EXAMPLE 8.8 & Exercise 8.76（Determine pressure drop）

Assume a car's exhaust system can be approximated as 4 m of 0.05-m-diameter cast iron pipe with equivalent of six 90° elbows and a muffler. The muffler acts as a resistor with a loss coefficient of KL = 8.5. Determine the pressure at the beginning of the exhaust system if the flowrate us 3.0×10^{-3} m^3/s, the temperature is 120° C, and the exhaust has the same properties as air. $\mu = 2.25\times10^{-5}\,N\cdot s/m^2$

The energy equation is

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+z_2+(f\frac{\ell}{D}+\sum K_L)\frac{V^2}{2g} \qquad (1)$$

其中，$z_1 = z_2$、 $p_2 = 0$ 且 $V_1 = V_2 = \frac{Q}{A} = \frac{3\times10^{-3}\,m^3/sec}{\pi(0.05m)^2/4} = 1.528m/s$ （2）

將（2）代入（1）→ $P_1 = (f\frac{\ell}{D}+\sum K_L)\frac{\rho V^2}{2}$ （3）

其中，$\rho = \frac{P}{RT} = \frac{101.3\times10^3\,N/m^2}{(286.7N\cdot m/kg\cdot K)(273+120)K} = 0.899kg/m^3$

由於 $\frac{\varepsilon}{D} = \frac{2.6\times10^{-4}m}{0.05m} = 0.0052$ 且 $Re = \frac{\rho VD}{\mu} = \frac{(0.899kg/m^3)(1.528m/s)(0.05m)}{2.25\times10^{-5}\,N\cdot s/m^2} = 3{,}053$

由 Moody chart 查得 $f = 0.047$

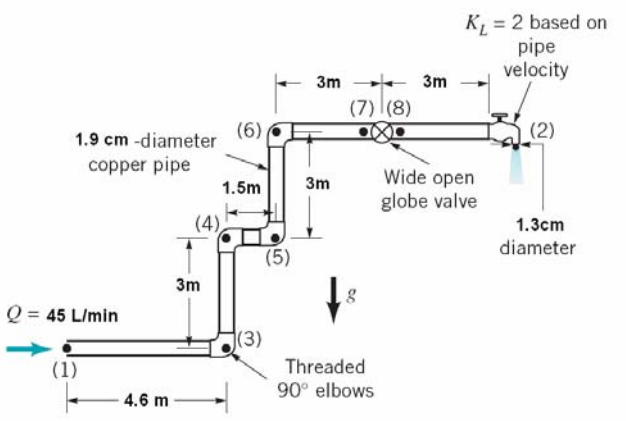
代入（3）

$$P_1 = (f\frac{\ell}{D}+\sum K_L)\frac{\rho V^2}{2}$$

$$= [0.047\frac{4m}{0.05m}+6(0.3)+8.5]\frac{1}{2}(0.899kg/m^3)(1.528m/s)^2 = 14.756N/m^2$$

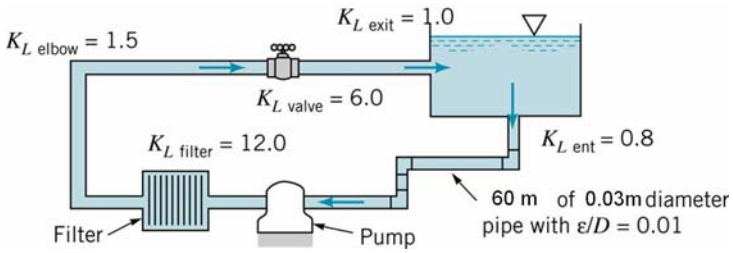
EXAMPLE 8.8（Determine pressure drop）

Water at 15°C flows from the basement to the second floor through the 1.9 cm-diameter copper pipe (a drawn tubing) at a rate of Q = 45 L/min = 7.5×10^{-4} ㎥/s and exits through a faucet of diameter 1.3 cm as shown. Determine the pressure at point (1) if: (a) all losses are neglected, (b) the only losses included are major losses, or (c) all losses are included.



EXAMPLE 8.11 & Exercise 8.99（Determine flowrate）

Water is circulated from a large tank, through a filter, and back to the tank as shown. The power added to the water by the pump is 270 N-m/s. Determine the flowrate through the filter.



