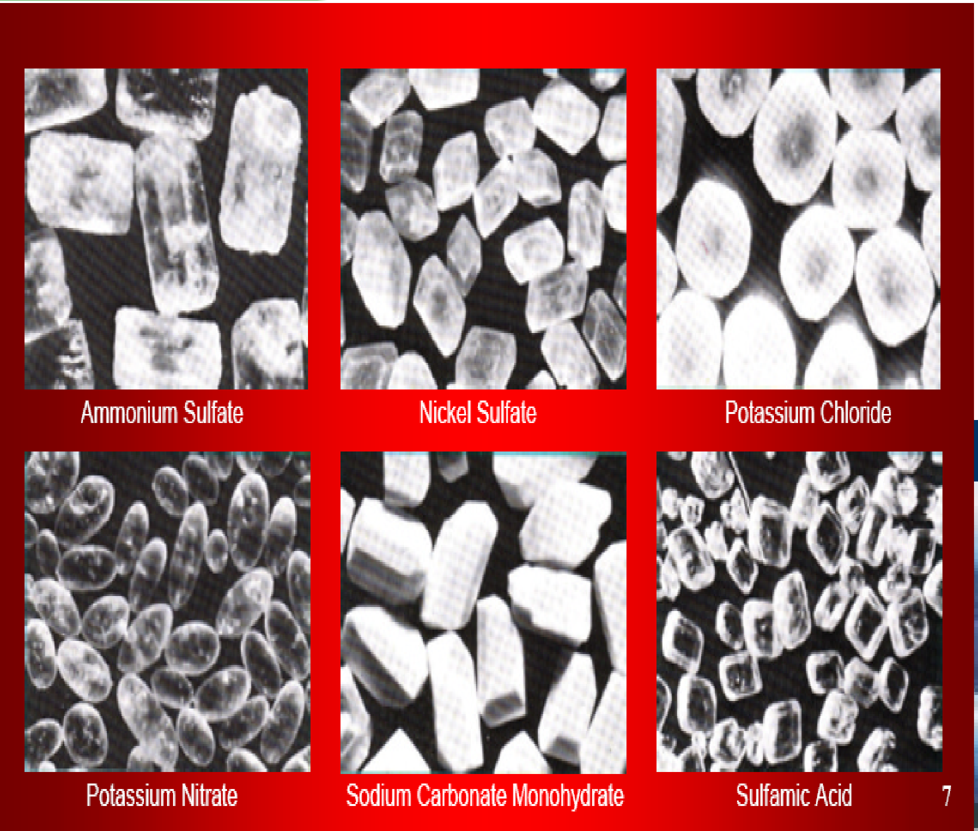
Particle Shape



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Shape Factor

- A normal way of expressing the shape factor is to make it
  - the ratio of the particle property to the property of a sphere having a diameter equal to the measured particle dimension

Volume-based Shape Factor

$$= \frac{\text{particle volume}}{\text{volume of a sphere of same diameter}}$$

$$\psi'_v = \frac{\psi_v D_p^{\ 3}}{\frac{\pi}{6} D_p^{\ 3}} = \frac{\psi_v}{\frac{\pi}{6}}$$

Sphericity

- A surface-volume shape factor

$$= \frac{\text{surface area of a sphere of volume equal to that of the particle}}{\text{surface area of the particle}}$$

Sphericity cont…

$$\psi = \frac{A_0}{A_P} = \frac{\pi D_0{}^2}{A_P}$$

$$= \frac{\pi\left(\frac{6V_p}{\pi}\right)^{2/3}}{A_p}$$

Where

A_o, A_p = surface area of the equivalent sphere and of the particle respectively

