Homework #2-3

Ch 13 Pump Selection and Application

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Homework 2.3

1) The efficiency and power required are important to the successful operation of a pump. Most centrifugal pumps can be operated at different speeds to obtain varying capacities. The capacity, head, and power vary when either the speed or impeller diameter is varied. These relationships are called affinity laws. Net positive suction head required (NPSH) is an important factor to consider in applying a pump. Low NPSH is desirable. NPSH prevents cavitation. NPSH margin must be a minimum of 10 percent. The $NPSH_A$ is dependent on the vapor pressure of the fluid being pumped, energy losses in the suction piping, the elevation of the fluid reservoir, and the pressure applied to the fluid in the reservoir.

Chapter 13: 22, 23, 25, 34 (only 2), 17, 19, 55, 65

22) Describe each part of this centrifugal pump designation: 1½×3-6

X×Y-Z 1½ in discharge connection, 3 in suction connection, 6 in or smaller casting size in impeller diameter

23) Specify size for delivering 100 gal/min of water at a total head of 300 ft from the composite rating chart. Pump size = 1½×3-10

25) For the 2×3-10 centrifugal pump, describe the performance that can be expected from a pump with an 8-in impeller operating against a system head of 200 ft. Give the expected capacity, the power required, the efficiency, and the required NPSH.

From the graph with system head of 200 ft $Q = 230$ gal/min

power required for pump $P = 22$ hp

efficiency of the pump $e = 54\%$

Flow rate is 230 gal/min and 8 in impeller NPSH = 11 ft

List appropriate type of pump

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

From the pump selection chart **rotary pump or reciprocating pump**

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

From the pump section chart **high speed centrifugal pump**

17) For a given centrifugal pump, if the speed of rotation of impeller is cut in half, how does the total head capability change?

$\frac{h_{a1}}{h_{a2}} = \left(\frac{N_1}{N_2}\right)^2$ $N_2 = \left(\frac{N_1}{2}\right)$ $\rightarrow$ $\frac{h_{a1}}{h_{a2}} = \left[\frac{N_1}{\left(\frac{N_1}{2}\right)}\right]^2$ $h_{a2} = \frac{h_{a1}}{4}$ **reduced by 4**

19) For a given size of centrifugal pump casing, if the diameter of its impeller is reduced by 25 percent, how much does the capacity change?

$\frac{Q_1}{Q_2} = \frac{D_1}{D_2}$ $D_2 = 0.75D_1$ $\frac{Q_2}{Q_1} = \frac{D_1}{0.75D_1}$ $\rightarrow$ $\frac{Q_1}{Q_1} = \frac{1}{0.75}$ $Q_2 = 0.75(Q_1)$

total capacity of the pump is reduced by **25%**

55) Determine the available NPSH for the system

$\gamma = 9.53\ KN/m^3$ $\nu = 3.6\times10^{-7}\ m^2/s$ DN80 = 77.9 mm DN80 $A = 4.768\times10^{-3}\ m^2$

$\epsilon = 4.6\times10^{-5}\ m$ $h_{sp} = \frac{P_{atm}}{\gamma} = \frac{101.8}{9.53} = 10.68\ m$ $V = \frac{Q}{A} = \frac{300\times10^{-3}}{4.768\times10^{-3}\times60} = 1.048\ m/s$

$N_R = \frac{VD}{\nu} = \frac{1.048\times0.0779}{3.6\times10^{-7}} = 2.26\times10^5$ $\frac{D}{\epsilon} = \frac{0.0779}{4.6\times10^{-5}} = 1693.478$ $f = 0.019$

DN50 = 52.5 mm DN50 $A = 2.168\times10^{-3}\ m^3$ $V = \frac{Q}{A} = \frac{300\times10^{-3}}{2.168\times10^{-3}\times60} = 2.306\ m/s$

$N_R = \frac{VD}{\nu} = \frac{2.306\times0.0525}{3.6\times10^{-7}} = 3.36\times10^5$ $\frac{D}{\epsilon} = \frac{0.0525}{4.6\times10^{-5}} = 1141.304$ $f = 0.025$