The energy equation is

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+z_1+h_p=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+z_2+(f\frac{\ell}{D}+\sum K_L)\frac{V^2}{2g} \qquad (1)$$

其中，$z_1=z_2$、 $p_1=p_2$ 、 $V_1=V_2=0$ 且

$$h_p=\frac{\dot{W}_p}{\gamma Q}=\frac{270\text{N}\cdot\text{m/s}}{9800\frac{\text{N}}{\text{m}^2}(\frac{\pi}{4}(0.03\text{m})^2)V}=\frac{38.977}{V} \qquad (2)$$

將（2）代入（1）→ $\frac{39}{V}=(f\frac{60\text{m}}{0.03\text{m}}+5(1.5)+12+6+1)\frac{V^2}{2(9.81\text{m/s}^2)}$ →

$$V^3=\frac{0.383}{f+0.01365} \qquad (3)$$

加上 $\text{Re}=\frac{\rho VD}{\mu}=\frac{10^3\text{kg/m}^3\text{Vm/s}(0.03\text{m})}{1.12\times10^{-3}\text{N}\cdot\text{s/m}^2}=26{,}785.714V$ （4）

透過 trial and error scheme…（請詳列過程）

◎先假設 f = 004 →代入（3）得到 V = 1.93 m/s；代入（4）得到 Re = 5.17 × 10^4 → 利用 ε/D 與 Re 查詢 Moody chart 得知 f = 0.039 （一猜就差不遠）→再確認。

◎再假設 f = 0039 →代入（3）得到 V = 1.94 m/s；代入（4）得到 Re = 5.19 × 10^4 → 利用 ε/D 與 Re 查詢 Moody chart 得知 f = 0.039（可）。

Flowrate Q = AV = …

EXAMPLE 8.13 & Exercise 8.100（Determine diameter）

A certain process requires 6.25×10^{-2} m^3/s of water to be delivered a pressure of 205 kPa. This water comes from a large diameter supply main in which the pressure remains at 415 kPa. If the galvanized iron pipe connecting the two locations is 60 m long and contains six threaded 90° elbows, determine the pipe diameter. Elevation differences are negligible.

The loss coefficient $K_L = 1.5$ for each elbow and $K_L = 0.5$ for the entrance.

$\upsilon = 1.12\times10^{-6}\,m^2/s \qquad \varepsilon = 0.15mm$

The energy equation is

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+z_2+(f\frac{\ell}{D}+\sum K_L)\frac{V^2}{2g} \qquad (1)$$

其中，$z_1 = z_2$、 $p_1 = 415$ kPa、 $p_2 = 205$ kPa 且

$$V_1 = 0、\ V_2=\frac{Q}{A}=\frac{6.25\times10^{-2}\,m^3/sec}{\pi D^2/4}=\frac{0.08}{D^2}m/s \qquad (2)$$

將（2）代入（1）→ $P_1-P_2=(f\frac{\ell}{D}+\sum K_L)\frac{\rho V^2}{2}$ →

$$(415-205)\times10^3\,N/m^2=(1+f\frac{60m}{D}+6(1.5)+0.5)\frac{10^3\,kg/m^3}{2}(\frac{0.08}{D^2})^2 \rightarrow$$

$$6250=(1+\frac{5.7f}{D})\frac{1}{D^4} \qquad (3)$$

加上 $\frac{\varepsilon}{D}=\frac{0.15mm}{D}$ （4）且 $Re=\frac{VD}{\upsilon}=\frac{(0.08/D^2)D}{1.12\times10^{-6}\,m^2/s}=\frac{7.14\times10^4}{D}$ （5）

透過 trial and error scheme…（請詳列過程）

◎先假設 D = 0.12 m →代入（3）得到 f = 6.23×10^{-3}；代入（4）得到 ε/D = 0.00125；代入（5）得到 Re = 5.95 × 10^5→利用 ε/D 與 Re 查詢 Moody chart 得知 f = 0.021 ≠ 6.23×10^{-3}（誤差 10 %以上）→再假設不同的 D 值

◎再假設 D = 0.15 m →代入（3）得到 f = 0.026；代入（4）得到 ε/D = 0.001；代入（5）得到 Re = 4.76 × 10^5→利用 ε/D 與 Re 查詢 Moody chart 得知 f = 0.0203 ≠ 0.026 （誤差 10 %以上）→再假設不同的 D 值

◎再假設 D = 0.14 m →代入（3）得到 f = 0.034；代入（4）得到 ε/D = 0.00111；代入（5）得到 Re = 5.1 × 10^5→利用 ε/D 與 Re 查詢 Moody chart 得知 f = 0.0205 ≠ 0.034 （誤差 10 %以上）→再假設不同的 D 值

◎再假設 D = 0.13 m →代入（3）得到 f = 0.023；代入（4）得到 ε/D = 0.00115；代入（5）得到 Re = 5.5 × 10^5→利用 ε/D 與 Re 查詢 Moody chart 得知 f = 0.0205 ≠ 0.023 （誤差 10 %以上）→再假設不同的 D 值

◎再假設 D = 0.135 m…..