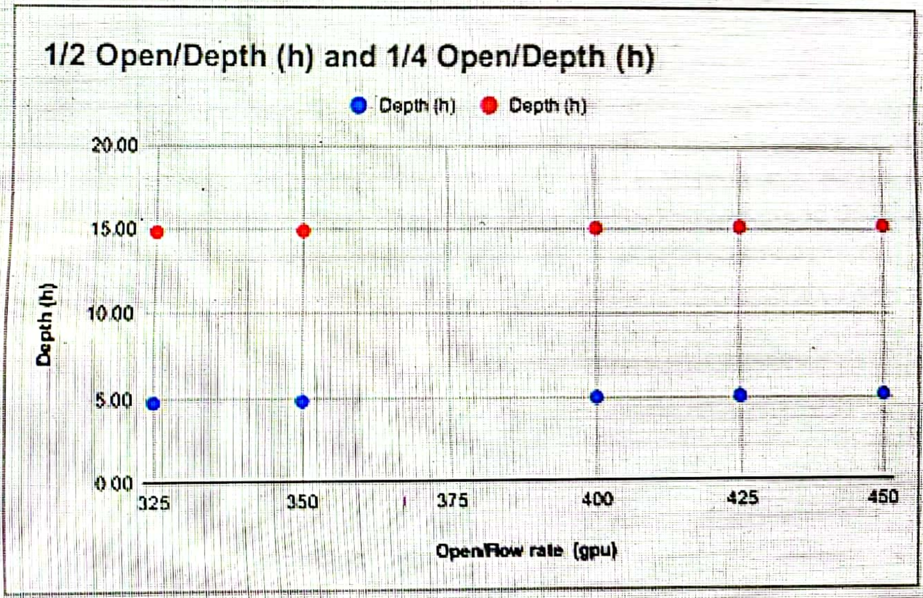
Gate Valve			
1/2 Open		1/4 Open	
Flow rate (gpu)	Depth (h)	Flow rate (gpu)	Depth (h)
325	4.79	325	14.82
350	4.86	350	14.89
400	5.04	400	15.06
425	5.13	425	15.16
450	5.22	450	15.25
425	5.13	425	15.16
400	5.04	400	15.06
350	4.86	350	14.89
325	4.79	325	14.82

DN90 Steel Pipe fT	0.017
1 gpm = (m³/s)	0.00006309
Area (m²)	0.006381
V (m/s)	3.95
D (m)	0.09
g (m/s^2)	9.81
z2 (m)	0.8
V^2/2g	0.797
Pressure (p)	680
n	0.000287
f	0.021
D/e	1958.7
L (m)	2.5

V (m/s)	Reynolds #	Friction Factor (f)	Pipe Friction Loss (m)
3.21	685972.8872	0.0220	0.487
3.46	738740.0323	0.0215	0.476
3.95	844274.3227	0.0210	0.465
4.20	897041.4678	0.0205	0.453
4.45	949808.613	0.0200	0.442

Gate Valve	1/2 Open	1/4 Open
Le/D	160	900
Valve hL (m)	2.17	12.20
Inlet hL (m)	0.399	0.399
Elbow hL(m)	0.407	0.407
K	2.72	15.3

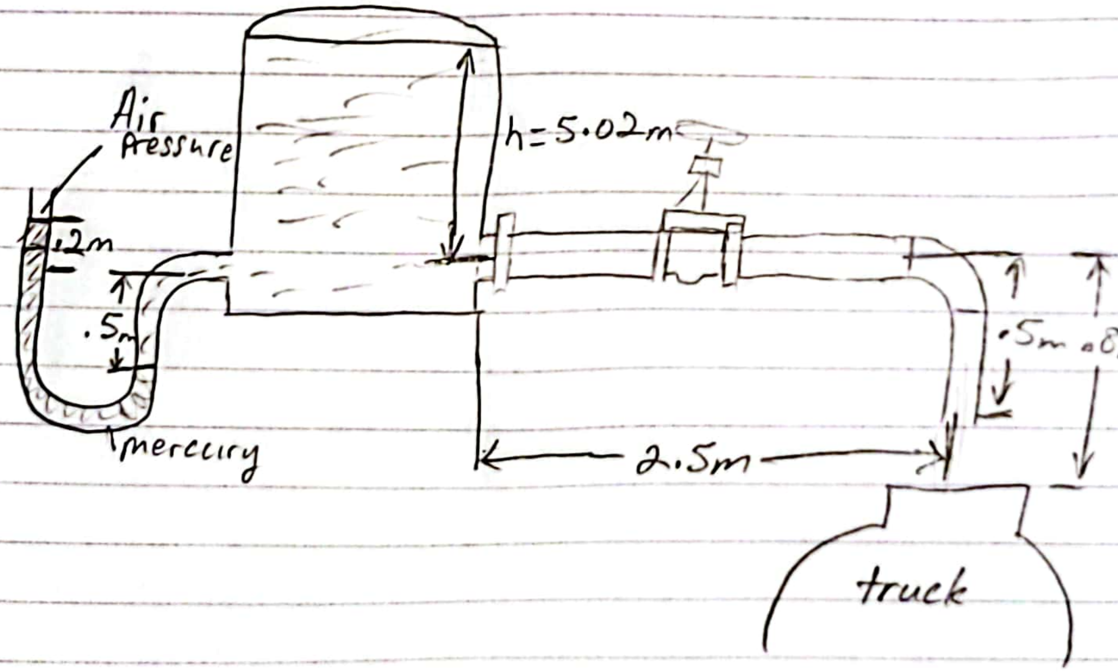


MET330 Test 1

Purpose

The purpose is to determine levels of gasoline to produce 400 gpm. Also choose the seperation distance between truck and tank. Find proper way of computing valve minor loss with valve ½ open.
Purposed to fully design a mercury U-tube manometer, and make sure the mercury does not overflow or back track. Need to determine tank diameter so that gas levels don't drop more than 1% of it's depth.
All calculations and data are to go on a spreadsheet.

