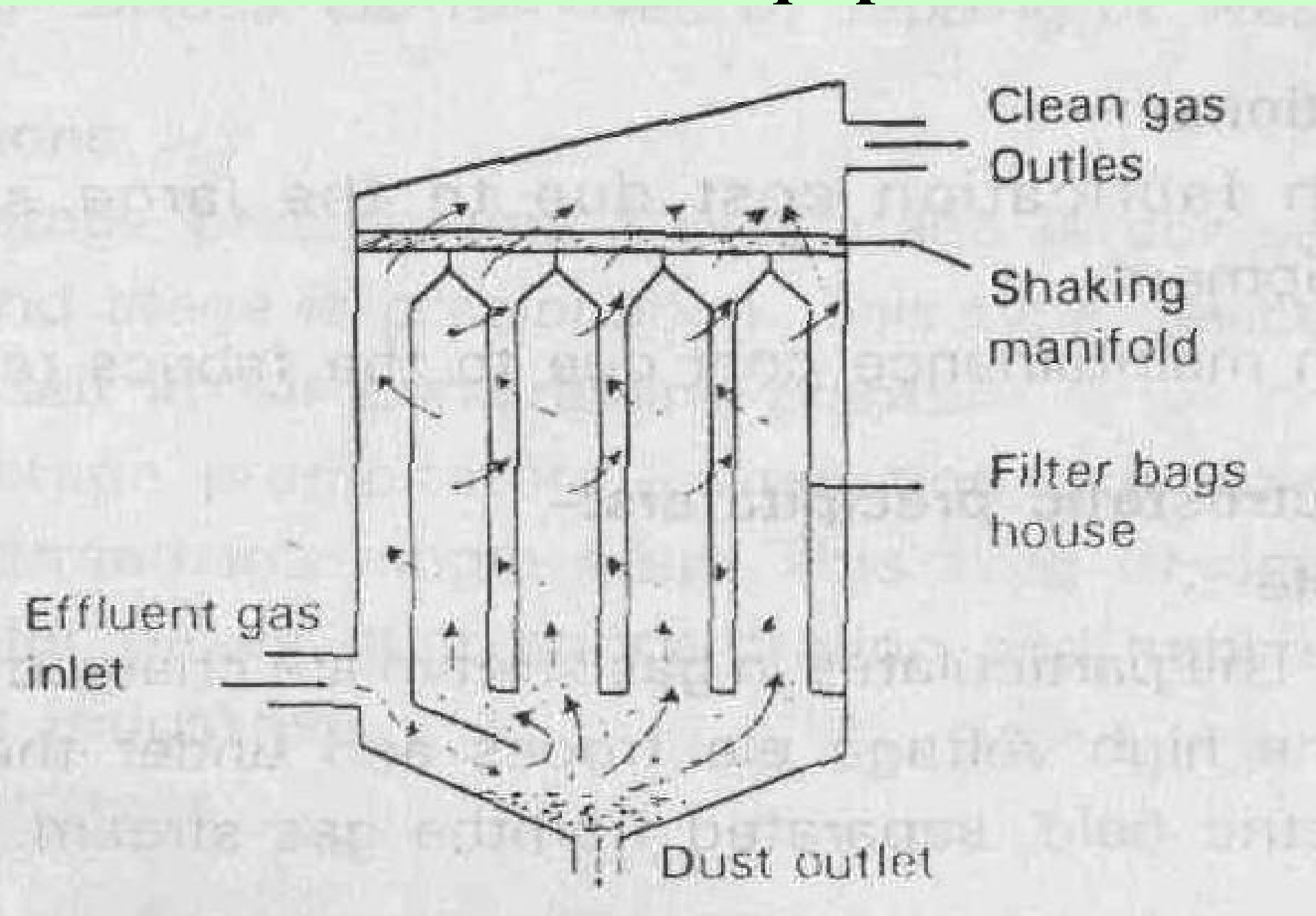
At high temp (250-350^{O}c)- Asbestos & Si coated

For acidic gases-Wool, Orlon, Vinyon, etc

For alkaline media- Asbestos & Nylon

For High chemical resistance- glass fibers

Fabric Filter: Equipment



Fabric filter: Equipment

Equipment: A typical fabric filter consists of a bag house made of tubular bags mounted on shaking manifold in such a manner that the suspended particles fall in to a hoper when dislodged from the fabrics.

The effluent gas inlet is situated at lower portion while the outlet for clean gas is at upper portion and the dust outlet is at the bottom of the hoper.

Operation: Particle laden gas enters the bags at bottom and passes through the fabrics. The spms deposit on the insides of the bags while the clean gas passes out. Cleaning of the bags is carried out by shaking and the spms from hoper are taken out at fixed intervals.

