MODULE 5: SEPARATION PROCESSES

DEBASREE GHOSH
ASSISTANT PROFESSOR
DEPT. OF CHEMICAL ENGINEERING
BIT MESRA

DISCLAIMER

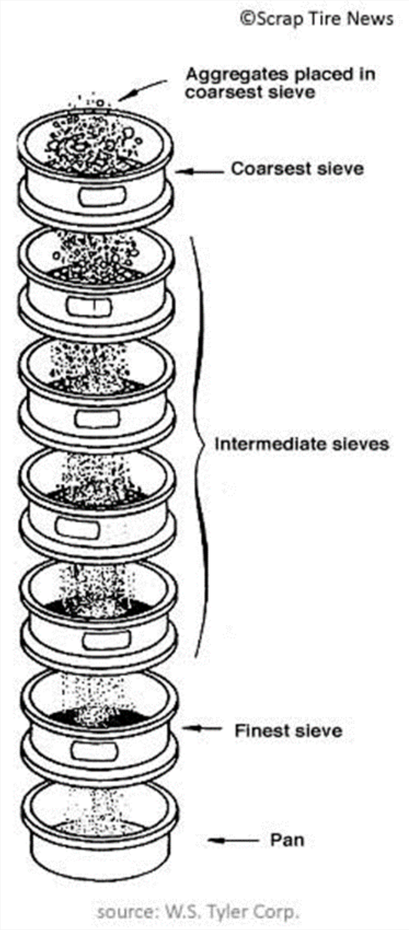
- This content provided herein are simply for educational purposes and not for any commercial purpose. Every effort has been made to ensure that the content provided on this course is accurate and helpful to the readers. However, this is not an exhaustive treatment of the subjects. No liability is assumed for losses or damages due to the information provided. You are responsible for your own choices, actions, and results. I have tried my level best to include the reference of any third-party material used herein. If missed, it is inadvertently.

SYLLABUS

- Module 5:Solid Solid Separation : Industrial Screening equipment :Screen effectiveness and Capacity. Wet Classification: Differential settling, Liquid cyclones, Drag, Rake and Spiral, Bowl, Hydroseparator, Hydaulic classifiers, Tabling, **Jigging, Froth floatation**, Dense media separation etc. **Magnetic separation, Electrostating Separation.** Gas-solid separation: Settling chambers, centrifugal settling, Cyclones, ESP, Scrubbers, Filters.

