AIR POLLUTION CONTROL TECHNOLOGIES

Mobile Sources

• Vaporization of Gasoline should be reduced.
• Oxygen containing additives reduce air requirement e.g., ethanol, MTBE (Hazardous).– Methanol: (Less photochemically reactive VOC, but emits HCHO (eye irritant), difficult to start in winters: Can be overcome by M85 (85% methanol, 15% gasoline)
– Ethanol: GASOHOL (10% ethanol & 90% Gasoline),
– CNG: Low HC, NOx high, inconvenient refueling, leakage hazard.
– LPG: Propane, NOx high

Three-Way Catalytic Converter

A three-way catalytic converter has three simultaneous tasks:

- Reduction of nitrogen oxides to nitrogen and oxygen.
- Oxidation of carbon monoxide to carbon dioxide.
- Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water.

Stationary Sources

Pre-combustion Control
– Switching to less sulphur and nitrogen fuel
Combustion Control
– Improving the combustion process
– New burners to reduce NOx
– New Fluidized bed boilers
– Integrated gasification combined cycle
Post-Combustion Control
– Particulate collection devices
– Flue gas desulphurization

Source Control Technology

- Air quality management sets the tools to control air pollutant emissions.

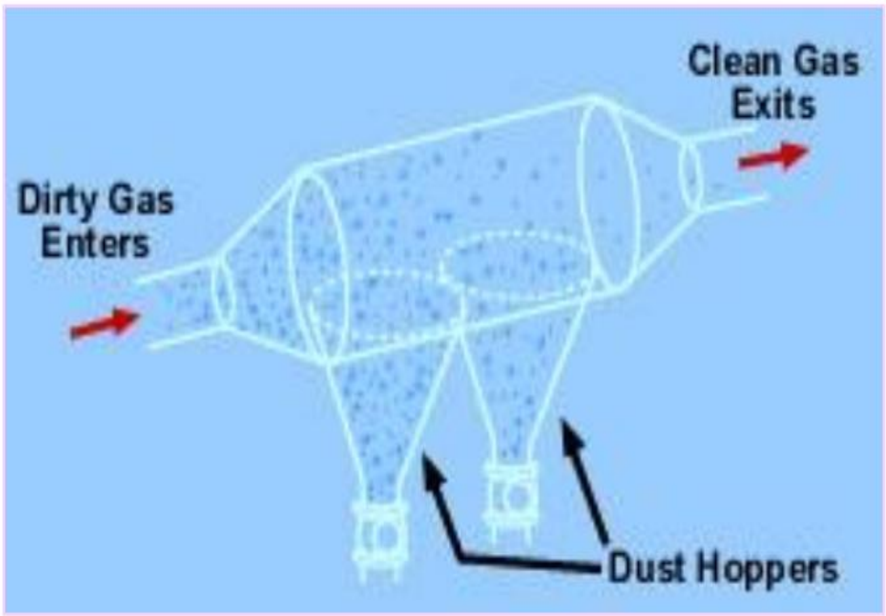
- Control measurements describes the equipment, processes or actions used to reduce air pollution.

- The extent of pollution reduction varies among technologies and measures.

- The selection of control technologies depends on environmental, engineering, economic factors and pollutant type.

Settling Chambers

- Settling chambers use the force of gravity to remove solid particles.
- The gas stream enters a chamber where the velocity of the gas is reduced. Large particles drop out of the gas and are recollected in hoppers. Because settling chambers are effective in removing only larger particles, they are used in conjunction with a more efficient control device.



