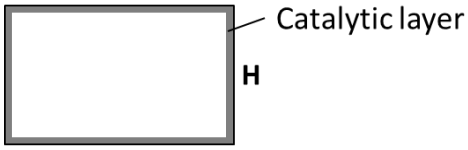
Exercise 7

A single rectangular microchannel coated with a heterogeneous catalyst was used to carry out a gas phase catalytic reaction. An unwanted homogeneous reaction (combustion) took place in the gas phase. You are asked to propose a multichannel design to reduce the contribution of the homogeneous reaction by a factor of ten.



Data

$r_{hom} = k_{hom} c_{gas}^2 (mol \cdot m^{-3} \cdot s^{-1})$ $\quad k_{hom} = 0.94\ mol^{-1} m^3 s^{-1}$

A pseudo-homogeneous model can be used to describe the kinetics of the heterogeneous reaction

$r_{het} = k_{het} c_{gas}^{0.5}\ (mol \cdot m^{-2} \cdot s^{-1})$ $\quad k_{het} = 1.8 \cdot 10^{-2}\ mol^{0.5} m^{-0.5} s^{-1}$

Channel dimensions in mm $(H \times W \times L) = 0.25 \times 0.5 \times 50$

Flowrate $\dot{Q} = 8.3 \cdot 10^{-8} m^3 s^{-1}$

Density $\rho = 4.81\ kg m^{-3}$

Viscosity $\mu = 1.8 \cdot 10^{-5} Pa \cdot s$

Inlet concentration of reactant $c_0 = 12\ mol\ m^{-3}$

Questions

1. Calculate the ratio of characteristic times $\varphi = \frac{t_{het}}{t_{hom}}$ for the single channel reactor
2. Design a multichannel reactor to treat the same flowrate, keeping the residence time, the channel length and the aspect ratio $\frac{H}{W}$ constant, such that φ is decreased by a factor of ten
3. Calculate the Reynolds number for the mono-channel and multi-channel reactors. What is the flow regime? ($hydraulic\ diameter = d_h = 4 \frac{\text{cross–sectional area}}{\text{wetted perimeter}}$)