Code: 9A23702

R09

B.Tech IV Year I Semester (R09) Supplementary Examinations June 2017

PROCESS EQUIPMENT DESIGN IN BIOTECHNOLOGY

(Biotechnology)

Time: 3 hours Max. Marks: 70

SECTION – A

Answer any five questions from the following: (05 x 04 = 20 Marks)

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1 Write the main design equation for heat exchangers. Explain each term mentioning units.

2 Define the term 'overall heat transfer coefficient'. Derive the expression for the same.

3 Consider a feed C_{A0} = 100, C_{B0} = 200, C_{i0} = 100 to a steady state flow reactor. The isothermal gas phase reaction is A + 3B → 6R, If C_A = 40, what is C_B, X_A and X_B there?

4 List the hydraulic parameters in the design of sieve tray tower for distillation.

5 Compare and contrast CSTR and PFR.

6 Write any four applications of dryers in bioprocess industry.

7 Describe long vertical evaporator. What are the measures for its performance?

8 How do you select devices for pressure and vacuum service?

SECTION – B

Answer any one question (01 x 50 = 50 Marks)

(Assume suitable additional data, if necessary)

1 The growth of bacteria to form a product, p is carried out in a 25 dm^3 CSTR (Chemostat). The bacteria consume the nutrient substrate. The CSTR was initially inoculated with the bacteria and now has reached steady state. Inly substrate (nutrient) is fed to the reactor at a volumetric rate of 5 dm^3/h and a concentration of 30g/dm^3. The growth law r_g(g/h dm^3) is:

$$r_g = \frac{\mu_{max} C_s C_c}{K_m + C_s}$$

and the rate of substrate consumption is related to growth rate with the stoichiometric relationship.

$-r_s = Y\, s/C^r g$

$C_c = Y_{c/s}[C_{s0} - C_s]$

(a) Write the mass balance of the cells and the substrate concentration in the CSTR operated at steady state.

(b) Solve the cell mass balance for the substrate concentration and calculate C_s.

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(c) Calculate the cell concentration C_{ci}.

(d) The reaction is now carried out in a 10 dm^3 batch reactor with initial concentrations of substrate C_{s0} = 30 g/dm^3 and the cells of C_{c0} = 0.1 g/dm^3. Plot C_s, C_c r_g and $-r_s$ as a function of time.

(e) Repeat (f) for a 100 dm^3 reactor.

2 A 100 m^3 fermentor of diameter 5 m is stirred using a turbine impeller 1.7 m in diameter at a speed of 80 rpm. The culture fluid inside the fermentor has the following properties.

$C_p = 4.2\ KJKg^{-1}°C^{-1}$

$K_{fb} = 0.6\ Wm^{-1}°C^{-1}$

$\rho = 10^3 m^{-3}$

$\mu_b = 10^{-3} Nsm^{-2}$

Assume that the viscosity at the wall is equal to the bulk fluid viscosity. Heat is generated by the fermentation at a rate of 2500 KW. This heat is removed to the cooling water flowing in a helical stainless-steel coil inside the vessel. The coil wall thickness is 6 mm and the thermal conductivity of the metal is 20 W m^{-1}° C^{-1}. There are no fouling layers present and the heat transfer co-efficient for the cooling water can be neglected. The fermentation temperature is 30°C and the cooling water enters the coils at 10°C.

(a) Calculate the fermentor-side-heat transfer coefficient.

(b) Calculate the overall heat transfer coefficient U. What proportion of the total resistance to heat transfer is due to pipe wall?

(c) The surface area needed for cooling depends on the cooling water flow rate. Prepare a graph showing the outlet cooling water-temperature and the area required for the heat transfer as function of coolant flow rate for $1.2\ X\ 10^5 kgh^{-1} \leq M_c \leq 2\ X\ 10^6 kgh^{-1}$.

(d) For a cooling water flow rate of 5 X 10^5 kg h^{-1}, estimate the length of cooling coil needed if the diameter is 10 cm.

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