Example 1: Cumulative Screen Analysis

Standard 10-mesh screen. Calculate mass ratios of the overflow and underflow to feed and overall effectiveness of screen.

		Cumulative fraction smaller than D_p		
Mesh	D_p, mm	Feed	Overflow	Underflow
4	4.699	0	0	
6	3.327	0.025	0.071	
8	2.362	0.15	0.43	0
10	1.651	0.47	0.85	0.195
14	1.168	0.73	0.97	0.58
20	0.833	0.885	0.99	0.83
28	0.589	0.94	1.00	0.91
35	0.417	0.96		0.94
65	0.208	0.98		0.975
Pan		1.00		1.00

Lecture : 3

Problem : 2

Sample feed, $\phi_s = 0.5$ & $\rho_p = 1.2\ g/cm^3$

$A_{ss} = ?$, $\bar{D}_{v_s} = ?$

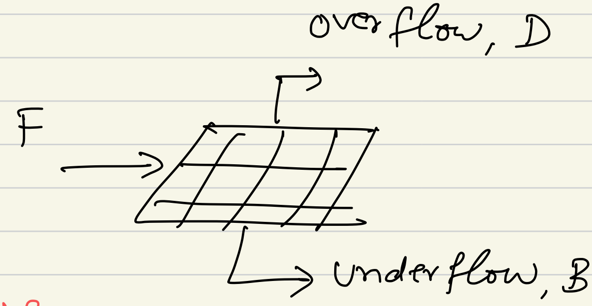
Mesh no	Screen opening, mm	Mass retained (g)
4	4.75	0
5	3.35	33.5
6	2.8	324
8	2.0	315.5
10	1.8	120
14	1.7	182
18	0.85	78
25	0.60	79
30	0.50	39
36	0.425	29
44	0.355	26
50	0.3	27
52	0.25	28
85	0.18	40
100	0.155	26
120	0.125	27
150	0.106	28
200	0.075	29
Pan	—	69
	Total	1500 g

$A_{ss} =$

$\bar{D}_{v_s} = 0.384\ mm$

Screen effectiveness (Screen efficiency):

A & B → Mixture



* For perfect screen,

All of material A will be in overflow & all of material B will be in underflow.

F, D, B – mass flow rate of feed, overflow & underflow

x_F, x_D, x_B – be mass fraction of material A in these streams

Material balance:

$$F = D + B$$

For material A,

$$F x_F = D x_D + B x_B$$

$$\frac{D}{F} = \frac{x_F - x_B}{x_D - x_B}$$

$$\frac{B}{F} = \frac{x_D - x_F}{x_D - x_B}$$

Screen effectiveness based on oversize materials,
* (Ratio of oversize material A that is actually in the over flow to the amount A entering with feed)

$$E_A = \frac{D x_D}{F x_F}$$

Screen effectiveness based on undersize materials

$$E_B = \frac{B(1-x_B)}{F(1-x_F)}$$

So, Combined overall effectiveness,

$$E = E_A E_B = \frac{D x_D}{F x_F} * \frac{B(1-x_B)}{F(1-x_F)}$$

$$\Rightarrow \boxed{E = \frac{(x_F - x_B)(x_D - x_F)\, x_D (1-x_B)}{(x_D - x_B)^2 (1-x_F)\, x_F}}$$

Problem: 3

$x_F = 0.47$

$x_D = 0.85$

$x_B = 0.195$

$\frac{D}{F} = 0.42$

$\frac{B}{F} = 0.58$

$E = 0.67$

Problem 4:

Calculate the equivalent volume sphere dia. x_V & surface-volume equivalent sphere dia x_{SV} of a cuboid particle of side length 1, 2, 4 mm.

$x_V = ?$

$x_{SV} = ?$

volume of cuboid $= 1 \times 2 \times 4 = 8\ mm^3$

$$\frac{\pi}{6} x_V^3 = 8 \Rightarrow \boxed{x_V = 2.481\ mm}$$

Surface area of cuboid particle

$$= 2(1\times2 + 2\times4 + 1\times4) = 28\ mm^2$$

Surface to volume ratio of the particle $= \frac{28}{8} = 3.5\ mm^2/mm^3$

For a sphere, ratio of surface area to volume

$$= \frac{6}{x_{SV}}$$

$$\frac{6}{x_{SV}} = 3.5 \Rightarrow \boxed{x_{SV} = 1.714\ mm}$$

Problem 5:

