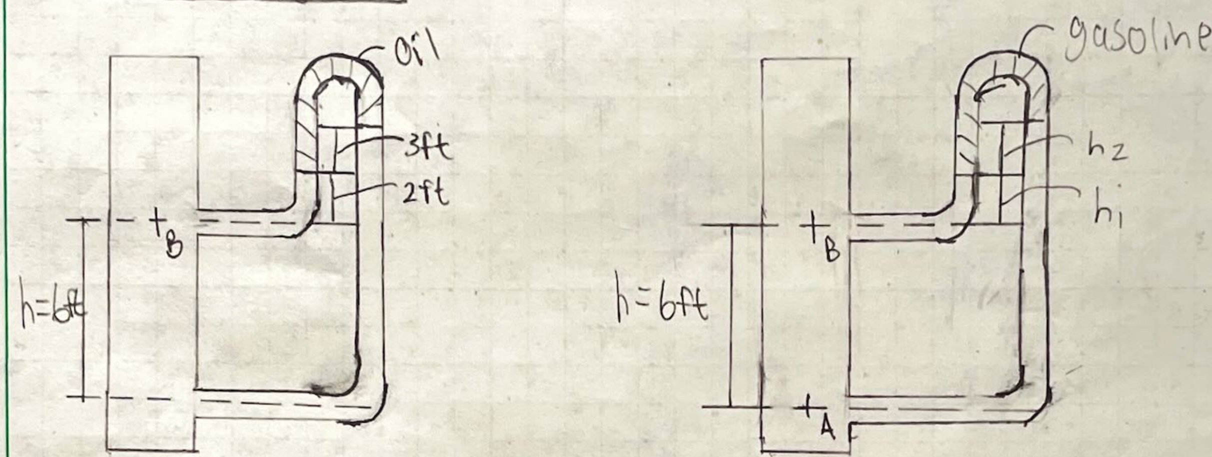
Problem 1.

Purpose:

The pressure difference $\Delta p = 2.7177$ psi. What would be the deflection of the manometer if gasoline was used instead of Oil? Also, what is the minimum height of the manomet so that the gasoline does not flow into the system?

Drawings + Diagrams:



Sources:

Mott, R, Untener, J. A., "Applied Fluid Mechanics", 7th edition, Pearson Education, Inc., (2015)

Design Considerations:

Constant Properties $\qquad$ h_1 inversly Proportional to h_2.

Incompressible fluids

Data + Variables:

$\gamma_{water} = 62.4\ lb/ft^3$ $\quad \gamma_{gas} = 42.4\ lb/ft^3$

$\Delta p = 2.7177\ psi \cdot 12^2\ ft = 391.35\ lb/ft^2$

$h = 6ft \quad h_1 = ? \quad h_2 = ?$

Problem 1 continued.

Procedure:

I will first use the Δp and set it equal to the new pressure equation using my $\gamma_{gasoine}$ and the existing γ_{water}. My variables will be my unknown heights h_1 & h_2. Using the relationship of the left and right side of the manometer being equal in value but opposite in sign I will be able to isolate my h_2 variable and solve for the deflection.

Calculations:

$$-\Delta p = -\gamma_{water}(h + h_1 + h_2) + \gamma_{gas}(h_2) + \gamma_{water}(h_1)$$

$$\Delta p = \gamma_{water}(h + h_1 + h_2) - \gamma_{gas}(h_2) - \gamma_{water}(h_1)$$

$$\Delta p = (\gamma_{water} \cdot h) + \cancel{(\gamma_{water} \cdot h_1)} + (\gamma_{water} \cdot h_2) - (\gamma_{gas} \cdot h_2) - \cancel{(\gamma_{water} \cdot h_1)}$$

$$391.35 \frac{lb}{ft^2} = (62.4 \frac{lb}{ft^3} \cdot 6ft) + 62.4 \frac{lb}{ft^3} \cdot h_2 \cancel{- 42.4 \frac{lb}{ft^3} \cdot h_2}$$

$$391.35 \frac{lb}{ft^2} = 374.4 \frac{lb}{ft^2} + 20 \frac{lb}{ft^3} h_2$$

$$16.95 \frac{lb}{ft^2} = 20 \frac{lb}{ft^3} h_2$$

$$0.8475 \text{ ft} = h_2$$

Summary:

Original $h_2 = 3ft$

$$\delta = \text{Original } h_2 - h_2$$

$$\delta = 3ft + 0.8475ft$$

$$\boxed{\delta = 3.85 \text{ ft}}$$

minimum height of manometer:

3.85ft on the left + 9ft on the right

$$\boxed{\approx 12.85 \text{ ft}}$$

Materials:

Water

gasoline

Problem 1 continued

Analysis:

