SOLID-SOLID SEPARATION

Screening

- Screening (Limiting Screen, Retaining Screen, Oversize , Undersize, Dry Screening, Wet Screening, Blinding, Actual Screen and Ideal Screen)
- Screening Mechanism : Stratification and Separation Probability
- Factors Affecting Screening Operation
- Screening Surfaces : Parallel Bars/rods, Punched Plates and Woven Wires
- Screen Size Designations : Mesh , Aperture
- Types of Standard Screens: Taylor Standard, US, British, Indian, German, South African
- Method of Reporting Sieve Analysis: Differential and Cumulative
- Effectiveness and Capacity
- Effect of Feed Rate on Effectiveness
- Factors affecting Effectiveness and Capacity
- Screening Equipment

Introduction

- Solids may be separated from solids (according to size) in the dry state by methods such as screening, magnetic separation and electrostatic separation.

Screening:

- A method of separating solid particles according to size alone is called screening.
- It refers to the separation of solid materials on the basis of size using screens of known openings.
- In screening, a mixture of solid particles of various sizes is dropped on a screening surface/screen (a surface provided with suitable openings) which acts as multiple go and no go gage.
- The material that passes through a given screen/screening surface is called the undersize or minus (-) material while the material that remains on the screen/screening surface is called the oversize or plus (+) material.
- A single screen can make a single separation of the material charged into two fractions.
- These are called unsized fractions as only the upper limit or lower limit of the particle sizes they contain is known and the other limit is not known.
- The material can be separated into sized fractions in which both the maximum and minimum particle sizes are known , by passing it through a series of screens of different sizes.
- Screening is commonly adopted for dry particulate solids and occasionally for wet particulate solids.
- **Materials for Screens**
- Metal bars, woven wire cloth, silk bolting cloth, perforated or slotted metal plates.

Importance of Screening Operation

- Remove the fines from a feed material before a reduction equipment such as Jaw crusher, Ball Mill or Rod Mill
- Prevent an incompletely crushed material (oversize) from entering into other unit operations.
- Produce a commercial or process grade material to meet specific particle size limits.
- Remove the fines from a finished product prior to shipping.

Types of standard screen series

- Usually, for carrying out the analysis, standard screens of either Tyler standard screen series, U.S. sieve series or Indian standard sieves are used.
- The testing sieves with square opening are constructed of woven wire screens, the mesh and dimensions of which are standardized.
- Every screen is identified in meshes per inch.
- In coarse screens, the term mesh refers to the distance between adjacent wires or rods.
- While in fine screens, the **mesh** is the number of openings per linear inch counting from the centre of any wire to a point exactly one inch distance.
- **Example:** A 200 mesh screen will have 200 openings per linear inch.
- The minimum clear space between the edges of the opening in the screening surface is termed as **screen aperture or screen size opening**.

Types of Screen Analysis

- Two methods of screen analysis: Differential and Cumulative
- **Differential Analysis:** The screen analysis in which the weight fraction of the material retained on each screen is reported in tabular or graphical form as a function of the mesh size/screen opening.

1. The fine particles are generally specified according to their screen analysis.
2. A screen analysis of a material is carried out by using testing sieves.
3. A set of standard screens is arranged serially in a stack in such way that the coarsest of the screens is at the top and the finest of the screens is at the bottom.

- The analysis is carried out by placing the sample on the top screen and shaking the stack in a definite manner, either, manually or mechanically for a definite length of the time.
- The material remained in each screen is removed and weighed.
- For reporting the screen analysis, the amount of material retained on each screen is expressed as the weight fraction of the total sample as a function of the mesh size.
- The screen analysis of a sample is reported either in a tabular form or graphs.
- As the particles retained on any one screen are passed through the screen immediately above it, two numbers are needed to specify the size, one for the screen through which the fraction passes and the other for the screen on which that fraction retained.
- Hence, the notation 10/14 means through 10 mesh and on 14 mesh.
- An analysis reported in a tabular form in this manner is called a **differential analysis**.

Differential Screen Analysis

Mesh	Screen Opening (Microns)	Average Particle Size (Microns)	Weight Fraction Retained
6/8	2362	2845	0.017
8/10	1651	2006	0.235
10/14	1168	1410	0.298
14/20	833	1000	0.217
20/28	589	711	0.105
28/35	417	503	0.062
35/48	295	356	0.028
48/65	208	252	0.017
65/100	147	178	0.010
100/150	104	126	0.005
150/200	74	89	0.02
Pan			0.004

- The average size of the particle retained on any particular screen is calculated as the arithmetic mean of two screen openings used to obtain the fraction.

