8.38

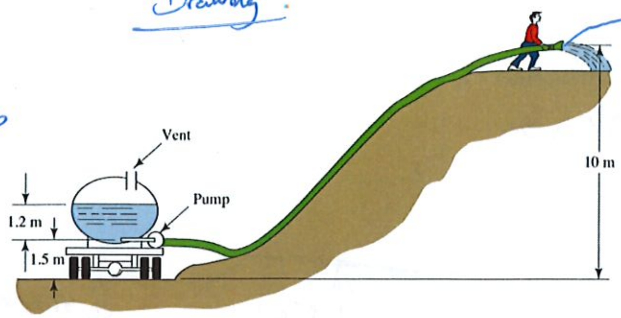
Doris Beck

Purpose

a) Calculate Power delivered by Pump

b) Pressure at the outlet of pump Point A =

Drawing



Nozzle requires 140kpa

Design consideration

The following must be assumed

- incompressible fluid
- isothermal process
- steady state

Data and variables

- Dimensions provided by drawing
- Hose ID = 25mm = 0.025m
- Solution specific gravity = 1.10 = sg
- dynamic viscosity = 2.0×10^{-3} Pa·s = η
- Hose length = 85m
- Flow rate = 95 L/min

- $\rho = 1.10\times1000\ kg/m^3 = 1100\ kg/m^3$
- $\gamma = 1.10\times9.81\ kN/m^3 = 10.791\ kN/m^3$

$V=\frac{Q}{A}$

$A=\frac{\pi D^2}{4} = \frac{\pi(0.025)^2}{4} = 4.9087\times10^{-4}\ m^2$

$Q = 95\ L/min\left(\frac{m^3}{1000L}\right)\left(\frac{1min}{60s}\right) = 0.001583\ m^3/s$

$V=\frac{Q}{A} = \frac{0.001583\ m^3/s}{4.9087\times10^{-4}\ m^2} = 3.2188\ m/s$

a)

$$\frac{P_1}{\gamma}+z_1+\frac{v_1^2}{2g}+h_A = \frac{P_2}{\gamma}+z_2+\frac{V_2^2}{2g}+h_L$$

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

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

$$= \frac{140\ kN/m^2}{10.791}+(10-2.7)+\left(\frac{3.2188^2}{2(9.81)}\right)+41.2160$$

$$= 61.9887\ m$$

$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$

$N_R = \frac{vD\rho}{\eta} = \frac{(3.2188)(0.025)(1100)}{2.0\times10^{-3}} = 44{,}258.5$

$\frac{D}{\epsilon} = \frac{0.025}{3.0\times10^{-7}} = 83{,}333.33$

using friction factor formula

$f = 0.022$ or 0.0234

$h_L = 0.022\left(\frac{85}{0.025}\right)\left(\frac{3.2188^2}{2(9.81)}\right) = 41.2160\ m$

$P = \gamma Q h_A$

$= (10.791\ kN/m^3)(0.001583\ m^3/s)(61.9887\ m)$

$= 1.059\ \frac{kN\cdot m}{s}$

$\boxed{=1.059\ kW}$

b)

$$\frac{P_3}{\gamma}+z_3+\frac{V_3^2}{2g}-h_L = \frac{P_2}{\gamma}+z_2+\frac{V_2^2}{2g}$$

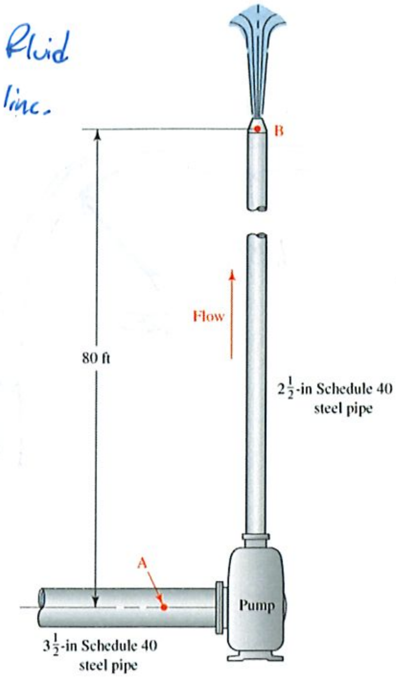
$$P_3 = \left(\frac{P_2-P_3^{\,0}}{\gamma}+(z_2-z_3)+\frac{V_2^2-V_3^{2\,0}}{2g}+h_L\right)\gamma$$

$$= \left(\frac{140}{10.791}+(10-1.5)+\frac{3.2188^2}{2(9.81)}+41.2160\right)10.791$$

$\boxed{=682.18\ Kpa}$

Purpose 8.44)

Compute the power delivered by the pump to the fluid considering friction energy loss in the discharge line.