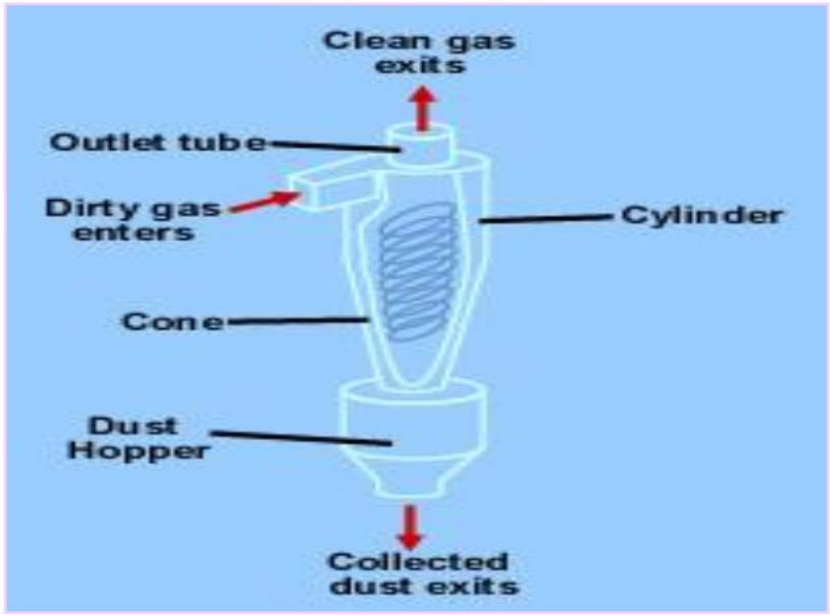
Cyclones

- The general principle of inertia separation is that the particulate-laden gas is forced to change direction. As gas changes direction, the inertia of the particles causes them to continue in the original direction and be separated from the gas stream.

- The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper.

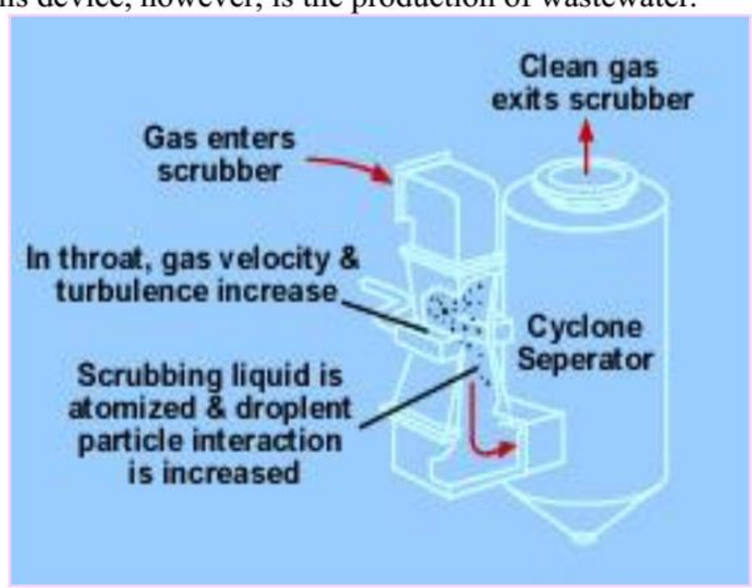
- The cleaner air leaves the cyclone through the top of the chamber, flowing upward in a spiral vortex, formed within a downward moving spiral.

- Cyclones are efficient in removing large particles but are not as efficient with smaller particles. For this reason, they are used with other particulate control devices.



Venturi Scrubbers

- Venturi scrubbers use a liquid stream to remove solid particles.
- In the venturi scrubber, gas laden with particulate matter passes through a short tube with flared ends and a constricted middle.
- This constriction causes the gas stream to speed up when the pressure is increased.
- The difference in velocity and pressure resulting from the constriction causes the particles and water to mix and combine.
- The reduced velocity at the expanded section of the throat allows the droplets of water containing the particles to drop out of the gas stream.
- Venturi scrubbers are effective in removing small particles, with removal efficiencies of up to 99 percent.
- One drawback of this device, however, is the production of wastewater.