$h_1 = f\cdot\left(\frac{L}{D}\right)\cdot\frac{v^2}{2g} = 0.019\times\frac{2}{0.0779}\times\frac{1.048^2}{2\times9.81} = 0.027\ m$

$h_2 = K\frac{v^2}{2g} = 75\times0.018\times\frac{1.048^2}{2\times9.81} = 0.075\ m$

$h_3 = 20\times f\cdot\frac{v^2}{2g} = 20\times0.018\times\frac{1.048^2}{2\times9.81} = 0.02\ m$

$h_4 = f\left(\frac{L}{D}\right)\cdot\frac{v^2}{2g} = 0.025\times\frac{1.5}{0.0525}\times\frac{2.306^2}{2\times9.81} = 0.19\ m$

$h_L = 0.027 + 0.075 + 0.02 + 0.19 =$ **0.312 m = NPSH**

65) $S_g = 0.48$ $T = 45°C$ $h_f = 0.92\ m$ $P_{atm} = 98.4\ kPa$ $NPSH_A = 1.50\ m$

$NPSH_A = h_{sp} \pm h_s - h_f - h_{sp}$ $h_{sp} = \frac{P_{abs}}{\gamma}$ $P_{abs} = P_{atm} + P_{tank}$ $h_{sp} = \frac{P_{atm}+P_{tank}}{\gamma}$

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

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

$\gamma = (0.48)(9.81) = 4.71\ KN/m^3$ h_{vp} @ $45°C = 340\ m$

$P_{tank} = (4.71\times(1.5 + 1.84 + 0.92 + 340)) - 98.4$

$P_{tank} = 1523.06\ KN/m^3$

Chapter 13: 22, 23, 25, 34 (only 2) 17, 19, 55, 65

1 We learned about affinity laws. We also learned that the efficiency and power for a pump are important. Net positive suc head required or (NPSH is a factor when getting a pum NPSH$_A$ depends on the fluid, energy losses in suction piping, elevation of fluid, and pressure.

13.22 x Y z 1 ½ in discharge connection, 3 in suction connection, or smaller casting size in impeller diameter

13.23 Pump size: 1 ½ × 3-10

13.25 Q = 230 gal/min
P = 22 hp Power
e = 54% efficiency
NPSH = 11 ft

13.34 a) rotary pump or reciprocating pump
b) high speed centrifugal pump

13.17 $\frac{h_{a_1}}{h_{a_2}} = \left(\frac{N_1}{N_2}\right)^2$ $N_2 = \frac{N_1}{2}$ $\frac{h_{a_1}}{h_{a_2}} = \left(\frac{N_1}{\left(\frac{N_1}{2}\right)}\right)^2$ $h_{a_2} = \frac{h_a}{4}$

reduced by 4

13.19 $\frac{Q_1}{Q_2} = \frac{D_1}{D_2}$ $D_2 = 0.75 D_1$ $\frac{Q_1}{Q_1} = \frac{D}{0.75 D_1}$ $\rightarrow \frac{Q_1}{Q_1} = \frac{1}{0.75}$ $Q = 0.75(Q_1)$

reduced by 25%

13.55 $\gamma = 9.53\ kN/m^3$
$\nu = 3.6 \times 10^{-7}\ m^2/s$
DN 80 = 77.9 mm
DN 80 $A = 4.768 \times 10^{-3}\ m^2$
$\varepsilon = 4.6 \times 10^{-5}\ m$ $h_{sp} = \frac{P_{atm}}{\gamma} = \frac{101.6}{9.53} = 10.66\ m$ $V = \frac{Q}{A} = \frac{300 \times 10^{-3}}{4.768 \times 10^{-3} \times 60} = 1.048\ m/s$

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

$\frac{D}{\varepsilon} = \frac{0.0779}{4.6 \times 10^{-5}} = 1693.478$ $f = 0.019$

DN 50 = 52.5 mm DN 50 $A = 2.168 \times 10^{-3}\ m^3$ $V = \frac{Q}{A} = \frac{300 \times 10^{-3}}{2.168 \times 10^{-3} \times 60}$
$= 2.306\ m/s$

