Colby Watts
MET 330 Test 1
2/9/2024

Colby Watts Test 1

A

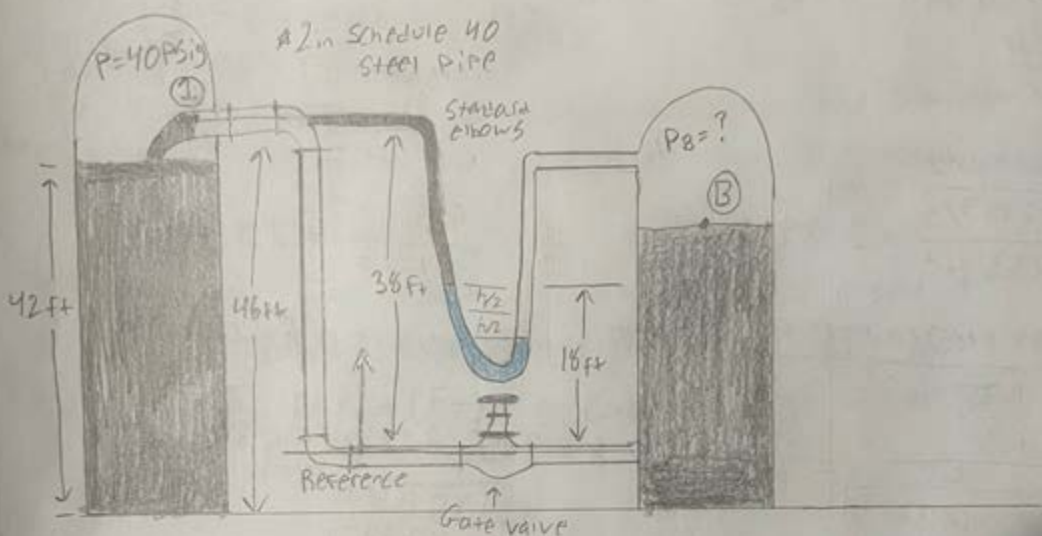
① Purpose

Determine required air pressure in the tank on the right in order to deliver 250 gpm of ethyl alcohol.

Drawings & Diagram

Mercury

ethyl Alcohol



- Sources

"Applied Fluid Mechanics" 8th edition

Notes & Problems Solved in Class

Moody Chart Calculator online "Advanced Delphi Systems" website

Conversion Calculator online

Data acquired from diagram and description

$P_1 = 40$ psig   2in Schedule 40 Diameter = 0.1723 ft (Appendix Table F1)

$T = 77^\circ F$ $L = 110$ ft   Pipe Roughness $= 1.5 \cdot 10^{-4}$ ft (Table 8.2)

$Q = 250$ gpm $= .557\ ft^3/s$ $g = 32.2\ ft/s^2$

Specific weight of ethyl Alcohol $\gamma = 49.01\ lb/ft^3$ $\rho = 1.53\ \frac{slugs}{ft^3}$

viscosity $= 1.37 \cdot 10^{-5}\ ft^2/s$ (Acquired From Appendix B)

Area of Pipe $= 0.0233\ ft^2$ (Appendix F)

Procedure

$$\frac{P_B}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_1}{\gamma} + \cancel{\frac{V_2^2}{2g}}^{\,0} + \cancel{z_2}^{\,0} + h_{L1B} \qquad V = \frac{Q}{A}$$

$$K = 20 f_T$$

$$\frac{P_B}{\gamma} = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 - h_{L1B} \qquad f_T = \frac{.5}{\log\left(\frac{1}{(3.7)(D/\varepsilon)}\right)}$$

$$h_{L1B} = f\,\frac{L}{D}\,\frac{V^2}{2g} + 2 \cdot K\,\frac{V^2}{2g}$$

relative roughness $= \left(\frac{\varepsilon}{D}\right)$

$$Re = \frac{VD}{\nu}$$

roughness $(\varepsilon) = 5.0 \cdot 10^{-6}$ ft
(Table 8.2)

Calculations

$$V = \frac{.557\ ft^3/s}{0.0233\ ft^2} = 2.39\ ft/s \qquad \frac{\varepsilon}{D} = \frac{5.0 \cdot 10^{-6}}{0.1723} = 2.9 \cdot 10^{-5}$$

$$Re = \frac{(2.39\ ft/s)(0.1723\ ft)}{1.37 \cdot 10^{-5}} = 3 \cdot 10^{4} \qquad \text{moody chart} = f = 0.023$$

$$f_T = \frac{.5}{\log\left(\frac{1}{(3.7)(2.9 \cdot 10^{-5})}\right)} = 0.019 \qquad K = 20 f_T = (20)(0.019) = .38$$

$$h_{L1B} = (0.023)\left(\frac{110}{0.1723}\right)\left(\frac{2.39^2}{2(32.2)}\right) + 2 \cdot (.38)\left(\frac{2.39^2}{2(32.2)}\right) = 1.37$$