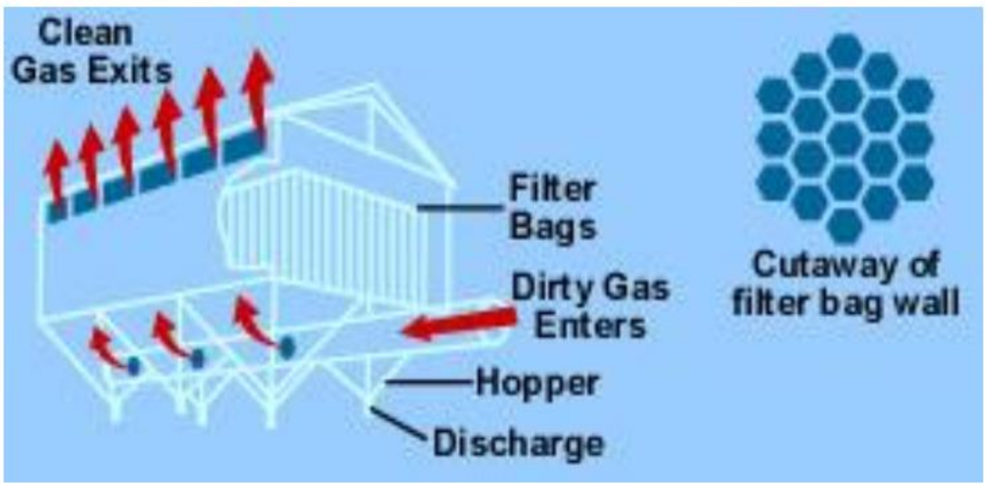
Fabric Filters

- Fabric filters, or baghouses, remove dust from a gas stream by passing the stream through a porous fabric. The fabric filter is efficient at removing fine particles and can exceed efficiencies of 99 percent in most applications.

- The selection of the fiber material and fabric construction is important to baghouse performance.

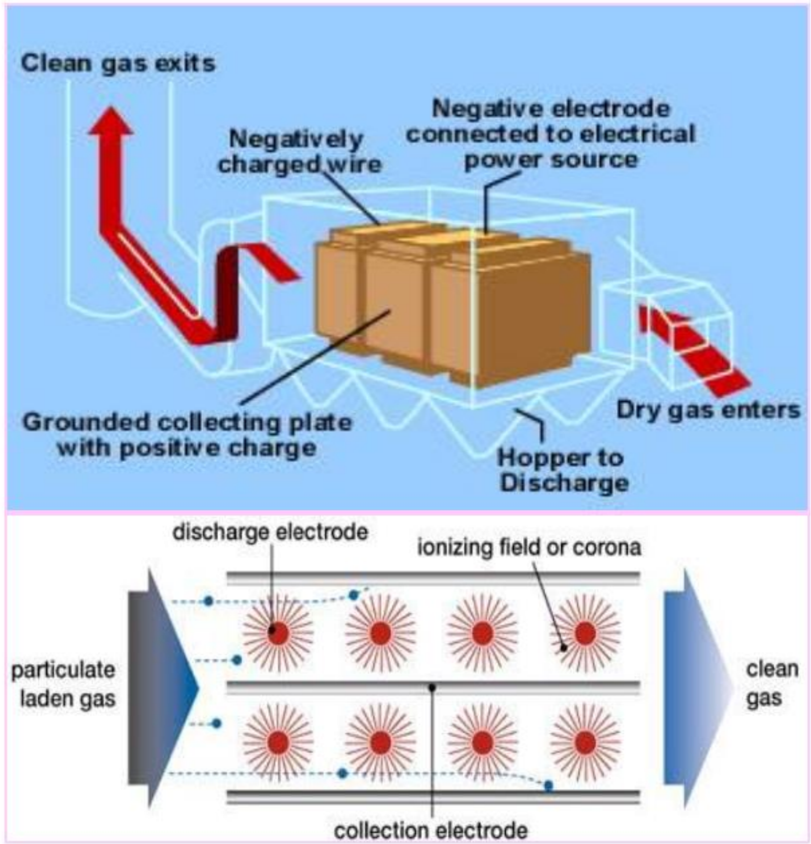
- The fiber material from which the fabric is made must have adequate strength characteristics at the maximum gas temperature expected and adequate chemical compatibility with both the gas and the collected dust.

- One disadvantage of the fabric filter is that high-temperature gases often have to be cooled before contacting the filter medium.



Electrostatic Precipitators (ESPs)

- An ESP is a particle control device that uses electrical forces to move the particles out of the flowing gas stream and onto collector plates.
- The ESP places electrical charges on the particles, causing them to be attracted to oppositely charged metal plates located in the precipitator.
- The particles are removed from the plates by "rapping" and collected in a hopper located below the unit.
- The removal efficiencies for ESPs are highly variable; however, for very small particles alone, the removal efficiency is about 99 percent.
- Electrostatic precipitators are not only used in utility applications but also other industries (for other exhaust gas particles) such as cement (dust), pulp & paper (salt cake & lime dust), petrochemicals (sulfuric acid mist), and steel (dust & fumes).



