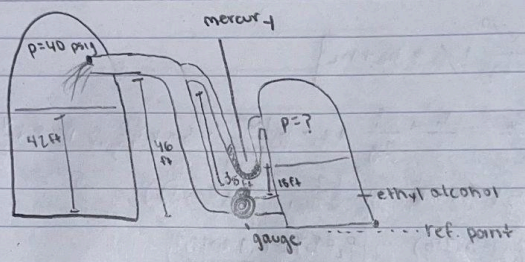
TEST 1

PURPOSE: DETERMINE THE REQUIRED PRESSURE AT DIFFERENT POINTS, MANOMETER READINGS, & CREATE A GRAPH OF P VS Q.

DRAWINGS/DIAGRAMS:



SOURCES:

MOTT, R, UNTENER, JA "APPLIED FLUID MECHANICS", 7TH EDITION PEARSON EDUCATOR, INC. (2015)

MET 330 CANVAS NOTES & EXAMPLE PROBLEMS

DESIGN CONSIDERATIONS

Constant properties, TRANSPORTING ETHYL ALCOHOL, PRESSURIZED AIR CONTROLS, T=77° F, INCOMPRESSIBLE FLUIDS (MERCURY & ETHYL ALCOHOL)

DATA & VARIABLES

$Q = 250$ gpm $\quad \varepsilon = 4.6 \times 10^{-5}$ $\quad h_1 = 46$ ft, 90° pipe elbow

$P_1 = 40$ psig $= 5670$ lb/ft^2 $\quad \gamma = 49.01$ lb/ft^3 $\quad d = 2.067$ in $\quad \gamma_{Hg} = 844.9$ lb/ft^3

$f_t = 0.09$

PROCEDURE:

FOR PROBLEM 1, BERNOULLI'S EQUATION WAS CALCULATED USING THE ENERGY LOSS EQUATIONS & CANCELLATION OF VARIABLES. THE MANOMETER READING WAS CALCULATED WITH UNIT CONVERSIONS TO PASCAL. DUE TO NO ENERGY LOSS IN PART TWO BERNOULLI'S EQUATION CAN BE SIMPLIFIED TO SOLVE FOR AIR PRESSURE, AND AN EQUATION FROM THE TEXTBOOK WAS USED TO GET THE MANOMETER READING. A PRESSURE VS FLOW RATE PLOT WAS THEN MADE USING THE CALCULATIONS FROM QUESTION 1.

CALCULATIONS

250 gpm = 0.557 ft3/s

① $h_L = k(V^2/2g)$ ← minor energy loss

$k = 30 f_t = 30 \times 0.019 = 0.57$

$V = Q/A = 0.557 \text{ ft}^3/\text{s} \,/\, 0.023 \text{ ft}^2 = 24.2 \text{ ft/s}$

$h_L = 0.57(24.2^2 / 2(32.2)) = 5.18 \text{ ft}$

$h_L = f\frac{LV^2}{D2g}$ $\quad L_e = \frac{kD}{f} = \frac{0.57 \times 2.067}{0.019}$

$h_L = 0.019\left(\frac{62.01(24.2^2)}{2.067(2)(32.2)}\right) \quad L_e = 62.01$

$h_L = 5.18 \text{ ft}$ ← major energy loss

$$\left[h_A + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_2 + h_L\right]$$

bernoulli and energy equations

$$\left[\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + h_L \quad \therefore \quad \frac{P_2}{\gamma} = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 - f\frac{LV^2}{D2g} + 3 \times k\frac{V^2}{2g} \quad \therefore \quad P_2 = P_1 \times \frac{V_1^2}{2g} - z_1\left(1 + f\frac{L}{D} + \right.\right.$$

$$P_2 = 5760 \text{ lb/ft}^2 \frac{24.2^2 \text{ ft/s}}{2(32.2)} - 38 \text{ ft}\left(1 + 0.019\left(\frac{62.01}{2.067}\right) + 3(0.57)\right)$$

$$P_2 = 5760 \text{ lb/ft}^2 + 38 - \frac{24.2^2}{64.4}(3.28) \qquad \boxed{P_2 = 5760.1 \text{ lb/ft}^2}$$

1a) $\Delta P = \gamma \times h$

$P_1 = 5760 \text{ lb/ft}^2 = 275740 \text{ Pa}$

$P_2 = 5801.9 \text{ lb/ft}^2 = 276177 \text{ Pa}$

$(276177 - 275740) = 844.9 \times h$

$\boxed{h = 0.387 \text{ Pascal}}$

② $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2$

$\frac{5760 \text{ lb/ft}^2}{49.01} + \frac{24.2^2 \text{ ft/s}}{2(32.2)} + 46 \text{ ft} = \frac{P_2}{49.01} + 18 \text{ ft}$

$117.5 + 9.09 + 46 = P_2/49.09 + 18$

$P_2 = \boxed{7588.82 \text{ lb/ft}^2}$

2a) manometer reading - equation 7.7 from book

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

$= \frac{7588.82 - 5760}{49.01} + (46 - 46) + \frac{-24.2^2}{2(32.2)}$

$h_A = 37.3 - 30 + 9.09$

$\boxed{h_A = 16.39 \text{ ft}}$

SUMMARY:

WITH THE PRESSURE OF THE LEFT TANK BEING 40 PSIG, THE PRESSURE OF THE RIGHT TANK WAS CALCULATED TO BE 5768.1 lb/ft^2 WHEN DELIVERING 250 GPM OF ETHYL ALCOHOL. WHEN THE SYSTEM STOPPED FLOWING, THE PRESSURE WAS 7585.52 lb/ft^2. THE MANOMETER READING INCREASED AFTER THE FLOW OF ALCOHOL STOPPED.

MATERIALS:

MERCURY MANOMETER, TWO TANKS, ETHYL ALCOHOL, PRESSURIZED, TEMP. CONTROLLED SYSTEM.

ANALYSIS:

AFTER CREATING THE GRAPH, IT WAS APPARENT THAT AS THE FLOW RATE INCREASED, THE PRESSURE IN THE TANK DECREASED. CALCULATING THE ENERGY LOSS WAS KEY IN THE FIRST PROBLEM DUE TO THE DIAMETER OF THE PIPE & HOW THAT AFFECTS PRESSURE & FLOW RATE.

Flow Rate (Q)	Pressure (P)
0	5798
25	5797.7
50	5796.8
75	5795.5
100	5793.4
125	5791
150	5787.5
175	5784.1
200	5579.4
225	5774.01
250	5768.1

P=5760+38-(v^2/64.4)(3.28)

V=Q/A <include unit change