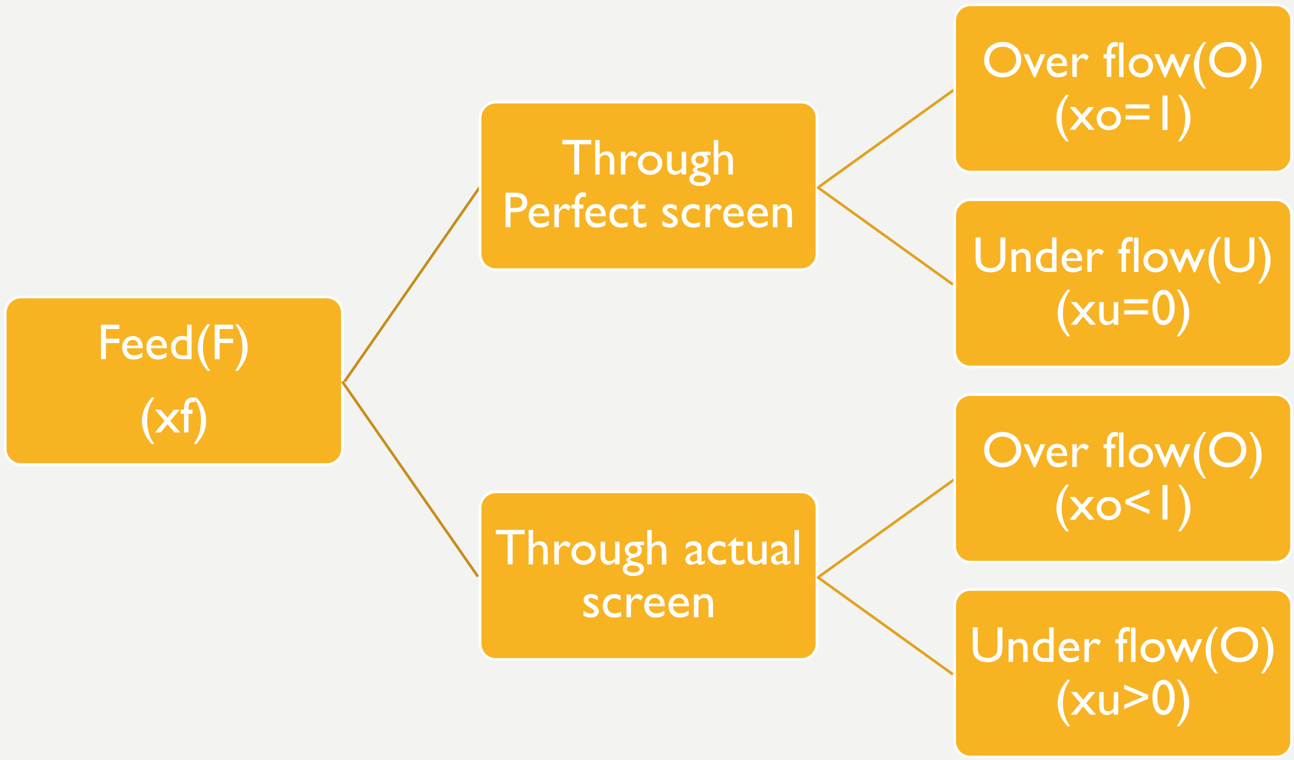
SOLID-SOLID SEPARATION

- **Industrial Screening equipment**
- xf= mass fraction of overflow in feed
- xo= mass fraction of overflow retained on the screen
- Xu= mass fraction of overflow passes through the screen



https://www.google.com/url?sa=i&url=https%3A%2F%2Fscraptirenews.com%2Finformation-center%2Fcrumb-rubber%2F&psig=AOvVaw1rt3AC434-fPr3FMt1EapB&ust=1597908806472000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCJik5qzgpusCFQAAAAAdAAAAABAj

SOLID-SOLID SEPARATION



SOLID-SOLID SEPARATION

- Efficiency of screen for overflow
- $\eta_o = \frac{o.x_o}{F.x_f} = \frac{mass\ of\ overflow\ retained\ on\ screen}{mass\ of\ overflow\ in\ feed}$

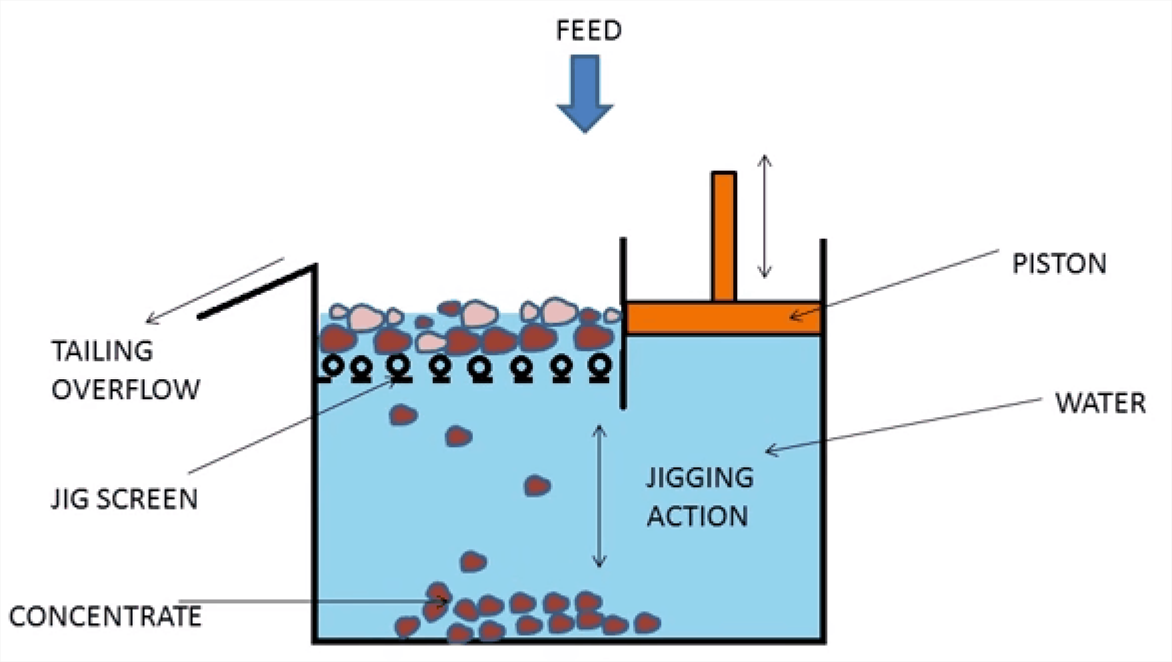
- Efficiency of screen for under flow
- $\eta_u = \frac{u.(1-x_u)}{F.(1-x_f)} = \frac{mass\ of\ overflow\ passes\ through\ screen}{mass\ of\ under\ flow\ in\ feed}$