Control of gaseous pollutants from stationary sources

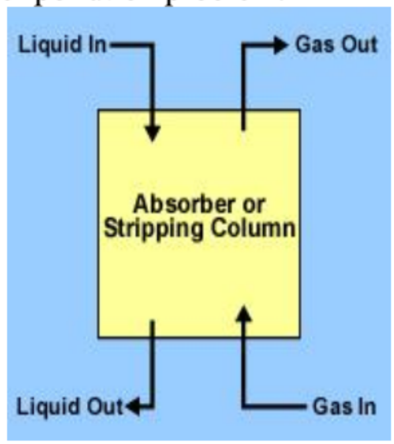
- The most common method for controlling gaseous pollutants is the addition of add-on control devices to recover or destroy a pollutant.
- There are four commonly used control technologies for gaseous pollutants:

➢ 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.

- In general, absorbers can achieve removal efficiencies grater than 95 percent. One potential problem with absorption is the generation of waste-water, which converts an air pollution problem to a water pollution problem.

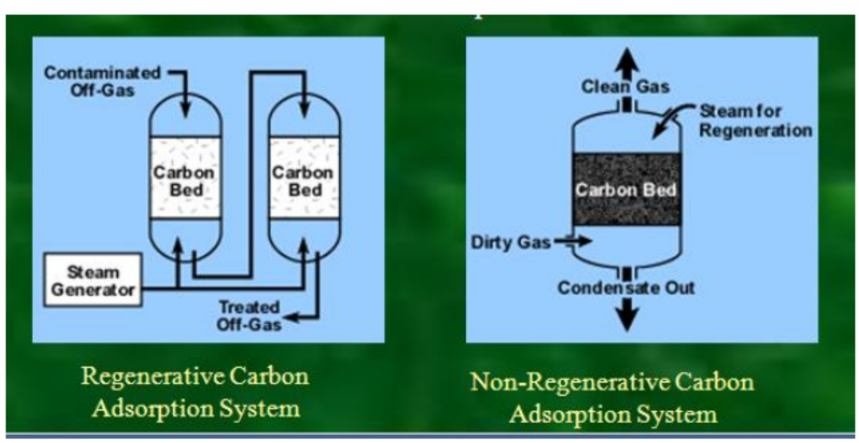


Adsorption

- 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, or remain on the outside attached to the surface. The former phenomenon is termed absorption (or dissolution) and the latter 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.
- Carbon adsorption systems are either regenerative or non-regenerative.

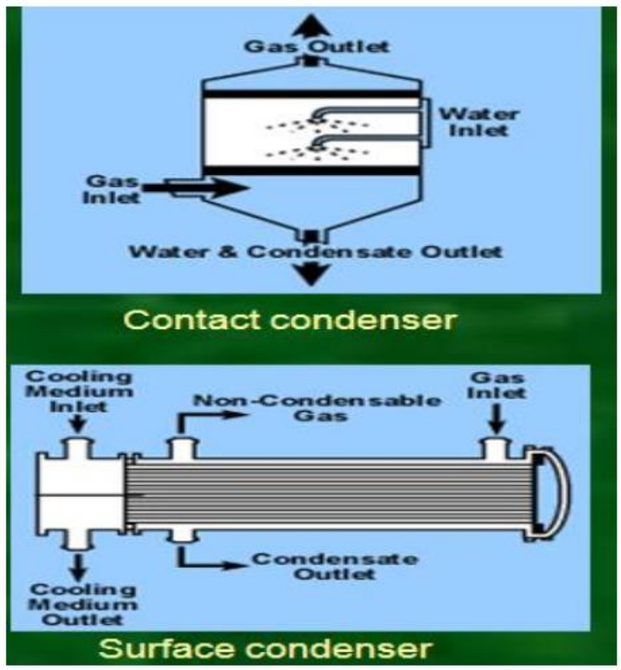
  - **Regenerative system** usually contains more than one carbon bed. As one bed actively removes pollutants, another bed is being regenerated for future use.

