

**GUJARAT TECHNOLOGICAL UNIVERSITY****BE - SEMESTER-VI • EXAMINATION – WINTER 2013****Subject Code: 161401****Date: 27-11-2013****Subject Name: Food Process Equipment Design****Time: 02:30 pm to 05:00 pm****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Provide neat tables

- Q.1 (a)** A home air conditioning system uses a counter flow heat exchanger to cool 0.8 kg/s of air from 45°C to 15°C. The cooling is accomplished by a stream of cooling water that enters the system with 0.5 kg/s flow rate and 8°C temperature. If the overall heat transfer coefficient is 35 W/m<sup>2</sup>K, what heat exchanger area is required? If the same air flow rate is maintained while the water flow rate is reduced to half, how much will be the percentage reduction in heat transfer? Use only NTU approach. **07**

- (b)** 1. Answer the following: **07**
- i. Name the different types of pressure vessel head used in the food processing industry.
  - ii. Differentiate dryer and evaporator with respect to process and machinery

- Q.2 (a)** A solution with an initial solid concentration of 10% is being concentrated in a single effect evaporator to a final solid concentration of 40% under a vacuum of 40 kPa. The boiling point rise of the solution is negligible. Steam at a pressure of 101 kPa (gauge) is used to concentrate the liquor. The feed is entering at a temperature of 35°C and the temperature of final liquor is 86°C corresponding to a vacuum of 40 kPa prevailing in the evaporator. If the feed rate is 1000 kg/h, find the quantity of steam required and the heat transfer area of the evaporator. The specific heat of the feed which is reasonably constant is 5 kJ/kg°C and the overall heat transfer coefficient is 1.9 kW/m<sup>2</sup>°C. **07**

- (b)** Discuss the followings; **07**
1. Diagram of Chevron plate
  2. Temperature profile diagram for cross flow mixed type and unmixed type.

**OR**

Design a cylindrical pressure vessel to hold 5 kilo liter juice of specific gravity 1.08 at operating pressure of 0.45 N/mm<sup>2</sup> and temperature of 72°C. The safety factor is 2 and all butt joints are checked thoroughly by radiograph. The permissible stress of the material at 50°C is 160 N/mm<sup>2</sup> and at 100°C is 142 N/mm<sup>2</sup>. Available plates in stock:

Length : any

Breadth: 710, 1250, 1500 and 2000mm

Thickness : 7, 9, 11, 14, 16, 25, 45, 63, 80 mm

Corners radius is 6 percent of heads radius.

$$V = \pi R_i^2 H; \quad t = p D_i / \{2f \eta - p\};$$

$$t = \{p R_i W\} / 2f \eta; \quad W = 0.25 [3 + \{R_i / R_c\}^{0.5}]$$

- Q.3 (a)** What do you understand by AMTD? Derive the following equation for counter flow Log Mean Temperature Difference **07**

$$T_{lm} = \frac{[(T_{h1} - T_{c2}) - (T_{h2} - T_{c1})]}{\ln \frac{T_{h1} - T_{c2}}{T_{h2} - T_{c1}}}$$

- (b) Discuss the advantages of PHE. The design of a water cooled steam condenser has been made by presuming that the  $U = 5000 \text{ W/m}^2\text{K}$ . while deciding this value, the engineer presumed that flowing water is very clean and accordingly he neglects the fouling resistance. Later it is found that the cooling water is not clean at all and that it has a fouling resistance of the order of  $0.0006$  to  $0.002 \text{ m}^2/\text{KW}$ . Should the design calculation remade? **07**

**OR**

- Q.3** (a) What is the significance of the power function in an agitator? Develop the power function equation and explain. **07**
- (b) Differentiate between with diagram. **07**
1. Feed forward and Feed Backward evaporators
  2. Mixed type and parallel type evaporators

- Q.4** (a) Suggest and justify: **07**
- i. Economical and safe pressure vessel head for pressure up to  $0.5 \text{ N/mm}^2$
  - ii. Agitator for viscous liquid during the process of thawing
  - iii. Agitator for the fibrous high moisture solids
- (b) Discuss different types of material hazards in the food processing industry. How the damage cause can be minimized. Explain with the examples. **07**

**OR**

- Q.4** (a) What do you understand by overall heat transfer coefficient? Derive the following equations; **07**

$$U = \frac{1}{\frac{1}{h_i} + \frac{\delta}{k} + \frac{1}{h_o}} \quad \text{---(1)}$$

$$U_o = \frac{h_o h_i}{h_o + h_i} \quad \text{---(2)}$$

- (b) With the help of neat sketch describe any one type of agitator used in the food processing industry. **07**
- Q.5** (a) A pressure vessel is designed considering safe permissible stress as  $48 \text{ N/mm}^2$  at  $68^\circ\text{C}$ . If the joint efficiency and joint checking efficiency are  $0.72$  and  $0.82$  respectively and the material has allowable stress at  $28$  and  $144^\circ\text{C}$  as  $190$  and  $142 \text{ N/mm}^2$  respectively. Find the safety factor for the pressure vessel. What is its significance? **07**
- (b) What do you understand by heat capacity ratio? Derive the following equation for effectiveness for parallel flow **07**

$$\epsilon = \frac{1 - \exp[-NTU(1+C)]}{(1+C)}$$

**OR**

- Q.5** (a) Explain how the dryers are evaluated? Ambient air (dry bulb  $28^\circ\text{C}$  and wet bulb  $18^\circ\text{C}$ ) is heated to  $72^\circ\text{C}$  and fed in to the drying chamber of LSU dryer to dry parboiled paddy. If the air coming out of the dryer has temperature of  $58^\circ\text{C}$ . With the help of Psychrometry chart find other data of air and evaluate the LSU dryer. Suggest the methods to improve the performance of the dryer? **07**
- (b) Discuss the followings; **07**
1. Recuperation and Regeneration
  2. Temperature profile for condensation and evaporation
  3. Log Mean Temperature Difference

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