2021

HI – 17 – 4i, HI – 17 – 5i.

Calculation task № _17__

Homogeneous liquid moves in a complex oil flow line. Determine the pressure at points **C** and **B**, if the flow line inner diameter is equal to 0.1 m (where $d_1 = d_2 = d_3$), the coefficient of dynamic viscosity of oil is 8.5 mPa·s, oil density is 865 kg /m^3, the pressure at point **A** is 4.6 MPa, flow rate of the fluid in the first section is 750 m^3/d, flow rate of the fluid in the second section is 345 m^3/d, lengths of sections are 1950, 2760 and 4230 m.

$d_1 = 0.1$ m

$d_2 = 0.1$ m $\qquad d_3 = 0.1$ m

$d = 0.1$ m

$P_A = 4.6 \times 10^6$ MPa

$L_1 = 1950$ m

$L_2 = 2760$ m

$L_3 = 4230$ m

$\rho_o := 865$ kg/m3

$\mu_o := 8.5 \cdot 10^{-3}$ Pa·s

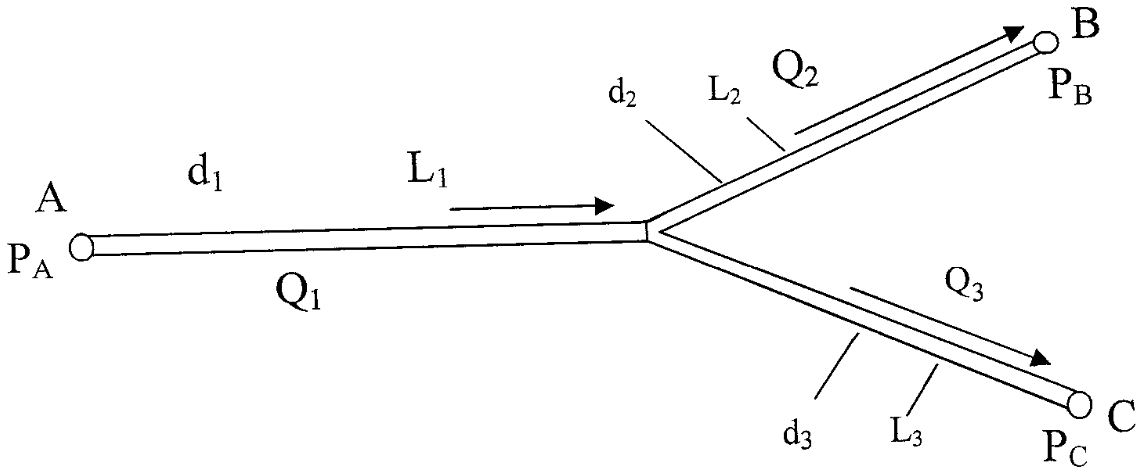
$Q_1 = 750$ m3/day

$Q_2 = 345$ m3/day

Determine : P_B – ? $\quad P_C$ – ?

Solution

Figure



Pressure at the point B :

$$P_B = P_A - \Delta P_{fr1} - \Delta P_{fr2}$$

Pressure at the point C :

$$P_C = P_A - \Delta P_{fr1} - \Delta P_{fr3}$$

Flow rate of the fluid in the third section :

$$Q_1 = Q_2 + Q_3$$

$Q_3 := Q_1 - Q_2$ $\qquad$ $Q_3 := 750 - 345$ $\quad = \quad 405 \quad m^3/day$

1. Velocity of oil in the sections of complex oil flow line :

$$V_1 := \frac{4 \cdot Q_1}{\pi \cdot d^2 \cdot 86400} \qquad V_1 := \frac{4 \cdot 750}{\pi \cdot 0.1^2 \cdot 86400} \qquad V_1 = 1.105 \ \frac{m}{s}$$

$$V_2 := \frac{4 \cdot Q_2}{\pi \cdot d^2 \cdot 86400} \qquad V_2 := \frac{4 \cdot 345}{\pi \cdot 0.1^2 \cdot 86400} \qquad V_2 = 0.508 \ \frac{m}{s}$$

$$V_3 := \frac{4 \cdot Q_3}{\pi \cdot d^2 \cdot 86400} \qquad V_3 := \frac{4 \cdot 405}{\pi \cdot 0.1^2 \cdot 86400} \qquad V_3 = 0.597 \ \frac{m}{s}$$

