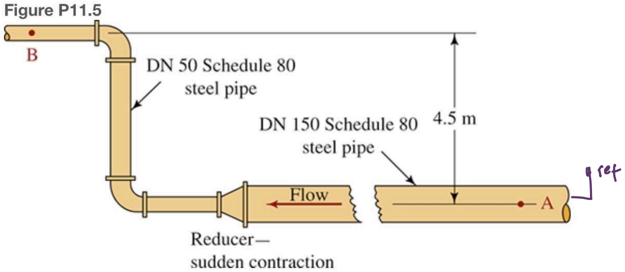
Hw 3.2

quarta-feira, 13 de novembro de 2024 12:59

11.5 Oil is flowing at the rate of $0.015\ \mathrm{m^3/s}$ (Q) in the system shown in **Fig. P11.5**. Data for the system are as follows:

- Oil specific weight $= 8.80\ \mathrm{kN/m^3}$ $= \gamma$
- Oil kinematic viscosity $= 2.12 \times 10^{-5}\ \mathrm{m^3/s}$ $= \mu$
- Length of DN 150 pipe $= 180\ \mathrm{m}$
- Length of DN 50 pipe $= 80\ \mathrm{m}$
- Elbows are long-radius type
- Pressure at $B = 12.5\ \mathrm{Mpa}$

Figure P11.5



Oil flow section for **Problem 11.5**.

Considering all pipe friction and minor losses, calculate the pressure at A.

diameter DN 150 schedule 80 steel pipe = 146.3 mm = 0.1463 m

diameter DN 50 schedule 80 steel pipe = 49.3 mm = 0.0493 m

$K_{elbows} = 20 f_T$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_a = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{L_{A-B}}$$

$$h_L = h_{L_{pipe\ A}} + h_{L_{contraction}} + h_{L_{elbow\ 1}} + h_{L_{elbow\ 2}} + h_{L_{pipe\ B}}$$

$$= f\frac{L}{D}\frac{V_A^2}{2g} + K\frac{V_B^2}{2g} + K\frac{V_B^2}{2g} + K\frac{V_B^2}{2g} + f\frac{L}{D}\frac{V_B^2}{2g}$$

$$= f\frac{L}{D}\frac{V_A^2}{2g} + \frac{V_B^2}{2g}\left[3K + f\frac{L}{D}\right]$$

$$A_A = \frac{1}{4}\pi D^2 = \frac{1}{4}\pi(0.1463)^2 = 0.0168\ \mathrm{m^2}$$

$$A_B = \frac{1}{4}\pi D^2 = \frac{1}{4}\pi(0.0493)^2 = 0.00190\ \mathrm{m^2}$$

$$Q = VA \rightarrow V = Q/A$$

$$V_A = 0.015/0.0168 = 0.893\ \mathrm{m/s}$$

$$V_B = 0.015/0.00190 = 7.89\ \mathrm{m/s}$$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \cancel{z_a} = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + f\frac{L_A}{D_A}\frac{V_A^2}{2g} + \frac{V_B^2}{2g}\left[\underset{20f_T}{2K} + \underset{table}{K} + f\frac{L_B}{D_B}\right]$$

1) guess P_A

2) calculate Re . D/

3) f

4) RHS

5) compare RHS to LHS

Ayala's rule

11.13 A device designed to allow cleaning of walls and windows on the second floor of homes is similar to the system shown in **Fig. P11.13**. Determine the velocity of flow from the nozzle if the pressure at the bottom is (a) 20 psig and (b) 80 psig. The nozzle has a loss coefficient K of 0.15 based on the outlet velocity head. The tube is smooth drawn aluminum and has an ID of 0.50 in. The 90° bend has a radius of 6.0 in. The total length of straight tube is 20.0 ft. The fluid is water at $100^\circ F$.

calculate Q

h

$P_A = 20$ psig and 80 psig

$K = 0.15$

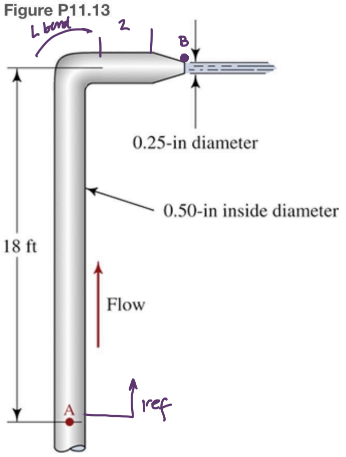
ID = 0.5 in

elbow = 90° bend $r = 6$ in

$L = 20$ ft

H_2O @ $100^\circ F$

Figure P11.13



$$\frac{P_A}{\gamma}+\frac{V_A^2}{2g}+\cancel{z_a}=\cancel{\frac{P_B}{\gamma}}+\frac{V_B^2}{2g}+z_B+h_{L_{A-B}}$$