Cuboid particle $5 \times 3 \times 1$ mm

(a) $x_v = 3.06$ mm

(b) Surface area of particle = $46\ mm^2$

Surface area of sphere = $\pi x_s^2 = 46$

$\Rightarrow \quad x_s = 3.83$ mm

(c) $x_{sv} = 1.96$ mm

$$\frac{6}{x_{sv}} = \frac{46}{15}$$

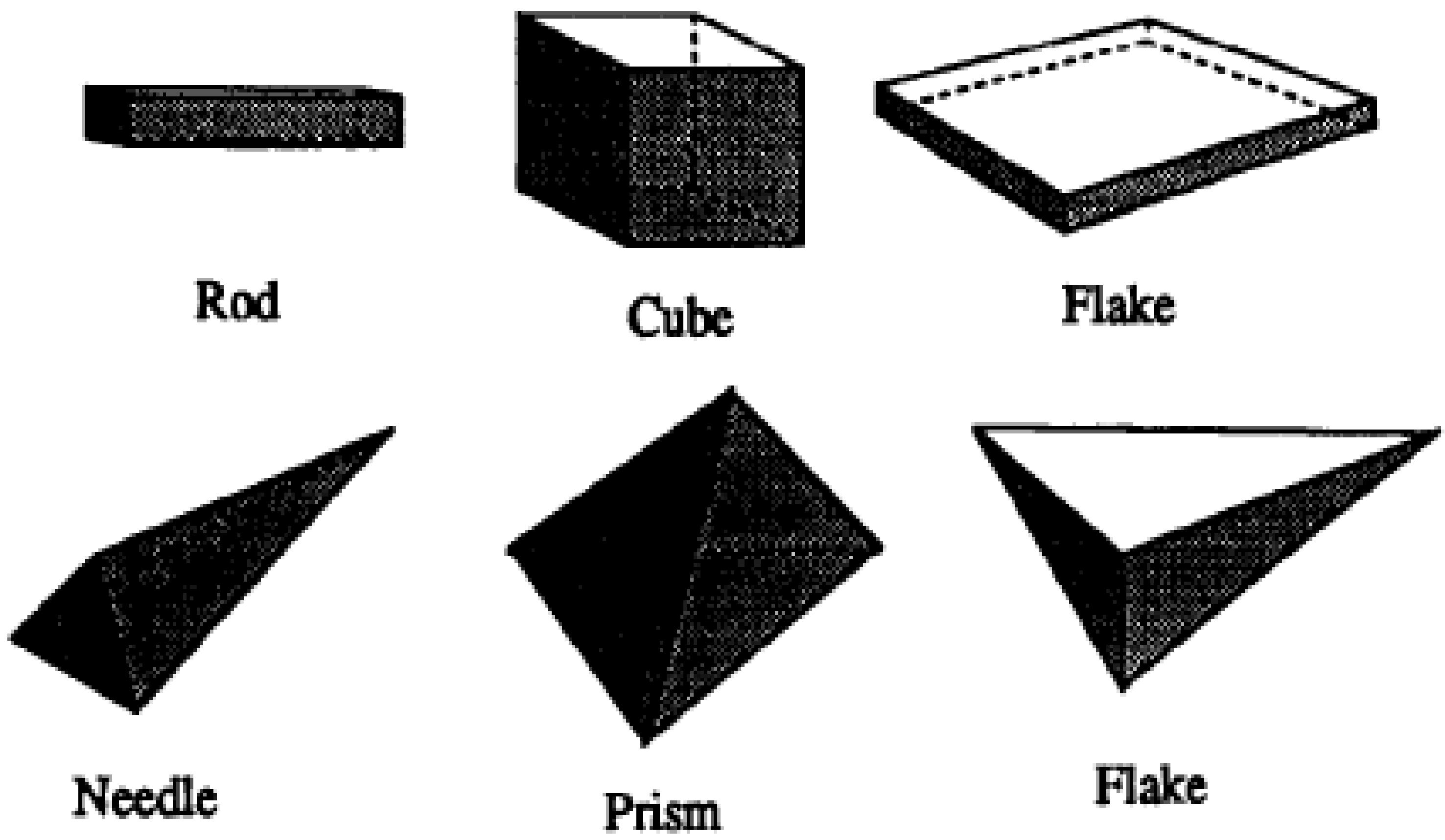
(d) Sieve dia, = 3 mm

(e) Area of a circle = $\frac{\pi}{4} x^2$

Projected area = $3\ mm^2$, $x_{p_1} = 1.95$ mm

$5\ mm^2$, $x_{p_2} = 2.52$ mm

$15\ mm^2$, $x_{p_3} = 4.37$ mm

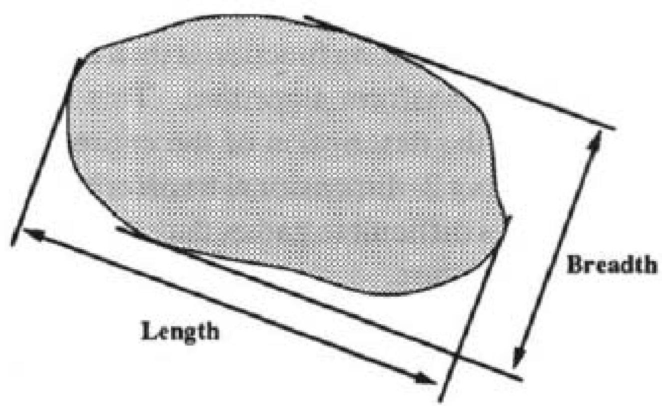


Form and proportions

❑ The **length** is the distance between two tangential planes which are perpendicular to those defining the thickness and breadth.

