3.6 PARTICULATE SCRUBBERS

Combustion is sometimes cause of harmful exhausts, but, in many cases, combustion may also be used for exhaust gas cleaning if the temperature is high enough oxygen is available.

1. Wet Scrubber

Wet scrubbers to solve air pollution control problems for over 40 years. The five principal designs customizable to meet your requirements:

- Scrubber with no moving parts
- Dynamic scrubber with integral fan
- High efficiency venturi scrubber
- Multi-venturi scrubber
- Packed towers for gas absorption

Working Principle/Operational Consideration:

- Scrubbing liquid is introduced into the scrubber as a spray directed down over a circular "scrubbing vane" arrangement.
- As the liquid drains through the vanes, it creates curtains of scrubbing liquid.
- Dust laden gas enters the scrubber tangentially and collides with the curtains initiating particle agglomeration.
- The coarse particles produced are washed down to the slurry outlet.
- A restriction disc located in the scrubbing vane assembly accelerates the spin velocity of the gas.
- This action combined with the flood of atomized liquid from the spray causes the formation of fine liquid droplets which encapsulate the fine particulates, again enhancing agglomeration.
- The cyclonic action of the saturated gas stream as it spins upward forces the agglomerated particles to fall out of suspension.
- The coarser droplets impinge on the mist eliminator vanes and the finer droplets are

forced to drop out of suspension by gravitational and centrifugal forces acting on the gas stream as it exits through the top.

Design and Performance Equations:

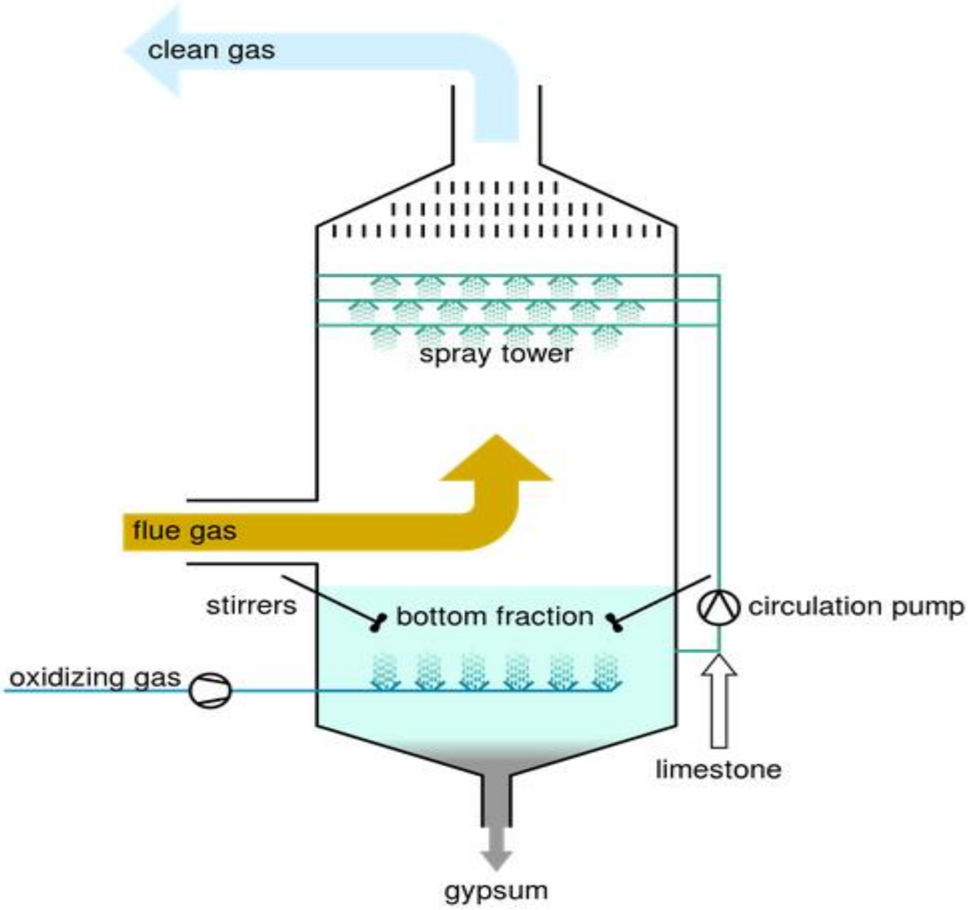

Figure 3.6.1 Wet scrubbers

[Source:https://energyeducation.ca/wiki/images/thumb/e/eb/Wetscrubber.png/360px-Wetscrubber.png]

- 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.
- The versatility of wet scrubbers allow them to be built in numerous configurations, all designed to provide good contact between the liquid and polluted gas stream.