Drawing and Design



Source:

Mott, R., Untener, J., "Applied Fluid Mechanics," 7th ed., Pearson Education Limited, 2016.

Design Considerations

- elbow (90°), 1/2 open gate valve, $T = 25°C$.
- DN90 steel pipe
- Incompressible fluids, constant properties.

Known Data & Variables

gas sg = .68, 25 °C
$Q = 400gpm = .025 m^3/s$

Procedure

I will first use Bernoulli's equation to determine "h" for a flow of 400 gpm. I will then calculate for pipe friction loss using $h_L = f\frac{L}{D}(\frac{v^2}{2g})$, Reynold's number, and relative roughness. I will also calculate all minor losses (inlet, elbow, and valve) using $h_L = K(\frac{v^2}{2g})$. Manipulating Bernoulli's equation to scenario, I also plugged in all losses (minor and pipe) and distance between tank and truck which is .8m. All needed data is attained from tables in book. The next task is to design the mercury U-manometer. I first have to select the PVC plastic tubing size from G.3 table. I selected pipe with an inside diameter of 13mm and outer diameter of . To determine change in pressure, I used $\Delta P = \gamma h$. Within the tank, I calculated 30.48 kPa. and designed manometer with pressure of 23.2 kPa.

I am now to determine the diameter of the tank so that gas levels don't drop more than 1% of depth after 5 minutes. All calculations and data have been requested to tabulated on a spreadsheet. Google sheets was used. A different operation condition was chosen to compare with the original. 1/4 open gate valve was decided. Same calculations for depth and flowrate for this operation.

For the depth of Fluid in Tank

Bernoulli's Principle for h

$$\frac{\overset{0}{P_1}}{\gamma_1} + \frac{\overset{0}{v_1^2}}{2g} + z_1 = \frac{\overset{0}{P_2}}{\gamma_2} + \frac{v_2^2}{2g} + z_2 + h_{L12}$$

$$z_1 = .797 + .8 + .464 + 2.16 + .405 + .398$$

$$\boxed{z_1 = h = 5.03}$$

Reynold's #

$$N_R = \frac{vD\rho}{\eta} = \frac{(3.95)(.0901)(680)}{2.87\times10^{-4}}$$

$$= 8.432\times10^{5} \rightarrow \text{Turbulent}$$

$$v_2 = \frac{400\,gpm}{6.381\times10^{-3}}\left(\frac{1\ m^3/s}{15850\,gpm}\right) = 3.95\ m^3/s$$

Minor losses

$$h_L = k(v^2/2g) = 2.72(3.95^2/(2\cdot9.81)) = 2.16m \text{ (Valve ML)}$$

$$k = Le/D(f_T) = 160(.017) = 2.72$$

Square Inlet ML

$$k = .5$$

$$h_L = .5(.797) = .398m$$

Calculations

$Q = 400\,gpm = .025\ m^3/s$

Gas

Density $\rho = 680\ kN/m^3$

$\eta = 2.87\times10^{-4}\ Pa\cdot s$

DN90 Steel Pipe

$D = .0901$

$160f_T = Le/D$

$\epsilon = 4.6\times10^{-5}$

$L = 2.5m$

Pipe Friction loss

$$h_L = f\frac{L}{D}\frac{v_2^2}{2g}$$

$$= .021\frac{2.5}{.0901}(.797) = .464$$

relative roughness

$D/\epsilon = 1958.7$

$f = .021$

Elbow ML (90°)

$$k = 30f_T = .51$$

$$h_L = .51(.797) = .405m$$

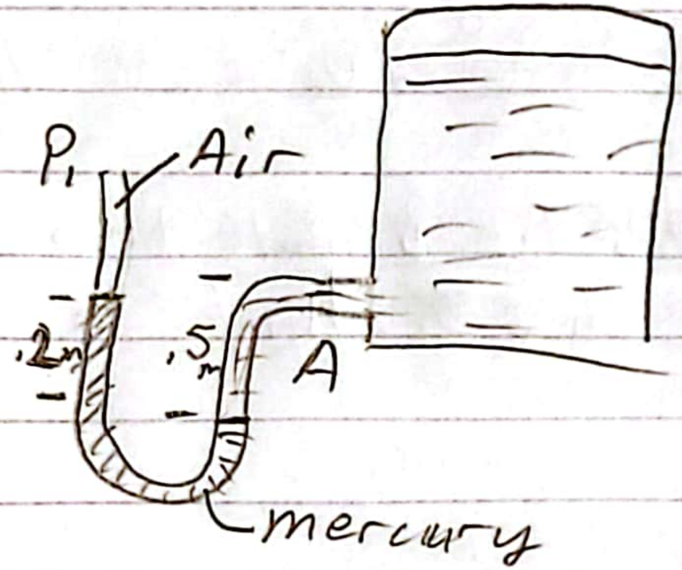
Designing Mercury Manometer

gasoline $Sg = .68$ $\quad$ $\gamma_{mercury} = 132.8\ kN/m^3$

gas $\gamma = 6.67$

$\Delta P = \gamma h = 6.67(4.57)$

$= 30.48\ kPa$



$P_A = P_1 - \gamma_{mercury}(.2) + \gamma_{gas}(.5)$

$P_A = 0 - 132.8(.2) + 6.67(.5)$

$= 23.2\ KPa$