❑ In practice it may be difficult to measure the particle thickness, particularly from microscopy, and so often we are limited to using simply the elongation ratio, as shown in Figure.

Elongation ratio = length/breadth



Particle shape and elongation

Shape Factor

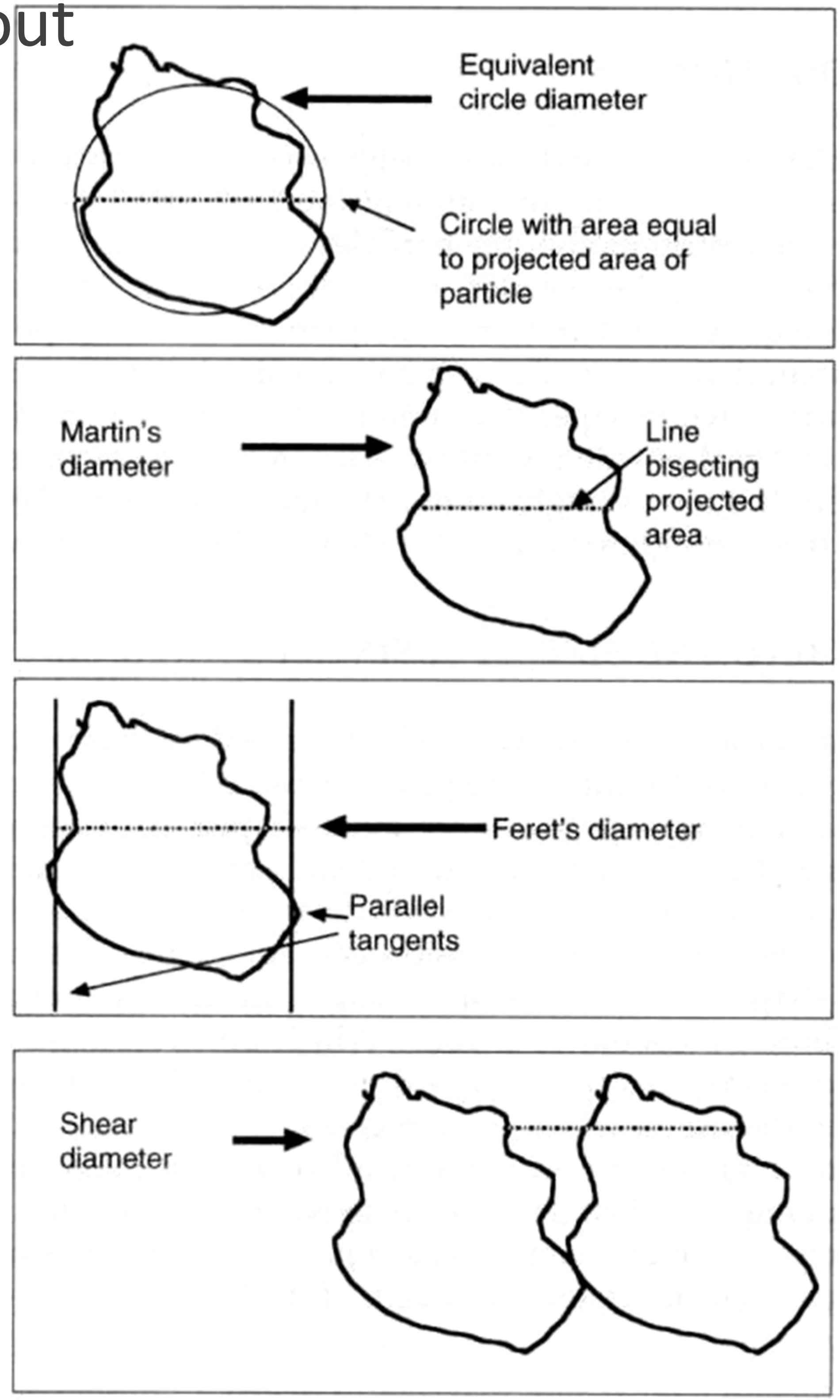
- The ratio of two equivalent diameters obtained by different methods is termed a shape factor.
- Shape factors describe the departure of the particle from a spherical form.
- One of the simplest is the sphericity, Ψ, defined by Wadell (1934) as:

$$\Psi = \frac{\text{surface area of a sphere having the same volume as the particle}}{\text{surface area of the particle}}$$

$$= \left(\frac{d_v}{d_s}\right)^2$$

Some terminology about diameters.

- Equivalent circle diameter
- Martin's diameter
- Feret's diameter
- Shear diameter



WORKED EXAMPLE 1.6

Consider a cuboid particle $5.00 \times 3.00 \times 1.00$ mm. Calculate for this particle the following diameters:

(a) the volume diameter (the diameter of a sphere having the same volume as the particle);

(b) the surface diameter (the diameter of a sphere having the same surface area as the particle);

(c) the surface-volume diameter (the diameter of a sphere having the same external surface to volume ratio as the particle);

(d) the sieve diameter (the width of the minimum aperture through which the particle will pass);

(e) the projected area diameters (the diameter of a circle having the same area as the projected area of the particle resting in a stable position).