Fluid Mechanics - Homework #3.3
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Summary: This week in fluid mechanics we learned about pumps, pump head, impeller sizes, cavitation, and were also given the chance to view and feel a real pump impeller. We also talked about pump selection, learned to use a pump performance chart, and began on our pump selection project.

Chapter 13:
17 - Kayla
19 - Kayla
22 - Ethan K
23 - Ethan E
25 - Ethan K.
34 (only select 2 for this problem) - Gershon
55 -Gershon
65 - Josiah
Design Problem 3 - Josiah

HW. 3.3

13-17

If the rotation speed is cut in half, the total head capability is reduced to 1/4 of its original value.

13-19

capacity change $= \left(\frac{0.75D}{D}\right)^2 = (0.75)^2$

$= 0.563$

- capacity decreases 56.3% from its original capacity

13-22

1-1/2x3-6 pump designation

- 1-1/2 discharge port
- 3 in suction port
- max nominal impeller size 6 in

13-23)

13.23) $Q = 100$ gpm

$h = 300$ ft

Per Figure 13.22

$1\frac{1}{2} \times 3 - 10$

Inlet: $1\frac{1}{2}$ in

Outlet: 3 in

Impeller: 10 in

13.25)

Pump Head: 200 ft.
Impeller size: 8in. diameter

Source: 13-28, student textbook

Capacity: ≈ 230 gal/min
Power required: ~20 HP

Efficiency: ~ 54%

NPSH: ~ 10.5 ft.

13-34)

13-34) For each of the following sets of operating conditions, list at least ~~two~~ one appropriate pump.

A) 500 gal/min of water at 80 ft of total head

$Q = 500\ gal/min$

$H = 80\ ft$

6 × 8 × 11.5 60 Hz 1775 rpm

4 × 6 × 7.5B -1 OHH 60 Hz 3520 rpm $\eta = 67\%$

B) 500 gal/min of water at 800 ft of head

$Q = 500\ gal/min$

$h_a = 800\ ft$

3 × 6 × 14 -1 OHH 60Hz 3570 rpm $\eta = 61.5\%$

4 × 6 × 14A-1 OHH 60 Hz 3570 rpm $\eta = 58\%$

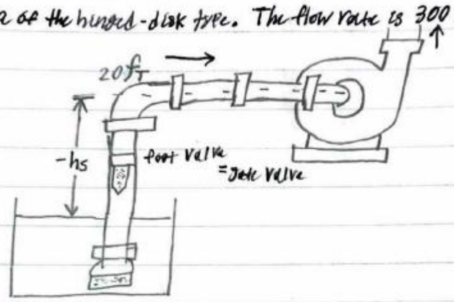
3 × 4 × 17 -1 OHH 60 Hz 3570 rpm $\eta = 49.2\%$

3 × 4 × 17-2 OHH 60 Hz 3570 rpm $\eta = 49.4\%$

4 × 6 × 17B-1 OHH 60 Hz 3570 rpm $\eta = 53\%$

13-55)

13-55) Determine the available NPSH for the system. The fluid is water at 80° and the atmospheric pressure is 101.8 kPa. The water level in the tank is 2.0m below the pump inlet. The vertical leg of the suction line is a DN 80 Schedule 40 steel pipe, whereas the horizontal leg is a DN 50 Schedule 40 pipe, 1.5m long. The elbow is of the long-radius type. Neglect the loss in the reducer. The foot valve and strainer are of the hinged-disk type. The flow rate is 300 L/min.



$T = 80\,°C$

$P_{atm} = 101.8\ kN/m^2$

$\gamma = 9.53\ kN/m^3$

$D_s = 0.0779\ m$

$A_s = 4.768 \times 10^{-3}\ m^2$

$D_{hL} = 0.0525\ m$

$A_{hL} = 2.168 \times 10^{-3}\ m^2$

$L = 1.5\,m$

$Q = 300\ L/min$

$\nu = 3.60 \times 10^{-7}\ m^2/s$

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

$$h_{sp} = \frac{P_{atm}}{\gamma} = \frac{101.8\ kN/m^2}{9.53\ kN/m^3} = 10.68\,m$$

$$h_s = -2.0\,m$$

Suction line:

$$v_s = \frac{Q}{A} = \frac{300\ L/min}{4.768 \times 10^{-3}\ m^2} \times \frac{1.0\ m^3/s}{60{,}000\ L/min} = 1.04\ m/s$$

$$N_R = \frac{vD}{\nu} = \frac{(1.04\ m/s)(0.0779\,m)}{3.60 \times 10^{-7}\ m^2/s} = 225{,}044$$

$$\frac{D}{\varepsilon} = \frac{0.0779\,m}{4.6 \times 10^{-5}\,m} = 1693$$

$$f_{T_s} = 0.017,\quad f_s = 0.01943$$

horizontal line:

