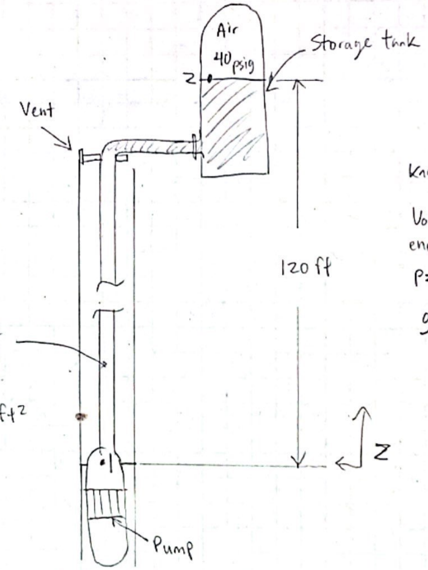
Chapter 7

(11)



A. = 0.00600 ft²

Known :

Volum flow rate : 745 gal/h = Q
energy loss = 10.5 lb·ft/lb = h_L
p_2 = 40 psig = 40 lb/in²

$g = 32.2\ ft^2$

a). Calculate Power delivered by the pump to the water. = h_A

$$h_A + \cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + \underbrace{\cancel{z_1}}_{=0} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L + \cancel{h_R} \qquad V_2 = \frac{Q}{A}$$

$$V = \left(\frac{Q}{A}\right) = \left(\frac{745\ gal/hr \left(\frac{1\ hr}{3600\ sec}\right)\left(\frac{0.1336\ ft^3}{1\ gal}\right)}{0.006\ ft^2}\right)$$

$V = 4.61$ ft/s

rewrite equation

$$h_a = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$h_a = \left(\frac{40\ lb/in^2}{62.4\ lb/ft^3}\right)\left(\frac{144\ in^2}{1\ ft^2}\right) + \frac{(4.61\ ft/s)^2}{2(32.2\ ft/s^2)} + 120\ ft + 10.5\ lb\text{-}ft/lb$$

$$h_a = (92.31\ ft) + (0.33\ ft) + 120\ ft + 10.5\ ft$$

$$h_a = 223.14\ ft$$

→ Con't

use h_A to find Power. P_A

$$P_A = \gamma Q h_A = (62.4\ lb/ft^3)(745\ gal/hr)\left(\frac{1\ hr}{3600\ sec}\right)\left(\frac{0.1336\ ft^3}{1\ gal}\right)(223.14\ ft)$$

$$P_a = 384.96\ lb\text{-}ft/s$$

Convert to horse power, hp

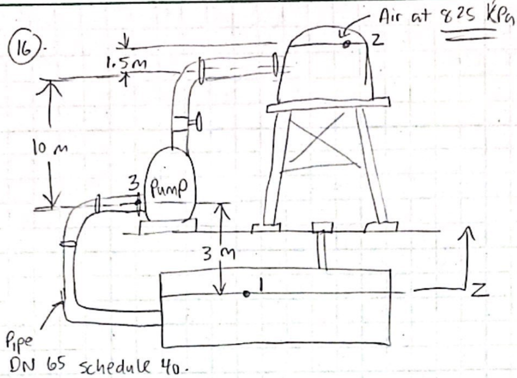
$$P_a = (384.96\ lb\text{-}ft/s)\left(\frac{1\ hp}{550\ lb\text{-}ft/s}\right)$$

$$\therefore P_a = 0.699\ hp \text{ or } \boxed{0.70\ hp}$$

b). if pump draws 1 hp, caculate its efficiency.

$$eff = \frac{P_a}{P_I} = \frac{0.70\ hp}{1\ hp} = 0.70 = \boxed{70\%}$$

(16).