- Wet scrubbers remove dust particles by capturing them in liquid droplets.
- The droplets are then collected, the liquid dissolving or absorbing the pollutant gases.
- 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).
- The resultant scrubbing liquid must be treated prior to any ultimate discharge or being reused in the plant.
- A wet scrubber's ability to collect small particles is often directly proportional to the power input into the scrubber.
- Low energy devices such as spray towers are used to collect particles larger than 5 micrometers.
- To obtain high efficiency removal of 1 micrometer (or less) particles generally requires high-energy devices such as venturi scrubbers or augmented devices such as condensation scrubbers.
- A properly designed and operated entrainment separator or mist eliminator is important to achieve high removal efficiencies.
- The greater the number of liquid droplets that are not captured by the mist eliminator, the higher the potential emission levels.
- Wet scrubbers that remove gaseous pollutants are referred to as absorbers.
- Good gas-to-liquid contact is essential to obtain high removal efficiencies in absorbers.
- Various wet-scrubber designs are used to remove gaseous pollutants, with the packed tower and the plate tower being the most common.
- If the gas stream contains both particulate matter and gases, wet scrubbers are generally the only single air pollution control device that can remove both pollutants.

- Wet scrubbers can achieve high removal efficiencies for either particles or gases and, in some instances, can achieve a high removal efficiency for both pollutants in the same system.
- In many cases, the best operating conditions for particles collection are the poorest for gas removal.
- In general, obtaining high simultaneous gas and particulate removal efficiencies requires that one of them be easily collected (i.e., that the gases are very soluble in the liquid or that the particles are large and readily captured), or by the use of a scrubbing reagent such as lime or sodium hydroxide.

2.Dynamic Scrubber

Working Principle/Operational Considerations

- Dust laden gas enters the lower chamber of the scrubber tangentially, imparting a cyclonic action to the stream.
- Coarse particles are removed by a combination of centrifugal and gravitational forces.
- The stream encounters slurry, created in a later stage, coming down from the upper chamber and becomes partially wetted, initiating agglomeration.
- As the stream spins through a series of scrubber vanes, intermediate sized particles impinge on the wetted surfaces of the vanes. These particles are then washed down.
- The gas stream containing the remaining fine dust is drawn into an adjacent chamber containing a wet- ted fan.
- Atomized scrubbing liquid is sprayed into the eye of the fan, further reducing droplet size.
- These droplets encapsulate the fine dust particles, thus enhancing agglomeration.
- The gas stream then flows into the upper chamber tangentially at high velocity.
- The wet agglomerated particles are forced by cyclonic action against the chamber walls and drain down to the internal discharge cone.

- The gas stream, free of liquid droplets, spins out through an outlet atop the scrubber.