$$h_L = h_{L\,pipe}+h_{L\,bend}+h_{L\,gradual\ cont.}$$

$$L\ bend = \frac{1}{4}2\pi r = \frac{1}{2}\pi r = \frac{1}{2}\pi\, 6 = 9.4248$$

$$h_L = f\frac{L}{D}\frac{V^2}{2g}+f\frac{L_{bend}}{D}\frac{V^2}{2g}+K\frac{V^2}{2g}$$

$$h_L = \frac{V^2}{2g}\frac{f}{D}\left[L+L_{bend}\right]+K\frac{V_2}{2g} \rightarrow \frac{8Q^2}{g\pi^2D_A^4}\frac{f}{D_A}\left[L+L_{bend}\right]+K\frac{8Q^2}{g\pi^2D_B^4}$$

$$\frac{P_a}{\gamma}+\frac{V_A^2}{2g}=\cancel{\frac{P_B}{\gamma}}+\frac{V_B^2}{2g}+z_B+\frac{8Q^2}{g\pi^2D_A^4}\frac{f}{D_A}\left[L+L_{bend}\right]+K\frac{8Q^2}{g\pi^2D_B^4}$$

$$\frac{P_a}{\gamma}=\cancel{\frac{P_B}{\gamma}}-\frac{8Q^2}{g\pi^2D_A^4}+\frac{8Q^2}{g\pi^2D_B^4}+\frac{8Q^2}{g\pi^2D_A^4}\frac{f}{D_A}\left[L+L_{bend}\right]+K\frac{8Q^2}{2g^2D_B^4}+z_B$$

$$\frac{P_a}{\gamma}-z_B=-\frac{8Q^2}{g\pi^2D_A^4}+\frac{8Q^2}{g\pi^2D_B^4}+\frac{8Q^2}{g\pi^2D_A^4}\frac{f}{D_A}\left[L+L_{bend}\right]+K\frac{8Q^2}{2g^2D_B^4}$$

table

1) guess Q

2) calculate Re, D/ε

3) f

3) f

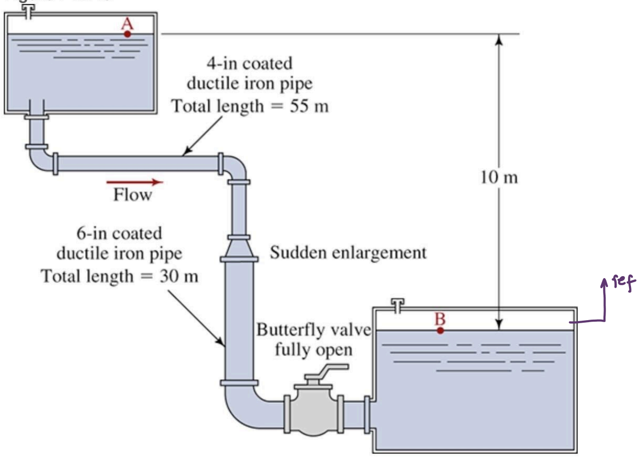
4) LHS

5) compare RHS and LHS

④ Ayala's rule

11.15 Water at $40^\circ C$ is flowing from A to B through the system shown in **Fig. P11.15**. Determine the volume flow rate of water if the vertical distance between the surfaces of the two reservoirs is 10 m. The elbows are standard.

Figure P11.15



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

$$z_a = h_{L_{A-B}}$$

$$h_L = h_{L_{Pipe\ A}} + h_{L_{elbow}} + h_{L_{elbow}} + h_{L_{sudden\ enlarge}} + h_{L_{elbow}} + h_{L_{pipe\ B}} + h_{L_{valve}}$$

$$h_L = f\frac{L}{D}\frac{V_A^2}{2g} + K\frac{V_A^2}{2g} + K\frac{V_A^2}{2g} + K\frac{V_B^2}{2g} + K\frac{V_B^2}{2g} + f\frac{L}{D}\frac{V_B^2}{2g} + K\frac{V_B^2}{2g}$$

$$h_L = \frac{V_A^2}{2g}\left[f\frac{L}{D} + \overset{20f_T}{2K}\right] + \frac{V_B^2}{2g}\left[f\frac{L}{D} + \overset{table}{K} + \overset{20f_T}{K} + \underset{45f_T}{K}\right]$$

$$z_a = \frac{8Q^2}{2g^2 D_A^4}\left[f\frac{L_A}{D_A} + \overset{40f_T}{2K}\right] + \frac{8Q^2}{2g^2 D_B^4}\left[f\frac{L_B}{D_B} + K + K + K\right]$$

1) guess Q

2) calculate Re , D/ε

3) f

4) RHS (already given)