$Q = 840\ L/min$

$\left(840\ \cancel{L}/\cancel{min}\right)\left(\frac{1\ \cancel{min}}{60\ sec}\right)\left(\frac{0.001\ m^3}{1\ \cancel{L}}\right) = 0.014\ m^3/s$

$Sg_{oil} = 0.85$

$h_{L_{system}} = 4.2\ N\cdot m/N$

$h_{L_{suction}} = 1.4\ N\cdot m/N$

$$h_A + \cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + \cancel{z_1} = \frac{P_2}{\gamma} + \cancel{\frac{V_2^2}{2g}} + z_2 + h_{L_{system}}$$

$$h_A = \frac{P_2}{\gamma} + z_2 + h_{L_{system}}$$

$$h_A = \frac{825\ KPa}{0.85(9810\ N/m^3)} + 14.5m + 4.2\ m = 117.64m$$

$$P = \gamma Q h_A = (0.85)(9810\ N/m^3)(0.014\ m^3/s)(117.64\ m)$$
$$= \boxed{13.73\ KW}$$

Cont →

B) energy loss at suction pipe

Point 1 to Point 3

$$V = \frac{Q}{A} = \frac{(0.014\ m^3/s)}{3.09 \times 10^{-3}\ m^2} = 4.53\ m/s$$

$$g = 9.81\ m/s^2$$

$$\cancel{h_A} + \cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + \cancel{z_1} = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_3 + h_{L\ suction}$$

$$\frac{P_3}{\gamma} = -\frac{V_3^2}{2g} - z_3 - h_L$$

$$P_3 = -\frac{V_3^2}{2g} - z_3 - h_L \times \gamma$$

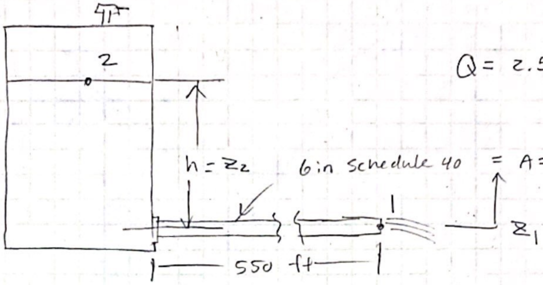
$$P_3 = \left(-\frac{(4.53\ m/s)^2}{2(9.81\ m/s^2)} - 3m - 1.4m\right)(0.85)(9810\ N/m^3)$$

$$P_3 = (-1.046\ m - 3m - 1.4m)(8338.5\ N/m^3)$$

$$P_3 = -45411.5\ N/m^2$$

$$\boxed{P_3 = -45.4\ kPa}$$

(33)



$Q = 2.50\ ft^3/s$

$h_L = f\frac{L}{D}\frac{V^2}{2g}$

$= A = 0.2006\ ft^2$

$D = 0.5054\ ft$

$$\cancel{h_A} + \cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + \cancel{z_1} = \cancel{\frac{P_2}{\gamma}} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$h = z_2 = \frac{V_2^2}{2g} + h_L$$

$$h = z_2 = \frac{V_2^2}{2g} + f\frac{L}{D}\frac{V_2^2}{2g}$$

$$h = \frac{V_2^2}{2g} \times \left(1 + f\frac{L}{D}\right)$$

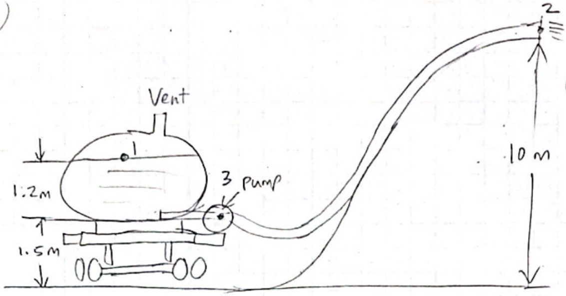
$$h = \frac{\left(\frac{Q}{A}\right)^2}{2g} \times \left(1 + f\frac{L}{D}\right)$$

$$h = \left(\frac{\left(\frac{2.50\ ft^3/s}{0.2006\ ft^2}\right)^2}{2(32.2\ ft/s^2)}\right)\left(1 + 0.016\left(\frac{550\ ft}{0.5054\ ft}\right)\right)$$

$$h = 2.41\ ft \times 18.41\ ft$$

$$\boxed{h = 44.4\ ft}$$

(38)