Fabric filter: Equipment

Applications:

1. Pigment and paint industries.
2. Pharmaceutical plants.
3. Metallurgical industries
4. Rock product industries- clay, ceramics, cement, carbon black, etc.

Limitations:

1. High fabrication cost due to the large size of the equipment (bag house).
2. High fabrication cost due to fabric replacement

Fabric filter: Equipment

Advantages:

1. Very high collection efficiency (99 to 99.99%)
2. Collection of spm in dry state
3. Useful for fine spm in particular
4. Simple installation
5. Simple operation
6. Low pressure drop
7. Low power consumption

Electrostatic precipitators

Principle:

The spm in gas stream are charged electrically over the high voltage electrodes and under the influence of electric field, separated from the gas stream.

Electric device:

Electrostatic precipitators consist of following parts:

- A source of high voltage for charging the particles electrically by ionization
- High voltage discharge electrode (usually -ve) of small cross sectional area (wire) and a collecting electrode (usually +ve) of large surface area (tube/plate) and lower potential.

Electrostatic precipitators

- A device for disposing the collected particles.
- An outer housing enclosing the electrodes.

Operation:

It involves four basic steps as under:

1. **Charging-** The particulates in incoming gas are charged electrically over the high voltage electrodes by ionization.
2. **Transporting-** The charged particulates are transported by the force exerted upon them in the electric field to the collecting surface.

Electrostatic precipitators

3. Discharging- The charged spm are precipitated on the collecting surface by the neutralization of their electric charge.

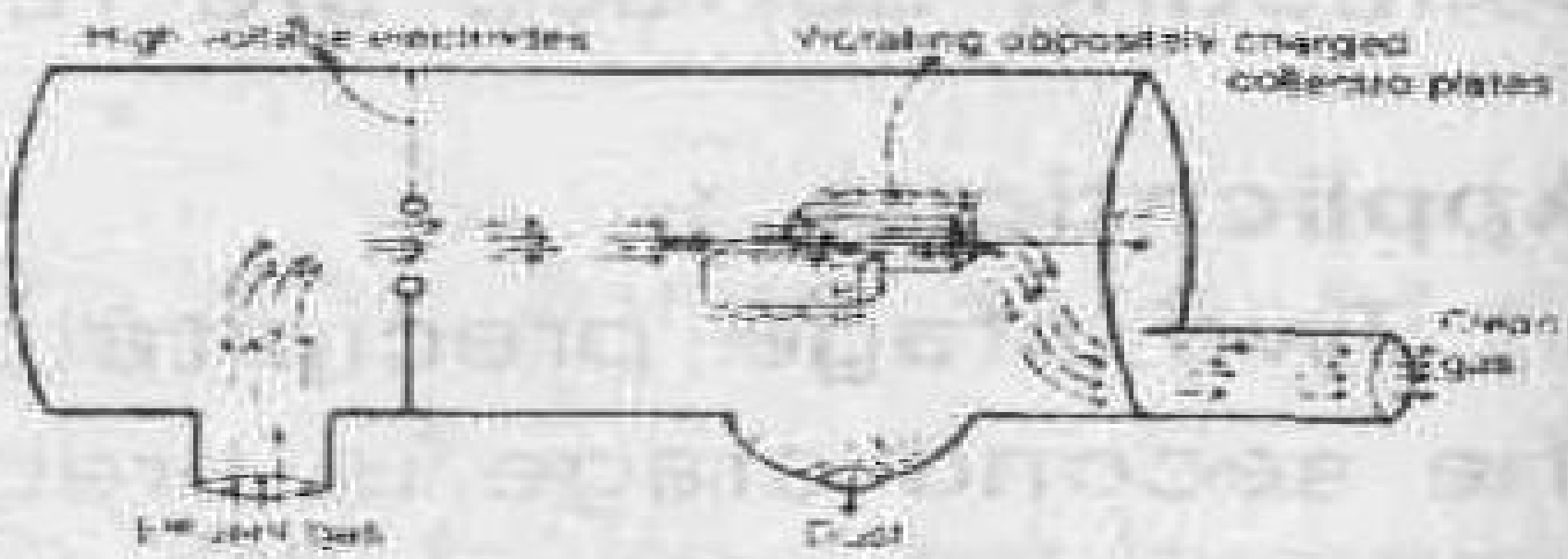
4. Removal- The precipitated spm from the collecting surface are removed by wrapping or washing.