$Z_1 = 20ft = 240 in$ $\quad V = 2.39\ ft/s = 68.52\ in/s^2$ $\quad g = 32.2 \cdot 2 = 64.4\ ft/s^2$

$\gamma = 49.01\ lb/ft^3 = 0.0283\ lb/in^3$ $\quad P = 40\ lb/in^2$ $\quad g = 64.4\ ft/s^2 = 772.8\ in/s^2$

$$\frac{P_B}{0.0283\ lb/in^2} = \frac{40\ lb/in^2}{.0283\ lb/in^3} + \frac{(68.52\ in/s^2)}{2(772.8\ in/s^2)} + 240 in - 1.37$$

$$\cancel{0.0283} \cdot \frac{P_B}{\cancel{0.0283\ lb/in^3}} = 1670.23\ psi \cdot 0.0283\ psi$$

$$\boxed{P_B = 46.76\ psi}$$

For the first part of the test I calculated pressure in the right tank using Bernoulli's equation.

$$\frac{P_B}{\gamma} = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} - Z_1 - h_{L1B}$$

To calculate for energy loss due to piping and angle fittings the equation I used was

$$h_{L1B} = f \frac{L}{D} \frac{V^2}{2g} + 2 \cdot K \frac{V^2}{2g}$$

To find f and K I used velocity, the Diameter and the kinematic viscosity to calculate for Reynolds number.

$$Re = \frac{VD}{\nu}$$

To calculate for moody's chart I also used the relative roughness equation $\left(\frac{\varepsilon}{D}\right)$. Now that goes into my friction factor (f_T) to calculate for pipe angle loss.

$$f_T = \frac{.5}{\log\left(\frac{1}{(3.7)(D/\varepsilon)}\right)}$$

For K I used $K = 20 f_T$ for pipe minor loss.

I plugged my values into the h_{L1B} equation which I can use for my Bernoulli's equation. I converted all units that has ft/s to in/s so my end value would be in psig.

Part 1 $\boxed{B}$

Purpose

Determine manometer reading

Procedure

$\Delta P = \gamma \cdot h$

$P_A - P_B = \gamma_{Hg} \cdot h - \gamma_{EA} \cdot h$

(Appendix B
Table B_2)

$\gamma_{EA} = 49.01\ lb/ft^3 \quad sg = .787$

$\gamma_{Hg} = 844.9\ lb/ft^3 \quad sg = 13.54$

$\gamma_{EA} = \gamma_{EA} \cdot sg(Hg)$

$\gamma_{Hg} = \gamma_{Hg} \cdot sg(EA)$

$h/2 = 18ft = 9ft$

$46ft - 38ft = 8ft$

Calculations

$\gamma_{EA} = 49.01\ lb/ft^3 \cdot 13.54 = 663.59\ lb/ft^3$

$\gamma_{Hg} = 844.9\ lb/ft^3 \cdot .787 = 664.93\ lb/ft^3$

$P_A - P_B = 664.93\ lb/ft^3 \cdot 9ft - 663.59\ lb/ft^3 \cdot 8ft$

$P_A - P_B = 5984.4267\ lb/ft^2 - 5308.7632\ lb/ft^3$

$P_A - P_B = 675.6635\ lb/ft^2 = \boxed{4.68\ Psi}$

To calculate the manometer reading I used a derivation of the Gamma · h equation.

$$\Delta P = \gamma \cdot h$$

which turned into

$$P_A - P_B = \gamma_{(Hg)} \cdot h - \gamma_{(EA)} \cdot h$$

to get specific weights I then calculated from pressure measurement problem chapter 3.

$$\gamma_{(Hg)} = \gamma(Hg) \cdot Sg(EA)$$

$$\gamma_{(EA)} = \gamma(EA) \cdot Sg(Hg)$$

Then I calculated that into the above equation and multiplied by the heights. Since the height of mercury is $h/2$ I got 9 ft and h for EA is 46-38=8ft.

$$\gamma_{EA} = 49.01 \ lb/ft^3 = .028 \ lb/in^3$$

Part 2

$$\Delta P = \gamma \cdot h$$

$$P_B - P_A = 0.028 \ lb/in^3 \cdot 240 \ in$$

$\boxed{\Delta P = 6.72 \ Psi}$ for manometer at the moment of no flow