Settling and Sedimentation-3

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RECAP

- ✓ Settling & Sedimentation: particles
  - ✓ Free Settling
  - ✓ Hindered Settling
  - ✓ Sedimentation
- ✓ Application
- ✓ Equipment
- ✓ Theory: Free Settling
  - ✓ Gravitational force → mass
  - ✓ Buoyant force → density difference
  - ✓ Drag force → resistance/drag
  - ✓ Terminal (settling) velocity
  - ✓ Drag coefficient

move/not?
direction?
fast?

TODAY'S TOPICS

Today Topics :

- Differential Settling (Classification)
  - settling
  - more than one type of solids
  - each type has size range
  - several settling velocities
- Sedimentation and Thickening

LESSON OUTOMES

Students should be able to

- ✓ comprehend & discuss concept & theory on
  - Differential Settling/Classification
  - Sedimentation and Thickening
- ✓ analyze & design of each type

Differential Settling and Separation of Solid n Classification

Differential settling method

It is the separation of solid particles into several **size fractions** based upon their **settling velocities** in a particular medium.

Consider two different materials

A: high density, $\rho_A = 7.5 \times 10^3$ kg/m^3 (eg. Galena)

B: low density, $\rho_B = 2.65 \times 10^3$ kg/m^3 (eg. Quartz)

$$v_{tA} = \left[\frac{4(\rho_{pA} - \rho)gD_{pA}}{3C_{DA}\rho}\right]^{1/2}$$

$$v_{tB} = \left[\frac{4(\rho_{pB} - \rho)gD_{pB}}{3C_{DB}\rho}\right]^{1/2}$$

Differential Settling and Separation of Solid in Classification

- For particle of equal settling velocity, $v_{tA} = v_{tB}$

$$\frac{D_{pA}}{D_{pB}} = \frac{(\rho_{pB} - \rho)}{(\rho_{pA} - \rho)} \frac{C_{DA}}{C_{DB}}$$

- High N_{Re}, in the turbulent Newton's law region, C_D constant

$$\frac{D_{pA}}{D_{pB}} = \left(\frac{\rho_{pB} - \rho}{\rho_{pA} - \rho} \right)^{1.0}$$

- For laminar Stokes' law settling

$$C_{DA} = \frac{24\mu}{D_{pA} v_{tA} \rho} \qquad C_{DB} = \frac{24\mu}{D_{pB} v_{tB} \rho}$$

Example : Separation of Silica and Galena

A mixture of silica (B) and galena (A) solid particles having a size range of 5.21×10^{-6} m to 2.50×10^{-5} m is to be separated by hydraulic classification using free settling conditions in water at 293.2 K. The specific gravity of silica is 2.65 and that of galena is 7.5. Calculate the size range of the various fractions obtained in the settling. If the settling is in the laminar region, the drag coefficients will be reasonably close to that for spheres.

Example : Problem Statement

Given:

mixture of silica (B) and galena (A)

D_p = 5.21 x 10^{-6} m to 2.50 x 10^{-5} m

T_{water} = 293.2 K

ρ_p = 2467 kg/m^3

specific gravity of silica is 2.65 and that of galena is 7.5

can find ρ and μ for water

Calculate: size range, D

Solution

- what is specific density of a material?
  - density material / density water
- density material =

  density water x specific gravity

- check settling type
  - N_{Re} → need v_t → largest particle + largest ρ $= A$

$$v_{tA} = \frac{gD_{pA}^2\left(\rho_{pA} - \rho\right)}{18\mu} = 2.203\times10^{-3}\, m/s$$

$$N_{Re} = \frac{D_{pA} v_{tA} \rho}{\mu} = 0.0547$$

→laminar, in the Stokes' law region

Solution

- Back to question → size range
  - know largest: A, can find size of smallest?
  - need to find intermediate ranges

