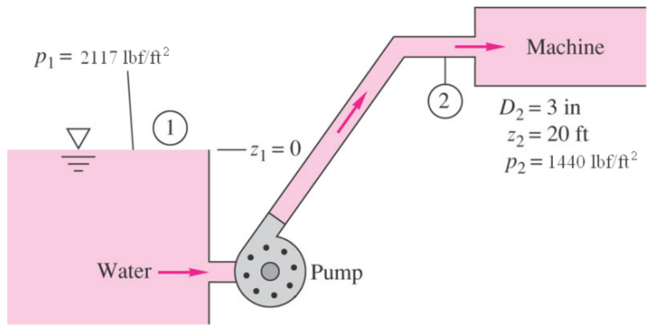
October 30, 2009

NAME

Fluids-ID

Quiz 7.

The pump in the figure delivers water at Q = 1.5 ft^3/s to a machine at section 2, which is 20 ft higher than the reservoir surface. The losses between 1 and 2 are given by $h_f = KV_2^2/(2g)$, where K = 7.5 is a dimensionless los coefficient. Take α = 1.07. Find the pump power $P = \gamma Q h_p$. (γ= 62.4 lbf/ft^3; g = 32.2 ft/s^2; 1 hp = 550 ft·lbf/s)



$$\frac{p_1}{\gamma} + \alpha_1 \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \alpha_2 \frac{V_2^2}{2g} + z_2 - h_p + h_f$$

<u>Solution:</u>

Find V_2 from the known flow rate and the pipe diameter:

$$V_2 = \frac{Q}{A_2} = \frac{1.5\ \text{ft}^3/\text{s}}{(\pi/4)(3/12\ \text{ft})^2} = 30.6\ \text{ft/s}$$ (+2 points)

The energy equation with $z_1 = 0$ and $V_1 = 0$ becomes

$$\frac{p_1}{\gamma} + \alpha_1 \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \alpha_2 \frac{V_2^2}{2g} + z_2 - h_p + h_f, \qquad h_f = K\frac{V_2^2}{2g}$$

or

$$h_p = \frac{p_2 - p_1}{\gamma} + z_2 + (\alpha_2 + K)\frac{V_2^2}{2g}$$ (+5 points)

From the given data, pump head is

$$h_p = \frac{(1440 - 2117)\,\text{lbf/ft}^2}{62.4\,\text{lbf/ft}^3} + 20\ \text{ft} + (1.07 + 7.5)\frac{(30.6\,\text{ft/s})^2}{2(32.2\,\text{ft/s}^2)} = 133\ \text{ft}$$ (+2 points)

Thus the pump power is

$$P = \gamma Q h_p = \left(62.4\frac{\text{lbf}}{\text{ft}^3}\right)\left(1.5\frac{\text{ft}^3}{\text{s}}\right)(133\ \text{ft}) = 12450\ \frac{\text{ft}\cdot\text{lbf}}{\text{s}}/550 = 22.6\ \text{hp}$$ (+1 points)