$V = Q/A$

$Q = 95 L/min$

$\left(95\ L/min\right)\left(\frac{1\ min}{60\ sec}\right)\left(\frac{0.001 m^3}{1 L}\right)$
$= 1.58 \times 10^{-3}\ m^3/s$

$A = \frac{\pi (0.025m)^2}{4}$

$A = 4.91 \times 10^{-4}\ m^2$

$V = \frac{Q}{A} = \frac{1.58 \times 10^{-3}\ m^3/s}{4.91 \times 10^{-4}\ m^2}$
$= 3.22\ m/s$

$\eta = 2 \times 10^{-3}\ Pa \cdot s$

$$h_A + \frac{P_1}{\gamma} + \cancel{\frac{V_1^2}{2g}} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

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

$\rho = (sg)(\rho_w)$
$= (1.10)(1000\ kg/m^3)$
$= 1100\ kg/m^3$

$Re = \frac{\rho V D}{\eta} = \frac{(1100\ kg/m^3)(3.22\ m/s)(0.025 m)}{2 \times 10^{-3}\ kg/m/s}$

$Re = 44275$

$h_L = f \frac{L}{D} \frac{V^2}{2g}$

$f = 0.024$

$$h_a = \left(\frac{P_2}{\gamma} - \frac{P_1}{\gamma}\right) + (z_2 - z_1) + \frac{(V_2)^2}{2g} + \left(f \frac{LV^2}{D2g}\right)$$

$$= \left(\frac{140}{10.79} - \frac{101}{10.79}\right) + (10 - 1.7) + \frac{(3.22)^2}{2(32.2)} + \left(0.024\left(\frac{85}{0.025} \times \frac{(3.22)^2}{2(9.81)}\right)\right)$$

$h_a = 16.39\ m$

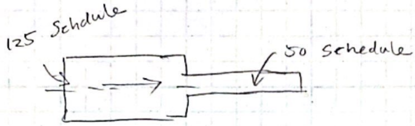
$P = 16.39m \times 10.79 \times 1.58 \times 10^{-3}$

$= \boxed{0.279\ KW}$

(20) h_L ? $V = \frac{Q}{A}$

DN 125 schedule 80 to DN 50 schedule 80

$Q = 500\ L/min \left(\frac{1 min}{60 sec}\right)\left(\frac{0.001 m^3}{1 L}\right) = 0.0083\ m^3/s$



$A = \frac{\pi}{4} D_1^2 = \frac{\pi}{4}($

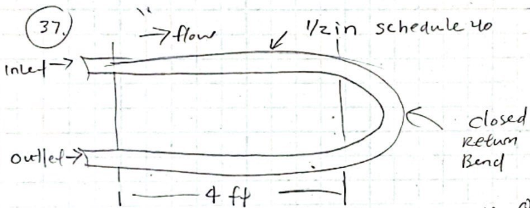
$D = 60.3 - 2(5.54)$
$= 49.2\ mm$ or $0.0492\ m$

$A_2 = \frac{\pi}{4}(0.0492 m)^2$
$= 19.04 \times 10^{-4} m^3$

$h_L = K\left(\frac{V_2^2}{2g}\right)$

$= 0.39\left(\frac{\left(\frac{0.0083 m^3/s}{19.04\times10^{-4} m^3}\right)^2}{2(9.81)}\right) = 0.39\left(\frac{19.0}{19.62}\right) = \boxed{0.378\ m}$

(37.)



$A = 0.0021\ ft^2$
$D = 0.0518\ ft$

$Q = 12.5\ gal/min$
$(12.5\ gal/min)\left(\frac{1 min}{60 sec}\right)\left(\frac{0.1336\ ft^3}{1 gal}\right)$
$= 0.0278\ ft^3/s$