Cumulative Analysis

- The second method of reporting screen analysis is a **cumulative analysis**.
- The cumulative analysis is obtained from the differential analysis by adding cumulatively, the individual weight fractions of material retained on each screen, starting with that retained on the largest mesh.

Mesh	Screen Opening (Microns)	Weight Fraction Retained
6	3327	0.0
8	2362	0.17
10	1651	[0+0.017+0.235]=0.252
14	1168	0.55
20	833	0.767
28	589	0.872
35	417	0.934
48	295	0.962
65	208	0.979
100	147	0.989
150	104	0.994
200	74	0.996
Pan	-	1.0

Capacity and Effectiveness of Screens

- The capacity and effectiveness are measures of the performance in industrial screening.
- The **Capacity** of a screen is the mass of material that can be fed per unit time to a unit area of the screen.
- For obtaining maximum effectiveness the capacity must be small and vice versa.
- As the capacity and effectiveness are opposing factors, a reasonable balance must be done between them in actual practice.
- The factors which tend to reduce the capacity and lower effectiveness are
- Blinding, Cohesion, motion or speed of the screen, moisture content of the feed

Effectiveness of Screens or Screen Efficiency

- Measuring the success of the screen in closely separating undersize and oversize materials.
- In the case of perfectly functioned screen, all the oversize material would be in the overflow and vice versa.
- The screen effectiveness based on the oversize material is the ratio of the amount of oversize material that is actually in the overflow to the amount of oversize material in the feed.

(or)

Screen effectiveness based on oversize material =	Quantity of oversize in the overflow / Quantity of oversize in the feed

Screen effectiveness based on undersize material =	Quantity of undersize in the underflow / Quantity of undersize in the feed

Effectiveness of Screens or Screen Efficiency

- Consider that the feed to a screen consists of materials A and B. Where A is the oversize and B is the undersize material.
- Let F = Mass flow rate of feed, (kg/h)
- D = Mass flow rate of overflow
- B = Mass flow rate of underflow
- x_F = Mass fraction of material A in the Feed
- x_B = Mass fraction of material A in the underflow
- x_D = Mass fraction of material A in the overflow
- **Overall material balance over a screen**

$$F = D + B \quad \text{----------(1)}$$

- **Material balance of 'A' over a screen**

$$x_F.F = x_D.D + x_B.B \quad \text{----------(2)}$$

- **$E = [(x_F-x_B)\,(x_D-x_F)\,x_D(1-x_B)] / [(x_D-x_B)^2\,(1-x_F)\,x_F]$ -----(3)**
- **E = Overall efficiency of the screen**

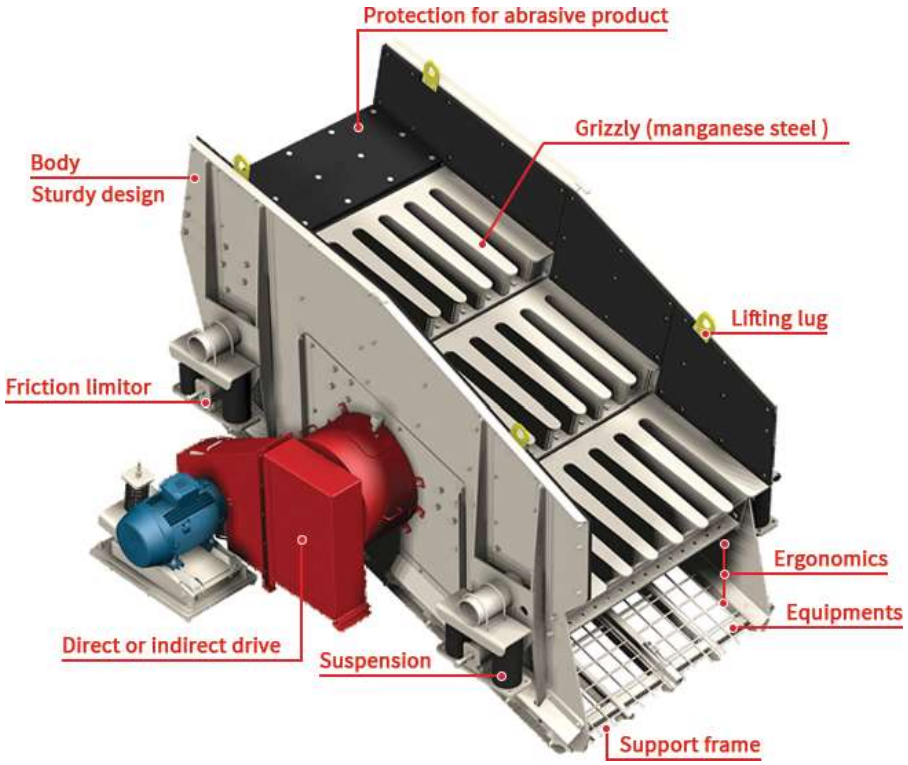
Factors Effecting the Performance of Screens