D_p = diameter of the equivalent sphere

V_p = particle volume

Ratio Of Specific Surface

$$= \frac{\text{specific surface of the particle}}{\text{specific surface of a sphere of the same “diameter”}}$$

$$\eta = \frac{specific\ surface\ (cm^2/gm)}{\dfrac{6\overline{D}_p}{\rho}}$$

- “diameter” is usually taken as the mean screen opening

Ratio Of Specific Surface

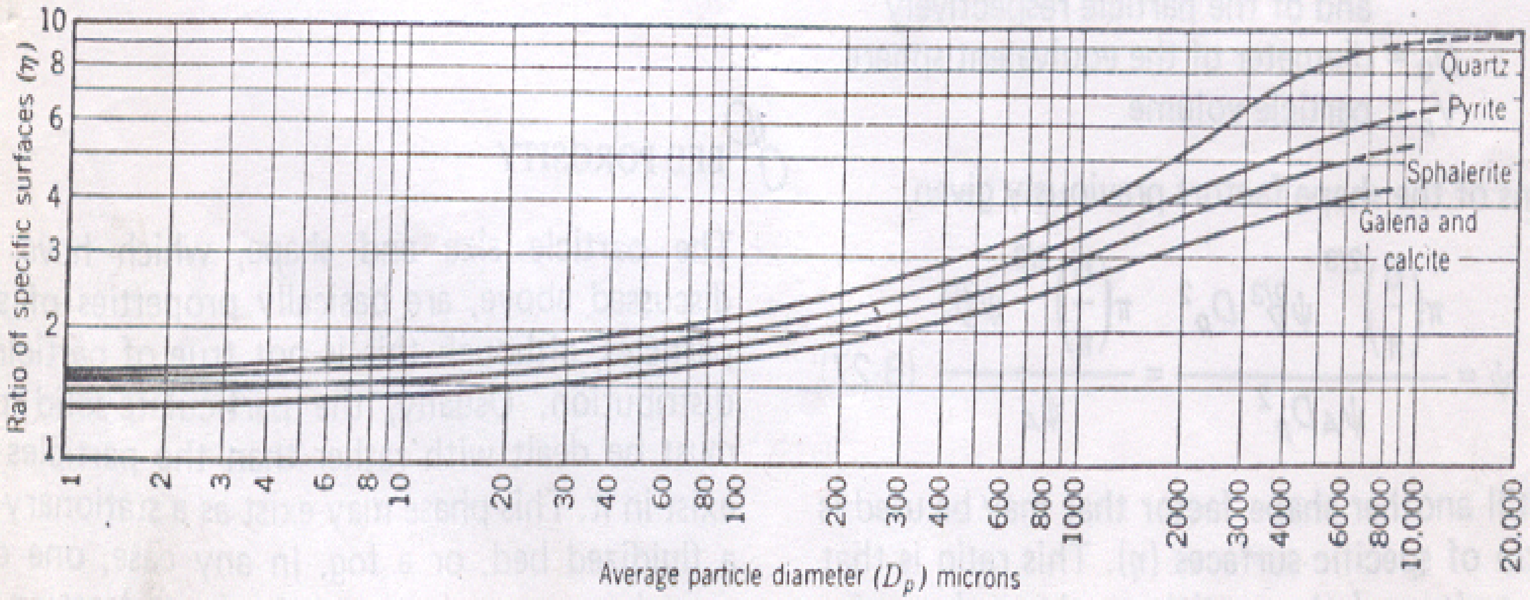

Figure B-11. Ratio of specific surface, η as a function of average particle diameter for the minerals of Figure B-10 (5). (U.S. Bureau of Mines Bull. No. 402, by courtesy of publisher.)