2. Reynolds number for sections of complex oil flow line :

$$Re_1 := \frac{V_1 \cdot d \cdot \rho_o}{\mu_o} \qquad Re_1 := \frac{1.105 \cdot 0.1 \cdot 865}{8.5 \times 10^{-3}} \qquad Re_1 = 11245$$

$$Re_2 := \frac{V_2 \cdot d \cdot \rho_o}{\mu_o} \qquad Re_2 := \frac{0.508 \cdot 0.1 \cdot 865}{8.5 \times 10^{-3}} \qquad Re_2 = 5169.6$$

$$Re_3 := \frac{V_3 \cdot d \cdot \rho_o}{\mu_o} \qquad Re_3 := \frac{0.597 \cdot 0.1 \cdot 865}{8.5 \times 10^{-3}} \qquad Re_3 = 6075.4$$

$Re_{cr} = 2320$

$Re_1 > Re_{cr}$ $\qquad$ $Re_2 > Re_{cr}$ $\qquad$ $Re_3 > Re_{cr}$

3. Coefficients of hydraulic resistance for sections of complex oil flow line :

$$\lambda_1 := \frac{0.3164}{Re_1^{0.25}} \qquad \lambda_1 := \frac{0.3164}{11245^{0.25}} \qquad \lambda_1 = 0.031$$

$$\lambda_2 := \frac{0.3164}{Re_2^{0.25}} \qquad \lambda_2 := \frac{0.3164}{5169.6^{0.25}} \qquad \lambda_2 = 0.0373$$

$$\lambda_3 := \frac{0.3164}{Re_3^{0.25}} \qquad \lambda_3 := \frac{0.3164}{6075.4^{0.25}} \qquad \lambda_3 = 0.036$$

4. Determine pressure losses in sections of complex oil flow line :

$$\Delta P_{fr1} := \lambda_1 \cdot \frac{L_1}{d} \cdot \frac{V_1^2}{2} \cdot \rho_o = 0.031 \cdot \frac{1950}{0.1} \cdot \frac{1.105^2}{2} \cdot 865 = 3.19 \times 10^5 \ \text{Pa}$$

$$\Delta P_{fr2} := \lambda_2 \cdot \frac{L_2}{d} \cdot \frac{V_2^2}{2} \cdot \rho_o \quad = \quad 0.0373 \cdot \frac{2760}{0.1} \cdot \frac{0.508^2}{2} \cdot 865 = 1.149 \times 10^5 \quad \text{Pa}$$

$$\Delta P_{fr3} := \lambda_3 \cdot \frac{L_3}{d} \cdot \frac{V_3^2}{2} \cdot \rho_o \quad = \quad 0.036 \cdot \frac{4230}{0.1} \cdot \frac{0.597^2}{2} \cdot 865 = 2.3 \times 10^5 \quad \text{Pa}$$

5. Determine the pressure at the point B :

$$P_B := P_A - \Delta P_{fr1} - \Delta P_{fr2} \quad = \quad 4.6 \times 10^6 - 3.19 \times 10^5 - 1.149 \times 10^5 = 4.17 \times 10^6 \quad \text{Pa}$$

6. Determine the pressure at the point C :

$$P_C := P_A - \Delta P_{fr1} - \Delta P_{fr3} \quad = \quad 4.6 \times 10^6 - 3.19 \times 10^5 - 2.3 \times 10^5 = 4.05 \times 10^6 \quad \text{Pa}$$

Answer : $P_B = 4.17 \times 10^6$ Pa ; $P_C = 4.05 \times 10^6$ Pa