



HCM UNIVERSITY OF TECHNOLOGY

FLUID MECHANICS

CI2003

Assignment

Submitted To:

Le Van Duc

PhD

Submitted By:

Nguyen Quy Khoi

August 9, 2020

Contents

1	Properties of Fluids
----------	-----------------------------

4

List of Tables

List of Figures

Chapter 1

Properties of Fluids

Q1.1

A steel vessel of 1% increase in volume when the pressure is increased by 70 MPa. At standard condition (pressure $P = 101.3$ KPa), the vessel is filled with $m = 450$ kg of water ($\rho = 1000$ kg/m³). Given bulk modulus of elasticity, $\kappa = 2.06 \times 10^9$ Pa. Compute the mass of water to add into the vessel to increase the pressure to 70 MPa.

Ans:

$$\begin{aligned} V &= \frac{m}{\rho} = \frac{450}{1000} = 0.45 \text{ (m}^3\text{)} \\ \kappa &= -V \frac{dP}{dV} \Rightarrow dm = \rho dV = -\rho V \frac{dP}{\kappa} \\ &= -1000 \times 0.45 \times \frac{101.3 \times 10^3 - 70 \times 10^6}{2.06 \times 10^9} = 15.27 \text{ (kg)} \end{aligned}$$

Q1.2

Determine the change in volume of $V_i = 3$ m³ of air when the pressure increases from $P_i = 100$ kPa to $P_f = 500$ kPa. Air is at $T = 23$ °C (assume ideal gas)

Ans:Assume isothermal condition: $P_i V_i = P_f V_f$

$$\Rightarrow \Delta V = V_f - V_i = \frac{P_i V_i}{P_f} - V_i = \frac{100 \times 3}{500} - 3 = -2.4 \text{ (m}^3\text{)}$$

Q1.3

They compress the air into a vessel having volume, $V_1 = 0.3 \text{ m}^3$ under pressure $P_1 = 100 \text{ at}$. After a period of leakage, the air pressure in the vessel is lowered to $P_2 = 90 \text{ at}$. Regardless of the deformation of the vessel, determine the volume of air that is leaked during that period (corresponding to the atmospheric pressure, 1 atm), if the constant temperature and atmospheric pressure are considered to be at 1 at.

Ans:For ideal gas, $\kappa = P_2 = -V_1 \frac{dP}{dV}$

$$\Rightarrow dV = -\frac{V_1}{P_2} dP = -\frac{0.3}{90} (90 - 100 - 1) = -0.0367 \text{ (m}^3\text{)}$$

Q1.4

A diameter piston $d = 50 \text{ mm}$ moves evenly in a cylinder $D = 50.1 \text{ mm}$. Determine the decrease in force acting on the piston (as a percentage) when the speed decreases by 5%.

Ans:Assume constant speed: $\frac{\Delta V}{V_1} = -5\%$

$$\text{We also have } \tau = \frac{F}{A} = \mu \frac{du}{dy} = \mu \frac{V}{l} \Rightarrow \frac{F_1}{V_1} = \frac{F_2}{V_2} = \mu \frac{A}{l}$$

$$\text{From the relation: } \frac{\Delta F}{F_1} = \frac{\Delta V}{V_1} = -5\%$$

Q1.5

A machine axis having diameter, $D = 75$ mm, with uniform movement with $V = 0.1$ m/s under the force, $F = 100$ N. The lubricating layer thickness, l in the bearing is $l = 0.07$ mm. Length of bearing $L = 200$ mm. Determine oil dynamic viscosity.

Ans:

$$A = (D+2l)\pi \times L = (75+2 \times 0.07)\pi \times 200 = 47211.85 \text{ (mm}^3\text{)} = 4.72 \times 10^{-5} \text{ (m}^3\text{)}$$

$$\tau = \frac{F}{A} = \mu \frac{V}{l} \Rightarrow \mu = \frac{F l}{A V} = \frac{100}{4.72 \times 10^{-5}} \times \frac{0.07 \times 10^{-3}}{0.1} = 1.483 \text{ (kg/m} \cdot \text{s)}$$

Q1.9

Determine the frictional force at the inner wall of a water supply pipe segment at $T = 20^\circ\text{C}$, radius $R = 80$ mm = 0.08 m, $L = 10$ m. The velocity at the points on the pipe cross-section varies according to the following:

$$u(r) = 0.5 \left(1 - \frac{r^2}{R^2} \right)$$

where r is the radius of considered point.

