Mean Diameter

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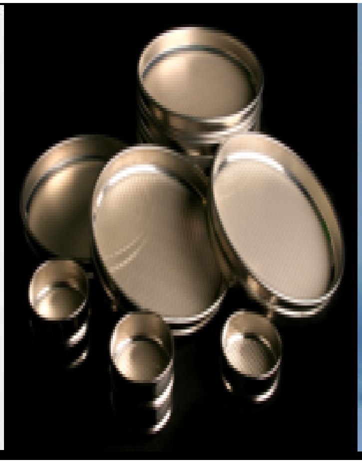

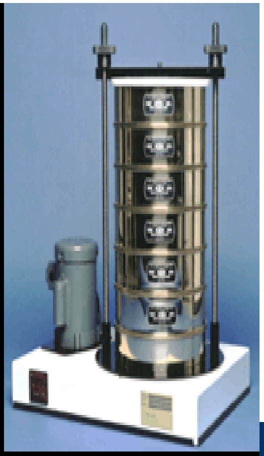

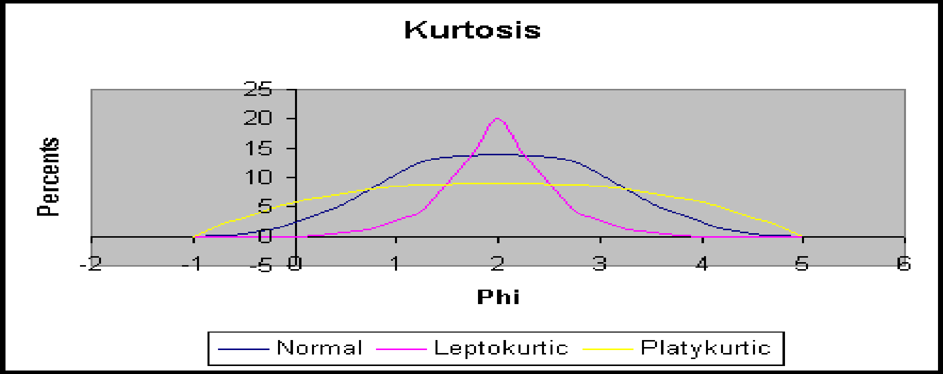

What?

- Particle size in terms of single linear dimension

- According to **BOND**

  for coarse particles opening through which 80% of the material will pass

How?

- Mean size based on volume
- Mean size based on surface
- Mean size based on length

Possible Uses

- Volume mean
  - Distribution of mass in a spray
- Surface mean
  - Adsorption
  - Crushing
  - Light diffusion
- Linear mean
  - Comparison of droplet evaporation

Major Assumption

- Each of the particle has the same shape

Mean Size Based on Volume

- Volume mean diameter
- Mean Volume diameter

Size Distribution Curve

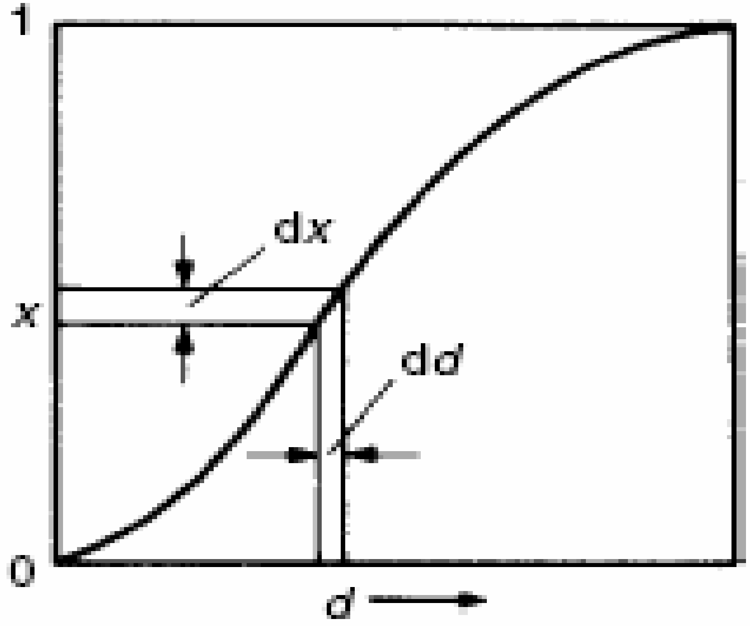

Figure 1.5. Size distribution curve—cumulative basis

Volume Mean Diameter, d_V

- Mean abscissa in the cumulative size distribution curve

$$d_v = \frac{\int_0^1 d \,\mathrm{d}x}{\int_0^1 \mathrm{d}x} = \int_0^1 d \,\mathrm{d}x.$$

Volume Mean Diameter, d_V

- In terms of particle numbers

$$d_v = \frac{\sum (n_i d_i^{\,4})}{\sum (n_i d_i^{\,3})}$$

Mean Volume Diameter, $d_v^{/}$

- If all the particles are of diameter $d_v^{/}$, then the total volume of particles is the same as in the mixture

$$d'_v = \sqrt[3]{\left(\frac{\Sigma (n_1 d_1^3)}{\Sigma n_1}\right)}$$

Mean Volume Diameter, d_v'