Advantage

- The specific surface of a material for which there are no data may be roughly estimated from the ratio of specific surfaces of a similar material

Specific Surface from Ratio

$$\text{Total Surface} = \frac{6\eta_1 m_1}{\rho (D_P)_1} + \frac{6\eta_2 m_2}{\rho (D_P)_2} + \ldots + \frac{6\eta_i m_i}{\rho (D_P)_i} = \frac{6}{\rho} \sum_{i=1}^{k} \frac{\eta_i m_i}{(D_P)_i}$$

$$\text{Average Specific Surface} = \frac{\dfrac{6}{\rho} \displaystyle\sum_{i=1}^{k} \dfrac{\eta_i m_i}{(D_P)_i}}{\sum m_i} = \frac{6}{\rho} \sum_{i=1}^{k} \frac{\eta_i x_i}{(D_P)_i}$$

Bed Porosity

- Fraction void volume

$$\epsilon = V_V / V_T$$

$$= 1 - V_P / V_T$$

$$= 1 - \frac{M_P}{\rho A H}$$

Porosity

- Porosity of a static bed depends upon
  - Particle shape and surface roughness
  - Particle size and size distribution
  - Size of the container relative to the particle diameter
  - Method of packing

Method of Packing

- Water-fill method initially gives more porous packing

BUT

- Vibration of the vessel and the effect of gas or liquid flow through it ultimately compacts the bed

Particle Shape and Surface Roughness

- The lower the particle sphericity, the more open is bed
- Particles settle across each other and pack with pointed ends against each other, preventing a close packing

Sphericity as a Function of Porosity

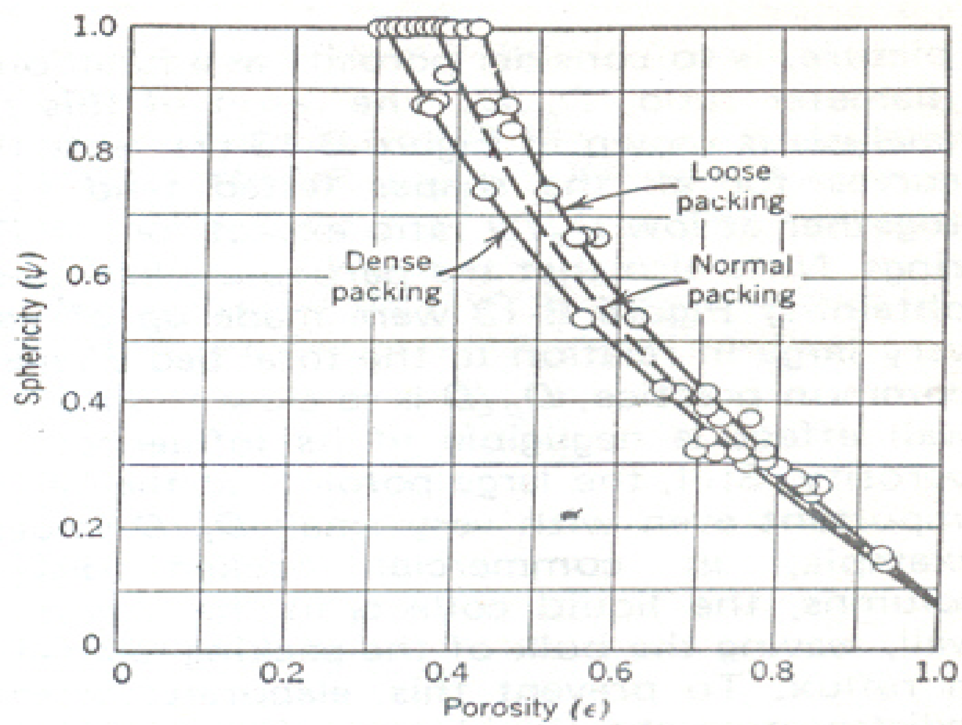

Figure B-12. Sphericity as a function of porosity for random-packed beds of uniformly sized particles (2). (By permission of John Wiley & Sons, copyright © 1950.)

Particle Size and Size Distribution

- Presence of fine and coarse particles results in a bed of lower porosity than would be obtained with uniform particles

Particle Size and Vessel Size

- The presence of container wall interrupts the pattern of particle-to-particle contacts
- Hence makes for a larger fraction voids at the wall

Reference

- Foust *et al*: **Principles of Unit Operations**, second edition, John Wiley & Sons, Page#711-714

- **ASSIGNMENT:**
  - **Problems** B-2, B-3, B-5, B-6, B-7