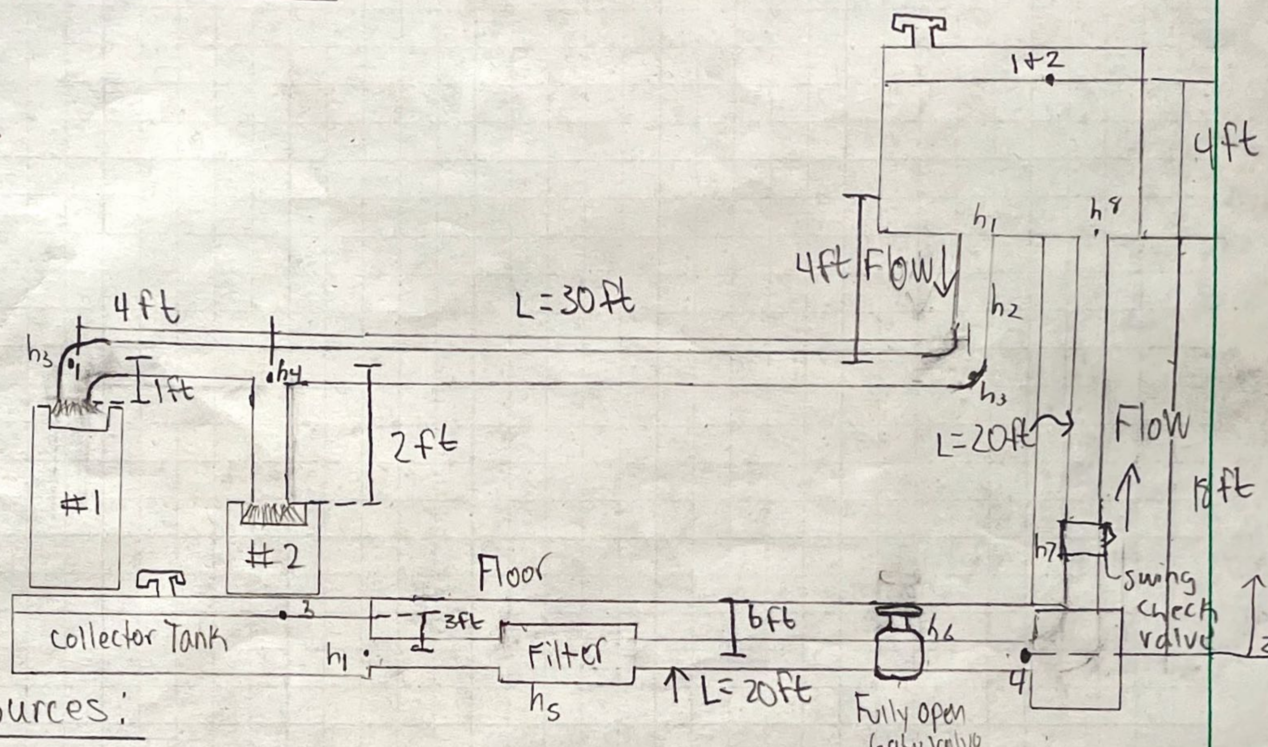
The gasoline has a smaller spesific weight than Oil. Therefore, the distance needed to increase to prevent the gasoline from entering the system.

Problem 2.

Purpose:

The system was designed for a flow rate of 30 gpm of coolant, but instead needed to be designed for 60 gpm. Redesign the system so that the pipe used is uniform & will give a velocity V = 3 m/s at 60 gpm. Then compute the pump head, the power delivered by the pump, and the pressure at the inlet of the pump.

Drawings & Diagrams:



Sources:

Mott, R., Untener, J.A., "Applied Fluid Mechanics" 7th edition, Pearson Education, Inc., (2015)

Design Considerations:

Constant Properties　　All uniform pipe size

Incompressible fluids

Data & Variables:

$V = 3\,m/s = 9.84\,ft/s$　　$Q = 60\,\frac{gal}{min} = 0.134\,\frac{ft^3}{s}$

$A = \frac{Q}{V}$　　$sg = 0.92$　　$K_{Filter} = 1.85$

$\eta = 3.6 \times 10^{-5}\,\frac{lb \cdot s}{ft^2}$　　$\rho = sg \cdot \rho_{water} = 0.92 \cdot 1.94 = 1.785\,\frac{slug}{ft^3}$

$\gamma_{coolant} = \rho \cdot g = 1.785 \cdot 32.2 = 57.48\,\frac{lb}{ft^3}$

Problem 2 Continued

Procedure:

First, I will use the flow rate and desired velocity to find the new desired pipe area. Then, with that area I will be able to use the energy loss equations with each friction constant given for each minor loss. From that I will know the total energy loss from friction. Then I will use Bernulli's to find the pump head. After that I will find the power needed to pump the coolant. Lastly I will use Bernulli's again to find the pressure at the inlet of the pump.

