Fluids | Homework 3.3 | Andrew Broemmer

Problem 13.22

$1\frac{1}{2} \times 3 - 6$

$1\frac{1}{2}$ ↑ Discharge Line ⌀

3 ↑ Suction Line ⌀

6 ↑ Max. Impeller ⌀

Problem 13.23

$Q = 100 \frac{gal}{min}$ $h_A = 300ft$

From Chart: $\boxed{\text{Pump } 1\frac{1}{2} \times 3 - 10}$

Problem 13.25

Pump: $2 \times 3 - 10$ 8" Impeller $h_A = 200ft$

$\boxed{\text{From Chart: } P \approx 22.5HP \quad \eta = 54\% \quad Q \approx 230 \frac{gal}{min} \quad NPSH \approx 10ft}$

34, 17, 19

17) $\frac{H_{a1}}{H_{a2}} = \left(\frac{N_1}{N_2}\right)^2$ The head capability will be 1/4 of the original value when the new speed is 1/2 of the old value

19) $\frac{Q}{ND^3}$ = constant

$\frac{Q'}{Q} = \left(\frac{D'}{D}\right)^3 \Rightarrow Q' = Q \times \left(\frac{0.75D}{D}\right)^3$ $\frac{Q - 0.4218Q}{Q} \times 100$

$Q' = 0.4218Q$ $= 57.8\%$

Capacity is reduced 57.8% below the original value

34) a) 500 gal/min of water @ 80 ft of total head

-Centrifugal pump

b) 500 gal/min of water @ 800 ft of total head

-Rotary pump

13.55 TABLE A.1

$\gamma = 9.53\ kN/m^3$
$\nu = 3.60 \times 10^{-7}\ m^2/s$

TABLE F.1
DN80
$D_{80} = 77.9\ mm = 0.0779\ m$
$A_{80} = 4.768 \times 10^{-3}\ m^2$
DN 50
$D_{50} = 52.5\ mm = 0.0525\ m$
$A_{50} = 2.168 \times 10^{-3}\ m^2$

TABLE 8.2
$\varepsilon = 4.6 \times 10^{-5}\ m$

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

$$v_{80} = Q/A_{80} = \frac{300\ L/min \times 10^{-3}}{4.768 \times 10^{-3}\ m \times 60} = 1.048\ m/s$$

$$N_R = \frac{1.048 \times 0.0779}{3.6 \times 10^{-7}} = 2.26 \times 10^5$$

$$\frac{D80}{\varepsilon} = \frac{0.0779}{4.6 \times 10^{-5}} = 1693.478$$

$f_{80} = 0.019$

$$v_{50} = Q/A_{50} = \frac{300\ L/min \times 10^{-3}}{2.168 \times 10^{-3}\ m^2 \times 60} = 2.306\ m/s$$

$$N_R = \frac{v_{50} D_{50}}{\nu} = \frac{2.306 \times 0.0525}{3.6 \times 10^{-7}} = 3.36 \times 10^5$$

$$D_{50}/\varepsilon = 0.0525 / 4.6 \times 10^{-5} = 1141.304$$

$f = 0.025$

$$h_1 = 0.019 \times 2/0.0779 \times \frac{1.048^2}{2 \times 9.81} = 0.0273\ m$$

$f_{3T} = 0.018$

$$h_2 = 7.5 \times 0.018 \times 1.048^2/(2 \times 9.81) = 0.075571\ m$$

$$h_3 = 20 \times 0.018 \times \frac{1.048^2}{2 \times 9.81}$$
$$= 0.020178\ m$$

$$h_4 = 0.025 \times \frac{1.5}{0.0525} \times \frac{2.306^2}{2 \times 9.81} = 0.1935\ m$$

$h_L = 0.0273 + 0.075371 + 0.020178 + 0.19 = 0.3238 m$

$NPSH = 10.607 - 2 - 0.3238 - 4.967 = \boxed{3.3112 m}$

13.65

Propane $sg = 0.48$ $T = 45°C$

$h_s = 1.84 m$ $h_f = 0.92 m$

$P_{atm} = 98.4 kPa$ $NPSH_A = 1.50 m$

$NPSH_A = h_{sp} \pm h_s - h_f - h_{vp}$ $h_{sp} = P_{abs}/\gamma$

$P_{abs} = P_{atm} + P_{tank}$ $h_{sp} = P_{ab} + P_{tank}/\gamma$

$NPSH_A = h_{sp} \pm h_s - h_f - h_{vp} = \left(\frac{P_{atm} + P_{tank}}{\gamma}\right) \pm h_s - h_f - h_{vp}$

$P_{tank} = [\gamma (NPSH_A + h_s + h_f + h_{vp})] - P_{atm}$

$\gamma = 0.48 \cdot 9.81 = 4.7088 kN/m^3$

$P_{tank} = [4.7088 \times (1.5 + 1.84 + 0.92 + 340)] - 98.4$

$= 1522.65149 = \boxed{1522.65 kN/m^2}$

Design Prob 3

$P_{required} = \frac{62.4 lb/ft^3 \times 32.2 ft/s^2 \times 55 ft \times 1500 gal/min}{3.6 \times 10^6}$

$= 46.05 kW$

$= \boxed{61.7 Hp}$

$Q = A \times V$

$Q = \pi/4 \times d^2 \times V$

$1500 \times 2.22 \times 10^{-3} = \pi/4 \times d^2 \times 67.64$

diameter of pipe $= \boxed{0.26 ft}$

$\cancel{P}/\rho g + \cancel{V^2}/2g + z = \frac{P}{\rho g} + V^2/2g + z$

$55 ft = \frac{2116}{62.18 \times 32.2} + \frac{V^2}{2 \times 32.2} + 125$

$\boxed{67.65 ft/s}$