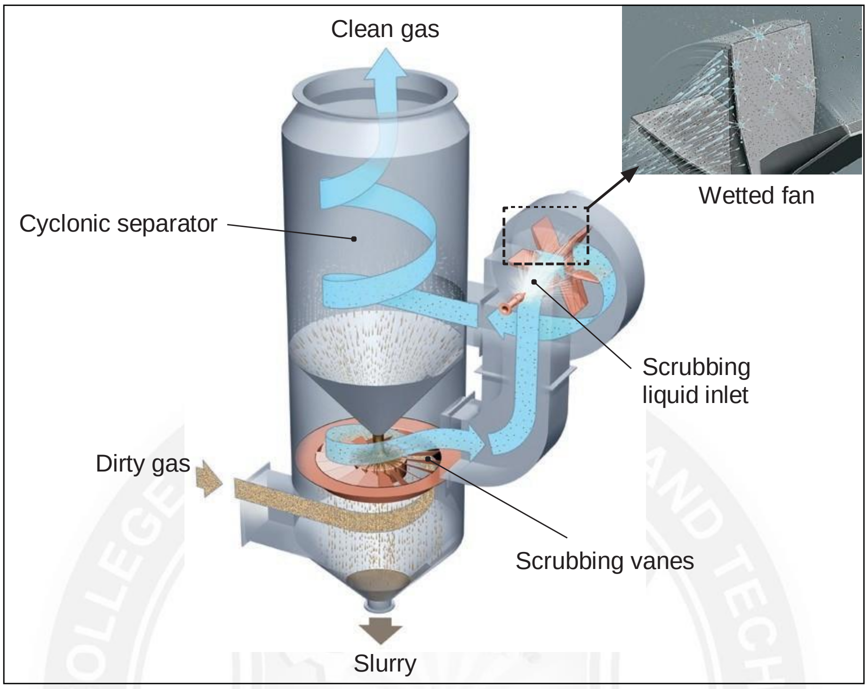

Figure 3.6.2 Dynamic Scrubber

[Source: https://www.nedermanmikropul.com/en]

3.Venturi Scrubber:

- The design of the MikroPul Venturi Scrubber consists of a “wet ap- proach” venturi followed by a liquid entrainment separator.
- Dust laden gases enter the venturi and instantly make contact with the tangentially introduced scrubbing liquid swirling down the venturi’s converging walls.
- At the venturi throat, the gas and liquid streams collide and the liquid breaks down into droplets which trap dust particles.
- This gas/liquid mixture passes through a flooded elbow, and then enters the entrainment separator through a tangential inlet.
- Centrifugal action removes the heavy wetted particles from the gas stream. As an alternate, when very large diameter separators are required, the liquid is separated by passing the stream through a chevron-type mist eliminator baffle.
- The dust/liquid mixture is discharged from the separator bottom drain and the cleaned gas leaves through the top of the separator.

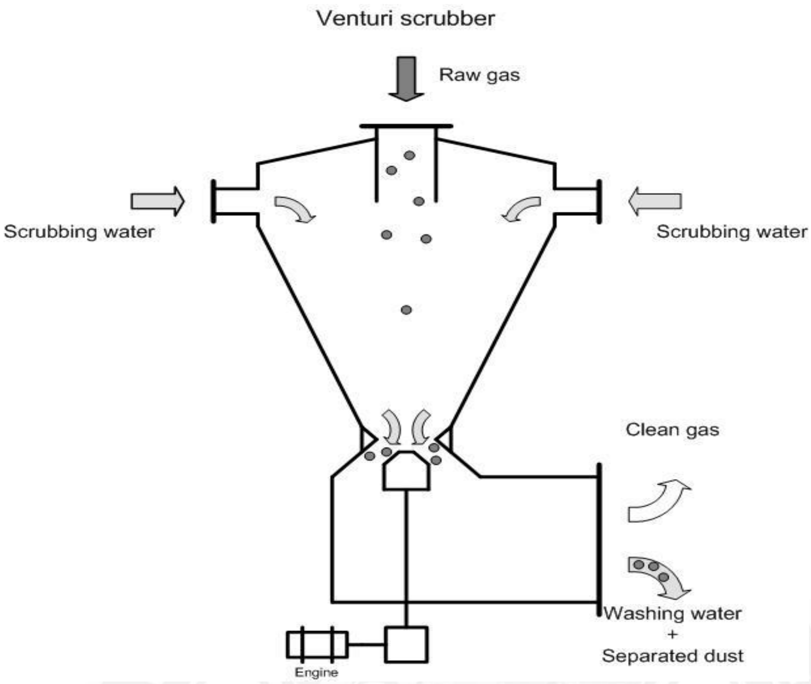

Figure 3.6.3 Venturi Scrubber

[Source:https://emis.vito.be/sites/emis/files/data_sheets/migrated/venturi_scrubber_luss_2.PNG]

4. Multi-venturi scrubber:

Working Principle/Operational Considerations

The dirty gases are directed through a venturi-rod deck where atomized scrub water is introduced cocurrently with the gas stream. The scrub water is sprayed through a series of low pressure, large orifice nozzles, dis- tributing it evenly across the deck.

The gas rapidly accelerates as it passes through the venturi-rods. This action creates smaller droplets, caus- ing encapsulation of the particles and increasing the collection efficiency of submicron particles.

As the gases exit the venturi-rod area, velocity slows causing the larger particulate laden droplets to fall out of the stream. The scrubbed gasses are then directed toward a two-stage demisting zone by distribution baffles or turning vanes. Primary demisting and gas distribution occurs in the pre- demist area, which removes 90% of the water. The remaining free water droplets are removed by impingement on the final stage demist vanes.

