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15ENG01/009
Petroleum Engineering
ENG 314 Assignment

i) $d_2 = 0.076m$

$d_1 = 0.152m$

$r_d = 0.8$

$Z_2 = 0.914m$

$C_d = 0.97$

Find Q:

$\therefore Q = AV$

$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2$

$\frac{P_1}{w} + \frac{P_2}{w} = 0$

$\frac{V_1^2}{2g} + Z_1 = \frac{V_2^2}{2g} + Z_2$

$\frac{V_1^2}{2g} - \frac{V_2^2}{2g} + (Z_1 - Z_2) = 0$

From Continuity equation, $A_1 V_1 = A_2 V_2$

$V_1 = \frac{A_2 V_2}{A_1} = \frac{\frac{\pi}{4} \times 0.076^2 \times V_2}{\frac{\pi}{4} \times 0.152^2}$

$= \frac{1}{4} \times V_2 = \frac{V_2}{4}$

$\frac{(\frac{V_2}{4})^2}{2g} - \frac{V_2^2}{2g} + (-0.914) = 0$

$\frac{V_2^2}{2g \times 16} - \frac{V_2^2}{2g} - 0.914 = 0$

$\frac{V_2^2}{2g}(1 - \frac{1}{16}) = 0.914$

$\frac{V_2^2}{2g}(\frac{15}{16}) = 0.914$

$V_2^2 = \frac{0.914 \times 16 \times 2 \times 9.81}{15}$

$V_2^2 = 19.13$

$V_2 = \sqrt{19.13} = 4.374 m/s$

$\therefore Q = A_2 V_2 = \frac{\pi}{4} \times (0.076)^2 \times 4.374$

$Q = 0.0198 m^3/s$

ii) at $P_1 = 15170 N/m^2$

$\frac{P_2}{w} = 0$

$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2$

$(\frac{P_1}{w} - \frac{P_2}{w}) + (\frac{V_1^2}{2g} - \frac{V_2^2}{2g}) + Z_1 - Z_2 = 0$

$(\frac{15170}{1000 \times 9.81} - 0) + (\frac{V_1^2}{2g} - \frac{V_2^2}{2g}) + (-0.914) = 0$

$1.546 + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} - 0.914 = 0$

$1.546 + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} = 0.914$

From Continuity equation, $V_1 = \frac{V_2}{4}$

$1.546 + \frac{(\frac{V_2}{4})^2}{2g} - \frac{V_2^2}{2g} = 0.914$

$\frac{V_2^2}{16 \times 2g} - \frac{V_2^2}{2g} = 0.914$

$1.546 + \frac{V_2^2}{2g}(1 - \frac{1}{16}) = 0.914$

$1.546 + \frac{V_2^2}{2g}(\frac{15}{16}) = 0.914$

$V_2^2 = \frac{0.914 \times 16 \times 2g}{15} - 1.546$

$V_2^2 = 19.128 - 1.546$

$V_2^2 = 17.582$

$V_2 = \sqrt{17.582} = 4.193 m/s$

$Q = A_2 V_2 = \frac{\pi}{4} \times (0.076)^2 \times 4.193$

$\therefore Q = 0.019\ m^3/s$

9) $d_1 = 300mm = 0.3m$, $A_1 = \pi \times (0.3)^2/4 = 0.0706m^2$

$d_2 = 150mm = 0.15m$, $A_2 = \pi \times (0.15)^2/4 = 0.01767m^2$

$Q = 40\ l/s = 40/1000 = 0.04 m^3/s$

$PE_1 = 10m$

$PE_2 = 6m$

$P_2 = ?$

$P_1 = 400\ kN/m^2$

$\therefore \frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + z_2$

$Q = A_1 V_1 \therefore V_1 = Q/A_1 = 0.04 / \frac{\pi}{4} \times (0.3)^2 = \frac{0.04}{0.0706} = 0.567 m/s$

$V_2 = Q/A_2 = 0.04/0.1767 = 2.264 m/s$

$\frac{P_2}{w} = \left(\frac{P_1}{w}\right) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) + (z_1 - z_2)$

$\frac{P_2}{w} = \frac{400}{9.81} + \left(\frac{(0.567)^2}{2 \times 9.81} - \frac{(2.264)^2}{2 \times 9.81}\right) + (10 - 6)$

