MET 330

HOMEWORK 2.4

CHAPTER 13

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13-22) CENTRIFUGAL PUMP DESIGNATION:

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

6 in. CASING-SIZE OF LARGEST IMPELLER

$1\frac{1}{2}$ in. NOMINAL DISCHARGE CONNECTION SIZE

3 in. NOMINAL SUCTION CONNECTION SIZE

13-23) FOR A PUMP TO DELIVER 100 gal/min OF WATER AT A TOTAL HEAD OF 300 ft (ACCORDING TO FIG. 13.22), THE PUMP NEEDED WILL BE:

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

13-25) FOR THE 2 × 3 − 10 CENTRIFUGAL PUMP PERFORMANCE CURVE (IN FIG. 13.28), THE EXPECTED PERFORMANCE FROM A PUMP WITH AN 8-in. IMPELLER OPERATING AGAINST A SYSTEM HEAD OF 200 ft. IS:

EXPECTED CAPACITY → $Q = 280$ gal/min

POWER REQUIRED → $P = 26$ hp

EFFICIENCY → $e = 53\%$

NPSH → $NPSH_R = 10.9$ ft

13-34) APPROPRIATE TYPE OF PUMP:

a) 500 gal/min OF WATER AT 80 ft OF TOTAL HEAD

ROTARY OR 3500 RPM CENTRIFUGAL

b) 500 gal/min OF WATER AT 800 ft OF HEAD

ROTARY

13-17) IF THE SPEED OF ROTATION OF THE IMPELLER IS CUT IN HALF, HOW DOES THE TOTAL HEAD CAPABILITY CHANGE?

$$h_{a_2} = h_{a_1}\left(\frac{N_2}{N_1}\right)^2 = h_{a_1}\left(\frac{0.5\,N_1}{N_1}\right)^2 = 0.25\,h_{a_1}$$

h_a IS DIVIDED BY 4

13-19) FOR A GIVEN SIZE OF CENTRIFUGAL PUMP CASING, IF THE DIAMETER OF THE IMPELLER IS REDUCED BY 25%, HOW MUCH DOES THE CAPACITY CHANGE?

$$Q_2 = Q_1 \frac{D_2}{D_1} = Q_1 \frac{0.75\,D_1}{D_1} = 0.75\,Q_1$$

25% REDUCTION

CONTINUED

13-55) GIVEN: WATER TEMPERATURE = 80°C
ATMOSPHERIC PRESSURE = 101.8 kPa
WATER LEVEL IN TANK = 2.0 m BELOW PUMP INLET
VERTICAL LEG (SUCTION LINE) = DN 80 SCHEDULE 40 STEEL PIPE
HORIZONTAL LEG = DN 50 SCHEDULE 40 PIPE (1.5 m LONG)
ELBOW = LONG RADIUS TYPE
FOOT VALVE AND STRAINER = HINGED DISK TYPE
FLOW RATE = 300 L/min

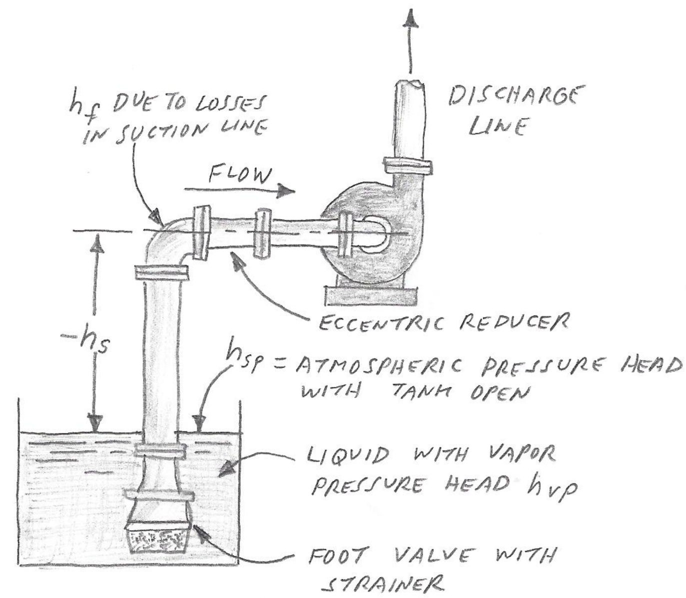
FIND: THE AVAILABLE NPSH FOR THE SYSTEM

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

$$h_{sp} = \frac{P_{ATM}}{\gamma} = \left(\frac{101.8\ kN}{m^2}\right)\left(\frac{m^3}{9.53\ kN}\right) = 10.68\ m$$

