End-Sem Examination (Nov 2021)

Biochemical Engineering (BT 303)

Total Marks: 30

- **Answer All the Questions and All the Questions carry EQUAL marks**
- **Assumptions Made Should be Justified Appropriately**
- **Ambiguous Answers Will NOT be Evaluated**

1. (a) Develop the equations for the rate of change of cell and dissolved oxygen concentrations with time in an oxygen-limited batch culture. Soluble carbon substrate is in excess. Assume Monod kinetics for cell growth with the dissolved oxygen as the growth limiting substrate. Ignore maintenance energy requirements, cell death and product formation other than the biomass itself.

   (b) In the production of a secondary metabolite in a 'batch' culture, nutrients are fed continuously in the solid form to the 'batch' in order to keep the cells growing at a constant specific growth rate equal to 10 % of their maximum specific growth rate. At the same time, in order to achieve a desired product formation, the dissolved oxygen concentration must not fall below 10 % of the saturation value and when it does the 'batch' is terminated. Using the data given below, calculate how long the 'batch' could theoretically run and what final biomass concentration is?

Assumptions:

There is no lag phase in growth

There is no maintenance energy requirements

There is no cell death

Inoculum is 100 % viable

There is no change in the volume of the batch despite the addition of the solids

Cell growth can be described by Monod Kinetics and the growth limiting substrate is the dissolved oxygen.

Oxygen transfer rate is equal to oxygen uptake rate without any accumulation/depletion terms in the mass balance for the dissolved oxygen. Oxygen consumed is used for biomass formation only.

Data:

Inoculum conc. = 0.02 kg/m^3

Maximum specific growth rate of cells = 0.2 h^{-1}

Saturation (equilibrium) dissolved oxygen concentration = 0.007 kg/m^3

The maximum achievable volumetric oxygen mass transfer coefficient = 80 h^{-1}

Yield coefficient for cells on oxygen = 1.5 kg cells/kg oxygen

(P.T.O)

2. Microbial growth has been studied in a continuous culture and the following parameters were obtained. $\mu_m = 0.2\ h^{-1}$, $K_s = 0.2\ g/dm^3$, $k_d = 0.002\ h^{-1}$, $Y_{X/S} = 0.4$ g cells/g substrate, and $Y_{P/S} = 0.2$ g product/g substrate. Tracer studies have indicated that the incomplete mixing can be described by a well-mixed volume $V_1 = 1.7\ dm^3$ and a stagnant volume of $V_2 = 0.3\ dm^3$ interacting each other within the chemostat with a constant flow rate relationship of $F_2 = 0.2\ F_1$ in dm^3/h.
   Chemostat operation is such that $X_i = 0$ and $S_i = 0.6\ g/dm^3$.
   a. Create a single graph of S, X and P versus the dilution rate in case of well-mixed volume
   b. Plot the cell production rate and product production rate as a function of dilution rate in case of well-mixed volume
   c. Estimate the dilution rate that will maximize the cell production rate and product production rate in case of well-mixed volume

3. In a Chemostat with cell recycle, as shown in Figure 1, the feed flow rate and culture volumes are F= 100ml/h and V= 1000 ml, respectively. The system is operated under glucose limitation, and yield coefficient, $Y_{X/S}$, is 0.5 g dw cells/g substrate. Glucose concentration in the feed is S_i= 10 g glucose/l. The kinetic constants of the organism are μ_m= 0.2 h^{-1}, K_S= 1 g glucose/l. The value of Ɛ is 1.5, and the recycle ratio is R= 0.7. The system is steady state. Find:

   (a) The specific growth rate (μ_{net}) of the organisms.
   (b) The substrate concentration in the recycle stream (S).
   (c) The cell (biomass) concentration in the recycle stream (X_R).
   (d) The cell concentration in the centrifuge effluent (X_2).

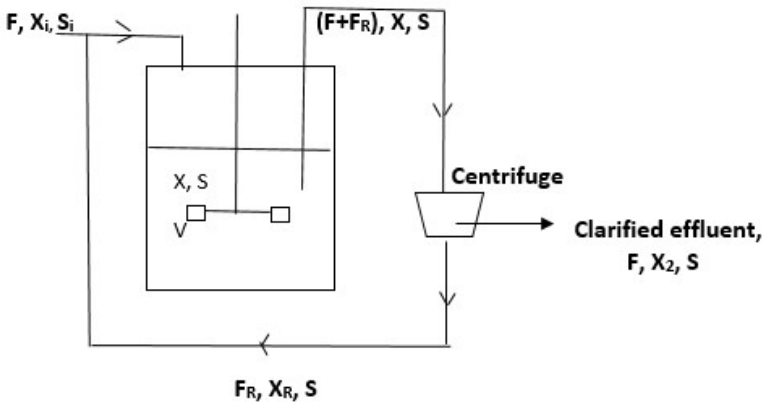

Fig.1

(P.T.O)

4. Chemostat cultivation of *E.coli* obeys Monod's equation:

$$\frac{dX}{dt} = \frac{\mu_m SX}{k_S + S}$$

Where $\mu_m = 0.7\ h^{-1}$ and $k_S = 5$ g/L. The cell yield ($Y_{X/S}$) is 0.65. You want to cultivate *E.coli* in either ONE chemostat or TWO in series. The flow rate and the substrate concentration of the inlet stream should be 500 L/h and 85 g/L, respectively. The substrate concentration of the outlet stream must be 5 g/L.

   a. If you use ONE chemostat, what should be size of the chemostat? What is the cell concentration of the outlet stream?
   b. If you use TWO chemostats in series, what sizes of the TWO chemostats will be most productive? What are the concentration of cells and substrate in the outlet stream of the FIRST chemostat?

----------End of the Question Paper----------