  - **Non-regenerative systems** have thinner beds of activated carbon. In a non-regenerative adsorber, the spent carbon is disposed of when it becomes saturated with the pollutant.



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. Condensers used for pollution control are contact condensers and surface condensers.
- **In a contact condenser**, the gas comes into contact with cold liquid.
- In a **surface condenser**, the gas contacts a cooled surface in which cooled liquid or gas is circulated, such as the outside of the tube.
- Removal efficiencies of condensers typically range from 50 percent to more than 95 percent, depending on design and applications.



Incineration

- Incineration, also known as combustion, is most used to control the emissions of organic compounds from process industries.
- This control technique refers to the rapid oxidation of a substance through the combination of oxygen with a combustible material in the presence of heat.
- When combustion is complete, the gaseous stream is converted to carbon dioxide and water vapor.
- Equipment used to control waste gases by combustion can be divided in three categories:
  - Direct combustion or flaring,
  - Thermal incineration and
  - Catalytic incineration.

Direct combustor

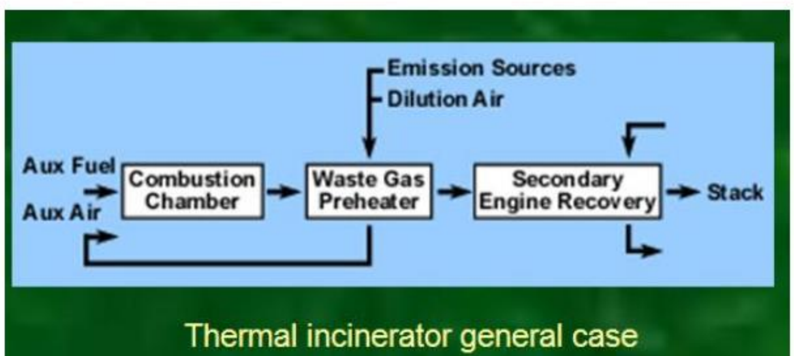
- **Direct combustor** is a device in which air and all the combustible waste gases react at the burner. Complete combustion must occur instantaneously since there is no residence chamber.

- 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.

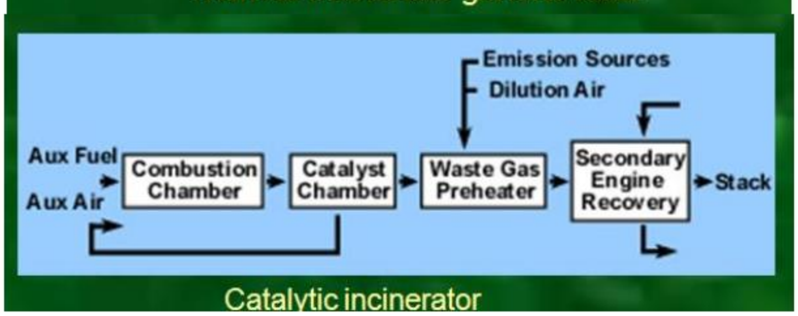
- In **thermal incinerators** the combustible waste gases pass over or around a burner flame into a residence chamber where oxidation of the waste gases is completed. Thermal incinerators can destroy gaseous pollutants at efficiencies of greater than 99 percent when operated correctly.

- **Catalytic incinerators** are very similar to thermal incinerators. The main difference is that after passing through the flame area, the gases pass over a catalyst bed.

  A catalyst promotes oxidation at lower temperatures, thereby reducing fuel costs. Destruction efficiencies greater than 95 percent are possible using a catalytic incinerator.



Thermal incinerator general case



Catalytic incinerator

Baghouse

A **baghouse** , bag filter (BF) or fabric filter (FF) is an air pollution control device that removes particulates out of air or gas released from commercial processes or combustion for electricity generation. Power plants, steel mills, pharmaceutical producers, food manufacturers, chemical producers and other industrial companies often use baghouses to control emission of air pollutants.

Most baghouses use long, cylindrical bags (or tubes) made of woven or felted fabric as a filter medium. (For applications where there is relatively low dust loading and gas temperatures are 250 °F or less, pleated, nonwoven cartridges are sometimes used as filtering media instead of bags.