- Overall efficiency of screen
- $\eta = \eta_0 \times \eta_u = \frac{O.x_o}{F.x_f}\frac{u.(1-x_u)}{F.(1-x_f)} = \frac{x_o(x_f-x_u)(x_o-x_f)(1-x_u)}{x_f(1-x_f)(x_o-x_u)^2}$

WET CLASSIFICATION

- Wet classifiers separate the coarse particles from fine particles by water or any other liquid.
- The velocity of coarse particles are higher than fine particles of same density.
- Similarly, high density particles move faster than low density particles of same size.
- Examples:

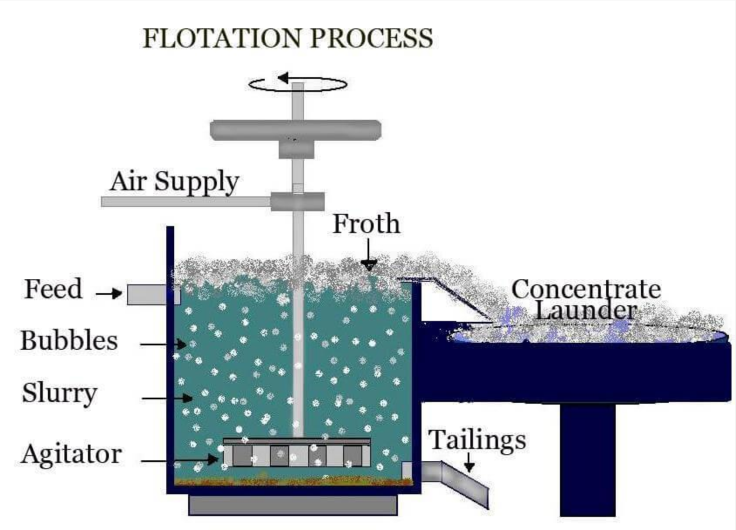
JIGGING



https://www.google.com/url?sa=i&url=https%3A%2F%2Fgfycat.com%2Fwholefarofffrog&psig=AOvVaw15Z_hixGYfXHECA1roHe8A&ust=1605590859984000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCLjzzpqqhu0CFQAAAAAdAAAAABAI

FROTH FLOTATION PROCESS

- Froth flotation is a highly versatile method for physically separating particles based on differences in the ability of air bubbles to selectively adhere to specific mineral surfaces in a mineral/water slurry.
- The particles with attached air bubbles are carried to the surface and removed, while the particles that remain completely wetted stay in the liquid phase.
- Froth flotation is currently in use for separating sulfide minerals from silica gangue; separating potassium chloride (sylvite) from sodium chloride (halite); separating coal from ash-forming minerals; removing silicate minerals from iron ores; separating