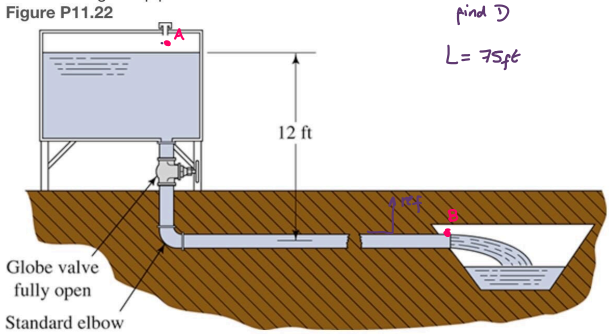
5) compare RHS to LHS

④ Ayala's rule

11.22 The tank shown in **Fig. P11.22** is to be drained to a sewer. Determine the size of new Schedule 40 steel pipe that will carry at least 400 gal/min of water at through the system shown.

The total length of pipe is 75 ft.

Figure P11.22



Q

find D

L= 75ft

$$\cancel{\frac{P_A}{\gamma}}^{0} + \cancel{\frac{V_A^2}{2g}}^{0} + z_a = \cancel{\frac{P_B}{\gamma}}^{0} + \frac{V_B^2}{2g} + \cancel{z_B}^{0} + h_{L_{A-B}}$$

$$h_L = h_{L_{pipe}} + h_{L_{valve}} + h_{L_{elbow}}$$

$$= f\frac{L}{D}\frac{V^2}{2g} + \overset{340\,ft}{K}\frac{V^2}{2g} + \overset{30ft}{K}\frac{V^2}{2g}$$

$$= \left[f\frac{L}{D} + 340ft + 30ft\right]\frac{V^2}{2g}$$

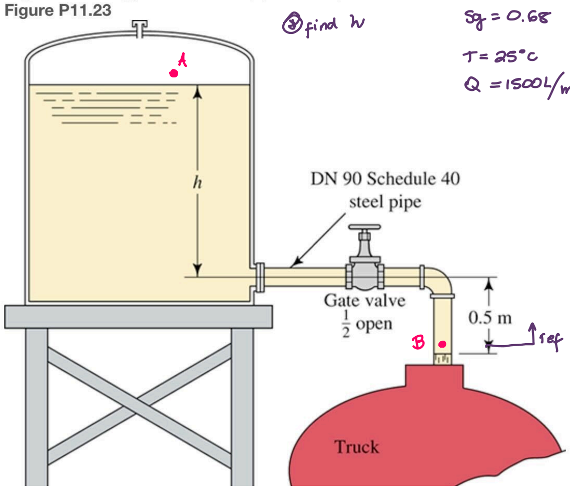
$$= \left[f\frac{L}{D} + 340ft + 30ft\right]\frac{8Q^2}{g\pi^2 D^4}$$

$$z_a = \left[f\frac{L}{D} + 340ft + 30ft\right]\frac{8Q}{g\pi^2 D^4} + \frac{8Q^2}{g\pi^2 D^4}$$

1) guess D
2) Re , D/ε
3) f
4) LHS @ given
5) compare RHS and LHS
@ Ayala's rule

11.23 **Figure P11.23** depicts gasoline flowing from a storage tank into a truck for transport. The gasoline has a specific gravity of 0.68 and the temperature is $25^\circ C$. Determine the required depth h in the tank to produce a flow of 1500 L/min into the truck. Because the pipes are short, neglect the energy losses due to pipe friction, but do consider minor losses.

Figure P11.23

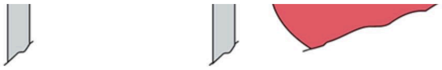


③ find h

Sg = 0.68

T= 25°c

Q =1500L/min



$$\cancel{\frac{P_A}{\gamma}} + \cancel{\frac{V_a^2}{2g}} + z_a = \cancel{\frac{P_B}{\gamma}} + \frac{V_B^2}{2g} + \cancel{z_B} + h_L$$

$$z_a = \frac{V_B^2}{2g} + h_L$$

$$h + 0.5\,m = \frac{V_B^2}{2g} + h_L$$

$$h_L = h_{elbow} + h_{value}$$

$$= \overset{\nearrow 30 f_T}{K}\frac{V^2}{2g} + \overset{\nearrow \text{table } (1.9)}{K}\frac{V^2}{2g}$$

$$= \frac{V^2}{2g}\left[30 f_T + 1.9\right] = \frac{8Q^2}{g\pi^2 D^4}\left[340 f_T + 1.9\right]$$

$$h + 0.5 = \frac{8Q^2}{g\pi^2 D^4} + \frac{8Q^2}{g\pi^2 D^4}\left[340 f_T + 1.9\right]$$

1) Re , D/ε

2) $f \rightarrow f_T$

3) RHS

4) find h