BEL302: Fluid Solid System

MAJOR: 29 April 2008 from 3:30 to 5:30 pm in Rm. No. II-LT2

(Total Marks = 50)

PART A

1. a) What is the significance of the sigma factor in centrifugation?

(5 marks)

1. b) Find the capacity of a tubular sedimenting and clarifying centrifuge with the following operating parameters: bowl diameter = 50 cm; bowl depth = 30 cm; liquid layer thickness = 10 cm; liquid density = 1.1 g/cm3; liquid viscosity = 2 cP; solid density = 1.3 g/cm3; cut diameter of particles = 30 microns; speed of rotation = 800 rpm.

(5 marks)

2. On the same diagram, sketch V vs. t in constant pressure filtration for a) incompressible flow and b) compressible flow

(5 marks)

PART B

1. Wheat straw and wheat bran are mixed for a certain cattle feed formulation. A study was carried to determine the performance of the mixer at three different speeds of mixing. The variance in the mass fraction of wheat-bran component amongst a selection of samples withdrawn from the mixer for three cases was evaluated. The results are given below

Time (min)	0.1	1	3	6	7.5	10	15	23	30
s_1	0.204	0.179	0.145	0.106	0.073	0.053	0.042	0.022	0.012
s_2	0.202	0.167	0.114	0.065	0.053	0.028	0.012	0.006	0.002
s_3	0.204	0.181	0.155	0.120	0.094	0.073	0.059	0.016	0.006

Where s_1, s_2 and s_3 are the variances for mixing speeds of 100, 200 and 300 rpm.

If the wheat bran component is estimated to represent 29% of the mixture by mass and each of the samples removed contains approximately 125 particles

a. Using a suitable diagram, comment on the quality of mixing in each case.
b. Determine the rates of mixing in each case
c. What speed of mixing would you recommend for this process?

(5+5+3 marks)

2. Considering the material balance across a differential disk element normal to the direction of flow in the cell column reactor is given by the equation

$$\frac{\partial c}{\partial t}+\frac{u_c}{e}\frac{\partial c}{\partial l}-v=D_L\frac{\partial^2 c}{\partial l^2}+\frac{1}{r}D_R\frac{\partial}{\partial r}(r\frac{\partial c}{\partial r}) \qquad (1)$$

Here, c is the substrate concentration, u_c is the superficial velocity, e is the voidage of the packed column, l is the axial length and r is the radial dimension. D_L and D_R are the axial and radial diffusion coefficients. The rate of reaction v, is given by substrate inhibition kinetics $v = v_{max} c/\left(K_C + c + c^2/K_I\right)$. If the radial diffusion component $\partial c/\partial r$ is negligible, show that the equation(1) can be expressed in the form

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} x_2 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ \dfrac{x_2}{\bar{e}D_L} - \dfrac{v}{D_L} \end{bmatrix} \varpi \qquad (2)$$

Where $c = x_1$, $\dot{c} = x_2$ and $u_c^{\,2} = \varpi$. The "dot" over the variable denotes time differentiation

[HINT: $\partial c/\partial l = 1/u_c.(\partial c/\partial t)$].

What is the expression for $\bar{e}$?

(8+2 marks)

3. Effluent from a dairy plant is being processed in a fluidized bed reactor. The active material, the bio-granules may be considered to be spherical. The reactor is operated mid-way between the minimum fluidization velocity and the velocity at which the transport of bio-granules begins to occur. Determine the volume of effluent being treated per day if the reactor has a uniform cross-section area of 0.7855 m^2.

***Data*:** mean bio-granule diameter = 5 mm; Density of bio-granule = 1300 kg m^{-3}; viscosity of effluent = 4.75 mN s m^{-2}; density of effluent = 1100 kg m^{-3}; *State and justify any assumptions you make.*

(12 marks)