$$v_{hL} = \frac{300\ L/min}{2.168 \times 10^{-3}\ m^2} \times \frac{1.0\ m^3/s}{60{,}000\ L/min} = 2.306\ m/s$$

$$N_R = \frac{(2.306\ m/s)(0.0525\,m)}{3.60 \times 10^{-7}\ m^2/s} = 336292$$

$$\frac{D}{\varepsilon} = \frac{0.0525\,m}{4.6 \times 10^{-5}\,m} = 1141$$

$$f_{T_{hL}} = 0.019,\quad f_{hL} = 0.02055$$

$$h_f = f_s(L/D_s)(V_s^2/2g) + f_{T_s}(8)(V_s^2/2g) + 2f_{T_{hL}}(20)(V_{hL}^2/2g) + f_{hL}(L/D_{hL})(V_{hL}^2/2g)$$

Suction Line — Foot Valve — Elbow — Horizontal Line

$$h_f = (0.01943)(1.5_m/0.0779_m)(1.04^2/2(9.81)) + (0.017)(8)(1.04^2/2(9.81))$$

$$+ 2(0.019)(20)(2.306^2/2(9.81)) + (0.02055)(1.5_m/0.0525_m)(2.306^2/2(9.81))$$

$$= 0.0206 + 0.00749 + 0.20598 + 0.15913$$

$$h_f = 0.393\,m$$

$$h_{vp} = 4.967\,m \text{ at } 80°C$$

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

$$= 10.68_m - (-2.0_m) - 0.393_m - 4.967_m$$

$$= 7.3198_m$$

$$NPSH_A > 1.10\,NPSH_r$$

$$NPSH_r < 7.3198_m/1.10 = \boxed{6.65\ m}$$

HW3B5

T = 45°C γ = 9.71 × .48 = 4.71
SG

SG = .48

P = 98.415 Pa

zorh = 1.8 m

h_L = 0.92

h_{up} = 340

$$\frac{P_{tank} + P_{atm}}{\gamma} - z - h_L$$

↓

$P_{tank} = \gamma h_L + z_{h}\gamma$ Patm

↓

P_{tank} = (0.92 + 1.8)(98.4)
(4.71)

P_{tank} = 1515.8

Design P3

L=

$Q = 1500 = 5775\ in^3/s$ — 8 inch pipe for 1500 rpm

$T = 90°$

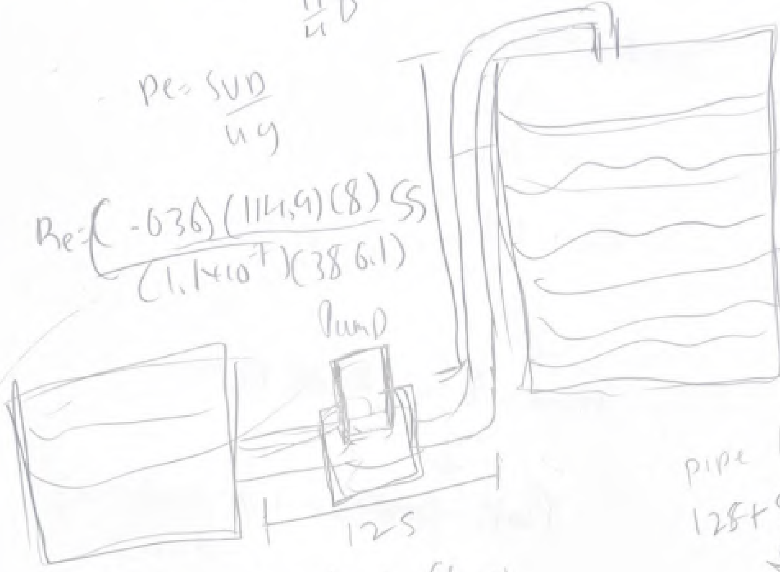
$Q = VA$

$V = \frac{5775}{\frac{\pi}{4}8^2} = 114.9$

ε steel $= .00236in$

$Re = \frac{SVD}{\mu g}$

$Re = \frac{(.036)(114.9)(8)}{(1.1\times10^{-7})(386.1)}$ 55



pipe lengt = 125 + 55 ft

↓

180 = 2160 in

Greater than 2K = Turbulent flow

$f = \left(1.14 + 2\log_{10}\frac{8}{.00236}\right)^{-2}$

↓

.0149

$h_f = \frac{4fLV^2}{2gD}$

$275in = ft = 22.9 \quad \frac{4\times(.0149)(2160)(114.9)^2}{2\times(386.1)\times8}$

$h_f = 275 inces + 55ft = 22.9 + 55$

pump with power of 40

$Hp = \frac{QH(SG)}{3960\times.8} = \frac{(5775)(77.9)}{3960\times.8} = \frac{(1500)(77.9)}{3960\times.8} = 36.89$