Dust-laden gas or air enters the baghouse through hoppers (large funnel-shaped containers used for storing and dispensing particulate) and is directed into the baghouse compartment. The gas is drawn through the bags, either on the inside or the outside depending on cleaning method, and a layer of dust accumulates on the filter media surface until air can no longer move through it.

When sufficient pressure drop (delta P) occurs, the cleaning process begins. Cleaning can take place while the baghouse is online (filtering) or is offline (in isolation). When the compartment is clean, normal filtering resumes.
Baghouses are very efficient particulate collectors because of the dust cake formed on the surface of the bags.

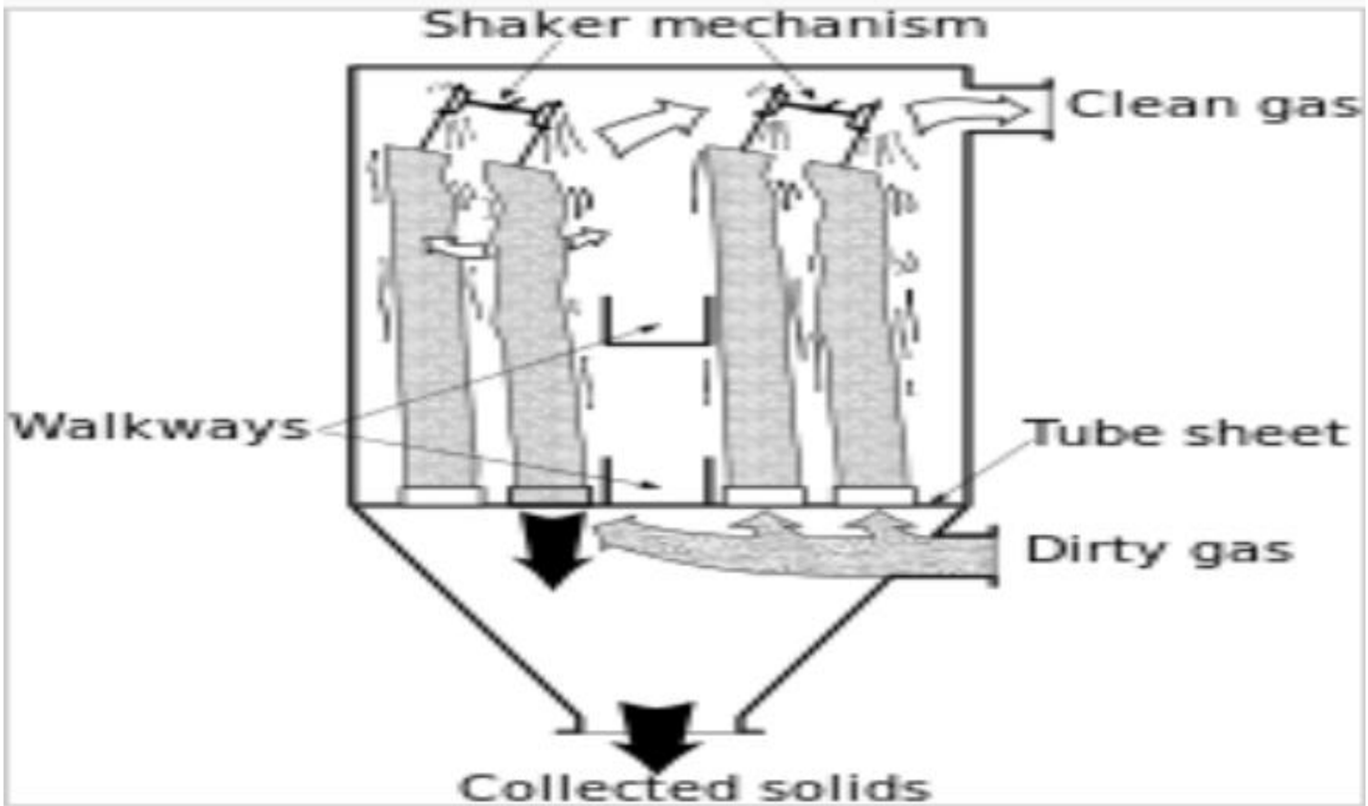
The fabric provides a surface on which dust collects through the following four mechanisms:

- Inertial collection - Dust particles strike the fibers placed perpendicular to the gas-flow direction instead of changing direction with the gas stream.