$N_R = \frac{vD}{\nu} = \frac{2.306 \times 0.0525}{3.6 \times 10^{-7}} = 3.36 \times 10^5$ $\frac{D}{\varepsilon} = \frac{0.0525}{4.6 \times 10^{-5}} = 1141.304$

$f = 0.0255$

$h_1 = f \cdot \frac{L}{D} \cdot \frac{v^2}{2g} = 0.019 \times \frac{2}{0.0779} \times \frac{1.048^2}{2(9.81)} = 0.027\ m$

$h_2 = K \frac{v^2}{2g} = 75 \times 0.018 \times \frac{1.0483}{2 \times 9.81} = 0.075$

$h_3 = 20 \cdot f \cdot \frac{v^2}{2g} = 20 \cdot 0.018 \cdot \frac{1.0483}{2 \cdot 9.81} = 0.02\ m$

$h_{ff} = f\left(\frac{L}{D}\right) \cdot \frac{v^2}{2g} = 0.025 \times \frac{1.5}{0.0525} \cdot \frac{2.306^2}{2 \cdot 9.81} = 0.19\,m$

$h_L = 0.027 + 0.075 + 0.02 + 0.19 = \underline{\underline{0.312\,m}} = NPSH$

13.65 $sg = 0.48$

$T = 45°C$

$h_f = 0.92\,m$

$P_{atm} = 98.4\ kPa$

$NPSH_A = 1.50\,m$

$NPSH_A = h_{sp} + h_s - h_f - h_{sp}$ $\quad h_{sp} = \frac{P_{abs}}{\gamma}$ $\quad P_{abs} = P_{atm} + P_{tank}$ $\quad h_{sp} = \frac{P_{atm} + P_{tank}}{\gamma}$

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

$P_{tank} = \gamma\,(NPSH_A + h_s + h_f + h_{sp})) - P_{atm}$

$\gamma = 0.48 \cdot 9.81 = 4.71\ kN/m^3 \qquad h_{vp}\ @\ 45°C = 340\,m$

$P_{tank} = (4.71 \cdot (1.5 + 1.84 + 0.92 + 340)) - 98.4$

$= \underline{\underline{1523.04\ kN/m^3}}$

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What I learn in class HW2-3

We learned how to find the right fittings for pipes and pumps. We used the 60Hz versions from a chart. Affinity law is used to select the diameter. It is also used to change the RPM. In Cavatation, we looked at the reasons the energy and prassure drops in a inlet suction. NPSH stands for Net Positive Suction Head. The margin needs to be at least 10%. NPSH depends on the vapor pressure of fluid being pump.

CH 13

22, 23, 25, 34 (only 2), 17, 19, 55, 65

22. Describe each part of this centrifugal pump designation $1\frac{1}{2} \times 3 - 6$

X × Y − Z

X = size of the discharge connection

Y = size of the suction connection, in nominal inch

Z = casing size in nominal inch that can accommodate an impeller

23. For the line of pumps shown in fig 13.22, specify a suitable size for delivering 100 gal/min of water at a total head of 300 ft

Q = 100 gal/min   H = 300 ft

Based chart $\boxed{1\frac{1}{2} \times 3 - 10}$

25. For 2 × 3 − 10 centrifugal, describe the performance that can be expected from a pump with an 8 in impeller operating against a system head of 200 ft.

Based on fig

capacity = Q = 230 gal/min

Power = P = 22 hp

efficiency = e = 54%

If 230 gal/min   Net positive suction head (NPSH) = 11 ft

34. Only 2. Find the best pump(s) based on specification

(a) Q = 500 gal/min   H = 80 ft

From pump chart   - reciprocating pump and rotary pump

(b) Q = 500 gal/min   H = 800 ft

- high speed centrifugal pump

17. For given centrifugal pump, if speed of rotation of the impeller is cut in half, how does the total head capability change?

$$\text{pump } \frac{h_{a_1} \text{ (Initial)}}{h_{a_2} \text{ (Final)}} = \left(\frac{N_1}{N_2}\right)^2 \text{ impeller}$$

