

12.30 Water at 40 °C is pumped from an open tank through 200 m of 50-mm-diameter smooth horizontal pipe as shown in Fig. P12.30 and discharges into the atmosphere with a velocity of 3 m/s. Minor losses are negligible. (a) If the efficiency of the pump is 70%, how much power is being supplied to the pump? (b) What is the NPSH_a at the pump inlet? Neglect losses in the short section of pipe connecting the pump to the tank. Assume standard atmospheric pressure.



$$(a) \quad \frac{p_1}{\rho} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{p_2}{\rho} + z_2 + \frac{V_2^2}{2g} + f \frac{L}{D} \frac{V_2^2}{2g} \quad (1)$$

Where $p_1 = p_2 = 0$, $V_1 = 0$, $V_2 = 3 \text{ m/s}$, $z_1 = 3 \text{ m}$, and $z_2 = 0$. Thus, Eq. (1) becomes

$$z_1 + h_p = \frac{V_2^2}{2g} \left(1 + f \frac{L}{D} \right) \quad (2)$$

Also,

$$Re = \frac{VD}{\nu} = \frac{(3 \frac{\text{m}}{\text{s}})(0.05 \text{ m})}{(6.580 \times 10^{-7} \frac{\text{m}^2}{\text{s}})} = 2.28 \times 10^5$$

and from Fig. 8.23 for smooth pipe $f = 0.0152$. Thus, from Eq. (2)

$$h_p = \frac{(3 \frac{\text{m}}{\text{s}})^2}{2(9.81 \frac{\text{m}}{\text{s}^2})} \left[1 + 0.0152 \left(\frac{200 \text{ m}}{0.05 \text{ m}} \right) \right] - 3 \text{ m} = 25.3 \text{ m}$$

Hence,

$$\begin{aligned} \text{Power gained by fluid} &= \dot{Q} \rho h_p \\ &= (9.731 \times 10^3 \frac{\text{N}}{\text{m}^2}) \left(\frac{\pi}{4} \right) (0.05 \text{ m})^2 (3 \frac{\text{m}}{\text{s}}) (25.3 \text{ m}) \\ &= 1.45 \times 10^3 \frac{\text{N} \cdot \text{m}}{\text{s}} = 1.45 \text{ kW} \end{aligned}$$

and

$$\begin{aligned} \text{Power supplied to pump} &= \frac{\text{Power gained by fluid}}{\text{Efficiency}} \\ &= \frac{1.45 \text{ kW}}{0.7} = \underline{2.07 \text{ kW}} \end{aligned}$$

(b) From Eq. 12.24

$$\text{NPSH} = \frac{p_s}{\rho} + \frac{V_s^2}{2g} - \frac{p_v}{\rho} \quad (3)$$

where p_s and V_s refer to the pressure and velocity at the pump inlet, respectively. Also,

$$\frac{p_1}{\rho} + \frac{V_1^2}{2g} + z_1 = \frac{p_s}{\rho} + \frac{V_s^2}{2g} + z_s + h_L$$

so that with $p_1 = p_{\text{atm}}$, $V_1 = 0$, $z_s = 0$, and $h_L = 0$ (cont.)

Fluid Mechanics Munson 6th Solutions Manual

**Bruce R. Munson, Donald F.
Young, Theodore H. Okiishi**



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