Problema 1

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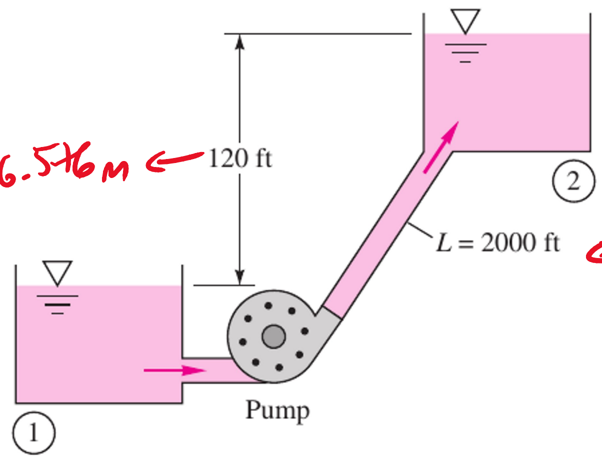
$$Q = 3\ ft^3/s = \boxed{0.0849\ m^3/s}$$



36.576 m ← 120 ft

L = 2000 ft ← 609.6 m

$$20\,^\circ C \rightarrow \left.\begin{array}{l} \rho = 10^3\ kg/m^3 \\ \mu = 10^{-3}\ Pa \cdot s \end{array}\right\} \text{Agua a } 20\,^\circ C$$

Ec. Energía

$$\cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + z_1 = \cancel{\frac{P_2}{\gamma}} + \cancel{\frac{V_2^2}{2g}} + z_2 + h_f - h_{bomba}$$

$$0 = z_2 - z_1 + h_f - h_{bomba}$$

Pérdidas de carga mayores

Ec Darcy

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

Tuberías hierro dúctil 6 in

$$D_i = 156\ mm = 0.156\ m$$

$$\varepsilon = 2.4 \times 10^{-4}\ m$$

$$h_{Bomba} = 210 \text{ m}$$

$$\dot{W} = Q \cdot \gamma \cdot h_{Bomba}$$

$$= 0.0849 \text{ m}^3/\text{s} \cdot 9.81 \cdot 10^3 \frac{\text{Pa}}{\text{m}} \cdot 210 \text{ m}$$

$$= 174902 \text{ W}$$

$$\boxed{\eta = \frac{\dot{W}_{Bomba}}{\dot{W}_{in}} \rightarrow W_{in} = \frac{\dot{W}_{Bomba}}{\eta} = 233 \text{ kW}}$$

Problema 2

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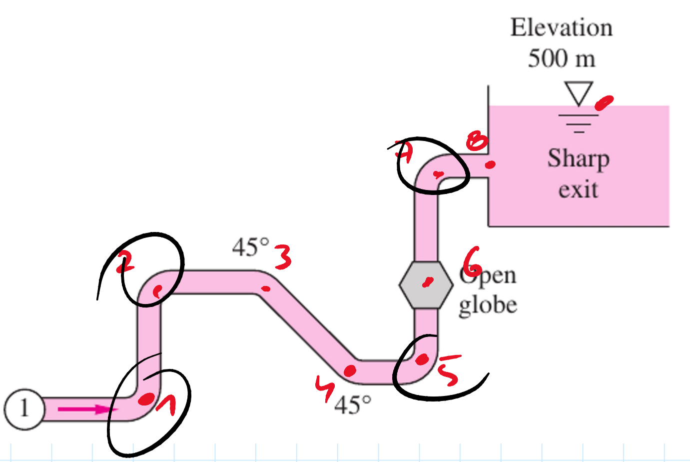

Agua @ 20°C

$\rho = 10^3$ kg/m³

$\mu = 10^{-3}$ Pa·s

$$\left.\begin{aligned} Q &= 0.005 \ m^3/s \\ D &= 5\times10^{-2} \ m \\ \varepsilon &= 2.4\times10^{-4} \ m \end{aligned}\right\} \text{CASO I}$$

Ec. energía

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \cancel{\frac{P_2}{\gamma}} + \cancel{\frac{V_2^2}{2g}} + z_2 + h_l + h_{l,m}$$

pérdidas mayores:

$$h_l = f\frac{L}{D}\frac{V^2}{2g}$$

pérdidas menores

elementos

1, 2, 5, 7 codos 90° radio largo

$K = 20 f_T = K_1, K_2, K_5, K_7$

3, 4 codos 45°

$K = 16 f_T = K_3 = K_4$

6 valvula globo abierta

$\frac{L_e}{D} = 340 \rightarrow K_6 = 340 \cdot f_T$

8 salida

$k_8 = 1$

$$h_{l,m} = \frac{V^2}{2g}\left(\sum_1^8 k_i\right)$$

$$p_1 = \left(z_2 + h_l + h_{l,m} - \frac{V_1^2}{2g} - z_1\right)\gamma$$

$p_1 = 3\,365$ kPa

Problema 3

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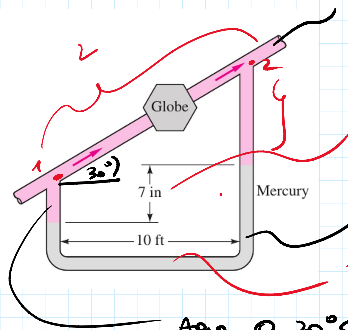


