Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI • EXAMINATION – SUMMER • 2014

Subject Code: 161401 **Date: 19-05-2014**

Subject Name: Food Process Equipment Design

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.**
4. **Use of steam table is permitted.**

Q.1 **(a)** A concurrent heat exchanger of 1m length cools oil from 150^0C to 100^0C by a stream of cooling water that enters the cooler at 15^0C and leaves at 25^0C. Subsequently the process conditions demand that the oil be cooled at 75^0C and the design engineer suggest that this be done by lengthening the cooler. If the oil and water flow rates, their inlet temperatures and other dimensions remains unchanged, then determine the length and outlet temperature of cooling water of the new cooler. Use NTU approach only. **07**

(b) An industrial tray dryer is designed to dry ten tones of grapes in a batch of six hours with two half an hour tempering in between. The initial moisture content of grapes was 525% (DB) and in the first one hour 1/3 of total available water was removed. After first tempering in next two hours 1/2 of the now available water is removed. After second tempering in the next two hours ¾ of now available water is removed then calculate the moisture content of the resin after each drying? If the capacity of the blower so that the maximum rise in absolute humidity will be 0.018 kg water vapor /kg dry air. If the density of the air is 1.12 kg/m3 and maximum permissible linear velocity is 2m/s. Then calculate the tray area required for the drying. **07**

Q.2 **(a)** i. List different types of agitators used in the food processing industry. **03**

ii. Which type of agitator you will recommend when, as solid-liquid mixing progresses, the viscosity of mix increases. Why? **04**

(b) What do you understand by effectiveness? Derive the following equation for effectiveness for counter flow **07**

$$\in = \frac{1-\exp\left[-\mathrm{NTU}(1-\mathrm{C})\right]}{1-\mathrm{C}\exp\left[-\mathrm{NTU}(1-\mathrm{C})\right]}$$

OR

(b) (i) Explain:

1. Chevron angle 2. T H E and 3. Steam economy **03**

(ii) Discuss the major and subsidiary loads used for designing a pressure vessel. **04**

Q.3 **(a)** List out the points need to be kept in mind regarding overall heat transfer coefficients. **07**

After being in service for a period of six months, a heat exchanger transfers 10% less heat than it does when new. Determine the effective fouling factor in terms of its clean (new) overall heat transfer coefficients. It may be presumed that the heat exchanger operates between the same temperature differentials and there is no change in the effective surface area due to scale build up.

(b) Write down the application of PHE in food industry. Draw the detailed diagram of Chevron plate with all notations. List out the advantages of PHE. **07**

OR

Q.3 **(a)** What do you understand by energy and material balance in processing of food products? Explain mass and energy balance in single and multiple effect evaporators with diagram. **07**

(b) Describe process hazards and material hazards with suitable examples of food processing industry. Also discuss their preventive safety measures. **07**

Q.4 **(a)** Describe different type of baffles and their dimensional limitations? What is the role of baffles in the process of agitation? **07**

(b) Design a pressure vessel head for pressure vessel (Diameter 1900mm and thickness is 6mm) having operating pressure of 0.40±0.05 N/mm^2 and temperature of 72^oC. The permissible stress at 30 and 200^oC are 200 and $144N/mm^2$ respectively. The joint efficiency and joint checking efficiency are 85 and 90 per cent respectively. The desired safety factor is 2. The If required following formula can be used: **07**

$t_{head} = C_e D_i \{p/f\}^{0.5}$; $t_{head} = \{p R_i W\} /2f$

$t_{head} = p D V / 2f$; $t_{head} = p D / 4f$;

$V = 0.25 (2 + K^2)$; $W = 0.25 [3+\{R_i / R_c\}^{0.5}]$

Available sheet thickness are: 5.5, 6, 8 and 10 mm

OR

Q.4 **(a)** What is meant by BPR and how does it affect the evaporation process? Explain Duhring's rule. What are the various feeding methods in multi effect evaporators with relative advantage of each method? **07**

(b) Design the shaft of an agitator, having angular speed of 160 RPM operated by 5HP motor with a impeller of 45 cm. The maximum torque and bending moment on full load are estimated to be 195 and 325 Kg m. The safe permissible shear and tensile stress are 400 and 600 kg/cm^2. **07**

Q.5 **(a)** (i) Explain: **03**

1. H U F 2. Capacity ratio and 3. Fouling factor

04

(ii) Design a blower to carry the librated moisture from grain dryer (capacity 6 t) by hot air of 55^oC. The dryer is fed with grains of 24% moisture content (WB) and dried to 14% moisture content (WB) in 6 hours. The density of the air is $1.1kg/m^3$ and absolute humidity of inlet and outlet air is 0.014 and 0.023 kg water vapor per kg dry air. Maximum pressure drop of 5 cm of water column is observed.

(b) Discuss feature and dimensional limitations of turbine agitator. **07**

OR

Q.5 **(a)** With the Bukingham's Π thermo derive the power function of an agitator. What is its significance? **07**

(b) Design a pressure vessel to hold 8KL of juice specific gravity of 0.97 operating at maximum pressure of 0.3±0.03 N/mm^2. The safe permissible stress at the operating temperature considering butt joints and its efficiency is 65 N/mm^2. The sheets available in the stock are: **07**

Length	Any
Width	1000, 1250, 1500 and 2200 mm
Thickness	5.5, 7, 9 and 10 mm

If required use the following: $V = \pi R_i^2 H$; $t_{vessel} = p D_i / \{2f - p\}$

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