The scrub water collected prior to the demist section flows down the scrubber floor to the drain trough. The de- watered scrubbed gases are exhausted via the scrubber outlet.

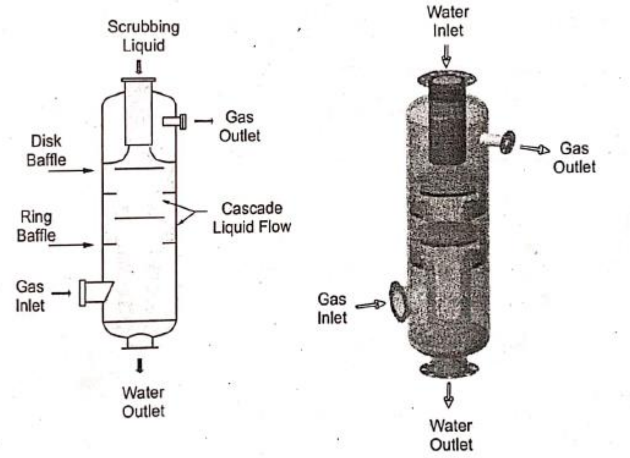

Figure 3.6.4 Multi-Venturi Scrubber

[Source:https://emis.vito.be/sites/emis/files/data_sheets/migrated/venturi_scrubber_luss_2.PNG]

Advantages:

- Can handle flammable and explosive dusts with little risk
- Can handle mists
- Relatively low maintenance
- Simple in design and easy to install
- Collection efficiency can be varied
- Provides cooling for hot gases; and
- Corrosive gases and dusts can be neutralized

Disadvantages:

- Effluent liquid can create water pollution problems
- Waste product collected wet
- High potential for corrosion problems
- Protection against freezing required
- Off gas may require reheating to avoid visible plume

- Collected PM may be contaminated, and may not be recyclable; and
- Disposal of waste sludge may be very expensive.

5.Two-stage scrubbers:

- The most commonly used is a Mikropul Venturi Scrubber with a Packed Bed section.
- It is used to remove particulate as well as gaseous contaminants from the gas stream.
- The principles of operation are as described for the Venturi scrubber and Packed Tower designs.
- The designs are optimized by using pH control, liquid circuit separation, and mist eliminators to enhance removal efficiencies for specific contaminants.

Another common 2-stage design is a Multi-venturi inlet with a Dynamic or Mikrovane Scrubber. It utilizes the Multi-Venturi rod deck technology as a pre-cleaner to the Dynamic Scrubber or as a retrofit component to enhance performance of an existing Dynamic or Mikrovane Scrubber.

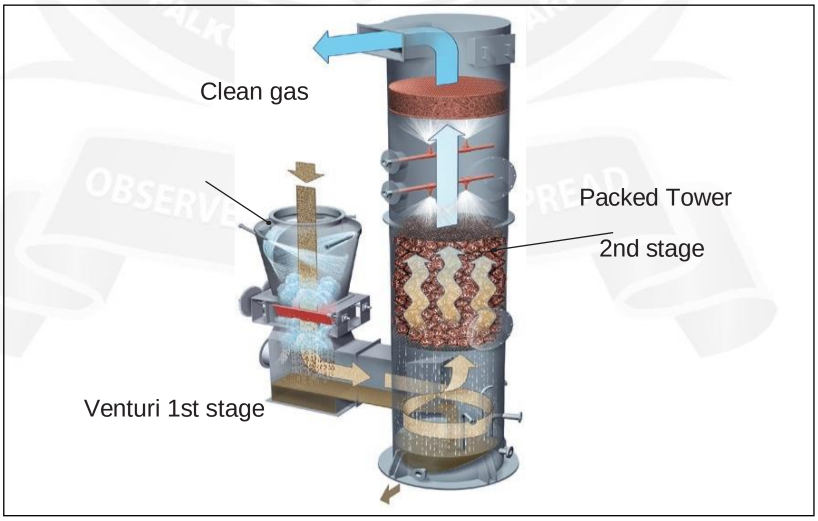

Figure 3.6.5 Two-stage scrubbers

[Source :https://www.nedermanmikropul.com/en]