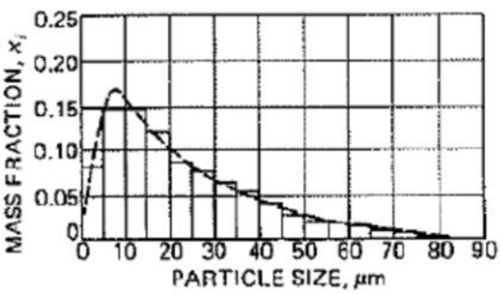
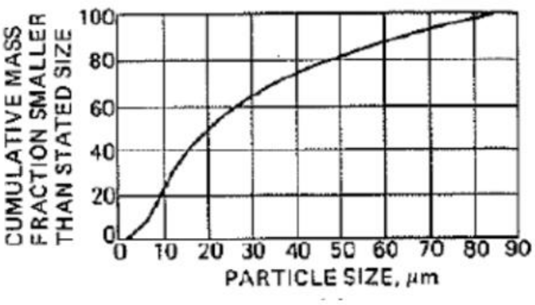
Differential and Cumulative Analysis

Information from such a particle-size analysis is tabulated to show the mass or number fraction in each size increment as a function of the average particle size (or size range) in the increment. Analysis tabulated in this way is called a *differential analysis.* The results are mostly presented in a histogram as shown in the figure below with a continuous curve like the dashed line used to approximate the distribution. A second way to present the information is through a *cumulative analysis* obtained by adding consecutively the individual increments starting with that containing the smallest particles and tabulating or plotting the cumulative.





Analytical representation of particle size

- Volume surface mean diameter
- Arithmetic mean diameter
- Mass mean diameter
- Volume mean diameter
- Surface mean diameter
- Linear mean diameter

1) Volume surface mean diameter

$D_s = 6/A_w \phi_s \rho_p$ ________________ 1

We have $A_w = 6/\phi_s \rho_p \sum_{i=1}^{n} x_i/D_{pi}$ ___________ 2

Therefore $D_s = 1/\sum_{i=1}^{n} x_i/D_{pi}$ _______________ 3

2) Surface Mean Diameter

$$D_s=\sum n_i d_i^3/\sum n_i d_i^2$$

3) Linear Mean diameter

$$D_l=\sum x_i/d_i/\sum x_i/d_i^2$$

Number of particle in the (N_w)

$$N_w=1/a\rho_p(\sum_{i=1}^{n} x_i/D_{pi}^3)$$

a=volume shape factor

ρ_p=density of particle

x_i=mass fraction

Screen Analysis

Assumption:- All the particles return in a single fraction are equal in shape and size is a arithmetic mean average of the mesh dimensions of the screen which define the fraction.

example: size of 10/14 mesh fraction= (1.651+1.168) /2

D_{pi} = 1.410mm

Screen blindness

Under the screening action elongated sticky flacky or soft particles may become wedged into particles from passing through screen. A screen plugged with solid particles is turn to be screen blindness.

Screen effectiveness

The effectiveness of the screen often called screen efficiency. It is a measure to the success a screen. The effectiveness based on material 'D' in overflow to the amount of 'D' entering with feed. Similarly the effectiveness based on material 'B' in underflow to the amount of 'B' entering with feed.

Effectiveness of a screen is found by

Let F= mass flow rate or amount of feed

D= mass flow rate or amount of overflow

B= mass flow rate or amount of underflow

Overall material balance is given by

$F=D+B$ __________ 1

X_f = mass fraction of 'D' in feed

X_d = mass fraction of material 'D' in overflow

X_b= mass fraction of material 'D' in underflow

$1-X_f$ = mass fraction of material 'B' in feed

$1-X_D$= mass fraction of material 'B' in overflow

$1-X_B$= mass fraction of material 'B' in underflow

<u>Mass balance for material D and B</u>

Mass balance for A

$Fx_F = Dx_D + Bx_B$ ____________ 2

from equation 1

$B = F - D$____________ 3

substitute 3 in 2

$Fx_F = Dx_D + (F-D)x_B$

$F(x_F-x_B)=D(x_D-x_B)$

$D/F=(x_f-x_B)/(x_D-x_B)$

<u>Mass balance of material 'B'</u>

$F(1-x_F)= D(1-x_D) + B(1-x_B)$ __________ 4

from 1 w.k.t,

$D= F-B$ ___________ 5

Substitute 5 in 4

$F(1-x_F)=(F-B)(1-x_D) + B(1-x_B)$

$F(x_D-x_F)=B(x_D-x_B)$

$B/F= (x_D-x_F)/(x_D-x_B)$

Effectiveness based on material D is ratio of material D in overflow to the material D in feed

$E_A= Dx_D/Fx_F$

$E_A=(x_F-x_B)x_D/(x_D-x_B)x_F$

similarly

$E_B = (1-x_B)B/(1-x_F)F$

$E_B = (1-x_B)(x_B-x_F)/(1-x_F)(x_D-x_B)$

overall effectiveness 'E' is defined as the product of two individual ratios

$E = E_A X E_B$

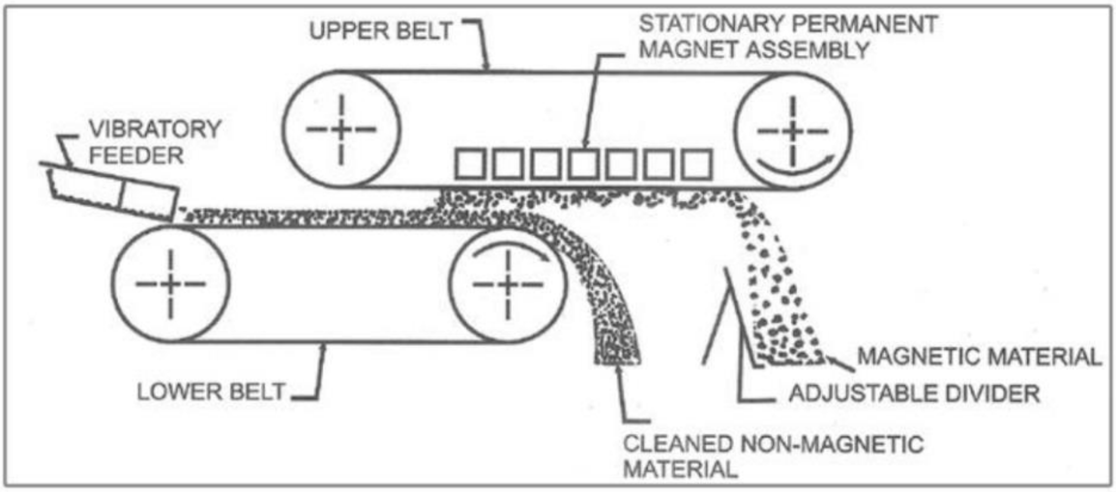
$E =((x_F-x_B)x_D/(x_D-x_B)x_F)/((1-x_B)(x_B-x_F)/(1-x_F)(x_D-x_B))$

$$E=[(x_F-x_B)x_D\ (1-x_B)(x_B-x_F)]/[(x_D-x_B)^2x_F(1-x_F)] * 100$$

Where E = screen effectiveness

Magnetic separation

- Materials that have different magnet attract ability may be separated by passing them through a magnetic field.
- Used to remove iron, steel and iron oxide from materials
- Electromagnet is used as a pulley which is under a conveyor belt.
- To remove magnetic material from slurry and also Fe from waste stream.