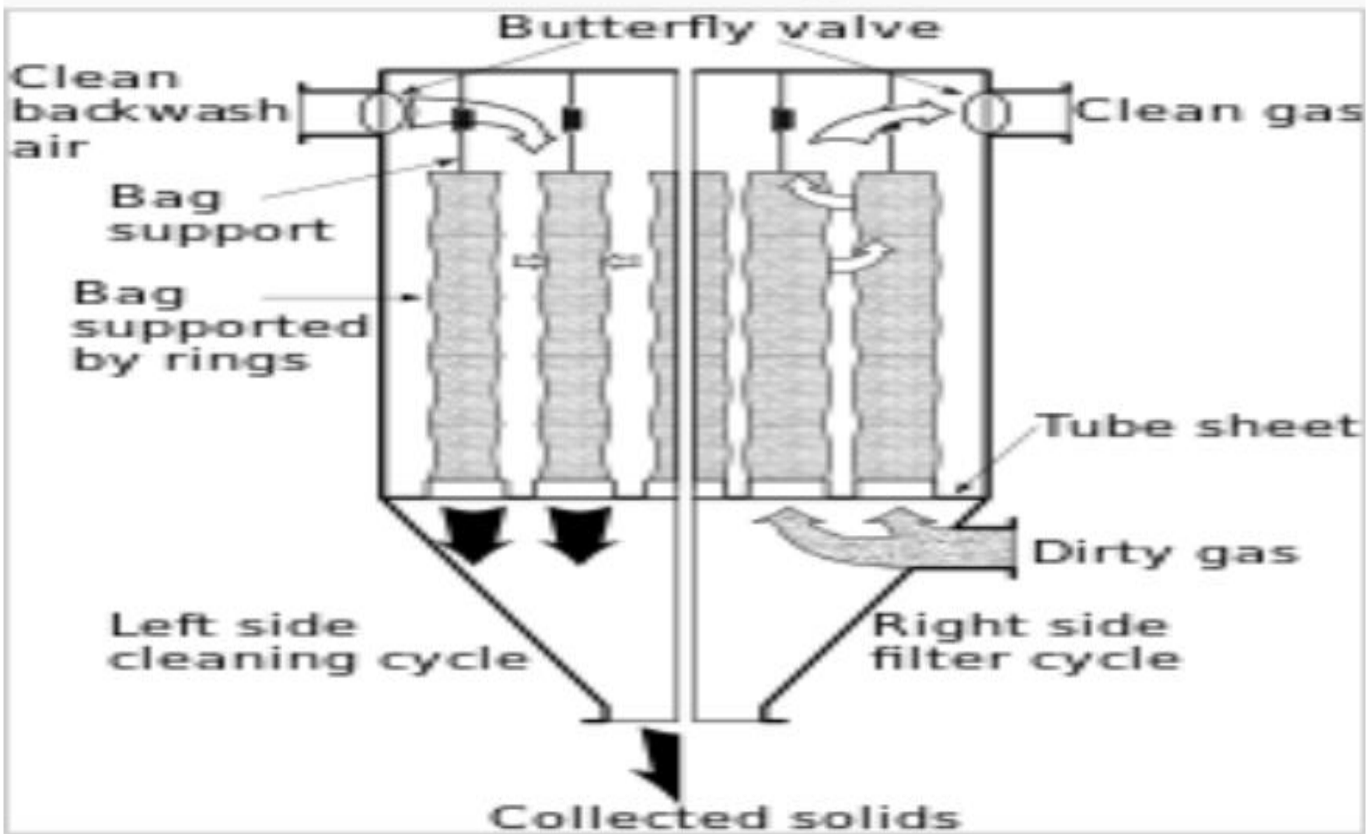
- Interception - Particles that do not cross the fluid streamlines come in contact with fibers because of the fiber size.

- Brownian movement - Submicrometre particles are diffused, increasing the probability of contact between the particles and collecting surfaces.

- Electrostatic forces - The presence of an electrostatic charge on the particles and the filter can increase dust capture.



Mechanical Shaker Baghouse



Reverse Air Baghouse