Ans:

From table at $T = 20^\circ\text{C} \Rightarrow \mu = 1.002 \times 10^{-3} \text{ (kg/m} \cdot \text{s)}$

$$A = 2\pi RL = 2\pi \times 0.08 \times 10 = 5.03 \text{ (m}^2\text{)}$$

$$F = \tau A = \mu \frac{du}{dr} A = \mu \frac{(-2)R}{R^2} A$$

$$= 1.002 \times 10^{-3} \times \frac{(-2) \times 0.08}{0.08^2} \times 5.03 = -0.126 \text{ (N)}$$

Q1.10

Determine the gauge pressure inside a water drop of diameter $d = 2$ mm = 0.002 m. The temperature of water is $T = 25^\circ\text{C}$.

Ans:

From table at $T = 25^\circ\text{C} \Rightarrow \sigma_s = 0.072 \text{ (N/m)}$

$$P_g = \Delta P_{\text{droplet}} = \frac{2\sigma_s}{d/2} = \frac{2 \times 0.072}{0.002/2} = 144 \text{ (Pa)}$$

Q1.11

A gas has a molar mass of $R = 32 \text{ kg/mol}$ under a pressure condition of $P = 5 \text{ at} = 490332.5 \text{ Pa}$, a temperature of $T = 30^\circ\text{C}$

1. Determine the gas density.
2. Determine the density of this gas if $P = \text{const}$, while temperature drops to $T_f = 15^\circ\text{C}$.
3. Determine the density of this gas if holding $T = \text{const}$, while the pressure drops to $P_f = 2 \text{ at}$.

Ans:

$$1. P = \rho RT \Rightarrow \rho = \frac{P}{RT} = \frac{32}{490332.5 \times (30 + 273)} = 0.215 \times 10^{-6} \text{ (kg/m}^3\text{)}$$

2. adiabatic condition

$$\rho T = \rho_f T_f \Rightarrow \rho_f = \frac{\rho T}{T_f} = \frac{0.215 \times 10^{-6} \times (30 + 273)}{15 + 273} = 0.226 \times 10^{-6} \text{ (kg/m}^3\text{)}$$

3. isothermal condition

$$\frac{P}{\rho} = \frac{P_f}{\rho_f} \Rightarrow \rho_f = \frac{\rho P_f}{P} = \frac{0.215 \times 10^{-6} \times 2}{5} = 0.086 \times 10^{-6} \text{ (kg/m}^3\text{)}$$

Q1.12

A liquid is compressed in a cylinder, the water initially has a volume of $V_o = 4 \text{ l}$ at normal pressure, $P_o = 1 \text{ at} = 98066.5 \text{ Pa}$. The pressure in the cylinder increases to $p_1 = 6 \text{ at}$, the water volume decreases by 1 cm^3 .

1. Compute the bulk modulus of elasticity of water.

2. If the pressure in the cylinder increases to 20 at, calculate the volume of water V_f in the cylinder.
3. Calculate the pressure in the cylinder, if the volume of the water is reduced by 0.1%.

Ans:

$$1. \kappa = -V_o \frac{dP}{dV} = -4 \times 10^{-3} \times \frac{6 \times 98066.5}{(-1) \times 10^{-6}} = 2.36 \times 10^9 \text{ (Pa)}$$

2. Cylinder increase pressure to 20 at

$$\Rightarrow dV = V_f - 4 \times 10^{-3} = \frac{-20}{6} = -3.33 \text{ (cm}^3\text{)} = -3.33 \times 10^{-3} \text{ (l)}$$

$$\Rightarrow V_f = 3.997 \text{ (l)}$$

$$3. dP = P_f - P_o = -\kappa \times \frac{dV}{V_o} = -2.36 \times 10^9 \times \frac{(-0.1)}{100} = 2.36 \times 10^6 \text{ (Pa)}$$

$$\Rightarrow P_f = 2.458 \text{ (MPa)}$$

Q1.13

The air moving through a narrow tube into a water tank forms a stream of bubbles $d = 3 \text{ mm}$ in diameter. Calculate the difference between air pressure in the narrowed section and surrounding water pressure. Give the surface tension of water $\sigma_s = 0.0728 \text{ N/m}$.

Ans: