— University of Mosul —
College of Petroleum & Mining Engineering

Fluid Flow I

Lecture (4)

Examples & Viscosity

Petroleum and Refining Engineering Department

Ass.P. Raqeeb Hummadi Rajab
Ass.L. Ghufran Faris Alrahhawi

Email: ghufranalrahhawi @uomosul.edu.iq

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Example (1)

A clean tube diameter2.5 mm is immersed in a liquid with a coefficient of surface tension =0.4 N/m. The angle of contact of the liquid with the glass can be assumed to be 135º. The density of the liquid =13600 kg/m^3. What would be the level of the liquid in the tube relative to the free surface of the liquid inside the tube.

Solution:

Given: d=2.5 mm, $\sigma = 4$ N/m, $\theta = 135°$, $\rho = 13600$ kg/m^3

Level of the liquid in the tube, h;

The liquid in the tube rises (or falls) due to capillary.

$$h = \frac{4\sigma cos\theta}{wd}$$

$$= \frac{4\times0.4\times cos135°}{(9.81\times13600)\times2.5\times10^{-3}} = -3.39 \times 10^{-3}\ m\ or\ -3.39\ mm$$

Negative sign indicates that there is a capillary depression (fall) of 3.39 mm.

Example (2)

Calculate the capillary rise in a glass tube of 2.5 mm diameter when immersed vertically in (a) water and (b) mercury. Take surface tensions σ = 0.0725 N/m for water and σ = 0.52 N/m for mercury in contact with air. The specific gravity for mercury is given as 13.6 and angle of contact 130º.

Solution:

a- Capillary rise of water θ = 0º:

$$h = \frac{2\sigma cos\theta}{\gamma R} = \frac{2\times 0.0725\times 1}{9810\times 1.25\times 10^{-3}} = 0.0118\,m = 1.18\,cm$$

b- Capillary fall of mercury θ = 130o:

$$h = \frac{2\sigma cos\theta}{\gamma R} = \frac{2\times 0.52\times cos130}{13.6\times 1000\times 9.81\times 1.25\times 10^{-3}} = -0.0040\,m = -0.4\,cm$$

The negative sign indicates the capillary depression.

Example 3

Calculate the capillary effect in millimeters in a glass tube of 4 mm diameter, when immersed in (i) water, and (ii) mercury. The temperature of the liquid is 20°C and the value of the surface tension of water and mercury at 20°C in contact with air are 0.073575 N/m and 0.51 N/m respectively. The angle of contact for water is zero that for mercury 130°. Take density of water at 20°C as equal to 998 kg/m³.

Solution:

a- **Capillary rise of water θ = 0°:**

$$h = \frac{2\sigma cos\theta}{\gamma R} = \frac{2\times0.073757\times1}{998\times9.81\times2\times10^{-3}} = 0.00751\, m = 7.51\, mm$$

b- **Capillary fall of mercury θ = 130°**

$$h = \frac{2\sigma cos\theta}{\gamma R} = \frac{2\times0.51\times cos130}{13.6\times1000\times9.81\times2\times10^{-3}} = -0.00245\, m = -2.45\, mm$$

Example (4)

Find out the minimum size of glass tube that can be used to measure water level if the capillary rise in the tube is to be restricted to 2 mm. Consider surface tension of water in contact with air as 0.073575 N/m.

Solution:

$$h = \frac{2\sigma cos\theta}{\gamma R} \rightarrow R = \frac{2\sigma cos\theta}{\gamma h} = \frac{2\times 0.073575\times 1}{9810\times 2\times 10^{-3}} = 0.0075\ m = 0.75\ cm$$

$\therefore$ D=2R=2×0.75=1.5cm

Example (5)

A soup bubble 50 mm in diameter contain a pressure (in excess of atmospheric) of 20 Pa. Calculate the tension in in the soap film.

Solution:

$$P = \frac{4\sigma}{R} \rightarrow \sigma = \frac{20\times 25\times 10^{-3}}{4} = 0.125\ N/m$$

VISCOSITY (μ)

Viscosity may be defined as the property of a fluid which determines its resistance to shearing stresses.

- It is a measure of the internal fluid friction which causes resistance to flow (shearing of fluid)
- Viscosity of fluids is due to cohesion and interaction between particles.

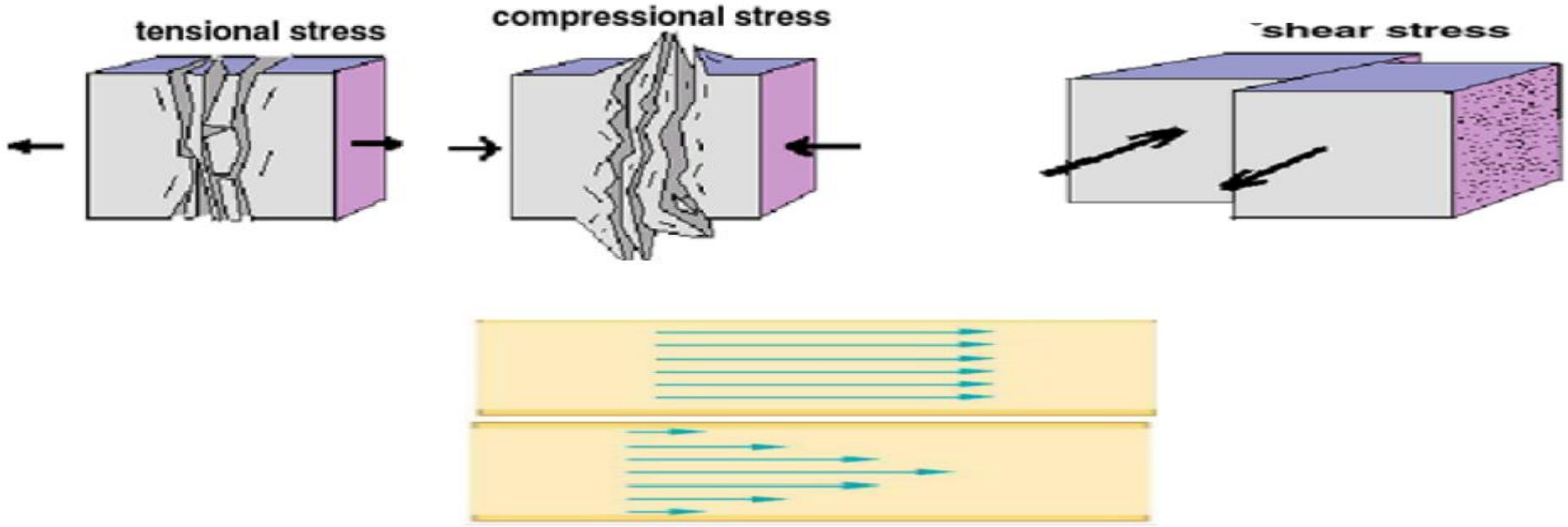

Fig (10)