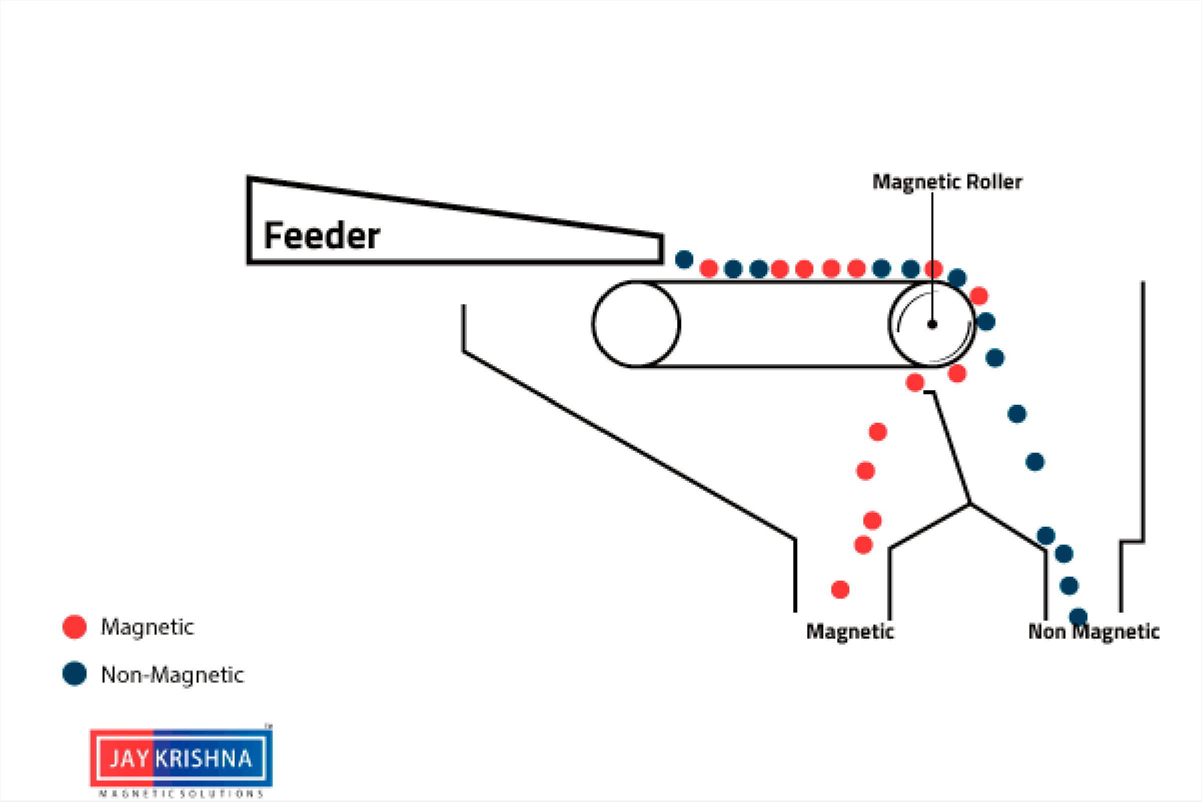


https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.911metallurgist.com%2Fblog%2Ffroth-flotation-process&psig=AOvVaw0h1qo_Wh2c-4A832aUS7Rm&ust=1606383154421000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCIif7uixne0CFQAAAAAdAAAAABAG

