10/10

MENG 263 - Assignment 3

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Question 1

Fluid: Water @ 80°C
$\gamma = 9.53\ kN/m^3$
$\rho = 971\ kg/m^3$
$\eta = 3.5 \times 10^{-4}$

$Q = 750\ L/min = 0.0125\ m^3/s$

$P_2 = 425\ kPa$

Pipe: Schedule 40 Steel
$\epsilon = 4.6 \times 10^{-5}\ m$

Discharge Line

1.5 inch Diameter ✓
OD = 48.3 mm = 0.0483 m
ID = 40.9 mm = 0.0409 m
$A = 1.314 \times 10^{-3}\ m^2$

$V_D = \frac{Q}{A} = \frac{0.0125}{1.314 \times 10^{-3}} = 9.513\ m/s$ ✓

$N_R = \frac{(9.513)(0.0409)(971)}{3.5 \times 10^{-4}} = 1079424$

$\frac{D}{\epsilon} = \frac{0.0409}{4.6 \times 10^{-5}} = 889.13$ ✓

$f_D = \frac{0.25}{\left[\log\left(\frac{1}{3.7(889)} + \frac{5.74}{1079424^{0.9}}\right)\right]^2}$

$f_D = 0.0206$

Suction Line

2.0 inch diameter ✓
OD = 60.3 mm = 0.0603 m
ID = 52.5 mm = 0.0525 m
$A = 2.168 \times 10^{-3}\ m^2$

$V_S = \frac{0.0125}{2.168 \times 10^{-3}} = 5.766\ m/s$ ✓

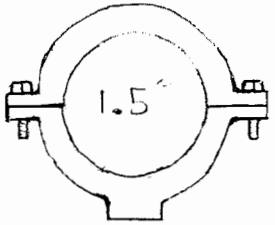
$N_R = \frac{(5.766)(0.0525)(971)}{3.5 \times 10^{-4}} = 839818$

$\frac{D}{\epsilon} = \frac{0.0525}{4.6 \times 10^{-5}} = 1141.30$ ✓

$f_S = \frac{0.25}{\left[\log\left(\frac{1}{3.7(1141)} + \frac{5.74}{839818^{0.9}}\right)\right]^2}$

$f_S = 0.0195$

1 90° STANDARD ELBOW - SUCTION LINE
2 FULLY OPEN Butterfly Valve
3 90° STANDARD ELBOW X 2
4 FULLY OPEN GLOBE VALVE
5 SPLIT RING PIPE CLAMP X 5



GREAT

Find total energy loss of system.

SUCTION LINE

- Pipe entrance - square — $k = 0.5$
- Butterfly Valve - open — $L_e/D = 45$
- 90° standard elbow — $L_e/D = 30$ ✓
- Pipe friction loss — $\frac{L}{D} = 0.4\ m / 0.0603\ m$

DISCHARGE LINE

- Globe Valve - open — $L_e/D = 340$
- 90° standard Elbow x 2 — $L_e/D = 60$ ✓
- Pipe friction loss — $\frac{L}{D} = 7.1\ m / 0.0409$

$$h_L = \frac{V_s^2}{2g}\left[\frac{L}{D} f_s + \sum \frac{L_e}{D} f_s + k\right] + \frac{V_D^2}{2g}\left[\frac{L}{D} f_D + \sum \frac{L_e}{D} f_D + k\right]$$

$$= \frac{5.77^2}{2(9.81)}\left[\frac{0.4}{0.0603}(0.0195) + 75(0.0195) + 0.5\right] + \frac{9.513^2}{2(9.81)}\left[\frac{7.1}{0.0409} + 400\right]0.0206$$

$$h_L = 58.05\ m$$ ✓

Find Head Added by Pump

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

$$h_A = \frac{P_2 - P_1^{\,0}}{\gamma} + (z_2 - z_1) + \frac{V_2^2 - V_1^{2\,0}}{2g} + h_L \quad \checkmark$$

$$= \frac{425k}{9.53k} + 4.65 - 1.2 + \frac{9.513^2}{2(9.81)} + 58.05$$

$$h_A = 110.71 \text{ m} \quad \checkmark$$

INTERESTING. THIS IS SO BIG BECAUSE YOUR DISCHARGE VELOCITY IS HIGH (DUE TO A SMALLER PIPE USE).

Choose A Pump

My h_A is probably too high due to choosing a too small pipe diameter. I'll run with it anyways.

Pump Specs

$h_A = 110.71 \text{ m}$ ✓

$Q = 750 \text{ L/min} = 45 \text{ m}^3/\text{h}$ ✓

BELL & GOSSETT ✓
SERIES 1510 ✓
1½ BC 3525 RPM ✓
9 inch Impeller ✓
35 Horsepower ✓

Net Positive Suction Head

$NPSH_r \approx 8 \text{ m}$ ✓

$NPSH_A = h_{sp} \pm h_s - h_f - h_{vp}$

$= \frac{101.3 \text{ kPa}}{9.53 \text{ kN/m}^3}$ ✓ $+ 1.2 \text{ m}$ ✓ $- 3.4 \text{ m}$ ✓ $- 5 \text{ m}$ ✓

$NPSH_A = 3.43 \text{ m}$ ✓ (Extreme Cavitation)

$NPSH_A \not> NPSH_R$ ∴ AHH! WILL CAVITATE.

Apparently my design is crap and I've wasted my entire long weekend.

HA. NOT REALLY. JUST USE A 2BC PUMP AND YOU WOULD LIKELY BE OK. ($NPSH_R = 3$ m)