6.102

6.102 Ethyl alcohol flows through a horizontal tube having a diameter of 10 mm. If the mean velocity is 0.15 m/s, what is the pressure drop per unit length along the tube? What is the velocity at a distance of 2 mm from the tube axis?

Check Reynolds number to determine if flow is laminar:

$$R_e = \frac{\rho V (2R)}{\mu} = \frac{(789\ \frac{kg}{m^3})(0.15\ \frac{m}{s})(0.010m)}{1.19 \times 10^{-3}\ \frac{N.s}{m^2}} = 995 < 2100$$

Thus, flow is laminar and

$$V = \frac{R^2}{8\mu}\frac{\Delta p}{\ell} \qquad (Eq.\ 6.152)$$

so that

$$\frac{\Delta p}{\ell} = \frac{8\mu V}{R^2} = \frac{8(1.19\times10^{-3}\ \frac{N.s}{m^2})(0.15\ \frac{m}{s})}{(\frac{0.010m}{2})^2} = \underline{\underline{57.1\ \frac{N}{m^2}\ per\ m}}$$

Since,

$$v_z = v_{max}\left[1 - (\frac{r}{R})^2\right] \qquad (Eq.\ 6.154)$$

and $v_{max} = 2V$, where V is the mean velocity, it follows that

$$v_z = 2V\left[1 - (\frac{r}{R})^2\right]$$

For $r = 3mm$,

$$v_z = 2(0.15\ \frac{m}{s})\left[1 - \left(\frac{2mm}{5mm}\right)^2\right] = \underline{\underline{0.252\ \frac{m}{s}}}$$