Calculation of Pressure drop parameter for flow conditions given in *Example 5-4*

The pressure drop parameter is given by

$$\alpha_p = \frac{4\, f\, G^2}{A_c\, \rho_0\, P_0\, D} \qquad (1)$$

From example 5-4, the parameter values are

G=7383.3 $\frac{lb_m}{h.ft^2}$

$A_c = 0.01414\ ft^2$

$\rho_0 = 0.413\ \frac{lb_m}{ft^3}$

$D = 0.0208\ ft$

$\mu = 0.0673\ \frac{lb_m}{h.ft}$

$P_0 = 10\ atm$=$8.823 * 10^{12}\ \frac{lb_m}{ft.h^2}$

$(1\ atm = 2116.22\ lbf/ft^2, 1\ lbf = 32.174\ \frac{lb_m\, ft}{s^2}, 1\ s = \frac{1}{3600}\, h\ )$

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

$$R_e = \frac{\rho_0\, v\, D}{\mu} \qquad (2)$$

In the above equation v is the velocity which can be calculated from the given volumetric flow rate i.e. $v_0 = 252.8\ ft^3/h$

Velocity is calculated as

$$v = \frac{v_0}{A_c} = \frac{252.8}{0.01414} = 17878\ ft/h$$

Substituting the values of $\rho_{0,}\ v, D, and\ \mu$ in Equation 2

$$R_e = \frac{0.413 * \ 17878 * \ 0.0208}{0.0673} = 2282$$

Since the Reynold number is very close to 2000, the flow regime can be considered as laminar flow

$For\ laminar\ flow,$

$$f = \frac{16}{R_e} = \frac{16}{2282} = 0.007$$

Substituting the values of $f, G, A_c, \rho_0, P_0, and\ D$ in Equation 1 we obtain

$$\alpha_p = 0.00143\ ft^{-3}$$

Or,

$$\alpha_p = 0.05\ m^{-3}$$

Let's consider a pipe length (l) of 1,000 ft

The volume of pipe is

$V = A_c * l = 14.14\ ft^3$

Now,

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

Or,

$$p = (1 - 0.00143 * 14.14)^{\frac{1}{2}}$$

$$p = (1 - 0.012)^{\frac{1}{2}}$$

Or,

$$\boxed{p = 0.99}$$

Thus, the pressure drop is approximately 1 % of the original pressure