Exercise 19

1. Estimate the Bodenstein number for a straight cylindrical capillary with an inner diameter of $d_t = 1.0\ mm$. The space-time of the gaseous reactant is $\tau = 1\ s$. ($D_m = 10^{-5} m^2 s^{-1}$)

2. Estimate the diameter of a straight cylindrical capillary with a length of $L = 0.2m$ required to obtain a Bodenstein number of $Bo = 100$. The space-time of the liquid reactant is $\tau = 300\ s$. ($\nu = 10^{-6} m^2 s^{-1}$; $D_m = 10^{-9} m^2 s^{-1}$). Can we assume stratified flow?

Solution

1. $Bo \cong 192 \frac{D_m}{d_t^2} \frac{L}{u} \cong 48 \frac{\tau}{t_{D,rad}}$

$$t_{D,rad} = \frac{\left(\frac{d_h}{2}\right)^2}{D_m} = \frac{\left(\frac{d_t}{2}\right)^2}{D_m} = \frac{(0.5 \cdot 10^{-3})^2}{10^{-5}} = 0.025s$$

$$Bo = 48 \frac{1}{0.025} = \mathbf{1920}$$

2. $Bo \cong 48 \frac{\tau}{t_{D,rad}}$

$$t_{D,rad} = 48 \frac{\tau}{Bo} = 48 \frac{300}{100} = 144s$$

$$t_{D,rad} = \frac{\left(\frac{d_t}{2}\right)^2}{D_m} \rightarrow d_t = 2\sqrt{t_{D,rad} \cdot D_m} = 2\sqrt{144 \cdot 10^{-9}} = \mathbf{7.6 \cdot 10^{-4} m}$$

$$Re = \frac{u \cdot d_t}{\nu} = \frac{\frac{L}{\tau} \cdot d_t}{\nu} = \frac{\frac{0.2}{300} \cdot 7.6 \cdot 10^{-4}}{10^{-6}} = \mathbf{0.5} < 100 \rightarrow \textbf{stratified}$$