$D = 1\,in = 25.4\times10^{-3}\,m$

$\varepsilon = 0$

$7\cdot 25.4\times10^{-3}\,m$

$SG = 13.54$

$3.048\,m \rightarrow \cos(\theta) = \frac{3.048}{L}$

$L = \frac{3.048\,m}{\cos(\theta)}$

Agua @ 20°C

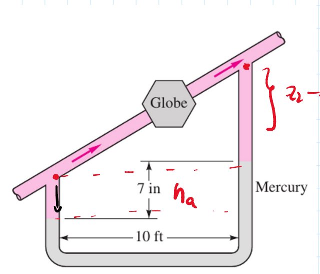
$\rho = 10^3\,kg/m^3$

$\mu = 10^{-3}\,Pa\cdot s$

$(3.048\,m)(\tan\theta) = z_2 - z_1$

Ec. Energía

$$\frac{p_1}{\gamma} + z_1 + \cancel{\frac{V_1^2}{2g}} = \frac{p_2}{\gamma} + z_2 + \cancel{\frac{V_2^2}{2g}} + h_f + h_{fm} \Rightarrow 0 = \frac{p_2 - p_1}{\gamma} + (z_2 - z_1) + h_f + h_{fm}$$



$$p_1 + h_a\cdot\gamma_w - h_a\cdot\gamma_{SG} - (z_2 - z_1)\cdot\gamma_w - p_2 = 0$$

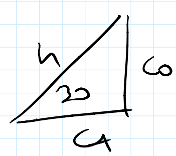
$$p_1 - p_2 = -\left(h_a\cdot\gamma_w - h_a\,\gamma_{SG} - (z_2 - z_1)\gamma_w\right)$$

$$\frac{p_1 - p_2}{\gamma_w} = -\left(h_a - h_a\cdot SG_{Hg} - (z_2 - z_1)\right) \Rightarrow \frac{p_2 - p_1}{\gamma_w} = h_a - h_a SG_{Hg} - (z_2 - z_1) \quad (1)$$

Pérdidas de carga mayores

Ecuación de Darcy:

$$h_f = f\cdot\frac{L}{D}\cdot\frac{V^2}{2g}$$



$\cos 30 = \frac{CA}{h}$

$h = \frac{CA}{\cos 30}$

$\tan 30 = \frac{CO}{CA}$

$CO = \tan 30\cdot CA$

Pérdidas de carga menores

$K_1 = 16$

Resolviendo (1)

$V = 1.65\,m/s$

$Q = 8.4\times10^{-4}\,m^3/s$

Ojo:

Si consideramos $K_1 = 160\,ft$ (de tablas)

$$f_T = f(\varepsilon/D,\ Re \to \infty)$$

Ecuación de Colebrook:

$$f^{-0.5} = -2\log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\, f^{0.5}}\right)$$

En este caso $\varepsilon = 0$

con $Re \to \infty$ este término tiende a 0

$$f(\varepsilon/D = 0,\ Re \to \infty)^{-0.5} = -2\log(x), \quad x \to 0$$

$\Rightarrow f^{-0.5}$ tiende a $-\infty$

$\Rightarrow f_T$ tiende a cero

En otras palabras, si consideramos paredes lisas, $f_T \approx 0 \Rightarrow K \approx 0$

Sin embargo esta puede no ser la situación

La ecuación de Colebrook es una ecuación empírica y no cubre el 100% de los casos