Calculations:

$Q = \frac{60 \text{ gal/min}}{449 \text{ gal/min}} \Rightarrow Q = 0.134 \text{ ft}^3/\text{s}$ $\quad V = (3 \text{ m/s})(3.28 \text{ ft/s})$, $V = 9.84 \text{ ft/s}$

$A = \frac{Q}{V} = \frac{0.134 \text{ ft}^3/\text{s}}{9.84 \text{ ft/s}}$

$A = 0.01362 \text{ ft}^2 \approx 0.01414 \text{ ft}^2 \Rightarrow$ Pipe is **1 ½ in schedule 40 steel pipe**

Energy Loss due to Friction

$h_L = h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8$

h_1 = entrance loss at resivor + collector tank

h_2 = all straight pipe loss

h_3 = 90° bend loss ×2

h_4 = T pipe loss

h_5 = Filter loss

h_6 = Fully open gate valve loss

h_7 = Swing check valve

h_8 = exit loss

$h_1 = \left[0.5\left(\frac{V^2}{2g}\right)\right] \cdot 2 = (0.5 \cdot 1.39) \cdot 2 = 1.39 \text{ ft}$

$h_2 = (0.02 \, L/D) \cdot \frac{V^2}{2g} = \left(0.02 \cdot \frac{71}{0.1342}\right) \cdot 1.39 = 14.76 \text{ ft}$

$h_3 = (0.02 f_T)\left(\frac{V^2}{2g}\right) = (0.02 \cdot 30) \cdot 1.39 = 1.67 \text{ ft}$

$h_4 = (0.02 f_T)\left(\frac{V^2}{2g}\right) + (0.02 f_T)\left(\frac{V^2}{2g}\right) = (0.02 \cdot 20) \cdot 1.39 + [(0.02 \cdot 60) \cdot 1.39] = 2.23 \text{ ft}$

$h_5 = K \cdot \frac{V^2}{2g} = 1.85 \cdot 1.39 = 2.58 \text{ ft}$

$h_6 = (0.02 \cdot f_T)\left(\frac{V^2}{2g}\right) = (0.02 \cdot 8) \cdot 1.39 = 0.22 \text{ ft}$

$h_7 = (0.02 f_T)\left(\frac{V^2}{2g}\right) = (0.02 \cdot 100) \cdot 1.39 = 2.79 \text{ ft}$

$h_8 = (1.0)\left(\frac{V^2}{2g}\right) = 1.0 \cdot 1.39 = 1.39 \text{ ft}$

Problem 2 continued

$h_L = 27.04\ ft$

$h_A + \cancel{\frac{P_A}{\gamma}} + \cancel{\frac{V^2}{2g}} + Z_A = \cancel{\frac{P_B}{\gamma}} + \cancel{\frac{V^2}{2g}} + \cancel{Z_B} + \cancel{h_R} + h_L$

$h_A = h_L$

$h_A = 27.04\ ft$

$P_A = h_A \gamma Q \qquad \gamma = 57.48\ \frac{lb}{ft^3}$

$P_A = (27.04\ ft)(57.04\ \frac{lb}{ft^3})(0.134\ \frac{ft^3}{s})$

$P_A = 208.3\ \frac{ft-lb}{s}$

$hp = \frac{208.3\ \frac{ft-lb}{s}}{550\ hp}$

$hp = 0.40$

$\boxed{P_A = 0.40\ hp}$

Pressure Before Inlet

$\cancel{h_A} + \cancel{\frac{P_A}{\gamma}} + \cancel{\frac{V^2}{2g}} + Z_A = \frac{P_4}{\gamma} + \frac{V^2}{2g} + Z_B + \cancel{h_L}$

$Z_A = \frac{P_4}{\gamma} + \frac{V_4^2}{2g}$

$3ft = \frac{P_4}{57.48\ \frac{lb}{ft^3}} + 1.39\ ft$

$\frac{(3ft - 1.39ft)}{57.48\ \frac{lb}{ft^3}} = P_4$

$P_4 = 92.3\ \frac{lb}{ft^2}$

$P_4 = \frac{92.3\ \frac{lb}{ft^2}}{144\ in^2}$

$\boxed{P_4 = 0.64\ psi}$

Problem 2 continued

Summary:

The pipe need for 60 gpm at a velocity of 3m/s is 1½ in Schedule 40 steel pipe

The power delivered by the pump is

0.40 hp

The pressure before the inlet of the pump is

0.64 psi

Materials:

1½ in schedule 40 steel pipe (71 ft)

Coolant 2 90° fittings T pipe fitting

Filter Gate valve Swing Check valve

Pump

Analysis:

The key to this problem is understending Bernulli's equation and the different manipulations that come with it.