$\frac{P_2}{w} = 40.77 - 0.245 + 4$

$\frac{P_2}{w} = 44.525$

$\therefore P_2 = w \times 44.525 = 44.8 \times 9.81\ kN/m^2$

$P_2 = 436.8\ kN/m^2$

14) Reading of the manometer = 170mm = 0.17m of mercury

$S_{Hg} = 13.6$

$S_p = 1.026$

to find the head, $h = y\left(\frac{S_{Hg}}{S_p} - 1\right)$

$h = 0.17\left(\frac{13.6}{1.026} - 1\right)$

$h = 2.083$

$\therefore$ Velocity of the submarine $V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.083} = 6.393 m/s$

$z_1 - z_2 = 2.0m$

$V_1 = 5 m/s$

$V_2 = 2 m/s$

$z_2 = 2.5m$

$h_f = \frac{0.35 (V_1 - V_2)^2}{2g}$

$\frac{P_2}{w} = ?$

$$\frac{P_1}{w} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{v_2^2}{2g} + z_2 + h_f$$

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} + z_1 - z_2 - h_f$$

$$\frac{P_2}{w} = 2.5 + \left(\frac{5^2}{2 \times 9.81} - \frac{2^2}{2 \times 9.81}\right) + (2.0) - \frac{0.35(5-2)^2}{2 \times 9.81}$$

$\frac{P_2}{w} = 5.411m$ of liquid

2) $d_1 = 20cm = 0.2m$ $\quad Q = ?$

$d_2 = 10cm = 0.1m$

$P_1 = 17.658 N/cm^2$ $\quad \therefore 17.658/100 = 0.176 N/m^2$

$P_2 = -30cm$ of mercury $\quad \therefore -30/100 \times 13.6 = -4.08m$ of water

$Cd = 0.98$

$Q = AV$

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + z_2$$

$$\frac{P_1}{w} + \frac{V_1^2}{2g} = \frac{P_2}{w} + \frac{V_2^2}{2g} \quad / \quad \frac{P_1}{w} - \frac{P_2}{w} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} = 0$$

$$[0.176 - (-4.08)] + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} = 0, \quad 4.26 + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} = 0$$

From Continuity Equation; $A_1 V_1 = A_2 V_2 \quad \therefore V_1 = \frac{A_2 V_2}{A_1}$

$$V_1 = \frac{\frac{\pi}{4} \times d_2^2 \times V_2}{\frac{\pi}{4} \times d_1^2} = \frac{d_2^2 \times V_2}{d_1^2} = \frac{0.1^2}{0.2^2} \times V_2 = \frac{1}{4} \times V_2 = \frac{V_2}{4}$$

$4.26 + \frac{\left(\frac{V_2}{4}\right)^2}{2g} - \frac{V_2^2}{2g} = 0$, $4.26 + \frac{V_2^2}{16 \times 2g} - \frac{V_2^2}{2g} = 0$

$4.26 + \frac{V_2^2}{2g}\left(1 - \frac{1}{16}\right) = 0$, $\frac{V_2^2}{2g}\left(1 - \frac{1}{16}\right) = -4.26$,

$\frac{V_2^2}{2g}\left(\frac{15}{16}\right) = -4.26$, $V_2^2 = \frac{-4.26 \times 16 \times 2g}{15}$, $\frac{-4.26 \times 16 \times 2 \times 9.81}{15}$

$V_2^2 = -89.15$, $V_2 = \sqrt{89.15}$, $V_2 = -9.44 m/s$

$Q = A_2 V_2 = \frac{\pi}{4} \times (0.1)^2 \times -9.44$

$= -0.074 m^3/s$

3) $d_1 = 15cm = 0.15m$, $A_1 = \frac{\pi}{4}(0.15)^2 = 0.01767 m^2$

$d_2 = 30cm = 0.3m$, $A_2 = \pi/4 \times (0.3)^2 = 0.0707 m^2$

$y = 50cm$ of mercury $= 0.5m$

$S_p = 0.9$ S_{Hg} = mercury = 16

$Cd = 0.64$

$Q = ?$

$Q = Cd \times \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$h = y\left(\frac{S_{Hg}}{S_p} - 1\right) = 0.5\left(\frac{13.6}{0.9} - 1\right) = 7.05$

$\therefore Q = \frac{0.64 \times 0.01767 \times 0.0707\sqrt{2 \times 9.81 \times 7.05}}{\sqrt{0.01767^2 - 0.0707^2}}$

$Q = 0.137 m^3/s$