Exercise 8

An exothermic homogeneous first-order liquid-phase chemical reaction was studied in a straight, circular mono-channel microreactor.

The reaction could be run quasi-isothermally using 80% w/w of solvent.

Data

Flowrate $\dot{Q} = 1.5 \cdot 10^{-7} m^3 s^{-1}$

Molecular weight of reactant A $MW = 0.21\ kg\ mol^{-1}$

Kinetics

$r = kc_A (mol \cdot m^{-3} \cdot s^{-1})$ $\quad k = 50\ s^{-1}$

Reactor dimensions

Diameter $D = 2 \cdot 10^{-4}\ m$

Length $L = 0.1\ m$

Fluid properties (assume independent of concentration)

Density $\rho = 900\ kg\ m^{-3}$

Viscosity $\mu = 1.2 \cdot 10^{-3} Pa \cdot s$

Heat capacity $c_p = 2200\ J\ kg^{-1}\ K^{-1}$

Heat conductivity $\lambda = 0.2\ W\ m^{-1}\ K^{-1}$

Nusselt number $Nu = 3.66$ (valid in laminar regime)

Questions

Design a reactor capable of processing (same conversion) quasi-isothermally the same molar flowrate of the reactant using only 40% w/w of solvent in the feed.

1. Propose a mono-channel design
2. Propose a multichannel design to maintain the pressure drop equal or smaller than in the first study. Pressure drop for circular channel in laminar regime $\Delta p = L \frac{32\ \mu\ u_m}{D^2}$