- Method of Feeding: Fed the material properly, Spread the material evenly over a full width of the screening surface, Must fed at low flow rate.
- Screening surfaces: Depends on speed and amplitude of vibration for best performance
- Screen Slope: Depends on slope of the screen however slope cannot be increased beyond a certain value because beyond that value material will travel down the screen much faster without getting screened and the screening efficiency reduces drastically.
- Vibration and Frequency: One has to select proper amplitude and vibration to prevent blinding of the screening cloth and for long bearing life. The frequency of vibration affects the capacity of the screening equipment by regulating the number of contacts between the material and the screening surface.
- Moisture in Feed: The moisture associated with feed material adversely affects the screening operation and should be removed.

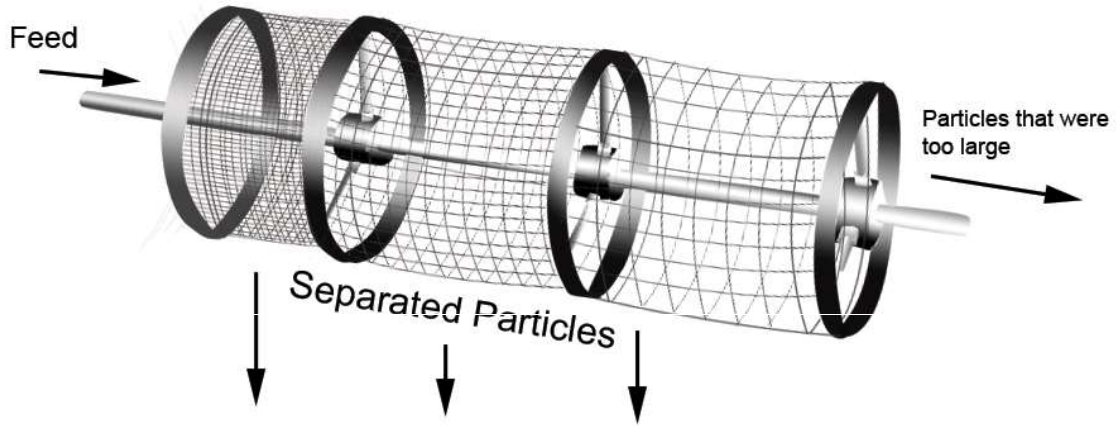
Screening Equipment

- Grizzlies
- Trommels
- Gyratory Screens
- Vibrating Screens

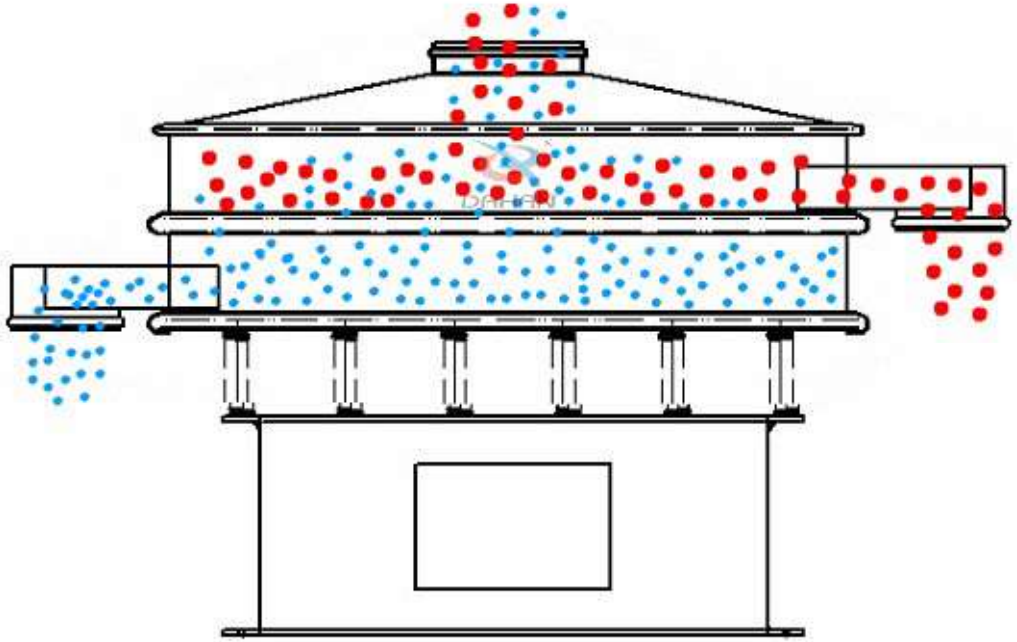
Grizzlies

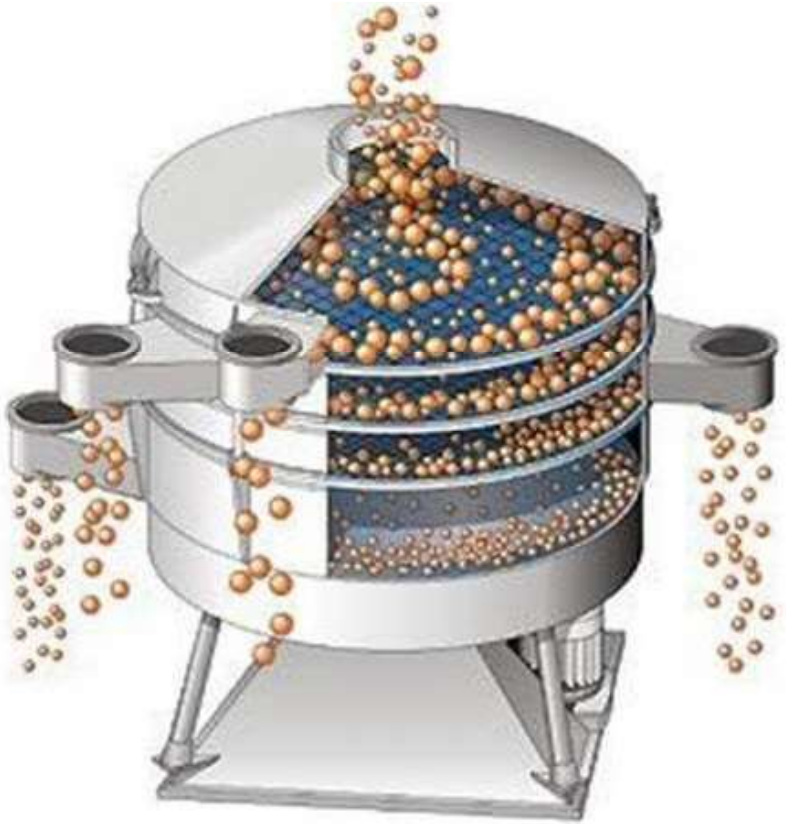

Protection for abrasive product
Grizzly (manganese steel)
Body
Sturdy design
Lifting lug
Friction limitor
Ergonomics
Equipments
Direct or indirect drive
Suspension
Support frame

