Calculation of Pressure drop parameter for flow conditions given in *Example 6-1*

The pressure drop parameter for a pipe flow is given by

$$\alpha_p = \frac{4\, f\, G^2}{A_c\, \rho\, P_0\, D} \qquad (1)$$

From example 6-1, the parameter values are

$F_{A0} = 22.6 * 10^{-6} \frac{mol}{s}$

$F_{A0} = 1.48 * 10^{-6} \frac{kg}{s}$ (MW of NOCL=65.5 g/mol)

$length = 0.2\ mm$

$P_0 = 1641\ kPa = \ 1641\ * 10^3\ Pa$

For microreactors with square dimension, the pipe diameter can be approximated by channel width

So,

$D = 0.2\ mm = 2 * 10^{-4}\ m^2$

$A_c = 4\ * 10^{-8}\ m^2$

Assuming that the during the reaction, the mixture properties are similar to those of air at 425 °C and 1641 kPa, the properties are

$\rho = 8.19\ kg/m^3$

$\mu = 0.34\ * 10^{-4} \frac{kg}{s.m}$

Now,

$$G = \frac{F_{A0}}{A_c} = \frac{1.48\ * 10^{-6}}{4 * 10^{-8}} = 37 \frac{kg}{s.m^2}$$

To determine the value of fanning friction factor, f, we need to calculate Reynold number, which is given by

$$R_e = \frac{\rho\, v\, D}{\mu} \qquad (2)$$

In the above equation v is the velocity which can be calculated from the given volumetric flow rate (v_0) and Area (A_c)

$$v_0 = \frac{F_{A0}}{\rho} = \frac{1.48 * 10^{-6}}{8.19} = 0.181 * 10^{-6} m^3/s$$

Velocity is calculated as

$$v = \frac{v_0}{A_c} = \frac{0.181 * 10^{-6}}{4 * 10^{-8}} = 4.52\ m/s$$

Substituting the values of $\rho, v, D, and\ \mu$ in Equation 2

$$R_e = \frac{8.19 * 4.52 * 2 * 10^{-4}}{0.34 * 10^{-4}} = 218$$

Since the Reynold number is very low and lies in the laminar flow regime,

$For\ laminar\ flow,$

$$f = \frac{16}{R_e} = \frac{16}{218} = 0.0734$$

Substituting the values of $f, G, A_c, \rho, P_0, and\ D$ in Equation 1 we obtain

$$\alpha_p = 3.74\ cm^{-3}$$

The volume of channel is

$$V = 10^{-5}\ dm^3 = 10^{-2}\ cm^3$$

Now,

$$p = \left(1 - \alpha_p V\right)^{1/2}$$

Or,

$$p = (1 - 3.74 * 10^{-2})^{1/2} \approx 1$$