Colby C. Burnam
MET 330
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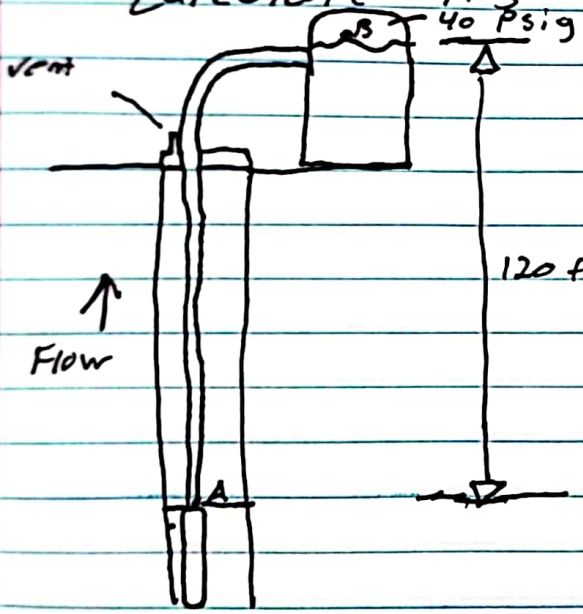
Ch. 7

11) A submersible deep-well pump delivers 745 gal/h of water through a 1-in Schedule 40 pipe when operating in the system sketched in Fig. 7.18. An energy loss of 10.5 lb-ft/lb occurs in the piping system.

(A) Calculate the Power (hp) delivered by the pump to the water.

(B) If the pump draws 1 hp, Calculate it's efficiency.



$$HP = 550 \frac{ft \cdot lbf}{s}$$

$$Q = 745 \frac{gal}{hr} \rightarrow 0.028 \frac{ft^3}{s}$$

$$V = Q/A$$

$$h_A = \frac{P_B - P_A}{\gamma} + (Z_B - Z_A) + \frac{V_B^2 - V_A^2}{2g} + h_L$$

A = 1 in Schedule 40
Appendix F → $A = 0.00600 ft^2$

$\gamma = 62.43 \frac{lbf}{ft^3}$

$V = Q/A$

$= 0.028 \frac{ft^3}{s} / 0.00600\ ft^2$

$V = 4.67 \frac{ft}{s}$

$P_A = \gamma h$

$= 62.43 \frac{lbf}{ft^3} \cdot 120\ ft$

$P_A = 7,491.6 \frac{lbf}{ft^2}$

$P_B = 40\ psig \times 12 = 480\ psfg$

General Energy Eq.:

$$h_A = \underbrace{\frac{P_B - P_A}{\gamma}}_{\text{pressure head}} + \underbrace{(Z_B - Z_A)}_{\text{Elevation head}} + \underbrace{\frac{V_B^2 - V_A^2}{2g}}_{\text{velocity head}} + h_L$$

$$h_A = \frac{480\ psfg - 7,491.6 \frac{lbf}{ft^2}}{\gamma}$$

$$h_A = \underbrace{\frac{-7,011.6\ lbf/ft^2}{62.43\ lbf/ft^3}}_{\text{pressure head}}$$

Pressure head $= -112.\ lbf/ft^2$

$$h_A = \frac{P_B - P_A}{\gamma} + (Z_B - Z_A) + \frac{V_B^2 - V_A^2}{2g} + h_L$$

Elevation head

$$h_A = +112 \frac{lbf}{ft^3} + (120_{ft} - 0_{ft})$$

Elevation head
120 ft

$$h_A = +112 \frac{lbf}{ft^2} + 120_{ft} + \frac{0^2 - 4.67^2 \frac{ft}{s}}{2g}$$

(velocity head)

$g = 32.17 \frac{ft}{s^2}$

$2g = 64.34$

Velocity head
$0.34 \frac{ft}{s}$

$= \frac{21.81 \frac{ft^2}{s}}{64.34 \frac{ft}{s^2}}$

$$h_A = +112 \frac{lbf}{ft^2} + 120_{ft} + 0.34 \frac{ft}{s} + h_L$$

$$h_L = 10.5 \frac{lb\text{-}ft}{lb}$$

$$h_A = 112 \frac{lbf}{ft^2} + 120_{ft} + 0.34 \frac{ft}{s} + 10.5 \frac{lb\text{-}ft}{lb}$$

$$h_A = 242.94 \frac{ft \cdot lbf}{s}$$

$$h_A = \frac{242.84 \text{ ft} \cdot \text{lbf/s}}{550 \text{ ft} \cdot \text{lbf/s}}$$

$$\boxed{h_A = 0.44 \text{ HP}}$$