Trommel

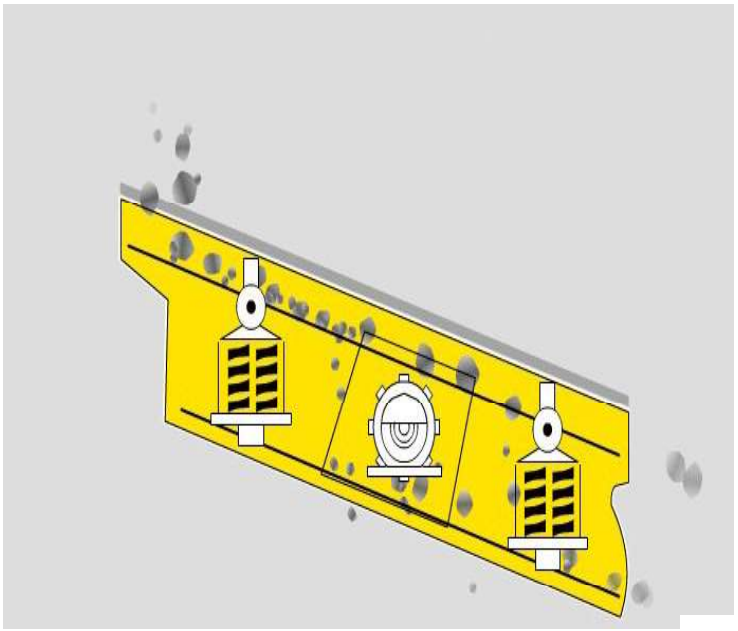


Gyratory Screen





Vibrating Screen



GAS-SOLID SEPARATION

Gas Cleaning

Necessity :

- To control Air Pollution
- To prevent dust from entering machine
- To prevent spreading of dust in the plant
- To prevent wastage of valuable materials
- To reduce the maintenance of equipment

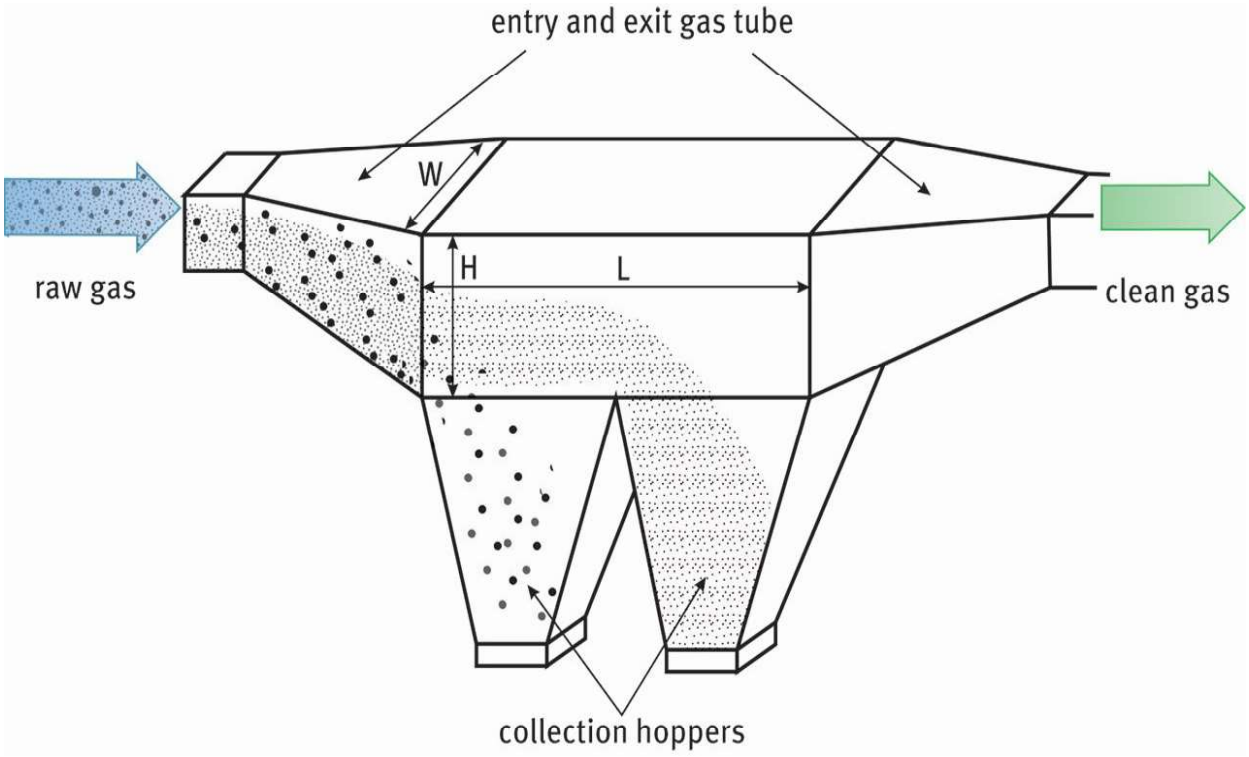
Factors Affecting:

- The properties of solid particles
- The quantity of dust to be handled
- The moisture content of dust and gas
- The temperature of gas-solid system

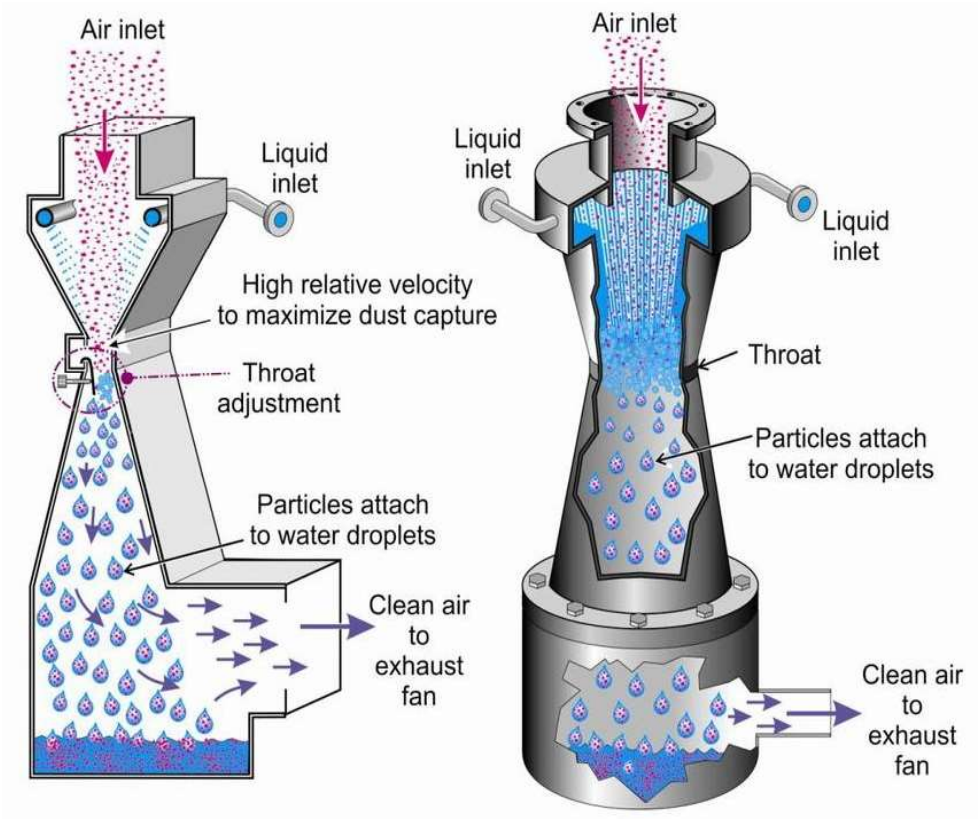
Principal Separation Mechanisms:

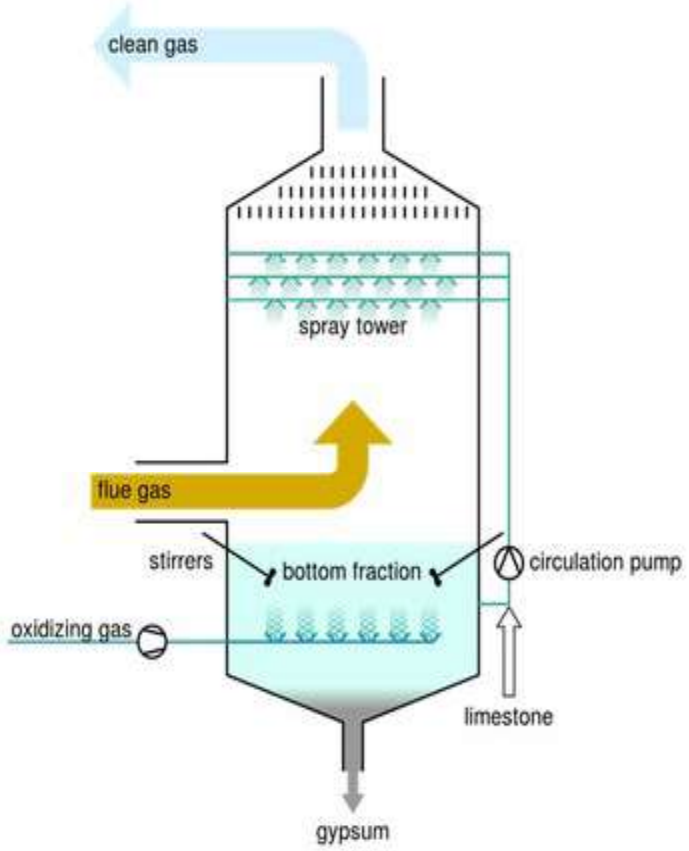
- Gravitational Settling
- Inertial Separation
- Washing with a liquid (Scrubbing)
- Electrostatic Precipitation
- Centrifugal Separation