Applications:

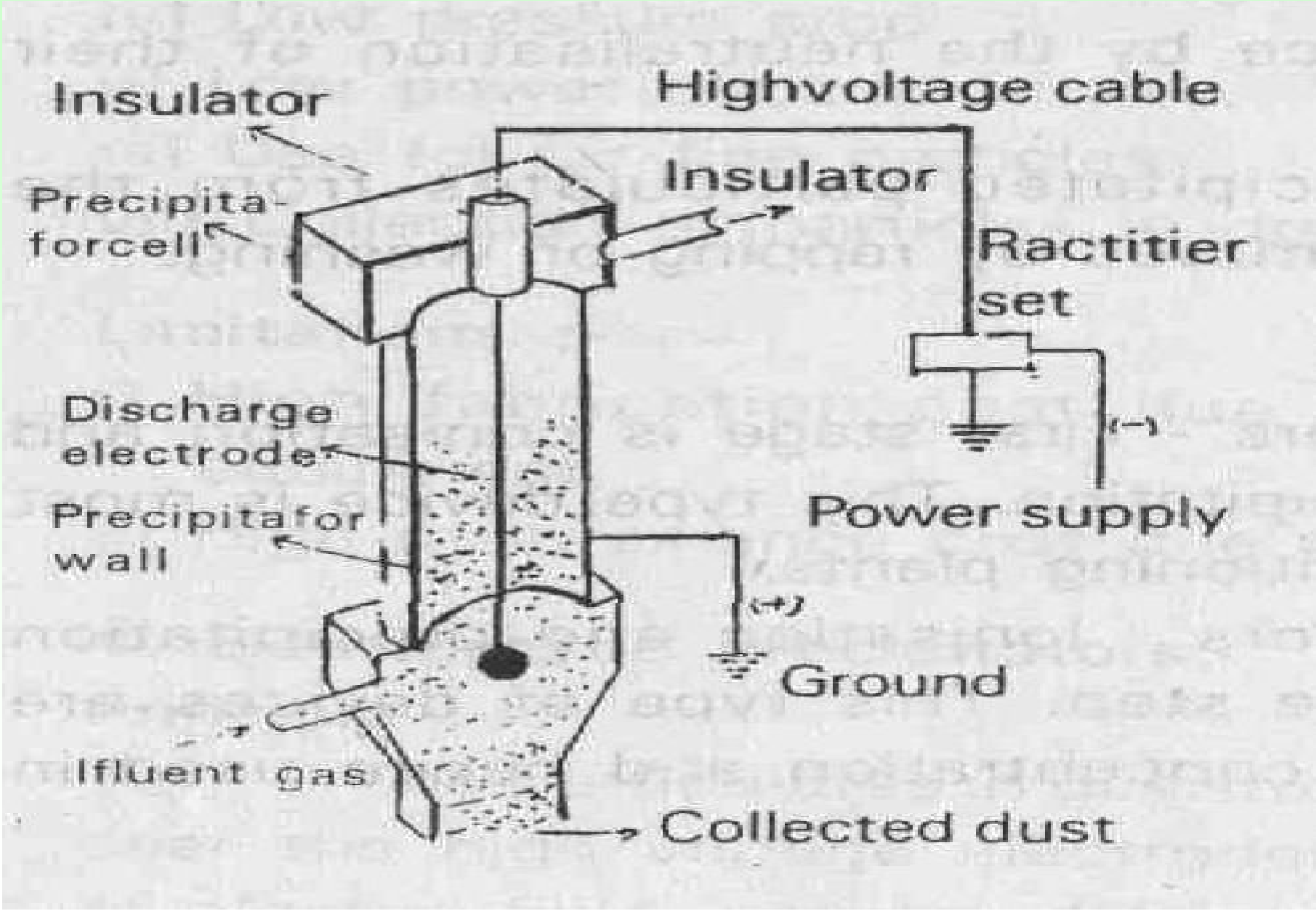
1. Two stage precipitators- First stage is ionization and the second one is precipitation. This type device is most widely used in air conditioning plants.

2. One stage precipitators- Ionization & precipitation are performed in a single step. This type of devices are suitable for heavy dust concentration and hence used

Electrostatic precipitator (Two Stage)



Electrostatic precipitator (One Stage)



Electrostatic precipitators

These are used in following industries

1. Power plants
2. Pulp & paper industries
3. Iron & steel plants
4. Chemical industries- Sulphuric acid manufacturing plants
5. Refineries
6. Mining & metallurgical industries
7. Rock product industries- Cement, ceramics, carbon black, etc.

Electrostatic precipitators

Advantages:

1. High collection efficiency (80 – 99.5%)
2. Applicable for efficient removal of the fine spm
3. Applicable for very large volumes of industrial effluent gases.
4. Applicable for high temperature industrial gases
5. Valuable dry particulate matter could be removed
6. Low maintenance cost
7. Low power consumption
8. Negligible treatment time
9. Low pressure drop.

Electrostatic precipitators

Limitations:

1. High initial cost
2. Tedious operations
3. More space requirement