OSF – Introdução

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1 de outubro de 2024

Conteúdo

1 Physichomemical Properties of solids

1.1 Single particles:

- Shape
- hardness
- compressive resistence
- electrical charge
- (intraparticle) porosity

1.2 Bulk solids:

- Particle size distribution
- (interparticle) porosity
- humidity
- agglomeration
- flowability
- ...

1.3 Solids suspensions (heterogenius mixture in a fluid, gás or liquid)

- Particle size distribution
- Concentration of solids
- viscosity of suspension
- flocculation
- settleability
- ...

Properties of single particles

1.4 Shape

(i) Regular shape:

particles which its geometry is well defined by matematical equations

- Sphere
- Cylinder
- Cube...

Sphere:

$$\begin{aligned} \text{Volume:} \quad & \pi\, d^3/6 = 4\,\pi\, r^3/3 \\ \text{Surface Area:} \quad & \pi\, d^2 = 4\,\pi\, r^2 \\ \text{Projected area in a plane:} \quad & \pi\, d^2/2 = \pi\, r^2 \end{aligned}$$

Note: Spheres are special as its compleetely symmetrical whilist the others depend on the orientation

(ii) Complex regular shapes

- Maximize surface area per Volume
- Used in packed columns in chem and biochem enginneering

(iii) Irregular shapes

- Cannot be identified by math equations
- Characteristic dimension d
  - Sphere Diameter with same volume
    $V_{\text{particle}} = V_{\text{sphere}}$
  - Sphere Diameter with same Surface area
    $S_{\text{particle}} = S_{\text{sphere}}$
  - Sphere Diameter with same Surface per volume
    $\frac{S_{\text{particle}}}{V_{\text{particle}}} = \frac{S_{\text{Sphere}}}{V_{\text{Sphere}}}$

Derivando propriedades:

Length	$L = d$	Volume	$V = \ddot{k}\, d^3$
Surface area	$S = \dot{k}\, d^2$	Mass	$m = \rho_S V = \rho_S \ddot{k}\, d^3$

- Surface factor: $\dot{k}_{\text{sphere}} = \pi$
- Volume factor: $\ddot{k}_{\text{sphere}} = \pi/6$

1.5 Particle Distribution Curves

$$\text{Cumulative} \iff \text{Frequency}$$

Diff ways to measure quantity

n: Number fraction s: surface fraction x: weight fraction

l: lenght fraction v: volume fraction

Property	Whole	Fraction
Number :	n_i, d_i	n_i
Length (m) :	$l = n_i\, d_i$	$l_i = \frac{n_i\, d_i}{\sum n_j\, d_j}$
Surface (m^2):	$s = n_i\, \dot{k}\, d_i^2$	$s_i = \frac{n_i\, d_i^2}{\sum n_j\, d_j^2}$
Volume (m^3):	$v = n_i\, \ddot{k}\, d_i^3$	$v_i = \frac{n_i\, d_i^3}{\sum n_j\, d_j^3}$
Mass (kg) :	$x = n_i\, \rho\, \ddot{k}\, d_i^3$	$x_i = \frac{n_i\, d_i^3}{\sum n_j\, d_j^3}$

Mean diameter:

Can be based on different properties of solid like weight, number or volume.

$$\bar{d_\alpha} = \frac{\int d \; \mathrm{d}\alpha}{\int \mathrm{d}\alpha} = \frac{\sum d_i\, \alpha_i}{\sum \alpha_i} : \alpha \begin{cases} x: & \text{Weight} \\ n: & \text{Number} \\ v: & \text{Volume} \\ s: & \text{Surface} \\ l: & \text{Lenght} \end{cases}$$

Weight and Number

$$\begin{cases} \text{Measured in number } n \\ \bar{d_x} = \bar{d_v} = \dfrac{\int d \; \mathrm{d}(n\, \rho\, \ddot{k}\, d^3)}{\int \mathrm{d}(n\, \rho\, \ddot{k}\, d^3)} = \dfrac{\int n\, d^3\, \mathrm{d}d}{\int n\, d^2\, \mathrm{d}d} = \\ = \dfrac{\sum d_i\, (n_i\, \rho\, \ddot{k}\, d_i^3)}{\sum (n_i\, \rho\, \ddot{k}\, d_i^3)} = \dfrac{\sum n_i\, d_i^4}{\sum n_i\, d_i^3} = \\ \text{Measured in Weight } x \\ = \dfrac{\sum x_i\, d_i}{\sum x_i} \end{cases}$$

Surface

$$\begin{cases} \text{Measured in number } n \\ \bar{d_S} = \dfrac{\int d \; \mathrm{d}(n\, \dot{k}\, d^2)}{\int \mathrm{d}(n\, \dot{k}\, d^2)} = \dfrac{\int d^2\, n_i\, \mathrm{d}d}{\int d\, n_i\, \mathrm{d}d} = \\ = \dfrac{\sum d_i\, (n_i\, \dot{k}\, d_i^2)}{\sum (n_i\, \dot{k}\, d_i^2)} = \dfrac{\sum n_i\, d_i^3}{\sum n_i\, d_i^2} = \\ \text{Measured in Weight } x \\ = \dfrac{\sum \left(\frac{x_i}{\rho\, \ddot{k}\, d_i^3}\right) d_i^3}{\sum \left(\frac{x_i}{\rho\, \ddot{k}\, d_i^3}\right) d_i^2} = \dfrac{\sum x_i}{\sum x_i / d_i} \end{cases}$$

Lenght

$$\begin{cases} \text{Measured in number } n \\ \bar{d_L} = \dfrac{\int d \; \mathrm{d}(n\, d)}{\int \mathrm{d}(n\, d)} = \dfrac{\int d\, n\, \mathrm{d}d}{\int n\, \mathrm{d}d} = \\ = \dfrac{\sum d_i\, (n_i\, d_i)}{\sum (n_i\, d_i)} = \dfrac{\sum n_i\, d_i^2}{\sum n_i\, d_i} = \\ \text{Measured in Weight } x \\ = \dfrac{\sum \left(\frac{x_i}{\rho\, \ddot{k}\, d_i^3}\right) d_i^2}{\sum \left(\frac{x_i}{\rho\, \ddot{k}\, d_i^3}\right) d_i} = \dfrac{\sum x_i / d_i}{\sum x_i / d_i^2} \end{cases}$$

Volume

$$\begin{cases} \bar{d_V} = \dfrac{\int d \; \mathrm{d}n\, \ddot{k}\, d^3}{\int \mathrm{d}n\, \ddot{k}\, d^3} = \dfrac{\int n\, d^3\, \mathrm{d}d}{\int n\, d^2\, \mathrm{d}d} = \\ = \dfrac{\sum d_i\, (n_i\, \ddot{k}\, d_i^3)}{\sum (n_i\, \ddot{k}\, d_i^3)} = \dfrac{\sum n_i\, d_i^4}{\sum n_i\, d_i^3} \\ \text{Assuming all particles have the same size} \\ \sum n_i\, \ddot{k}\, \bar{d}_V^3 = \ddot{k}\, \bar{d}_V^3 \sum n_i = \sum n_i\, \ddot{k}\, d_i^3 \implies \\ \implies \bar{d_V} = \sqrt{\frac{\sum n_i\, d_i^3}{\sum n_i}} \end{cases}$$