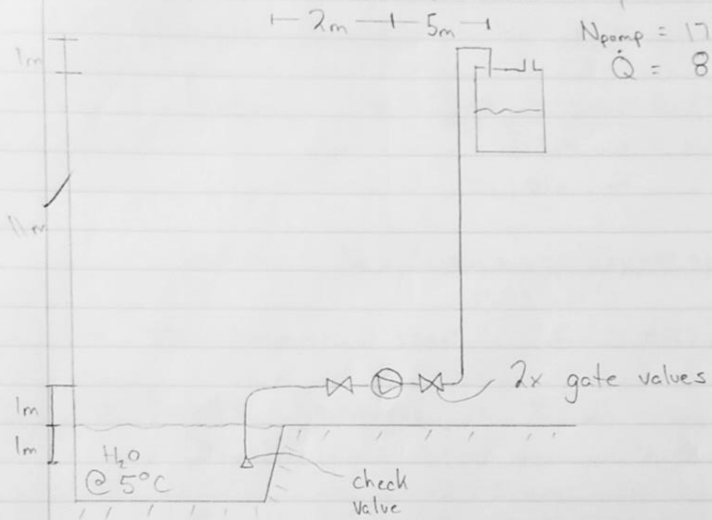
Connor Kutzner

ENG 292 - Fluids & Thermodynamics Assignment #2

$N_{pump} = 1750$ rpm

$\dot{Q} = 8$ L/s

20/20



Pipe Size

$Q = vA$ → choosing $v = 3\,m/s$

$Q = 8\,L/s \left(\frac{1\,m^3}{1000\,L}\right) = 0.008\,m^3/s$

$A = \frac{0.008\,m^3/s}{3\,m/s}$

$A = 0.00267\,m^2$ → $A = \frac{\pi d^2}{4}$

$d = \sqrt{\frac{4A}{\pi}} = 0.0583\,m$

→ choosing $2\frac{1}{2}$" sch 40 (ID = 0.062713 m)
($A = 0.0030889\,m^2$)

Suction Line:

→ choosing 3" sch 40 (ID = 0.077928 m)
($A = 47.696\,cm^2$)

Flow Velocities:

→ Discharge: $V = \frac{0.008\,m^3/s}{0.0030889\,m^2} = \boxed{2.59\,m/s}$

Suction: $V = \frac{0.008}{0.0047696} = \boxed{1.68\,m/s}$

→ Reynold's number $N_R = \frac{vD\rho}{\mu}$

Discharge $N_R = \frac{(2.59)\,m/s\,(0.062713)\,m\,(999.9)\,kg/m^3}{(1.519 \times 10^{-3})\,kg/m\cdot s}$

$= 106,919$ ✓

Suction $N_R = \frac{(1.68)(0.077928)(999.9)}{(1.519 \times 10^{-3})} = 86,179$ ✓

→ Use commercial steel ($\varepsilon = 0.045$ mm) ✓

→ Relative Roughness $= \varepsilon / D$

Discharge: $= \frac{0.045\ mm}{62.713\ mm} = 7.18 \times 10^{-4}$ ✓

Suction: $= \frac{0.045}{77.928} = 5.77 \times 10^{-4}$ ✓

→ Friction Factor (f)

Discharge: $f = 0.0214$ ✓

Suction: $f = 0.0214$ ✓

→ Pipe Length:

Discharge: 18m ✓

Suction: 4m ✓

→ Pipe head loss $h_{LP} = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right)$

Discharge: $h_{LP} = 0.0214\left(\frac{18\,m}{0.062713\,m}\right)\left(2.59\ m/s\right)^2 / 2(9.81)\,m/s^2$ ✓

$h_{LP} = \underline{2.1\ m}$

Suction: $h_{LP} = 0.0214\left(\frac{4}{0.077928}\right)\left(\frac{1.68^2}{2(9.81)}\right)$ ✓

$h_{LP} = \underline{0.16\ m}$

→ Fitting head loss $h_{LF} = \sum K \left(\frac{v^2}{2g}\right)$

Discharge: 1 gate valve: $K = 0.16$

3 flanged elbows: $K \approx 0.39$

* note the K-value for the flanged elbows were from a 2" pipe.

1 Discharge: $K = 1.0$

$$h_{LF} = \left((0.16) + 3(0.39) + 1.0\right)\left(\frac{2.59^2}{2(9.81)}\right) = 0.80\ m$$ ✓

Suction: 1 elbow: $K = 0.39$ + 1 gate valve: $K = 0.16$

1 check valve: $K = 2.0$

$$h_{LF} = (0.16 + 0.39 + 2.0)\left(\frac{1.68^2}{2(9.81)}\right) = 0.36\ m$$ ✓

→ Total h_L $h_L = h_{LP} + h_{LF}$

Discharge: $h_L = 2.1m + 0.80m = \boxed{2.90\ m}$

Suction: $h_L = 0.16m + 0.36m = \boxed{0.52m}$

→ head added

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

$$h_A = \left(\frac{P_2 - P_1}{\gamma}\right) + (z_2 - z_1) + \frac{V_2^2 - V_1^2}{2g} + h_L$$

$$h_A = \left(\frac{\emptyset - (999.9)(9.81)(1)}{(999.9)(9.81)}\right) + (13 - \emptyset) + \left(\frac{2.59^2 - 1.68^2}{2(9.81)}\right) + 2.90 + 0.52$$

$$h_A = -1m + 13m + 0.215m + 3.42m$$

$$h_A = \boxed{15.64\ m}$$ ✓

→ Pump Selection: $Q = 8\ L/s$ or $0.008\ m^3/s$ (127 gpm)

$h_A = 15.64m$ $n = 1750$ rpm

→ B & G model 1510 - 1½ BC @ 1750 rpm

- 8" impeller
- 3HP

→ $NPSH_R = 7\ ft \times \frac{0.3048\ m}{1\ ft} = 2.13\ m$ ✓

→ $NPSH_A$:

$$NPSH_A = \frac{P_{ATM}}{\gamma} - h_e - h_f - \frac{P_v}{\gamma}$$

$$NPSH_A = \frac{101.3\ kPa}{9.81\ kN/m^3} - 1m - 0.52m - \frac{0.9\ kPa}{9.81\ kN/m^3}$$

$$NPSH_A = 8.7m$$

✓

→ $NPSH_A\ (8.7) > NPSH_R\ (2.13)$ ✓