Code No: M0823/R07

Set No. 1

IV B.Tech. I Semester Supplementary Examinations, February/March - 2011

CHEMICAL PROCESS EQUIPMENT DESIGN

(Chemical Engineering)

Time: 3 Hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. Explain in detail the general design considerations [16]

2. a) Describe different types of flanges and operating conditions when these are used. [8]
   b) Discuss various types of pressure seals used in high pressure vessels on rotating shafts. [8]

3. Explain the design parameters involved in mechanical and fluidic devices. [16]

4. Write about the following:
   a) Design of supports for vessels. [8]
   b) Design and selection of piping systems. [8]

5. Solution of organic solids in water is to be concentrated from 8 to 45% solids in a single effect evaporator. Steam is available at a gauge pressure of 1.03 atm (120.5°C). A pressure of 102 mm Hg abs is to be maintained in the vapour space. The feed rate to the evaporator is 20,000 kg/hr. u is 2800 w/m^{2}C. The solution has negligible BPE and negligible heat of dilution. Calculate steam consumption, economy and the heating surface required if the temperature of feed is a) 51.7°C b) 21.1°C.
   Saturation temperature corresponding to 102 mm Hg = 51.7°C.
   Latent heat of vaporisation at 51.7°C = 2.373 x 10^6 J/kg.
   Latent heat of condensation of steam at 120.5°C = 2.196 x 10^6 J/kg.
   CP of feed solution is 3.77 J/g°C. [16]

6. Explain the design aspects for the construction of cooling towers. [16]

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7. For a high pressure vessel the following data is applicable :
   Internal diameter of the shell – 30 cm
   Internal pressure – 150 N/mm^2
   External pressure – Atmospheric
   Material – High Tensile steel (Cr Mo V)
   Permissible tensile stress (based on UTS) – 500 N/mm^2
   Permissible tensile stress (based on Y.S) – 700 N/mm^2
   Modulus of elasticity – 2×10^5 N/mm^2.
   Coefficient of linear expansion – 12.5×10^{-6}
   Calculate i) Vessel shell thickness
   ii) Variation of stress along the thickness. [16]

8. a) The area of heat transfer is 10 square meters. The aniline flow rate is 4500 kg/h Toluene at 37^0 C flowing at the rate of 3900 kg/h.counter current flow. The average specific heat of aniline is 2.1 and that of toluene is 1.85kJ/kgK. If the flow is counter current, Calculate the LMTD and the overall heat transfer coefficient. If the dirt factor is 0.0003m2 K/W, find the clean coefficient. [8]
   b) Write short notes on the following:
   i) Types of baffles used in shell and tube heat exchanger with figures [4]
   ii) Tube sheet layout and tube count [4]

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Set No. 2

IV B.Tech. I Semester Supplementary Examinations, February/March - 2011

CHEMICAL PROCESS EQUIPMENT DESIGN

(Chemical Engineering)

Time: 3 Hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
****

1. Write short notes on the following: [8+8]
   a) Plate hydraulic design.
   b) Pressure drop in packed towers.

2. Explain the term process design. By means of an illustrative example, explain how the process design is carried out. [16]

3. It is required to heat 4000kg/hr of benzene from 27^0C TO 50^0C using Toluene in a counter current DPHE. The toluene is cooled from 70^0C to 38^0C in the process. A dirt factor of $0.0001 m^2k/W$ is to be provided for each stream. Hair pins of 6m in length are available. The ID of the outer pipe is 5.2cm and inner pipe is 3.2cm.the wall thickness is 2mm. benzene is allowed to flow in the inner pipe. Find out the minimum number of hair pins required for this purpose. [16]

Property	Benzene	Toluene
Þ kg/m^3	880	870
C_p j/kg^0C	1800	1850
μ pa.s	0.5×10^{-3}	1.85×10^{-3}
kW/m^0C	0.16	0.15

4. Explain the following terms : [8+8]
   a) Stresses in thin and thick walled shells
   b) Theories of failure

5. Explain the aspects involved in the design of single effect evaporator [16]

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6. An absorber packed to the height of 5 m, is currently being used to remove a volatile organic chemical (VOC) pollutant from an exhaust stream. Fifteen cubic meters per minute of gas at 289°K and 1.013x 10^5 Pa, containing 5.0 mole % VOC is fed to the bottom of the absorber tower. By feeding a non-volatile, VOC – free solvent stream to the top of the tower, the VOC concentration is reduced to 0.3%. The solvent stream leaves the bottom of the tower containing3.65 mole % VOC. At the pressure and temperature of the tower, the equilibrium for the VOC – solvent system may be represented by YA = 0.8XA. The cross section area of the tower is 0.2 m^2. Determine the molar composition of the liquid stream flowing counter current to the gas stream at the point in the tower where the bulk gas composition is 2.5% VOC. [16]

7. a) Design of packed towers using absorption coefficients. [8]
   b) Explain the power drop calculations in the design of packed towers for absorption. [8]

