Kerry fM 4.2

problem 6.17 oil with a specific gravity of 0.90 is flowing downward through the venturimeter shown in fig. If the manometer deflection H is 28 in, calculate the volume flow rate of oil

Given $SG_{oil} = 0.90$, $h = 28$ in, $D_A = 4$ in, $D_B = 2$ in, $SG_{Hg} = 13.54$

Solution $h = 28 \times 0.0254 = 0.7112$ meters

$\rho_{water} = 1000\ kg/m^3$, $\rho_{oil} \times \rho_{water} = 0.90 \times 1000 = 900\ kg/m^3$

$\rho_{Hg} = SG_{Hg} \times \rho_{water} = 13.54 \times 1000 = 13540\ kg/m^3$

$\Delta p = (\rho_{Hg} - \rho_{oil}) g h \Rightarrow (13540 - 900) \times 9.81 \times 0.7112 = 88187.66\ pa$

Flow rate

$A_A \times V_A = A_B \times V_B$

Area at A: $A_A = \pi \frac{D_A}{2}^2 = \pi \left(\frac{4 \times 0.0254}{2}\right)^2 = 0.008107319\ m^2$

area at B: $A_B = \pi \left(\frac{D_B}{2}\right)^2 = \pi \left(\frac{2 \times 0.0254}{2}\right)^2 = 0.002027\ m^2$

$V_A^2 = V_B^2 \times \left(\frac{1}{4}\right)^2$

$P_A + \frac{1}{2} \rho_{oil} V_A^2 = P_B + \frac{1}{2} \rho_{oil} V_B^2 \Rightarrow 88246.85 = \frac{1}{2} \times 900 \left(V_B^2 - \frac{V_B^2}{16}\right)$

$\Leftrightarrow 88246.85 = 421.875 V_B^2 \Rightarrow \frac{88246.85}{421.875} = 209.17$

$V_B = \sqrt{209.17} = 14.46\ m/s$

$Q = A_B \times V_B = 0.002027 \times 14.46 = 0.0293\ m^3/s \Rightarrow \boxed{29.3\ L/s}$

problem: 6.91 To what height will the jet of fluid rise for the conditions shown in fig

Given: $H_f = 2.60m$, $H_{js} = 0.85m$, $H_{je} = 75 = 0.07m$

solution: Bernoulli's between two points

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

$\rho g h_1 = \frac{1}{2}\rho v_2^2 + \rho g h_2 \Rightarrow g(h_1 - h_2) = \frac{1}{2}v_2^2 \Rightarrow v_2^2 = 2g(h_1 - h_2) \Rightarrow v_2 = \sqrt{2g(h_1 - h_2)}$

Velocity at jet exit

$v_2 = \sqrt{2 \times 9.81 \times (2.60 - 0.925)} = 5.73 \, m/s$

Kinetic equation for projectile motion

$v^2 = v_2^2 - 2gh_{jet} \Rightarrow 0 = (5.73)^2 - 2 \times 9.81 \times h_{jet}$

$h_{jet} = \frac{(5.73)^2}{2 \times 9.81} = \boxed{1.673 m}$

problem 7.30 water at 60°F flows from large reservoir through a fluid motor at the rate of 1000 gal/min in the system shown in fig. If the motor removes 37 hp from the fluid calculate losses in the system

given: $Q = 1000\ gal/min$, $h = 165\ ft$, $P = 37\ hp$, 8 inches, $\rho = 62.4\ lb/ft^3$

Solution: $Q = 1000\ gal/min \times 0.13368\ ft^3/gal \times \frac{1}{60}\ min/s = 2.228\ ft^3/s$

velocity in pipe

$D = 8\ in \times 0.0833 = 0.6666\ ft$

$A = \pi \left(\frac{D}{2}\right)^2 = \pi \left(\frac{0.6666}{2}\right)^2 = 0.349\ ft^2$

$V = \frac{Q}{A} = \frac{2.228}{0.349} = 6.38\ ft/s$

$P = 37\ hp \times 550 = 20350\ ft\ lb/s$

$h_{motor} = \frac{P}{\rho g Q} = \frac{20350}{62.4 \times 32.2 \times 2.228} = 4.56$

Bernoulli equation at surface of reservoir

$\frac{P_1}{\rho g} + h_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + h_2 + \frac{V_2^2}{2g} + h_{motor} + h_{loss}$

$h_1 = h_2 + \frac{V_2^2}{2g} + h_{motor} + h_{loss}$

$h_{loss} = h_1 - h_2 - \frac{V_2^2}{2g} - h_{motor}$

$\frac{V_2^2}{2g} = \frac{(6.38)^2}{2 \times 32.2} = 0.63\ ft$

$h_{loss} = 165 - 0 - 0.63 - 4.56 = \boxed{159.81\ ft}$

problem 7.42 professor Crocker is building a cabin on a hillside has proposed the water system in fig. The distribution tank in the cabin maintains a pressure of 30.0 psig above the water. There is an energy loss of 15.5 lb-ft/lb in the piping. When the pump is delivering 40 gal/min of water, compute the horsepower delivered by the pump to water

Given: $P_t = 30$ psig, Energy loss $= 15.5$ lb-ft/lb, flow rate $= 40$ gal/min, Elevation change $= 209$ ft

covert flow rate

$Q = 40\,gal/min \times 0.1336\,ft^3/gal \times \frac{1}{60}\,min/s = 0.089\,ft^3/s$

total dynamic head

$h_p = 30\,psig \times 2.31\,ft/psig = 69.3\,ft$

$h_z = 209\,ft$

$h_L = 15.5\,lb\text{-}ft/lb$

total head: $H = h_p + h_z + h_L = 69.3 + 209 + 15.5 = 293.8\,ft$

Power pores pump

$power = \rho \times g \times Q \times H \Rightarrow 62.4 \times 32.2 \times 0.089 \times 293.8 = 52539.05\,ft\,lb/s$

$power(hp) = \frac{Power(ft\,lb/s)}{550} \Rightarrow \frac{52357.89}{550} = \boxed{95.5\,hp}$