En este ejemplo si consideramos $K_1 = 0$:

$$V = 56.2\ m/s$$

34 veces el valor si consideramos $K = 16$

$\Rightarrow$ Las pérdidas de carga menores no pueden ser despreciadas

Problema 4

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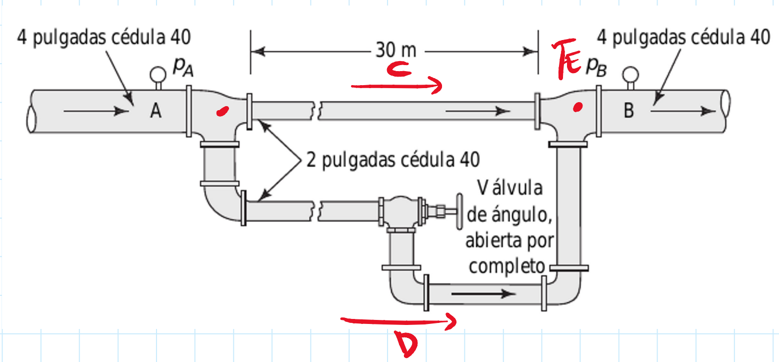

$$Q = 850\ L/min$$

$$= 850 \left[\frac{10^{-3} m^3}{L}\right]\left[\frac{1 min}{60 s}\right]$$

$$= 0.1417\ m^3/s$$

Tuberías:

4 in cédula 40 $\rightarrow$ $D_A = D_B = 102.3$ mm

2 in cédula 40 $\rightarrow$ $D_C = D_D = 52.5$ mm

Acero comercial:

$$\varepsilon = 4.6 \times 10^{-5}$$

Flujos volumétricos:

$$Q_A = Q_C + Q_D = Q_B$$

$$Q_A = \frac{\pi D_C^2}{4} V_C + \frac{\pi D_D^2}{4} V_D \xrightarrow{D_C = D_D} Q_A = \frac{\pi D_C^2}{4}(V_C + V_D)$$

Paso correcto (ruta C)

Ec. Energía

$$\frac{P_A}{\gamma} + \cancel{z_A} + \cancel{\frac{V_A^2}{2g}} = \frac{P_B}{\gamma} + \cancel{z_B} + \cancel{\frac{V_B^2}{2g}} + (h_f + h_{lm})_C \quad z_2 = z_1 \quad D_1 = D_2$$

$$0 = \frac{P_B - P_A}{\gamma} + (h_f + h_{lm})_C$$

Pérdidas de carga mayores

$$h_f = f_C \cdot \frac{L_C}{D_C} \cdot \frac{V_C^2}{2g}$$

$\downarrow$

ε/D conocido

ε/D conocido

V_c desconocido

Pérdidas de carga menores:

Elementos

1: T_E paso directo

$$K_{1c} = 20\, f_{T_A}$$

2: T_r paso directo

$$K_{2c} = 20\, f_{t_C}$$

$$h_{lm} = \frac{V_A^2}{2g} K_{1c} + \frac{V_C^2}{2g} K_{2c}$$

Paso por el ramal (ruta D)

Ec. energía

$z_1 = z_2$ $\quad D_1 = D_2$

$$\frac{P_A}{\gamma} + \cancel{z_A} + \cancel{\frac{V_A^2}{2g}} = \frac{P_B}{\gamma} + \cancel{z_B} + \cancel{\frac{V_B^2}{2g}} + (h_l + h_{lm})_D$$

$$0 = \frac{P_B - P_A}{\gamma} + (h_l + h_{lm})_D$$

Pérdidas mayores

$$h_l = f_D \frac{L_D}{D_D} \frac{V_D^2}{2g_D}$$

↳ ε/D conocido

Re desconocido

Pérdidas menores

Elementos

1: T_E, paso por el ramal

$K_{1D} = 60 f_{T_D}$

2: codo estandar 90°

$K_{2D} = 30 f_{T_D}$

3- valvula de angulo 100% abierta

$K_{3D} = 150 f_{T_D}$

4: codo estandar 90°

hl

$K_{4D} = 30 f_{T_D}$

5: codo estandar 90°

$K_{5D} = 30 f_{T_D}$

6: Te, paso por el ramal

$K_{6D} = 60 f_{T_D}$

$$hl_{m,D} = \frac{V_A^2}{2g} K_{1D} + \frac{V_D^2}{2g}\left(\sum_{i=2}^{6} K_{iD}\right)$$

Para obtener V_C y V_D:

$$Q_A = \frac{\pi D_C^2}{4}(V_C + V_D) \quad (1)$$

$$(h_l + hl_m)_C = (hl + hl_m)_D \quad (2)$$

$$\left.\begin{aligned} 0 &= Q_A - \frac{\pi D_C^2}{4}(V_C + V_D) \\ 0 &= (h_l + hl_m)_C - (hl + hl_m)_D \end{aligned}\right\}$$

Sistema de ecuaciones no lineales (1) y (2)

$$\left.\begin{aligned} Q_C &= 8.63 \times 10^{-3} \ m^3/s \\ Q_D &= 5.48 \times 10^{-3} \ m^3/s \end{aligned}\right\} \quad Q_C + Q_D = Q_A \ //$$