Gravity Settling Chamber

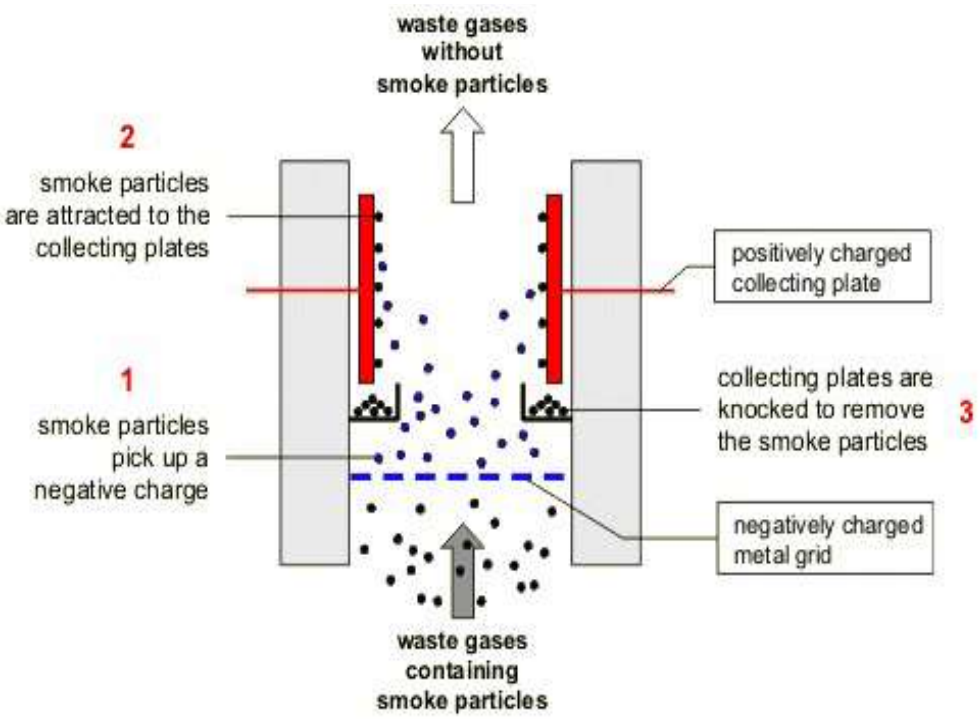


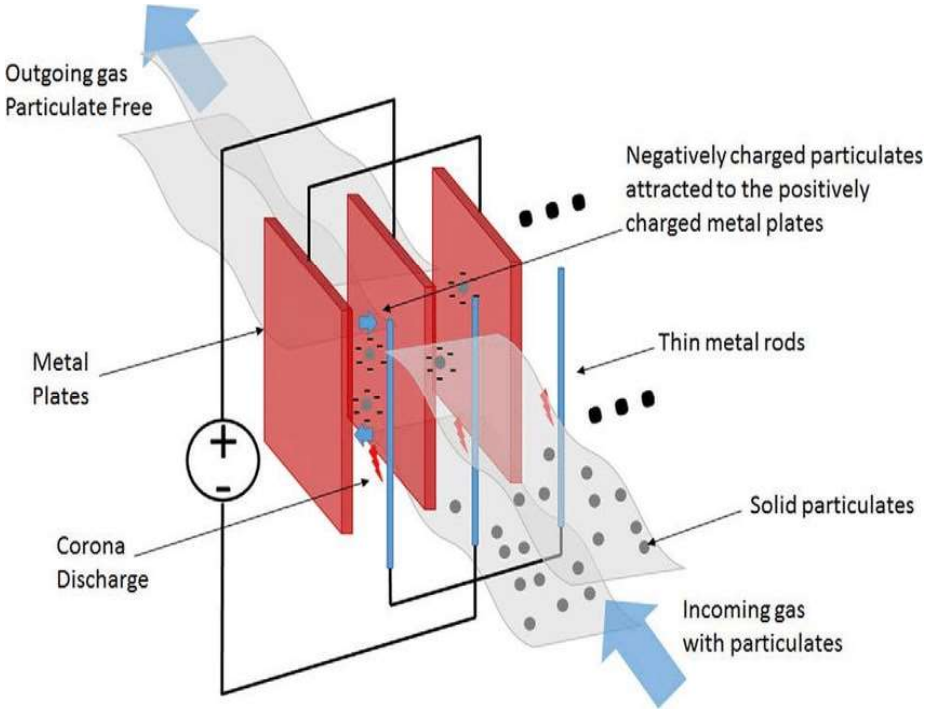
Wet Scrubber



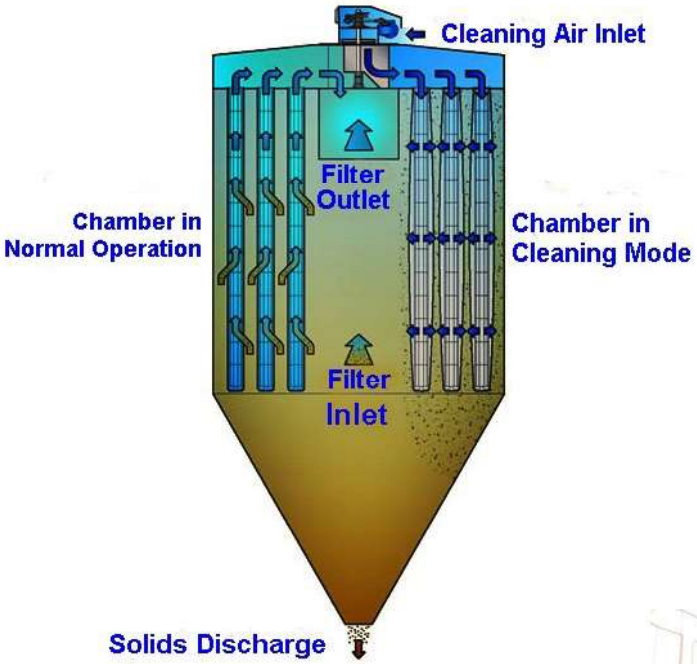