$V = \frac{Q}{A} \quad \frac{0.0278\ ft^3/s}{0.0021\ ft^2}$

$V = 13.24\ ft/s$

$h_L = K\left(\frac{V^2}{2g}\right)$

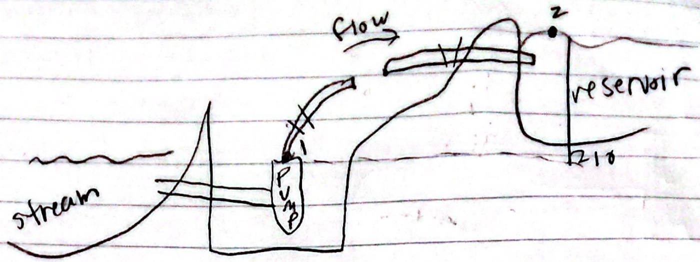
$h_L = 1.3 \times \left(\frac{13.24^2}{2(32.2)}\right) = 3.54\ ft$

$hf = f \times \frac{LV^2}{D 2g}$

$hf = 0.0415 \left(\frac{4\times2}{0.0518}\right)\left(\frac{13.24}{2(32.2)}\right) = 17.28\ ft$

$P_{1,2} = \gamma(h_L + hf)$
$= 68.47\ (3.54 + 17.28)$
$= 1425.5\ lb/ft^2 \left(\frac{1 ft^2}{144 in^2}\right)$
$= 9.89\ lb/in^2$ or $\boxed{9.89\ psi}$

8.46)



$$\frac{P_1}{\gamma}+z_1+\frac{v_1^2}{2g}+h_A=\frac{P_2}{\gamma}+z_2+\frac{v_2^2}{2g}+h_L$$

$$V=\frac{A}{\frac{\pi}{4}\times\left(\frac{8}{12}\right)^2}=11.46$$

$$N_R=\frac{vD}{v_w}\rightarrow\frac{11.46\times\frac{8}{12}}{1.21\times10^{-5}}=631404.95$$

$$\frac{\varepsilon}{d}\rightarrow\frac{1.5\times10^{-4}}{\frac{8}{12}}=2.25\times10^{-4}$$

$$h_L\rightarrow0.0153\times\frac{2500}{\left(\frac{8}{12}\right)}\times\frac{11.46^2}{2\times32.2}=117$$

$$P_1=\gamma(z_2-z_1)+h_L\rightarrow62.4\times(210-0)+117)\times\frac{1}{144}=141.7\text{ psig}$$

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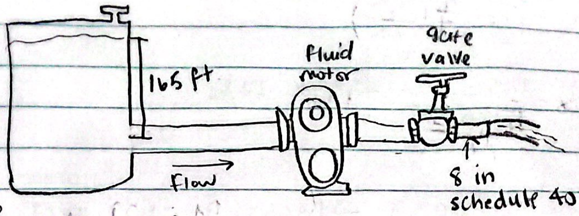
HW # 1.4

7.30)



$$\cancel{h_A} + \frac{P_1}{\gamma} + \cancel{\frac{v_1^2}{2g}}^{0} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} - h_R + h_L + z_2$$

$$z_1 + h_R - h_L = z_2 + \frac{v_2^2}{2g}$$

$$h_R = \frac{37 \times 550}{62.4 \times 2.228} = 146.37$$

$$h_L = (z_1 - z_2) - \frac{v_2^2}{2g} - h_R$$

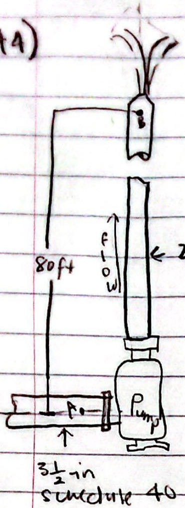
$$V = \frac{Q}{A} \rightarrow \frac{2.228}{\frac{\pi}{4}\left(\frac{8}{12}\right)^2} = 6.38 \text{ ft/s}$$

$$\rightarrow (165 - 0) - \frac{6.38^2}{2 \times 32.2} - 146.37$$

$$= 17.93 \text{ ft}$$

$h_L =$

8.44)



$$V_A = \frac{Q}{A} \rightarrow \frac{0.5}{\frac{\pi}{4}\left(\frac{3.5}{12}\right)^2} = 7.28 \text{ ft/s}$$

$$V_B = \frac{0.5}{\frac{\pi}{4}\left(\frac{2.5}{12}\right)^2} = 15.03 \text{ ft/s}$$