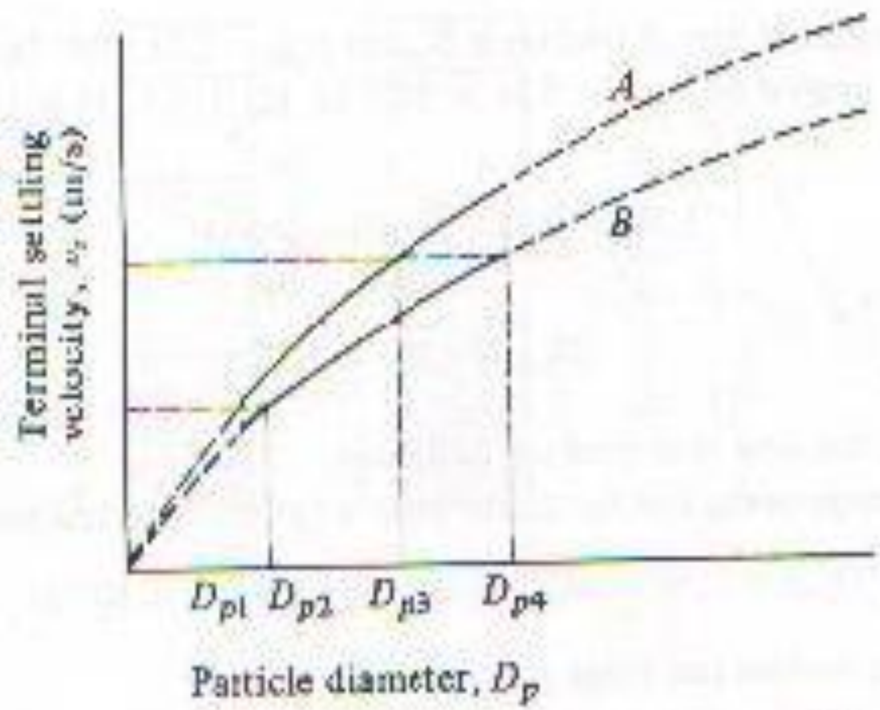


FIGURE 14.3-3 Settling and separation of two materials A and B in Newton's law region.

$$v_t \ \alpha \ D_p$$

$$D_{p4} = 2.50\times10^{-5}\,m$$

$$D_{p1} = 5.21\times10^{-6}\,m$$

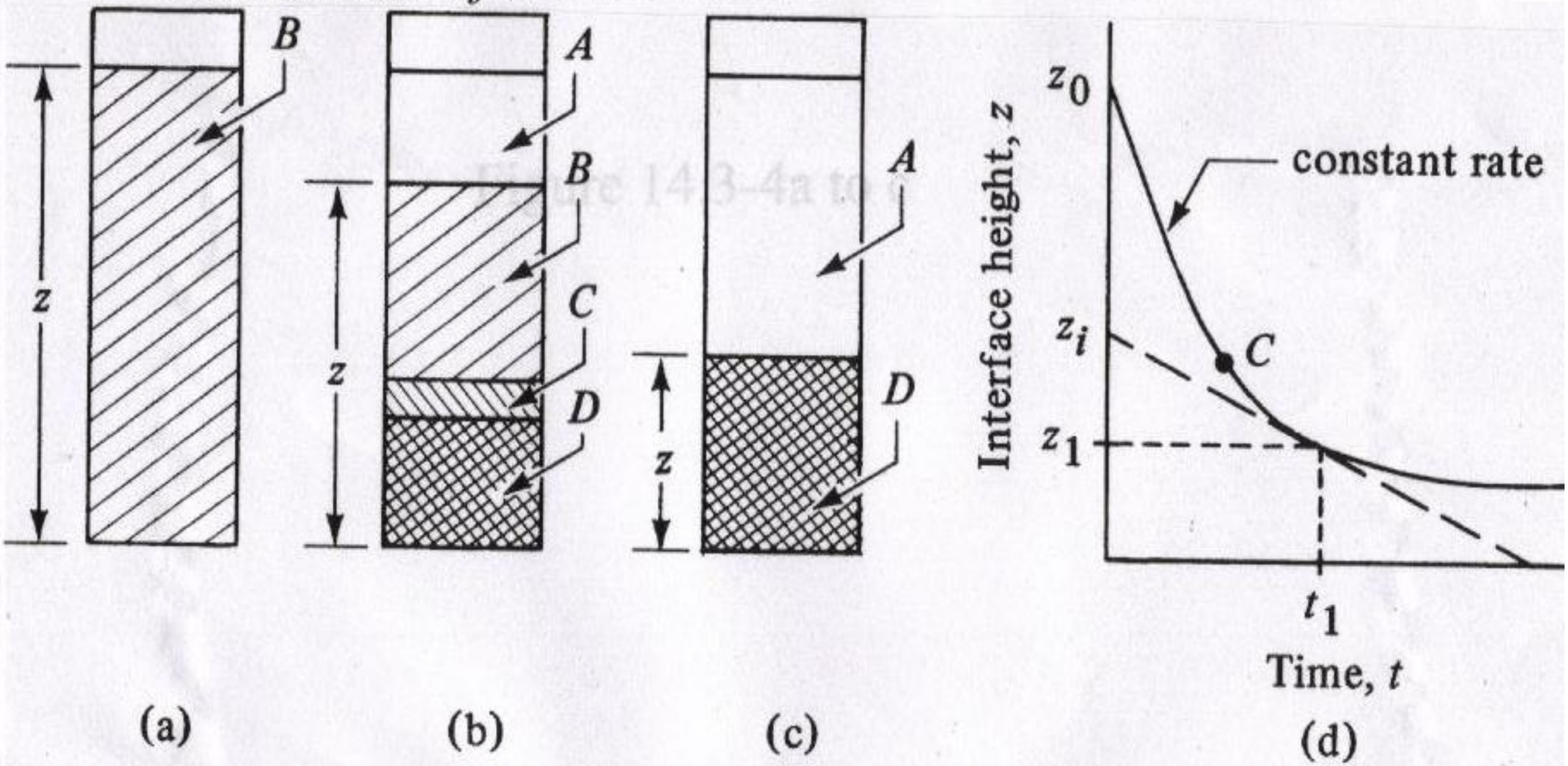
$$\text{From plot}: v_t \text{ for } D_{pA3} = v_t \text{ for } D_{pB4}$$