FROTH FLOTATION PROCESS

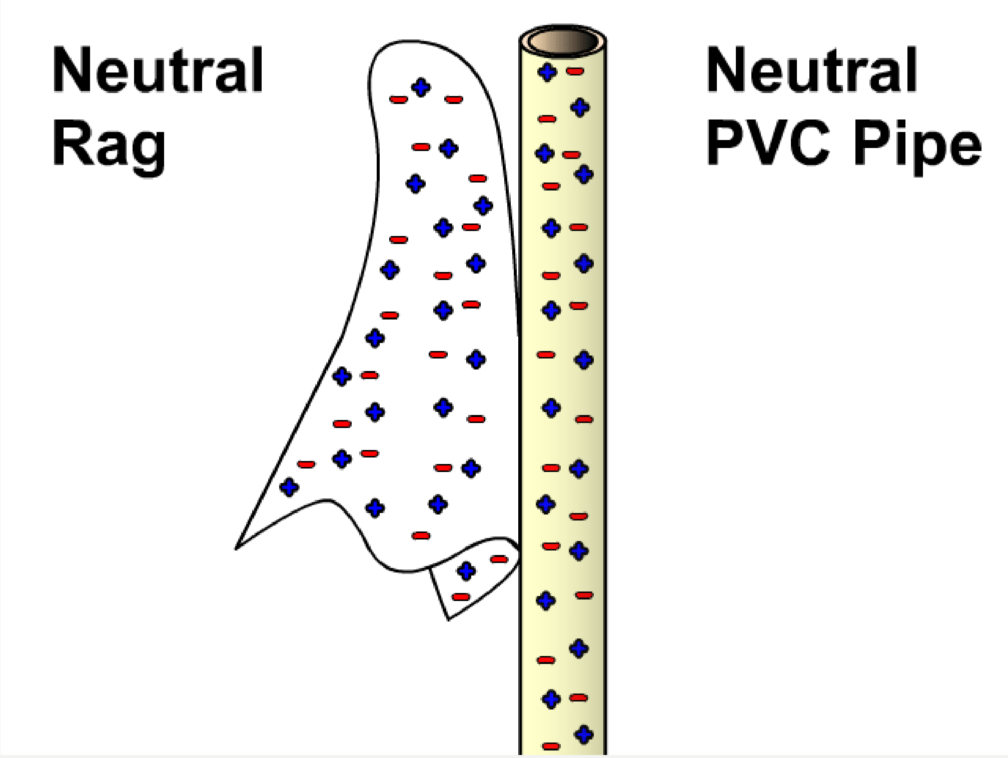
- The process is particularly useful for processing fine-grained ores that are not amenable to conventional gravity concentration.
- The basis of froth flotation is the difference in wettabilities of different minerals. Particles range from those that are easily wettable by water (hydrophilic) to those that are water-repellent (hydrophobic).
- If a mixture of hydrophobic and hydrophilic particles are suspended in water, and air is bubbled through the suspension, then the hydrophobic particles will tend to attach to the air bubbles and float to the surface.
- Once the particles are rendered hydrophobic, they must be brought in contact with gas bubbles so that the bubbles can attach to the surface. If the bubbles and surfaces never come in contact, then no flotation can occur.
- The bubble must be large enough for its buoyancy to lift the particle to the surface. At the same time, increased surface area of bubbles also carries more water into the froth as the film between the bubbles.

MAGNETIC SEPARATION



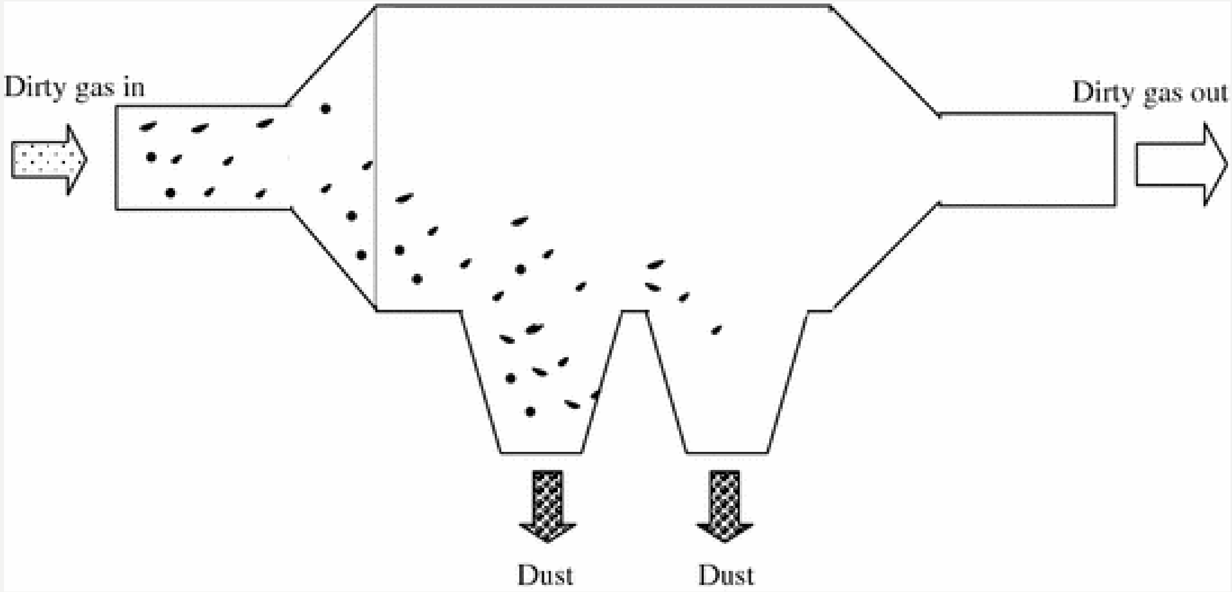
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.jkmagnetic.com%2Froller-type-magnetic-separator%2F&psig=AOvVaw0e7UO7wC9jw8j0ExeRNxgU&ust=1605591323895000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCKiS1firhu0CFQAAAAAdAAAAABAD