Design Considerations

- Incompressible fluid
- isothermal process
- steady state

Data and Variables

Pressure at Point B = 25 psig
Pressure at Point A = -3.5 psig
Volume flow rate = 0.50 ft³/s
Dynamic viscosity = 4.0×10^{-5} lb·s/ft²
Sg = 1.026 × 62.416 lb/ft³ = 64.0388 lb/ft³
Consider friction energy loss

$$h_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$$

$$h_A = \frac{P_B - P_A}{\gamma} + (z_B - z_A) + \frac{V_B^2 - V_A^2}{2g} + h_L$$

$$= \frac{25-(-3.5)}{64.0388} + (80-0) + \frac{(14.6678)^2 - (7.4836)^2}{2(32.2)} + 23.0918$$

$$= 106.0075 \text{ ft}$$

$$P = \gamma Q h_A$$

$$= 64.0388(0.50)(106.0075)$$

$$= 3394.0075 \text{ ft·lb/s} * \frac{1 \text{ ft·lb/s}}{550 \text{ hp}}$$

$$\boxed{= 6.17 \text{ hp}}$$

$$V = \frac{Q}{A}$$

$$A_A = \frac{\pi D^2}{4} = \frac{\pi (3.5)^2}{4} = 9.6211 \text{ in}^2$$

$$A_B = \frac{\pi (2.5)^2}{4} = 4.9087 \text{ in}^2$$

$$V_A = \frac{0.5 \text{ ft}^3/\text{s}}{(9.6211 \text{ in}^2)\left(\frac{1 \text{ ft}^2}{144 \text{ in}^2}\right)} = 7.4836 \text{ ft/s}$$

$$V_B = \frac{0.5 \text{ ft}^3/\text{s}}{(4.9087 \text{ in}^2)\left(\frac{1 \text{ ft}^2}{144 \text{ in}^2}\right)} = 14.6678 \text{ ft/s}$$

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V_B^2}{2g}\right)$$

$$N_R = \frac{v D \rho}{\eta} = \frac{(14.6678)\left(\frac{2.5}{12}\right)(64.0388)}{4.0 \times 10^{-5}} = 4{,}892{,}230.78$$

$$\frac{D}{\varepsilon} = \frac{\left(\frac{2.5}{12}\right)}{1.5 \times 10^{-4}} = 1388.8889$$

$f = 0.018$ or 0.01827 using friction factor formula

$$h_L = 0.018\left(\frac{80}{\left(\frac{2.5}{12}\right)}\right)\left(\frac{14.6678^2}{2(32.2)}\right) = 23.0913 \text{ ft}$$

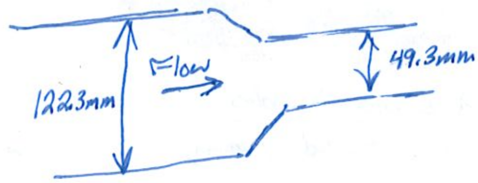
10.20)

Purpose

determine energy loss for sudden contraction from DN 125 sch 80 steel pipe to a DN 50 sch 80 pipe.

Design considerations

- Incompressible fluids
-



Data and Variables

Flow rate = 500L/min

Cone angle for the contraction = 105°

Information provided by Dwg

DN 125 sch 80 pipe ID = 122.3mm
DN 50 sch 80 pipe ID = 49.3mm
} from Table F.2

$$\frac{D_1}{D_2} = \frac{122.3mm}{49.3mm} = 2.4807$$

$$V_2 = \frac{Q}{A} = \frac{500 L/m}{1.905\times10^{-3} m^2} \times \frac{1 m^3/s}{60000 L/min} = 4.3745 m/s$$

$$K = 0.38$$

$$h_L = K(V_2^2/2g) = 0.38\left(\frac{(4.3745 m/s)^2}{2(9.81 m/s^2)}\right)$$

$$\boxed{= 0.3706m}$$

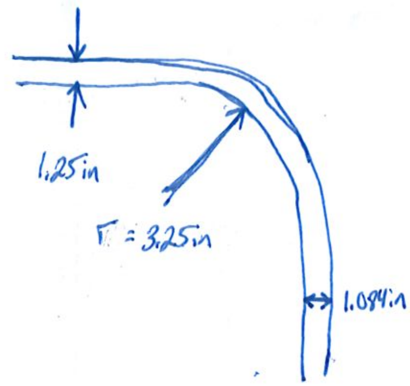
10.48)

Purpose

Calculate energy loss

Design consideration

- Incompressible fluid
- Isothermal process
-



Data and Variables

90° Bend steel tube

OD = 1 1/4 in

Wall thickness = 0.083 in

Mean bend radius = 3.25 in

Flow rate of hydralic oil = 27.5 gal/min

Table 6.1

$A = 6.409 \times 10^{-3}$

ID = 1.084 in

$$\frac{r}{D} = \frac{\left(\frac{3.25}{12}\right)}{\left(\frac{1.084}{12}\right)} = 2.9981$$

$$\frac{D}{\varepsilon} = \frac{\left(\frac{1.084}{12}\right)}{1.5\times10^{-4}} = 602.222$$

$$f_T = 0.022$$

$$h_L = K\left(\frac{V^2}{2g}\right) = 0.66\left(\frac{9.5564\ ft/s^2}{2(32.2\ ft/s)}\right)$$

$$\boxed{= 0.9359\ ft}$$

$$K = f_T\left(\frac{Le}{D}\right) = 0.022(30) = 0.66$$

$$V = \frac{Q}{A} = \frac{27.5\ gal/min}{6.409\times10^{-3}\ ft^2} \times \frac{1\ ft^3/s}{449\ gal/min} = 9.5564\ ft/s$$