$$\text{From plot}: v_t \text{ for } D_{pB2} = v_t \text{ for } D_{pA1}$$

$$\frac{D_{pA}}{D_{pB}} = \left(\frac{\rho_{pB}-\rho}{\rho_{pA}-\rho}\right)^{1/2}$$

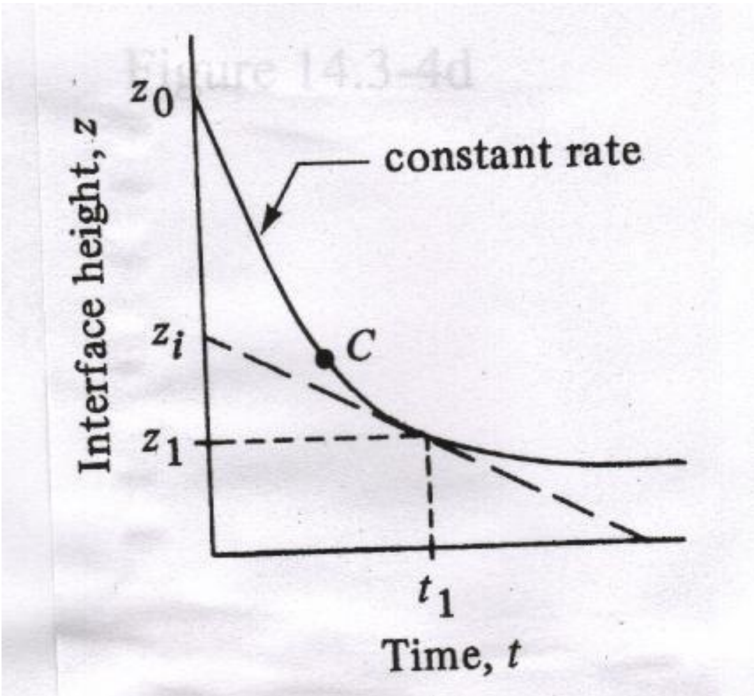
Sedimentation and Thickening

Mechanism of Sedimentation



Batch sedimentation results : (a) original uniform suspension, (b) zones of settling after a given time, (c) compression of zone D after zones B and C disappear, (d) clear liquid interface height z versus time of settling.

Sedimentation and Thickening



velocity at t_1

$$v_1 = \frac{z_i - z_1}{t_1 - 0}$$

average concentrat ion of suspension

$$c_1 z_1 = c_0 z_0$$

$$c_1 = \left(\frac{z_0}{z_i} \right) c_0$$

c_0 = original slurry concentrat ion

[kg/m ^{3}]

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  - Hindered Settling
  - Sedimentation
- Application
- Equipment
- Theory: Free Settling
  - Gravitational force → mass
  - Buoyant force → density difference
  - Drag force → resistance/drag
  - Terminal (settling) velocity
  - Drag coefficient
- discussed theory
  - Differential Settling in Classification
  - Sedimentation and Thickening
- differentiate the three
- tried out example questions

References:

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[4] Steinour, H.H. Ind.Eng.Chem., 36, 618, 840, 1944.

Question & Answers

THANK YOU