ELECTROSTATING SEPARATION



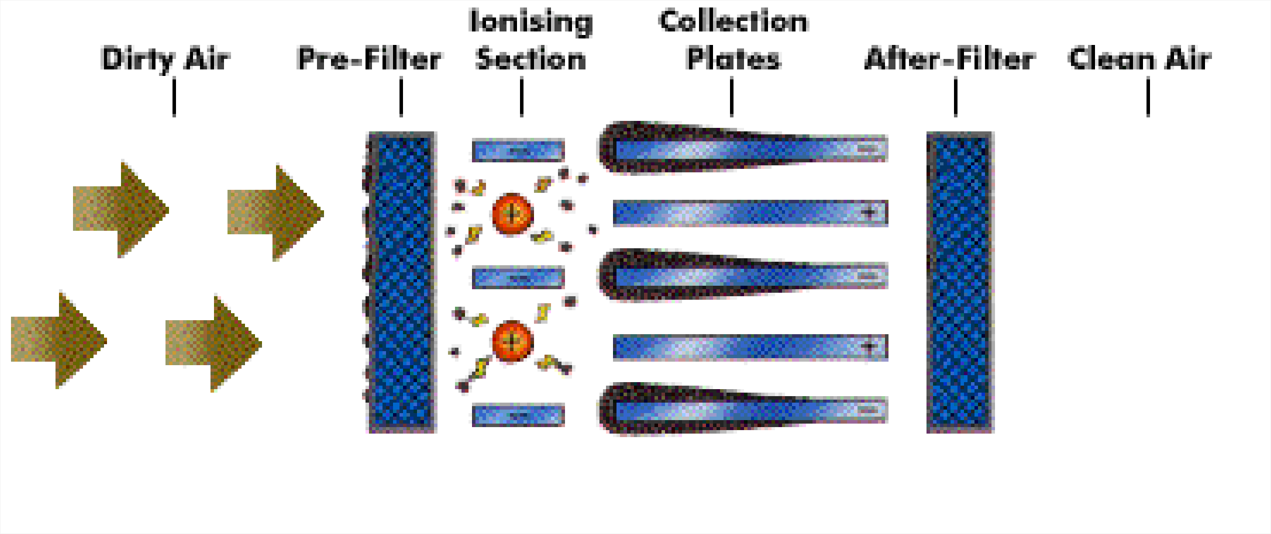
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.stickmanphysics.com%2Fstickman-physics-home%2Funit-7-electrostatics%2Felectrostatics-conduction-induction-and-friction%2F&psig=AOvVaw2ofFqJ3__EWt-eiSnHgoxN&ust=1605592163452000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNDQ3Ymvhu0CFQAAAAAdAAAAABA3

