Exam.Code:1033
Sub. Code: 7871

1059

M. E. (Bio-Technology)
Second Semester
ME-BIO-202: Bioprocess and Bioreactor Engineering

Time allowed: 3 Hours | Max. Marks: 50

NOTE: *Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section. Assume any missing data.*

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I. Answer the following:-

A. Enlist various heat-transfer configurations for bioreactors.

B. Define fouling factor.

C. Describe different types of heat-transfer equipment with help of suitable sketches.

D. Define impeller flooding.

E. State distinct advantages of fed-batch culture.

F. Compare operating characteristics of stirred and air-driven bioreactors.

G. What are the various practical considerations for bioreactor construction?

H. Describe various types of agitators you come across in bioprocessing.

I. Discuss the importance of mixing in bioprocessing.

J. What are the possible reasons of non-ideality in a bioreactor? (1 each)

SECTION_A

2. A stirred fermenter of diameter 5m contains an internal helical coil for heat transfer. The fermenter is mixed using a turbine impeller of 1.8 m diameter operated at 60 rpm. The fermenter broth has $\mu_b = 5 \times 10^{-3}$ Pa s^{-1}; $\rho = 1000$ kg m^{-3}; $C_p = 4.2$ kJ kg^{-1} C^{-1}; $k_{fb} = 0.70$ W m^{-1} °C^{-1}. Neglecting viscosity changes at the wall of the coil, calculate the heat-transfer coefficient. 10

3. Describe the various factors considered during the scale up of bioreactor. Enlist types of scale-up approaches. Justify whether "constant k_La" is a suitable approach for scale-up of fermentation dealing with shear-sensitive cells. 10

4. A well-mixed fermenter of volume V contains cells initially at concentration x_0. A sterile feed enters the fermenter with the volumetric flow rate F, fermentation broth leaves at the same rate. The concentration

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of the substrate in the feed is s_i. The equation for rate of cell growth is: $r_X = k_1X$ and the expression for rate of substrate consumption is $r_S = k_2X$; where k_1 and k_2 are rate constants with dimensions T^{-1}, have dimensions L^3MT^{-1} and x is the concentration of cells in the fermenter.

a) Derive a differential equation for the unsteady state mass balance of cells.

b) From this equation, what must be the relationship between F, k1 and the volume of liquid in the fermenter at steady state?

c) Solve the differential equation to obtain an expression for cell concentration in the fermenter as a function of time.

d) Calculate how long it takes for the cell concentration in the fermenter to reach 4.0 gl^{-1}; if F = 2200 l h^{-1}; V= 10 000 l; x_0 = 0.5 g l^{-1}; k_1 = 0.33 h^{-1}. 10

SECTION_B

5. A strain of *Azobacter vinelandii* is cultured in a 15 m^3 stirred fermenter for alginate production. Under current operating conditions k_La is 0.17s^{-1}. Oxygen solubility in the broth is approximately 8 x 10^{-3} kg m^{-3}. What is the maximum possible cell concentration if the specific rate of oxygen uptake is 12.5 mmol g^{-1} h^{-1}? What maximum cell concentration can now be supported by the fermenter if the bacteria suffer growth inhibition after copper sulphate is accidently added to the broth? 10

6. A particular fermentation is to be carried out in a chemostat. Before carrying out the actual fermentation, it was decided to evaluate the flow characteristics of the chemostat by introducing a tracer in the form of pulse input. The time vs concentration of the tracer data is presented in table below.

Time (min.)	0	10	20	30	40	50	60	70
Tracer Conc. (g/l)	0	2	6	7	4	3	1	0

Find the average residence time and the variance. The bioreactor is being used for fermentation of molasses which obeys an overall first-order reaction kinetics with k_1 = 0.3 h^{-1}. Find the fractional conversion of the reactant. 10

7. a) Give a brief account on the following system utilities: i) air and gases ii) process water.

b) Also emphasize on i) how the problems related to above utilities can be anticipated and ii) the proactive measures to minimize these problems.

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