Seat No.: _____ Enrolment No._____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**Subject code: 161401**

**Subject Name: Food Process Equipment Design**

**Date:16/05/2011** **Time: 10.30 am – 01.00 pm**

**Total Marks: 70**

## Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

**Q.1** **(a)** List major and subsidiary loads considered while designing the pressure vessel. With the neat sketches describe different types pressure head used for the pressure vessels used in the food processing industry. **07**

**(b)** What is the purpose of agitation in the food industry? What are the factors considered while selecting the agitator in the food process industry? **07**

**Q.2** **(a)** A single shell pass four tubes counter flow heat exchanger is used as an economizer on a steam generator. Fuel gas ($C_p$ = 1.05KJ/kg K) enter the exchanger at $250^0$C and leaves at $150^0$C with a flow rate of 0.5kg/s. The feed water ($C_p$ = 4.18KJ/kg K) enters at $125^0$C at the rate of 0.35kg/s. Determine the number of transfer units and the effectiveness of the heat exchanger. Suppose a change in operating condition occurs that the feed heater must be by passed so the water enters at $60^0$C with a flow rate of 0.30kg/s. Workout the exit temperature of water when the exchanger operates under a changed condition. Presume that the effectiveness of exchanger remains unchanged. Correction factor = 0.78 **07**

**(b)** Why counter flow arrangement is more effective than parallel flow? Prove that **07**

$$T_{h2} - T_{c1} = (T_{h1} - T_{c2}) e^{-UA\left(\frac{1}{Cc} + \frac{1}{Ch}\right)}$$

**OR**

**(b)** Differentiate between counter flow and parallel flow with the help of temperature profile diagram. Also prove that **07**

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

**Q.3** **(a)** Differentiate between the following (ANY TWO) **07**

1. Recuperation and Regeneration with reference to heat exchanger
2. Mixed and Unmixed cross flow show with figure
3. Condensation and Evaporation in terms of energy exchange

**(b)** Discuss how the efficiency of the dryer is evaluated. Ambient air ($20^o$C, RH 69%) is heated to $70^o$C and fed in to the drying chamber. If the air coming out of the dryer has temperature of $55^o$C and the wet bulb temperature of $30^o$C. Calculate all the efficiencies of the dryer. How they can be improved. **07**

**OR**

**Q.3** **(a)** Derive an equation for overall heat transfer coefficient at inner and outer surfaces of cylinder when scale is formed. The design of water cooled steam condenser has been made by presuming that the overall heat transfer coefficient **07**

U =5020W/$m^2$ k. While deciding this value, engineer presumed that the flowing water is very clean and accordingly he neglected the fouling resistance. Later it is found that the cooling water is not clean at all and it has a fouling resistance of order of 0.0006 to 0.02$m^2$KW. Should the design calculation remade.

**(b)** Describe working of turbine type agitator with different types of its blades and their limitations with the neat sketch. **07**

**Q.4** **(a)** A solution of organic colloids in water is to be concentrated from 10 – 15% solid in case single effect evaporator. Steam is available at a gauge pressure 1kg/$cm^2$(120$^0$C). A pressure of 100mm mercury absolute is to be maintained in the space which corresponds to boiling point of water of 51$^0$C. The feed rate to the evaporator is 25000kg/hr. The overall heat transfer coefficient can be 2500Kcal/hr $m^2$ $^0$C. The solution has negligible boiling temperature and heat of dilution. Calculate the steam consumption, economy and the heating surface required. If the temperature of feed is (1) 51$^0$C, (2) 21$^0$C, (3) 93$^0$C. **07**

The specific heat of the feed solution is 0.90Kcal/gm $^0$C and latent heat of vaporization of solution may be taken equal to that of water. Radiation losses may be neglected.

Latent heat of vaporization at 120$^0$C = 525Kcal/gm & 51$^0$C = 563Kcal/gm

**(b)** Design a pressure vessel to sterilize the 10 t liquid food of specific gravity 0.92 at 0.25 N/$mm^2$ and 120$^o$C. The safe permissible stress at 120$^o$C with safety factor 2.5 after considering all efficiencies is 67 N/$mm^2$. **07**

Sheets available in the stock are: Length any size.

Width: 1250, 1500 and 2000 mm and thickness: 5.5, 6.0 and 7.0 mm

If required use the following: Corners radius is 6 percent of heads radius.

$V = \pi R_i^2 H$; $W = 0.25 [3+\{R_i / R_c\}^{0.5}]$

$t_{head} = \{p R_i W\} /2f$; $t_{vessel} = p D_i / \{2f - p\}$

**OR**

**Q.4** **(a)** Define evaporation and drying. Discuss the liquid characteristics important by the evaporation point of view. Classify the evaporators according to the method of feed. **07**

**(b)** A LSU dryer (Capacity 10 t) 2400 x 2400 mm having 6 discharge rollers having angular speed of 10 RPM mounted on the shaft of 50mm. The height of drying chamber is 5000 mm. The bulk density of the material is 560 N/$m^3$, frictional coefficient is 0.48 and the ratio of lateral pressure to vertical pressure is 0.135. The safe stress of the steel used is 1000 N/$cm^2$. Design the roller for its width, thickness and power requirement if retention time in the dryer is to be 45 minutes. **07**

**Q.5** **(a)** What is purpose of baffling in the process of agitation? For Newtonian liquids develop the power number equation. What is its significance? **07**

**(b)** A spray dryer is fed with liquid (containing 28% solids) 500 kg/h at 42$^o$C. Hot air at 220$^o$C and 0.02 kg water vapor per kg dry air is used to dry the liquid to powder with 3% moisture content dry basis at 85$^o$C. The exit air temperature is 115$^o$C. Calculate the capacity ($m^3$/sec) of blower required and the absolute humidity of the exit air. Specific heat of dry air, water vapor, solids and water are 1.005, 1.90, 1.25 and 4.2KJ/Kg $^o$C. the latent heat of vaporization is 2500KJ/Kg. **07**

**OR**

**Q.5** **(a)** What is boiling point elevation? Describe the Duhring lines with help of diagram. Why PHE is more preferable in food industries? Draw the diagram of plate with all notations. **07**

**(b)** What are different types of process and material hazards in the food processing industry? How they can lead to fail the well design equipments? Describe with suitable examples. **07**

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