If impeller is cut in half $N_2 = \frac{N_1}{2}$

$$\frac{h_{a_1}}{h_{a_2}} = \left[\frac{N_1}{\frac{N_1}{2}}\right]^2 = \frac{h_{a_1}}{h_{a_2}} = 4$$

$$\boxed{h_{a_2} = \frac{h_{a_1}}{4}}$$

19 For a given size of centrifugal pump casing if the diameter of the impeller is reduced by 25%, how much does the capacity change

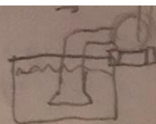
Eq 13-8

$$\frac{Q_1}{Q_2} = \frac{D_1}{D_2} \qquad \overset{25\%}{D_2 = 0.75 D_1}$$

$$\frac{Q_1}{Q_2} = \frac{D_1}{0.75 D_1} = \frac{1}{0.75}$$

$$Q_2 = 0.75(Q_1)$$

Final capacity of the pump is $\boxed{75\%}$



1

13.5 Determine the available NPSH for the system shown in figure 13.38(b)

Table A.1 $\gamma = 9.53\ kN/m^3$

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

Table F.1 $D_{80} = 77.9\ mm = 0.0779\ m$

$A_{80} = 4.769 \times 10^{-3}\ m^2$

Table 9.2 steel material

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

static pressure head $h_{sp} = \frac{P_{atm}}{\gamma} = \frac{101.8}{9.53} = 10.68\ m$

DN 80

$V = \frac{Q}{A_{80}} = \frac{300 \times 10^{-3}}{4.769 \times 10^{-3}}$

$= 1.048\ m/s$

Reynold's #

$N_R = \frac{V_{80} D_{80}}{\nu} = \frac{(1.048\ m/s)(0.0779\ m)}{3.6 \times 10^{-7}}$

$N_R = 2.26 \times 10^5$

$\frac{D_{80}}{\varepsilon} = \frac{0.0779}{4.6 \times 10^{-5}} = 1693.478$

Moody diagram 9.7 $f_{80} = 0.019$

DN 50

$V = \frac{Q}{A_{50}} = \frac{300 \times 10^{-3}}{(2.168 \times 10^{-3})(60)} = 2.306\ m/s$

Reynold's #

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

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

$f_{50} = 0.025$

energy loss

$h_1 = f_{80}\left(\frac{L}{D}\right)\left(\frac{V_{80}^2}{2g}\right) = 0.019\left(\frac{2}{0.0779}\right)\left(\frac{1.048^2}{2 \times 9.81}\right)$

$h_1 = 0.0273$

$k = 75(0.018)$

$h_2 = K_1 \frac{V_{80}^2}{2g} = 75(0.018)\left(\frac{1.048^2}{2 \times 9.81}\right)$

$h_2 = 0.075571\ m$

4

$f_{3T} = 0.018$

$$h_3 = 20\,(f_{3T})\left(\frac{v_{30}^2}{2g}\right) = 20\,(0.018)\left(\frac{1.098^2}{(2)(9.81)}\right)$$

$= 0.02178\,m$

$$h_1 = f_{50}\left(\frac{L}{D}\right)_{50}\left(\frac{v_{50}^2}{2g}\right) = 0.025\left(\frac{1.5}{0.0525}\right)\left(\frac{2.306^2}{2(9.81)}\right)$$

$= 0.1935\,m$

$h_L = h_1 + h_2 + h_3 + h_4$

$h_L = 0.3238\,m$

$NPSH = h_{sp} \pm h_L - h_{vp} - h_s$

$= 10.682 - 2 - 0.3238 - 4.967$

$= 3.391\,m$

$NPSH = 3.4\,m$

63 $NPSH_a \geq 150.0\,m$

Propane @ 45°C

$sg = 0.48$ $p_{atm} = 94.7\,kPa$ absolute $h_s = 1.84\,m$

$h_f = 0.92$ $h_{sp} = 340\,m$

$h_{sp} = NPSH_a$

$h_s + h_f + h_{vp} = 1.50 + 1.84 + 0.92 + 340 = 344.3\,m$

$P_{sp} = (0.48)(9.81\,kN/m^3)(344.3\,m)$

$= 1621\,kN/m^2$

$P_{tank} = (P_{sp})(P_{atm}) =$

$= (1621\,kPa)(1621\,kPa) =$

$= 1523\,kPa$ gage