8. Derive an expression for optimum economic pipe diameter for an incompressible fluid flowing in laminar flow. [16]

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Set No. 3

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CHEMICAL PROCESS EQUIPMENT DESIGN

(Chemical Engineering)

Time: 3 Hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
****

1. In a countercurrent-flow heat exchanger, 1.25 kg/s of benzene (specific heat 1.9 kJ/kgK and density 880 kg/m3) is to be cooled from 350 K to 300 K with water which is available at 290 K. In the heat exchanger, tubes of 25 mm external and 22 mm internal diameter are employed and the water passes through the tubes. If the film coefficients for the water and benzene are 0.85 and 1.70 kW/m2 K respectively and the scale resistance can be neglected, what total length of tube will be required if the minimum quantity of water is to be used and its temperature is not to be allowed to rise above 320 K? [16]

2. Discuss the factors to be considered in addition to basic process design variables when a design engineer selects double pipe heat exchangers. [16]

3. A pressure vessel of 1.5m in diameter, subjected to combined loading, operates at an internal pressure of 12kg/cm^2.the allowable stress of the material of fabrication is 1000kg/ cm^2. Welded joint efficiency is 85%.weight of the vessel with all its contents is 6000kg.Torque exerted over the vessel is 50kg. Neglect the bending moment. Corrosion allowance of 2mm may be taken. Calculate the various induced stresses and find whether it is higher than the allowable stress of the material. [16]

4. Explain the following terms : [8+8]
   i) Stresses in thin and thick walled shells
   ii) Tranportation of slurries

5. Explain the design aspects involved in the design of CSTR and PFR. [16]

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Set No. 3

6. a) Discuss the phenomenon "Entrainment Flooding" briefly. [4]
   b) A 100 moles of mixture contains 80 moles of organic acid and 20 moles of the non volatile component. The organic acid is a mixture of three components out of which 30 moles are of most volatile acid and 25 moles each of the other two acids. Distillation is to be carried out at 100°C, and a total pressure of 200 mm Hg. At 100°C, the vapour pressure of the acids is 20, 14 and 8 mm Hg and at equilibrium the mixture obeys Raoults law. The vaporization efficiency for each component may be taken as 0.9. The distillation is to be carried out until 99% of the least volatile acid is vaporized. Estimate the quantity of stream required for distillation. [12]

7. Write a note on various factors involved in the design of sieve tray distillation tower. [16]

8. Write short notes on the following: [4x4=16]
   a) Plate hydraulic design.
   b) Pressure drop in packed towers.
   c) Height of transfer unit.
   d) Mechanical features of batch reactor design.

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Set No. 4

IV B.Tech. I Semester Supplementary Examinations, February/March - 2011

CHEMICAL PROCESS EQUIPMENT DESIGN

(Chemical Engineering)

Time: 3 Hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
****

1. Discuss in detail the following: [4x4=16]
   a) health and safety hazards
   b) loss prevention
   c) Hazops study
   d) fault-tree analysis

2. Discuss the factors to be considered in addition to basic process design variables when a design engineer selects shell and tube heat exchangers. [16]

3. In a contact sulphuric acid plant, the gases leaving the first convertor are to be cooled from 845 to 675 K by means of the air required for the combustion of the sulphur. The air enters the heat exchanger at 495 K. If the flow of each of the streams is 2 m3/s at NTP, suggest a suitable design for a shell-and-tube type of heat exchanger employing tubes of 25 mm internal diameter. [8x2=16]
   (i) Assume parallel co-current flow of the gas streams.
   (ii) Assume parallel countercurrent flow.

4. What are the design aspects involved in the transportation of gases and liquids. [16]

5. Explain the following terms: [8x2=16]
   a) Design of storage vessels b) Design of supports to vessels.

6. Explain the design aspects involved in the design of CSTR and PFR. [16]

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Set No. 4

7. The hydrolysis of acetic anhydride is conducted in a reaction battery consisting of two vessels. The temperature of the first reactor is maintained at 10 and the second at 15. The reaction is of 1st order with specific reaction rates as below: [16]

Temperature, ^{0}C	10	15
K, min^{-1}	0.0567	0.086

The inlet composition is 177kmol/m3 and the feed rate is 0.095m^3/min.
The vessels are of the same size and the desired conversion is 95%.
Calculate the size of the vessels needed the size of the vessel if one vessel is at 10^{0}C.

8. (a) A valve tray tower with 24 inches plate spacing and liquid cross flow contains straight segmental downcomers. The overflow weir at the downcomer entrance is formed by an extension of the downcomer plate. The height of this weir is 3inches. The ID of the tower is 5ft and the weir length is 0.6D. If the liquid with a density of 55lb/ft^3 flows across the plate at a rate of 30000lb/hr, estimate the residence time in the downcomer from this plate. [8]

(b) Define and explain what is meant by optimum pipe diameter. How is it calculated? [8]