$$\gamma_f = sg \times \gamma_w \rightarrow 1.026 \times 1.94 = 1.99 \text{ lb/ft}^3$$

$$N_R = \frac{V_B D_A \gamma_f}{\mu} \rightarrow \frac{15.03 \times \frac{2.5}{12} \times 1.99}{4\times10^{-5}} = 1.54\times10^5$$

$$\frac{D_B}{\varepsilon} \rightarrow \frac{\left(\frac{2.5}{12}\right)}{1.5\times10^{-4}} = 1372$$

$$f = \frac{0.25}{\log\left(\frac{1}{3.7\left(\frac{D}{\varepsilon}\right)} + \frac{5.47}{N_R^{0.9}}\right)^2} = 0.02$$

$$h_L = \frac{fLV_B^2}{2gD} \rightarrow \frac{0.02\times80\times15.03^2}{2\times32.2\times\frac{2.5}{12}} = 27.27 \text{ ft}$$

$$sg_f = 1.026 \times 62.4 = 64.02$$

$$\overset{0}{\cancel{z_1}} + h_A + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\rightarrow \frac{-35}{64.02} + \frac{7.28^2}{2\times32.2} + h_A = \frac{25}{64.02} + \frac{15.03^2}{2\times32.2} + 80 + 27.27 = 174.5$$

$$P = \frac{h_A \times sg_f \times Q}{550} \rightarrow \frac{174.5\times64.02\times0.5}{500} = 10.15 \text{ hp}$$

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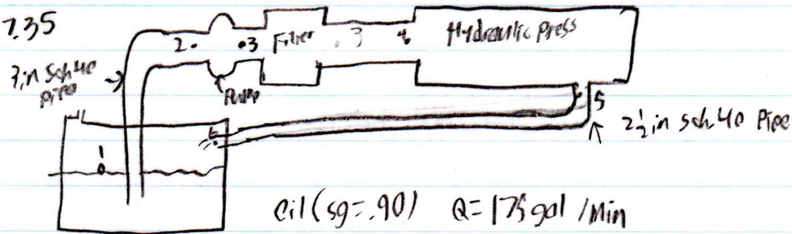
MET 330 HW1.4

2/10/22

7-35,42 8-47,62 10-46,48

7.35



Oil (sg = .90) Q = 175 gal/min

Pump Power = 28.4 hp Pump eff. = 80%

Loss from 1 to 2: 2.8 lb-ft/lb Loss from 3 to 4: 28.5 lb-ft/lb

Loss from 5 to 6: 3.5 lb-ft/lb Pipes are steel

Find power removed by the press

$$\cancel{\frac{P_1}{\gamma}}_0 + \cancel{z_1}_0 + \cancel{\frac{V_1^2}{2g}}_0 + h_A - h_R - h_L = \cancel{\frac{P_6}{\gamma}}_0 + z_6 + \frac{V_6^2}{2g}$$

$Q = 175\ \text{gal/min} = 23.395\ \text{ft}^3/\text{min} = .468\ \text{ft}^3/\text{sec}$ $D_1 = 3.07\text{in} = .2558\ \text{ft}$ $A_1 = .0514\ \text{ft}^2$

$D_2 = 2.47\text{in} = .2058\ \text{ft}$ $A_2 = .0333\ \text{ft}^2$

$$V_1 = \frac{28.095\ \text{ft}^3/\text{min}}{.0514\ \text{ft}^2} = 546.5\ \text{ft/min} = 9.11\ \text{ft/sec}$$

$$V_2 = \frac{28.095\ \text{ft}^3/\text{min}}{.0333\ \text{ft}^2} = 844.3\ \text{ft/min} = 14.07\ \text{ft/sec}$$

$\nu = 2.11 \times 10^{-3}\ \text{ft}^2/\text{s}$ $\rho = 62.4\ \text{LB/ft}^3 \cdot .9 = 56.16\ \text{LB/ft}^3$