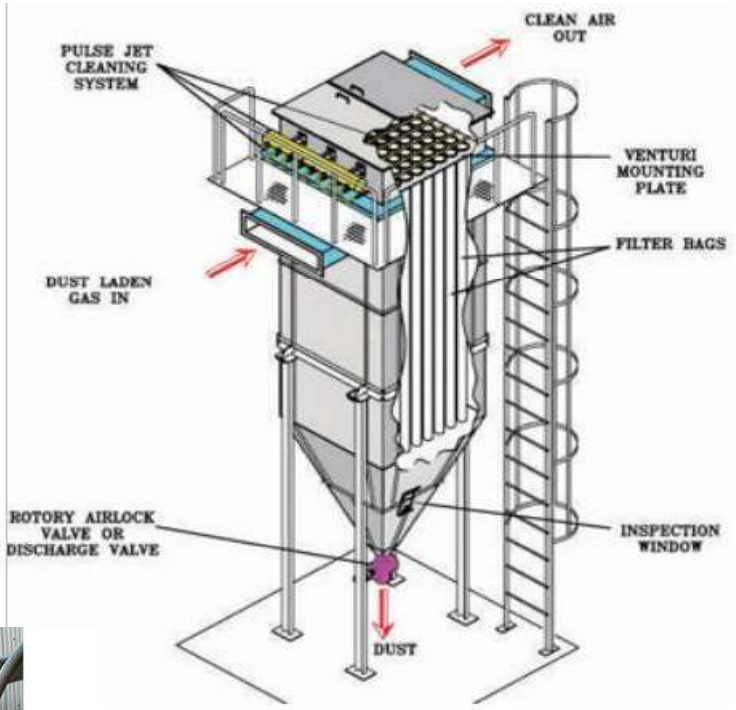
Electrostatic Precipitator





Bag Filters





Pulse Jet Bag Filter

Cyclone Separator