8.54

8.54 Gasoline flows in a smooth pipe of 40-mm diameter at a rate of 0.001 m³/s. If it were possible to prevent turbulence from occurring, what would be the ratio of the head loss for the actual turbulent flow compared to that if it were laminar flow?

Let $(\ )_t$ denote the turbulent flow and $(\ )_\ell$ the laminar flow.

Thus, $h_{L_t} = f_t \frac{\ell}{D} \frac{V^2}{2g}$ and $h_{L_\ell} = f_\ell \frac{\ell}{D} \frac{V^2}{2g}$ (1)

where

$$V = V_t = V_\ell = \frac{Q}{A} = \frac{0.001 \frac{m^3}{s}}{\frac{\pi}{4}(0.04m)^2} = 0.796 \frac{m}{s}$$

From Table 1.6 $\rho = 680 \frac{kg}{m^3}$ and $\mu = 3.1 \times 10^{-4} \frac{N\cdot s}{m^2}$ so that

$$Re = \frac{\rho V D}{\mu} = \frac{(680 \frac{kg}{m^3})(0.796 \frac{m}{s})(0.04m)}{3.1\times10^{-4} \frac{N\cdot s}{m^2}} = 6.98\times10^4$$

Hence, from Fig. 8.20, for a smooth pipe $f_t = 0.0192$

while for laminar flow $f_\ell = \frac{64}{Re} = \frac{64}{6.98\times10^4} = 9.16\times10^{-4}$

Thus, from Eq. (1)

$$\frac{h_{L_t}}{h_{L_\ell}} = \frac{f_t}{f_\ell} = \frac{0.0192}{9.16\times10^{-4}} = \underline{\underline{21.0}}$$