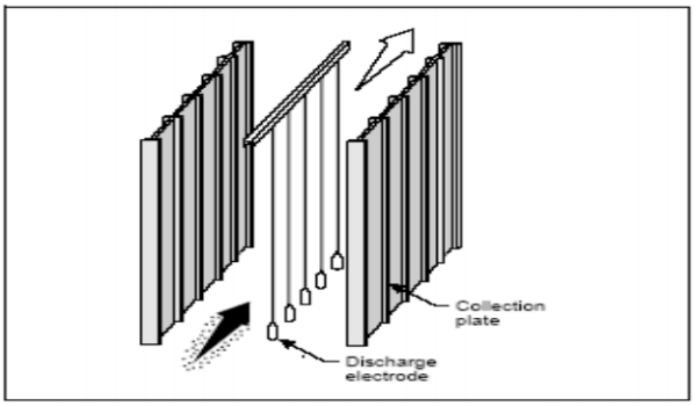


Electrostatic precipitation

- Capable of collecting very fine particles < 2micro meter
- Considered as an alternating process such as filtration, where gases of hot and corrosive.
- ESP is used mainly in metallurgical, cement and electrical power industries.
- Main application removal of fined fly ash formed in combustion of pulverised coal in power station boilers.

Principle:-

- Gas ionised in passing between a high voltage electrode and an earthened electrode
- Dust particle become charged and are attracted to the earthened electrode.



- The precipitate dust is removed from the electrode mechanically by vibration or by washing.
- Wires are normally used for high voltage electrode . Plates or tubes for earthened electrode.
- Gas is passed between two electrodes charge to a potential difference of 10-60 kV. It is subjected to action of corona discharge.
- Most industrial gases are sufficiently conducting to be readily ionized. Most important conducting gases are Co_2, Co, So2, and H_2O vapour.

- Gas velocity varies from 0.6 to 0.8 m/s, with an average contact time of 0.8 m/s.
- collection effiency n= 90% obtained at low gas velocity.
- ESP gas flow- 50m^3/s, temperature -800 k
- Pressure drop is low.

What is the difference between differential and cumulative analysis and how do they relate with each other?

Differential particle size distribution is the percentage of particles from the total that are within a specified size range; for example, 30% within 1-10um range, 50% within 10-20um range, and 20% within 20-30um range.

Cumulative particle size distribution is the sum of the differential distributions. The cumulative distribution is obtained by accumulation of differential distribution, for instance, 80% of the particles are smaller than 20um.

Differential particle size distribution and cumulative particle size distribution are related to each other.

Screen Analysis

The fine particles are generally specified accordingly to their screen analysis. A screen analysis of a material is carried out by using testing sieves. A set of standard screens is arranged serially in a stack in such a way that the coarsest and finest of the screens is at the top and bottom respectively. An analysis is carried out by placing the sample on the top screen and shaking in a definite manner, either manually or mechanically, for a definite period of time. The material retained on each screen is to be removed and weighed. The amount of material retained on each screen is expressed as the weight fraction of the total sample. As the particles retained on any one screen are passed through the screen immediately above it, two numbers are needed to specify the size, first the screen through which the fraction passes and the other on which that fraction is retained. Hence, the notation 8/10 means the material is such that it passes through the screen of mesh number 8 and collects on the screen of mesh number 10 (through 8 mesh and on 10 mesh). An analysis reported in a tabular form is called a differential analysis.

Screen analysis apparatus.

The material that is retained on the screen is the oversize and the material passes, it is the undersize. Thus, a -8 to +10 fraction means, the fraction of the material that passes through 8 mesh screen but is retained on a 10 mesh screen. Other method of screen analysis is a cumulative analysis. It 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, and tabulating the cumulative sums against the screen opening of the retaining screen of the last to be added.

Below is an example of how one can present the analysis after passing them through the mesh.

Differential Screen Analysis

Mesh	Weight fraction retained
6/8	0.017
8/10	0.235
10/14	0.298
14/20	0.217
20/28	0.105
28/35	0.062
35/48	0.028
48/65	0.017
65/100	0.010
100/150	0.005
150/200	0.002
Pan	0.004
	1.000

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