$\varepsilon_{steel} = 5 \times 10^{-6}\ \text{ft}$ $N_{R_1} = \dfrac{9.11\ \text{ft/sec} \cdot .2558\ \text{ft} \cdot \cancel{56.16\ \text{LB/ft}^3}}{2.11 \times 10^{-3}\ \text{ft}^2/\text{s}} = 1104$ Laminar

$N_{R_2} = \dfrac{14.07\ \text{ft/sec} \cdot .2058\ \text{ft}}{2.11 \times 10^{-3}\ \text{ft}^2/\text{s}} = 1373$ Laminar

$f_1 = 64/1104 = .0579$ $f_2 = 64/1373 = .0466$

~~$h_{L1} = .0579$~~

$h_L = 2.8 + 28.5 + 3.5 = 34.8\ \text{ft}$ $P_A = .8 \cdot 28.4\ \text{hp} \cdot \dfrac{550\ \text{LB-ft/s}}{\text{hp}} = 12496\ \text{LB-ft/s}$

$$h_A = \frac{12496\ \text{LB-ft/s}}{56.16\ \text{LB/ft}^3 \cdot .468\ \text{ft}^3/\text{sec}} = 475.2\ \text{ft}$$

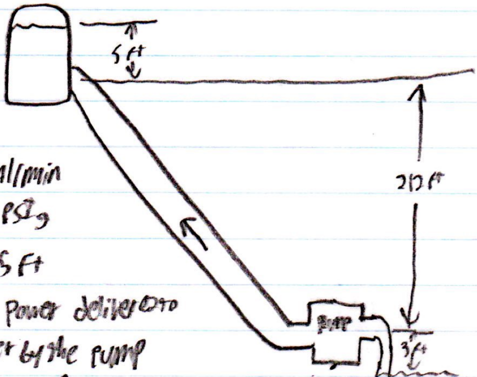
$$h_A - h_r - h_L = Z_B + \frac{V_B^2}{2g} = 475.2\,ft - h_p - 34.8\,ft = 1\,ft + \frac{(14.07\,ft/s)^2}{64.4\,ft/s^2}$$

$$= 1\,ft + 3.075\,ft$$

$$h_p = 475.2\,ft - 34.8\,ft - 1\,ft - 3.075\,ft = 434.2\,ft$$

$$P = 434.2\,ft \cdot 56.16\,lb/ft^3 \cdot .468\,ft^3/sec = \frac{11419\,LB\text{-}ft/s}{550\,\frac{LB\text{-}ft/s}{hp}} = \boxed{20.8\,hp}$$

7.42



$Q = 40\,gal/min$

$P_2 = 30\,psig$

$H_L = 15.5\,ft$

Find the power delivered to the water by the pump

$40\,gal = 5.347\,ft^3$

$5.347\,\frac{ft^3}{min} = .0891\,ft^3/sec$

$$\frac{P_1}{\gamma}_{\searrow 0} + Z_{1\,\searrow 0} + \frac{V_1^2}{2g}_{\searrow 0} + h_A - h_R{}_{\searrow 0} + h_L = \frac{P_2}{\gamma} + Z_2 + \frac{V_2^2}{2g}_{\searrow 0}$$

$$h_A = \frac{30\,PSI}{.0361\,LB/in^3} + 220\,ft = 69.2\,ft + 220\,ft = 289.2\,ft$$

$$P = 289.2\,ft \cdot 62.4\,lb/ft^3 \cdot .0891\,ft^3/sec = \frac{1608\,LB\text{-}ft/s}{550\,\frac{LB\text{-}ft/s}{hp}} = \boxed{2.92\,hp}$$

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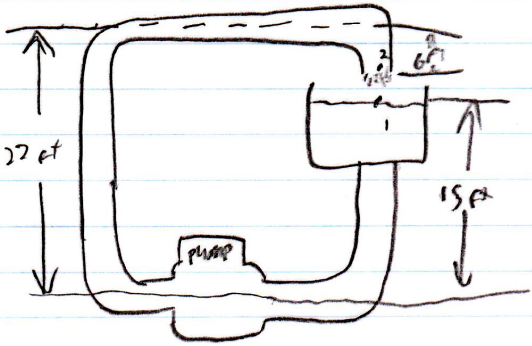
8.49



