SECTION II: KINETICS AND BIOREACTOR DESIGN:

LESSON 10.2. - Bioreactor design – Design Equations - Examples

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AIMS FOR TODAY’S LESSON

10.1 Design equations
10.2 Exercises
10.3 Tank vs Tubular reactor: Comparing efficiency
10.4 Recycle, By-pass and Purge
10.5 Bioreactor association
Working on Bacteria

OK germs
She's set up another experiment
Messing with scientists

This is what we did last time —

This time we'll do this
She won't know which is right!

What does a Greek cow say?

@twisteddoodles
Example #1:

An enzymatic process where the following reaction takes place

\[ A \rightarrow R, \]

can be described using a first-order kinetic equation:

\[ r \text{ (mole} \cdot \text{L}^{-1} \cdot \text{h}^{-1}) = 1.2 \cdot [A] \]

This reaction is carried out using a batch reactor where the working temperature is constantly 50°C. The reactant mixture presents an initial concentration of 12 moles/L in A.

What is the reaction time (\( t_R \)) needed in order to reach an \( X_A \) of 0.80?
Example #2:

One current containing 3 moles/L of substrate and 0.01 g/L of enzyme is fed into a Continuous Stirred Tank Reactor (CSTR). The kinetic parameters corresponding to the equation describing the process (Michaelis-Menten equation) are:

\[ K_{\text{cat}} = 2 \text{ moles/(min.gE)} \]  and  \[ K_M = 0.1 \text{ (mole S)/L} \]

Calculate the volume needed to treat a 30 L/min stream so that an output conversion of 99.5% is achieved.
Example #3:

The growth of an aerobic microorganism is carried out within a 3 L bioreactor working as a continuous stirred tank fed with 0.15 L/h. If growth can adequately be described using the kinetic model proposed by Monod, and nitrogenous substrate can be considered as limiting nutrient, calculate both biomass and limiting substrate concentrations when steady state is achieved.

Inlet substrate concentration is 0.4 g/L.

Kinetic parameters for the biological system under the operating conditions are:

\[ \mu^{\text{max}} = 0.2 \text{ h}^{-1}, \ K_N = 0.06 \text{ g N/L}, \ Y_{X/N} = 4.6 \text{ gX / gN}. \]
Example #4:

30 g/h of a certain yeast need to be obtained. The kinetic model describing its growth has been obtained, taking into account that it is **limited by the amount of nitrogenous substrate** present in the fermentation broth.

Calculate the volume of the continuous tank reactor required for this production.

Kinetic model:

\[
R_X (gX / L \cdot h) = \mu_m \cdot [N] \cdot [X]
\]

\[
R_N (gN / L \cdot h) = -Y_{N/X} \cdot R_X
\]

where: \( \mu_m = 0.5 \) L / g N.h; \( Y_{N/X} = 0.17 \) gN / gX;

And \( F = 12 \) L / h; \( [N]_0 = 0.8 \) gN / L
Example #5:

A 100 L bioreactor consisting in a continuous stirred tank is fed with a 10 L/h current containing 0.75 g/L of a growth limiting substrate.

The kinetic model describing the system has been previously obtained.

Calculate the amount of product generated per hour.

Data:

Kinetic model:

\[
\begin{align*}
R_X (gX / L \cdot h) &= 0.46 \cdot [N] \cdot [X] \\
R_N (gN / L \cdot h) &= -0.15 \cdot R_X \\
R_P (gP / L \cdot h) &= 0.71 \cdot R_X 
\end{align*}
\]
A continuous tubular reactor is used in order to carry out the reaction

\[ A + B \rightarrow R + S \]
catalyzed by an enzyme. The fed stream contains "A" and "B" in an equimolecular ratio at a 500 L/min flow. The concentration of "A" at the entrance is 0.18 M

In order to achieve an output conversion of 85%, what volume of the reactor is needed?

Although the enzymatic process, the kinetics of the reaction taking place can be expressed as:

\[ r = 10 \cdot [A] \cdot [B] \text{ (mole / L / min)} \]
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