GAS-SOLID SEPARATION: SETTLING CHAMBERS



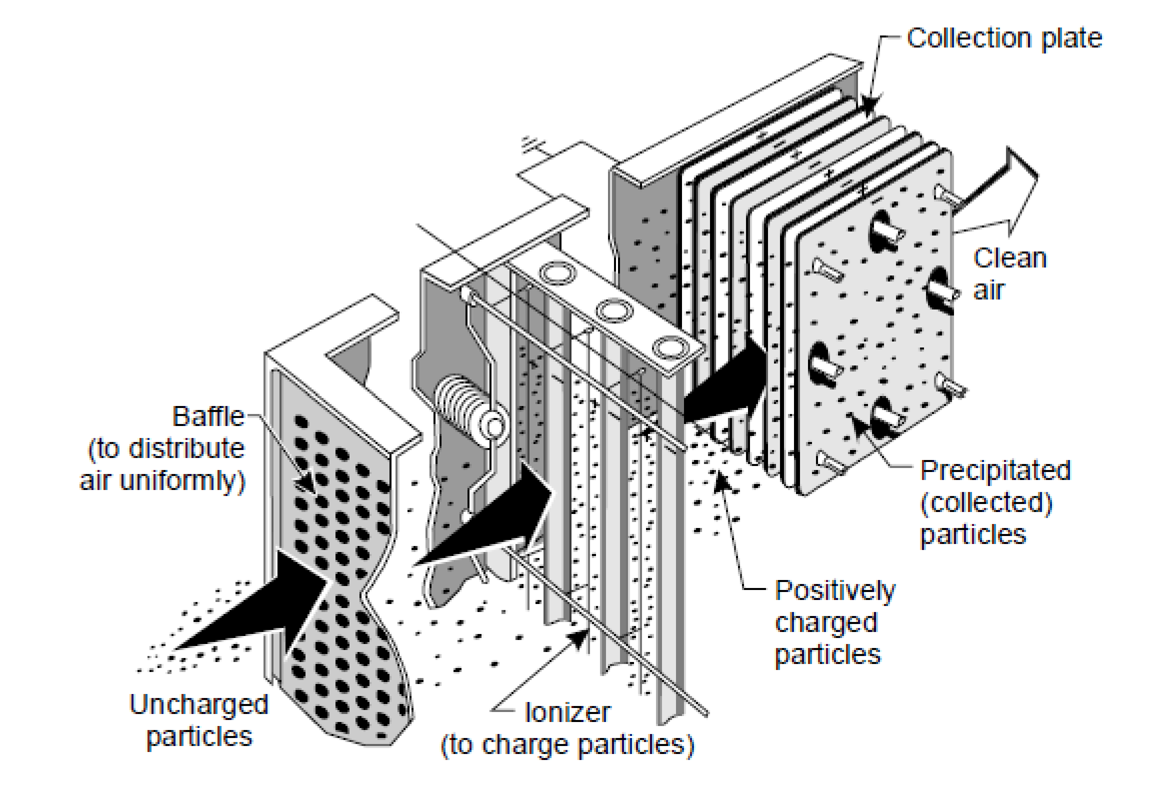
https://www.google.com/url?sa=i&url=https%3A%2F%2Flink.springer.com%2Fchapter%2F10.1007%2F978-3-319-21596-9_4&psig=AOvVaw1wHg-dF6WNLqtITkcgmIAL&ust=1606385507569000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCOjhocC6ne0CFQAAAAAdAAAAABAY

GAS-SOLID SEPARATION: ESP



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.globalspec.com%2Flearnmore%2Fmanufacturing_process_equipment%2Fair_quality%2Felectrostatic_precipitators&psig=AOvVaw0fkOzIQm_7mV0bOVDeNaIe&ust=1606385860751000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCJi9le27ne0CFQAAAAAdAAAAABAN

GAS-SOLID SEPARATION: ESP



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.globalspec.com%2Flearnmore%2Fmanufacturing_process_equipment%2Fair_quality%2Felectrostatic_precipitators&psig=AOvVaw0fkOzIQm_7mV0bOVDeNaIe&ust=1606385860751000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCJi9le27ne0CFQAAAAAdAAAAABAv

GAS-SOLID SEPARATION: ESP

- Electrostatic precipitators are ubiquitous nowadays in **thermal power plants** due to ever-increasing concern about environmental pollution. Electrostatic precipitator uses the high-intensity electric field to ionize the dust particles in the air stream and then the dust particles are collected by oppositely charged collectors (electrodes). The dust particles, once collected are removed from the collector plates periodically by hammering the collectors by a different mechanism.