$V_C = 4.01$ m/s

$V_D = 2.53$ m/s

Para obtener $P_A - P_D$:

$$p_A - p_B = \gamma(h_l + h_{lm})_c$$

$$p_A - p_B = 99.8 \ kPa$$

Problema 5

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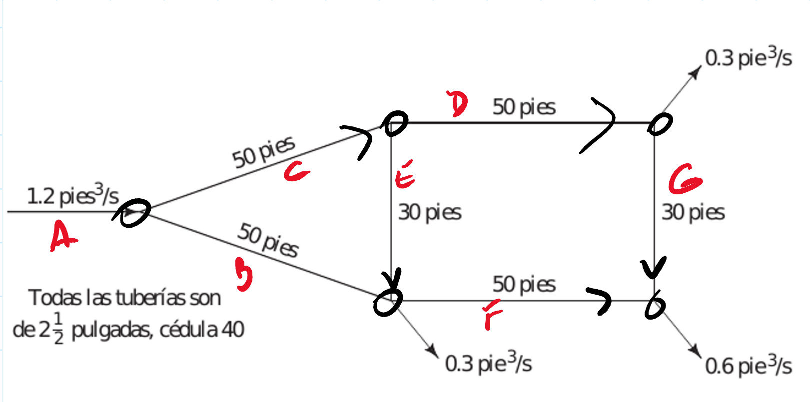

Ve+vd-vchl

Flujos:

$$Q_A = Q_B + Q_C \quad (1)$$

$$Q_B + Q_E = Q_F + 0.3 \text{ pie}^3/s \quad (2)$$

$$Q_G + Q_F = 0.6 \text{ pie}^3/s \quad (3)$$

$$Q_D = 0.3 + Q_G \quad (4)$$

$$Q_C = Q_E + Q_D \quad (5)$$

v

Pérdidas de carga

$$h_{l_B} = h_{l_C} + h_{l_E} \quad (6)$$

Resolviendo el sistema de ecuaciones no lineales 1 — 6 :

$$V_B = 5.58 \text{ m/s}$$

$V_C = 5.42$ m/s

$V_D = 3.77$ m/s

$V_E = 1.60$ m/s

$V_F = 4.51$ m/s

$V_G = 0.98$ m/s

Problema 6

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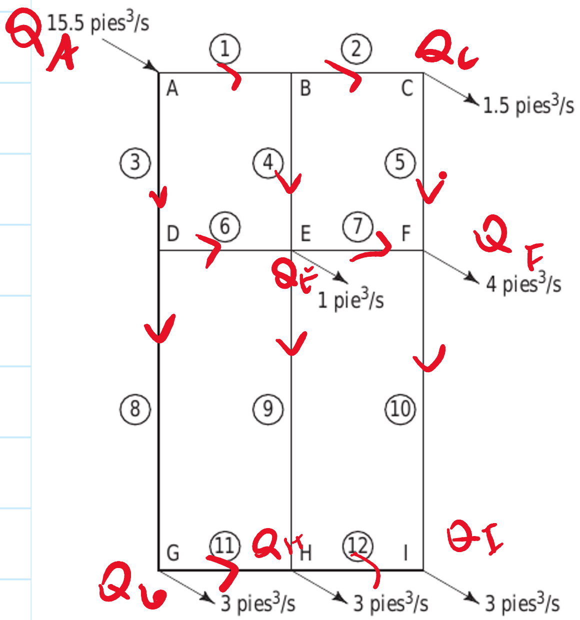

Datos de las tuberías
Todas las tuberías son cédula 40

Tubo núm.	Longitud (pies)	Tamaño (pulg)
1	1500	16
2	1500	16
3	2000	18
4	2000	12
5	2000	16
6	1500	16
7	1500	12
8	4000	14
9	4000	12
10	4000	8
11	1500	12
12	1500	8

1º Iteración

Flujos volumétricos:

Nods

A		$0 = Q_A - Q_1 - Q_3$
B		$0 = Q_1 - Q_4 - Q_2$
C		$0 = Q_2 - Q_C - Q_5$
D		$0 = Q_3 - Q_6 - Q_8$
E		$0 = Q_6 + Q_4 - Q_E - Q_9 - Q_F$
F		$0 = Q_7 + Q_5 - Q_F - Q_{10}$
G		$0 = Q_8 - Q_G - Q_{11}$
H		$0 = Q_{11} + Q_9 - Q_H - Q_{12}$
I		$0 = Q_{12} + Q_{10} - Q_I$

Pérdidas de carga:

De A a E:

$$0 = h_{l_3} + h_{l_6} - (h_{l_1} + h_{l_4})$$

2ª iteración