$$h_s = 2.0\ m$$

$$h_{vp} = 4.8\ m$$



$$h_f = \underbrace{f_3\left(\frac{L}{D}\right)_3\left(\frac{V_3^2}{2g}\right)}_{\text{FRICTION 3 in}} + \underbrace{K_1\frac{V_3^2}{2g}}_{\text{FOOT VALVE}} + \underbrace{f_{3T}(20)\frac{V_3^2}{2g}}_{\text{ELBOW}} + \underbrace{f_2\left(\frac{L}{D}\right)_2\frac{V_2^2}{2g}}_{\text{FRICTION 2 in}}$$

$$f_{3T} = 0.018$$

$$K_1 = 75 f_{3T} = 75(0.018) = 1.35$$

$$V_3 = \frac{Q}{A_3} = \left(\frac{300\ L/min}{4.768 \times 10^{-3}\ m^2}\right)\left(\frac{1\ m^3/s}{60000\ L/min}\right) = \frac{1.05\ m}{s}$$

$$\frac{V_3^2}{2g} = \frac{(1.05)^2}{2(9.81)} = 0.0560\ m$$

$$N_{R_3} = \frac{V_3 D_3}{\nu} = \frac{(1.05)(0.0779)}{3.60 \times 10^{-7}} = 2.3 \times 10^5$$

$$\frac{D_3}{\varepsilon} = \frac{0.0779}{4.6 \times 10^{-5}}(1) = 1694$$

$$f_3 = 0.0195$$

$$V_2 = \frac{Q}{A_2} = \frac{(300\ L/m)/(60000\ L/m)}{2.168 \times 10^{-3}} = \frac{2.31\ m}{s}$$

$$\frac{V_2^2}{2g} = \frac{(2.31)^2}{2(9.81)} = 0.271\ m$$

$$N_{R_2} = \frac{V_2 D_2}{\nu} = \frac{(2.31)(0.0525)}{3.60 \times 10^{-7}} = 3.4 \times 10^5$$

$$\frac{D_2}{\varepsilon} = 1141 \qquad f_2 = 0.0202$$

$$h_f = (0.0195)\frac{2.0\ m}{0.0779\ m}(0.056\ m) + 1.35(0.056) + (0.018)(20)(0.056) + (0.0202)\frac{1.5}{0.0525}(0.271)$$

$$h_f = 0.280\ m$$

$$NPSH_a = 10.68 - 2.0 - 0.280 - 4.97 \longrightarrow NPSH_a = 3.43\ m$$

13-65) GIVEN: PUMP DRAWS PROPANE AT 45°C

s.g. = 0,48

LEVEL IN TANK IS 1.84 m BELOW PUMP INLET

ENERGY LOSSES IN SUCTION LINE = 0.92 m

ATMOSPHERIC PRESSURE = 98.4 kPa ABSOLUTE

DETERMINE: FIND THE REQUIRED PRESSURE ABOVE THE PROPANE IN THE TANK TO ENSURE THAT THE $NPSH_A$ IS AT LEAST 1.50 m

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$h_{vp} = 340\,m$

$(NPSH_R)_2 = \left(\frac{N_2}{N_1}\right)^2 (NPSH_R)_1$

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

$P_{sp} = \gamma h_{sp} = (0.48)(9.81\,kN/m^3)(344.3\,m) = 1621\,kN/m^2 = 1621\,kPa$ ABSOLUTE

GAGE PRESSURE: $P_{TANK} = P_{sp} - P_{ATM} = 1621\,kPa - 98.4\,kPa$

GAGE PRESSURE: $P_{TANK} = 1523\,kPa$ GAGE