- In terms of mass fraction

$$d_v' = \frac{1}{\sqrt[3]{\sum\left(\frac{x_i}{d_i^{\ 3}}\right)}}$$

Mean Size Based on Surface

- Surface Mean diameter
- Mean Surface diameter

Size Distribution Curve

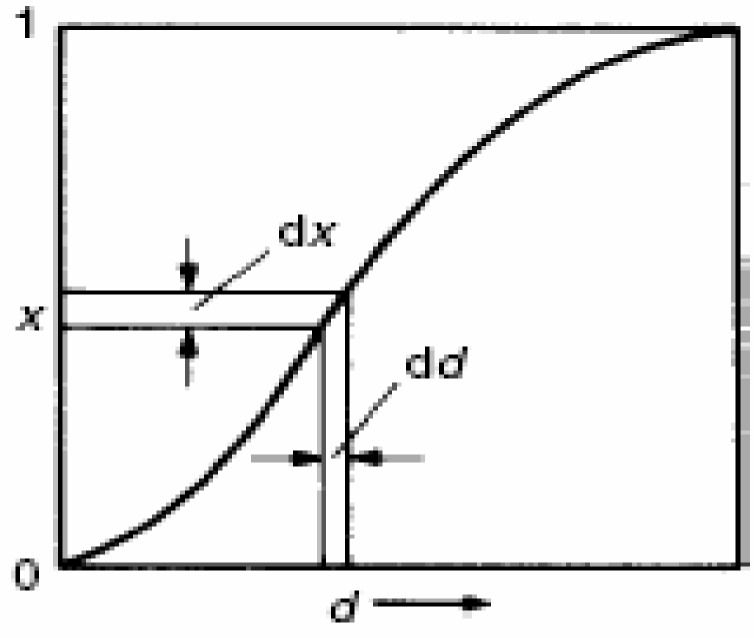

Figure 1.5. Size distribution curve—cumulative basis

Surface Mean Diameter, d_s

- Mean abscissa in the distribution curve where surface in each fraction is plotted against size

$$d_s = \frac{\Sigma[(n_1 d_1) S_1]}{\Sigma(n_1 S_1)} = \frac{\Sigma(n_1 k_2 d_1^3)}{\Sigma(n_1 k_2 d_1^2)} = \frac{\Sigma(n_1 d_1^3)}{\Sigma(n_1 d_1^2)}$$

Surface Mean Diameter, d_s

- In terms of mass fraction

$$d_s = \frac{\Sigma x_1}{\Sigma\left(\frac{x_1}{d_1}\right)} = \frac{1}{\Sigma\left(\frac{x_1}{d_1}\right)}$$

- Surface mean diameter is also known as ***Sauter mean diameter***

Sauter Mean Diameter (SMD)

- Diameter of a sphere that has the same volume/surface area ratio as a particle of interest
- Diameter of a drop having the same volume/surface area ratio as the entire spray
- Diameter of the particle with the same specific surface as the powder

Sauter Mean Diameter (SMD)

- The SMD is common measure in fluid dynamics as a way estimating the average particle size
- SMD is also referred to as D[3,2]
- It is especially important in calculations where the active surface area is important.
  - Such areas include catalysis and applications in fuel combustion

Mean Surface Diameter, $d_s^{/}$

- The ***mean surface diameter*** is defined as the size of particle $d_s^{/}$ which is such that if all the particles are of this size, the total surface will be the same as in the mixture

$$d'_s = \sqrt{\left(\frac{\Sigma(n_1 d_1^2)}{\Sigma n_1}\right)}$$

Mean Surface Diameter, d_s'

- In terms of mass fraction

$$d'_s = \sqrt{\left(\frac{\Sigma(x_1/d_1)}{\Sigma(x_1/d_1^3)}\right)}$$

Mean Size Based on Length

- Length mean diameter
- Mean length diameter

Length Mean Diameter, d_l

- A ***length mean diameter*** may be defined as:

$$d_l = \frac{\Sigma[(n_1 d_1) d_1]}{\Sigma(n_1 d_1)} = \frac{\Sigma(n_1 d_1^2)}{\Sigma(n_1 d_1)} = \frac{\Sigma\left(\dfrac{x_1}{d_1}\right)}{\Sigma\left(\dfrac{x_1}{d_1^2}\right)}$$

Mean Length Diameter, $d_l^/$

- A ***mean length diameter*** or arithmetic mean diameter may also be defined by:

$$d'_l = \frac{\Sigma(n_1 d_1)}{\Sigma n_1} = \frac{\Sigma\left(\dfrac{x_1}{d_1^2}\right)}{\Sigma\left(\dfrac{x_1}{d_1^3}\right)}$$

Example 1.1

- The size analysis of a powdered material on a mass basis is represented by a straight line from o percent mass at 1µm particle size to 100 percent mass at 101µm particle size as shown in figure

  Calculate the surface mean diameter of the particles constituting the system

Problem

- A spray-dried detergent has the following screen analysis:

Tyler Screen Mesh	Weight Fraction
-10+14	0.02
-14+20	0.05
-20+28	0.10
-28+35	0.18
-35+48	0.25
-48+65	0.25
-65	0.15

Problem

- **Determine the various diameters of this material**
  - Mean size based on volume
  - Mean size based on surface
  - Mean size based on length

Reference

- Richardson et al., ***Coulson & Richardson's CHEMICAL ENGINEERING,*** volume 2, fifth edition, page 10-14