TAOCO is making a food flavor ingredient (YUM) by enzymatic reaction of glucose (glucose-> YUM) in a continuous flow well-mixed tank reaction system (see diagram below). As a business, TAOCO is interested in process performance, which can be evaluated by production of YUM, efficient conversion of glucose, time needed to start up the process, and the amount of waste produced.

Starting up the process involves getting the system to steady state from initial conditions. At the start up of this process, the reactor is initially filled with fluid at Cin. At time =0, the inlet/outlet flows are started and the reaction begins.

Note: This process asymptotically approaches steady state operation.

Assume that the mixing in the tank is perfect, i.e. entering materials are instantaneously mixed and the composition is spatially uniform inside of the tank. Assume that concentration leaving the tank is the same as the concentration inside of the tank and that the flowrates and volume of fluid in the tank is constant.

V – tank volume (L)

F – volumetric flowrate (L/hr)

Cin – feed concentration of glucose (mol/L)

C(t) – glucose concentration in tank/outlet (mol/L)

r – reaction rate, dC/dt (mol/L-hr)

Vm, Km – enzymatic reaction rate constants (mol/L-hr, mol/L)

1. (50 points) Draw a picture and define the system/flows. D**evelop a mathematical model/solution for this process** (i.e. do a component mass balance on the system) for **the glucose concentration as a function of time** (0<t<100) during the start up process, i.e. solve for C(t).

V=500 L F=100 L/hr Cin = 100 mol/L Vm = 10 mol/L-hr Km=5 mol/L

1. (5 points) Assume that the value of the glucose concentration at t=100 is the asymptotic steady state value (i.e. when conversion is 100%). **Provide an appropriate plot of the % conversion vs. time** (0<t<100).
2. (10 points) During start up, assume that product collection can begin when the conversion reaches 99% of the asymptotic steady state value. Using your model, **calculate the start up time (hr),** i.e. the time until product can first be collected.
3. (10 points) **Calculate the amount of waste** **(mol)** generated during start up. (Waste is all the moles of material used/produced before collection starts.)
4. (10 points) Productivity is the amount of YUM (mol/hr) that is produced in the outlet stream at steady state (t=100). Using your model, c**alculate the productivity**, i.e. mols of YUM produced/hr at steady state

1. (15 points) You are hired as a summer engineering intern and your project is to investigate ways to improve this process, i.e. make changes that will increase profitability. Unfortunately, you cannot change the kinetic parameters of the enzyme, but you can change the rest of the process operational parameters (including reactor size). Using your model, carefully analyze the impact of changes of operational parameters on process performance and economic profitability (revenue, expenses).

What changes would you suggest making? Clearly explain/justify your suggested changes.

(suggestion: vary the operational parameters and use your model to assess /evaluate the impacts of these changes. ).