https://www.electrical4u.com/advantages-and-disadvantages-of-electrostatic-precipitator/

ADVANTAGES OF ELECTROSTATIC PRECIPITATOR(ESP)

- **The High Efficiency of Removal of Particles/Pollutants :**

The efficiency of an electrostatic precipitator depends on a lot of factors like the resistivity of the particles, the corona power ratio etc. For removal of particles under normal circumstances, their efficiency is very high, up to 99% removal of dust particles. Electrostatic precipitators have relatively high collection efficiencies (99-100%) over a wide range of particle sizes (~0.05-5 µm).

- **Collection of Dry as Well as Wet Pollutants:**

There are two types of electrostatic precipitators: wet and dry. Dry ESPs are used for collection of dry pollutants like ash or cement particles. Wet ESPs are used to remove wet particles like as resin, oil, paint, tar, acid or anything that is not dry in the conventional sense.

- **Low Operating Costs:**

Operating costs for electrostatic precipitators are low and in the long run, they are economically feasible.

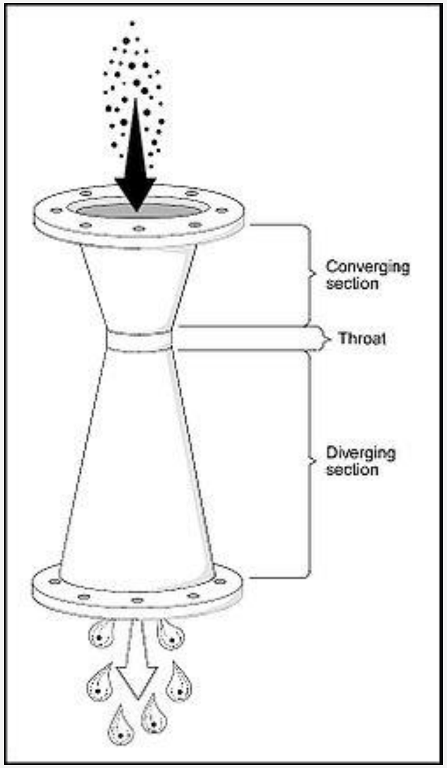
https://www.electrical4u.com/advantages-and-disadvantages-of-electrostatic-precipitator/

DISADVANTAGES OF ESP

- **High Capital Costs**: Electrostatic precipitators have a high initial capital cost, which makes it prohibitive for small-scale industries. They are expensive to purchase and install.
- **Requires Large Space**: In addition to being costly, they require large space to be set up. Again the value proposition for small-scale industries gets reduced as they are costly as well as need a lot of space to be set up.
- **Not Flexible Once Installed**: Electrostatic precipitators do not offer the flexibility of operation. Once installed, it is difficult to change the capacity of the ESP or move it to a different location. So proper planning needs to be done regarding the capacity, type and location for installing the ESP.
- **They cannot be used to collect gaseous pollutants**: An electrostatic precipitator can be used for collecting only dry and wet pollutants and not for gaseous pollutants. This is a major disadvantage of ESPs.

- https://www.electrical4u.com/advantages-and-disadvantages-of-electrostatic-precipitator/

GAS-SOLID SEPARATION: SCRUBBERS



Venturi scrubber

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.wikiwand.com%2Fen%2FVenturi_scrubber&psig=AOvVaw3l-2qLFMsNmWHnpNyc3yNr&ust=1606386855227000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCKjdlsq_ne0CFQAAAAAdAAAAABAb

QUESTIONS

- Discuss the working of following equipment's with neat sketch. Also, discuss their advantage & disadvantages.

1. *Differential settling*
2. *Liquid cyclones*
3. *Hydro-separator*
4. *Hydraulic classifiers*
5. *Jigging*
6. *Froth floatation*
7. *Dense media separation*
8. *Magnetic separation,*
9. *Electro-stating Separation.*
10. *Settling chambers,*
11. *centrifugal settling,*
12. *Cyclones,*
13. *ESP*
14. *Scrubbers*

- Reference:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations Chemical Engineering", McGraw-Hill, Inc.

2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.