Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– VI• EXAMINATION–SUMMER 2015

Subject code: 161401 **Date:01/05/2015**

Subject Name: Food Process Equipment Design

Time: 10:30 am to 01:00 pm **Total Marks: 70**

Instructions:

I. **Attempt all questions.**
II. **Make suitable assumptions wherever necessary.**
III. **Figures to the right indicate full marks.**
IV. **Provide steam table**

Q.1 **(a)** A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20^0C to 50^0C by hot water, which enters the thin-walled 2cm diameter tubes at 80^0C and leaves at 40^0C. The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 W/m^{20}C on the glycerin (shell) side and 160 W/m^{20}C on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (***a***) before any fouling occurs and (***b***) after fouling with a fouling factor of 0.0006 m^{20}C/ W occurs on the outer surfaces of the tubes. **07**

(b) Differentiate between single and multiple effect evaporators. Explain steam economy. Give the classification of evaporators with diagram. **07**

Q.2 **(a)** Calculate the power requirement (in horse power) and capacity of the blower (in cubic meter per minute), to cool the grains (0.75 t/h) by 10^oC. The maximum permissible rise in air temperature is 6^oC. The density of the air is 1.1 kg/m^3 and specific heat of food and air is 2.4 and 1.03kJ/kg ^{o}C respectively. Considering there is no loss of moisture and pressure drop of 1.5 cm water column during the process of cooling. **07**

(b) Steam in the condenser of a power plant is to be condensed at a temperature of 30^0C with cooling water from a nearby lake, which enters the tubes of the condenser at 14^0C and leaves at 22^0C. The surface area of the tubes is 45 m^2, and the overall heat transfer coefficient is 2100 W/m^0C. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. The heat of vaporization of water at 30^0C is 2431 kJ/kg and the specific heat of cold water is 4184 J/kg^{0}C. **07**

OR

(b) Write down the steps for designing the pressure vessel and its head. Which type of head will be most suitable in which condition? **07**

Q.3 **(a)** What is the difference between AMTD and LMTD. Give the limitations of AMTD. Derive the equation of Number of Transfer Unit for parallel flow: **07**

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

(b) Design an agitator shaft to rotate at 56 rpm with 3 hp motor. Impeller diameter of 65 cm. The maximum bending moment and torque are 277 and 189 Nm. Permissible shear and tensile stresses are 400 and 600 N/cm^2 respectively. **07**

OR

Q.3 **(a)** List out the maximum operating conditions and advantages of PHE. **07**

(b) Design a pressure vessel to sterilize the 2.5 t liquid food of specific gravity 0.92 at 0.35 N/mm^2 and 55°C. The safe permissible stress at 40 and 100°C are 165 and 130 N/mm^2 respectively. The desired safety factor is 2.5. The company wishes to check all joints with the radiograph. The joint efficiency is 90%. **07**

Sheets available in the stock are: Length any size.

Width: 1250, 1500 and 2000 mm and Thickness: 5.5, 6.0, 8.0 and 10 mm

Corners radius is 6 percent of heads radius.

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

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

Q.4 **(a)** What are the different types of an agitator used in the food industry? Which type of agitator you will recommend for the bakery kneading purpose and why? **07**

(b) Develop the equation of overall heat transfer coefficient for plane wall and pipes. List out the points to be kept in mind with respect to overall heat transfer coefficient. **07**

OR

Q.4 **(a)** What is significance of power function number of an agitator? What are the properties of agitator shaft is considered for designing it? **07**

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

$$Q = UA\Delta T_{LM}$$

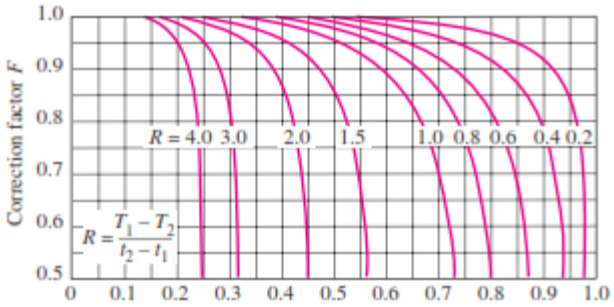
Q.5 **(a)** Discuss the possible process hazards of a specific food industry. What precaution one should take to minimize the same. **07**

(b) Explain the mass and enthalpy balance of single and multiple effects of evaporators. Also discuss the feed forward and feed backward flow pattern. **07**

OR

Q.5 **(a)** With the Bukingham's Π theorem derive the power function of an agitator. Discuss its relationship with Reynold's number and Flow number. **07**

(b) Apple juice is being concentrated in a natural-circulation single effect evaporator. At steady-state conditions, dilute juice is the feed introduced at a rate of 0.67 kg/s. The concentration of the dilute juice is 11% total solids. The juice is concentrated to 75% total solids. The specific heats of dilute apple juice and concentrate are 3.9 and 2.3 kJ/kg °C, respectively. The steam pressure is measured to be 304.42 kPa. The inlet feed temperature is 43.3°C. The product inside the evaporator boils at 62.2°C. The overall heat-transfer coefficient is assumed to be 943 W/m^2°C. Assume negligible boiling-point elevation. Calculate the mass flow rate of concentrated product, steam requirements, steam economy, and the heat-transfer area. Also draw the sketch of the system. **07**



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