$D_S = 4.03\ in = .336\ ft$
$A_S = .0886\ ft^2$
$D_D = 3.07\ in = .256\ ft$
$A_D = .0514\ ft^2$
$\gamma = .890$
$\nu = 2.15\times10^{-3}\ ft^2/s$

suction: 4 in. schedule 40 steel pipe, 25 ft.
Discharge: 3 in schedule 40 steel pipe, 75 ft.
Q = 300 gal/min, heavy machine tool lubricating oil @ 104°F
Find power delivered by the pump to the oil

$V_S = 300\ gal/min = \frac{48.16\ ft^3/min}{60\ sec/min} = \frac{.8027\ ft^3/sec}{.0886\ ft^2} = 9.06\ ft/sec$

$V_D = \frac{.8027\ ft^3/sec}{.0514\ ft^2} = 15.61\ ft/sec$

$N_{RS} = \frac{9.06\ ft/sec \cdot .336\ ft}{2.15\times10^{-3}\ ft^2/s} = 1415$, Laminar $f_S = \frac{64}{1415} = .0452$

$N_{RD} = \frac{15.61\ ft/sec \cdot .256\ ft}{2.15\times10^{-3}\ ft^2/s} = 1858$, Laminar $f_D = \frac{64}{1858} = .0344$

$h_{LS} = .0452 \cdot \frac{25\ ft}{.336\ ft} \cdot \frac{(9.06\ ft/sec)^2}{64.4\ ft/sec^2} = .0452 \cdot 74.4 \cdot 1.275\ ft = 4.29\ ft$

$h_{LD} = .0344 \cdot \frac{75\ ft}{.256\ ft} \cdot \frac{(15.61\ ft/sec)^2}{64.4\ ft/sec^2} = .0344 \cdot 293 \cdot 3.79\ ft = 38.23\ ft$

$h_L = 4.29\ ft + 38.23\ ft = 42.52\ ft$

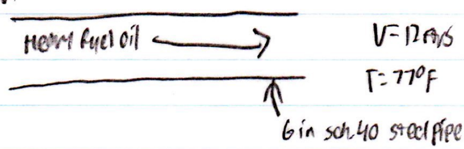
$$\cancelto{}{\frac{P_1}{\gamma}} + \cancelto{0}{z_1} + \cancelto{0}{\frac{V_1^2}{2g}} + h_A - \cancelto{0}{h_R} - h_L = \cancelto{0}{\frac{P_2}{\gamma}} + z_2 + \frac{V_2^2}{2g}$$

$$h_a - h_L = z_2 + \frac{V_2^2}{2g} \qquad h_a = z_2 + \frac{V_2^2}{2g} + h_L = 1\text{ft} + \frac{(15.61\text{ ft/sec})^2}{64.4\text{ ft/s}^2} + 42.52\text{ ft}$$

$h_a = 1\text{ft} + 3.79\text{ ft} + 42.50\text{ ft} = 47.3\text{ ft}$

$P = 47.3\text{ft} \cdot 62.4\text{ lb/ft}^3 \cdot .89 \cdot .8007\text{ ft}^3/\text{sec} = \dfrac{2109\text{ LB-ft/s}}{550\ \frac{\text{LB-ft/s}}{\text{hp}}} = \boxed{3.83\text{ hp}}$

8.62 ~~Heav~~:



Find friction factor

$\gamma = .906 \quad \nu = 1.27\times10^{-3}\text{ ft}^2/\text{s} \quad D = 6.065\text{ in} = .505\text{ ft} \quad A = .2006\text{ ft}^2$

$N_R = \dfrac{12\text{ ft/s} \cdot .505\text{ft}}{1.27\times10^{-3}\text{ ft}^2/\text{s}} = 4776$, turbulent

$\varepsilon = 5.0\times10^{-6}\text{ ft} \qquad D/\varepsilon = \dfrac{.505\text{ ft}}{5.0\times10^{-6}\text{ ft}} = 101083$

$\boxed{f = .038}$ (Moody's Diagram)