Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. SEMESTER III–EXAMINATION – WINTER 2015

Subject code: 2733005 **Date: 04/12/2015**

Subject Name: Advanced Heat Transfer

Time: 2:30 PM to 5:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Notations used have their conventional meanings.**

Q.1	**(a)**	State various types of condensers and differentiate between horizontal condenser and vertical condenser.	**07**
	(b)	Starting with the assumptions, derive the equation for determining the tube and shell side heat transfer coefficient, overall heat transfer coefficient and pressure drop in case of kettle type reboiler.	**07**
Q.2	**(a)**	Discuss various types of fluidized bed and its heating system in brief.	**07**
	(b)	An average convective heat transfer coefficent for flow of 90°C air over a flat plate is measured by observing the temerature time history of a 40 mm thick copper slab (ρ = 9000 kg/m^3 , C_P = 0.38 kJ/kg-°C , K = 370 W/m °C) exposed to air maintained at 90°C. In one test run, the initial temperature of the plate was 200°C , and in 4.5 minutes the temperature decreased by 35°C, Determine the heat transfer coefficient for this case. Neglect internal thermal resistance.	**07**
		OR	
	(b)	Calculate the amount of steam required for concentrating the solution of caustic soda (NaOH) from 28% w/w of solids to 40% w/w of solids in a single effect evaporator. The feed rate is 25000 kg/hr and its temperature is 60°C. The absolute pressure in the evaporator is 0.2 kg/cm^2. (Boiling point 60°C). Saturated steam is available at 1.4 kg/cm^2 (108.7 ^{o}C) is to be used as heating medium. The elevation in boiling point is 25 ^{o}C. If the overall heat transfer coefficient is 670 kcal/ (hr. m^2. ^{o}C), calculate the heating surface required for the desired operation. The enthalpy data for various streams are as follows: Vapor at 0.2 kg/cm^2 = 623 kcal/kg, 28 % NaOH at 60°C = 50 kcal/kg, 40% NaOH at 85°C = 90 kcal/kg, Latent heat of steam at 1.4 kg/cm^2 = 534 kcal/kg.	**07**
Q.3	**(a)**	Discuss the factor affecting the performance of an evaporation operation	**07**
	(b)	Explain the steps for the designing of Spiral flow heat exchanger.	**07**
		OR	
Q.3	**(a)**	Discuss unsteady state heat conduction and explain lumped heat capacity system in case of unsteady state conduction.	**07**
	(b)	With special reference to fin efficiency and fin effectiveness, explain the construction and working of finned tube heat exchanger.	**07**
Q.4	**(a)**	Discuss pool boiling in case of heat transfer in boiling liquids.	**07**
	(b)	Discuss transient heat conduction in case of semi – infinite solids.	**07**
		OR	
Q.4		Mobil therm oil is used as heating medium in chemical industry. Its operating range is from -1.1°C to 316°C. It is required to cool 9000kg/h of mobil therm oil from 260°C to 200°C by using atmospheric air as a cooling medium in air cooler. Design the suitable air cooler.	**14**

Properties of mobil therm oil at 230°C are as under

- Density, $\rho = 850 kg/m^3$, Viscosity, $\mu = 0.595$ cP
- Specific heat $C_L = 2.5$ kJ/(kg. ^{0}C)
- Thermal conductivity, k = 0.1159W/(m. ^{0}C)
- Maximum possible temperature of atm air in the ares as 48°C and outlet temp of air = 75 °C
- Specific heat of air at 61.5 °C, C_{Pa}= 1.0467 kJ/(kg. °C)
- $F_t = 0.98$
- Tube O. D. =19.05 mm , Fin O. D. = 38 mm
- Tube pitch = 43 mm (equilateral triangular)
- No of fins per 1 meter length = 315
- Fin thickness = 0.889 mm
- Tube length L = 1200 mm
- Width of air facing area W =1200 mm
- Number of banks = 3
- H_{od}= 5000W/(m^2. °C) , h_{id}=5000W/(m^2. °C)
- Tube inside diameter d_i=14.8336 mm(for 14 BWG tube)
- No of tube side passes =4
- Friction factor, $f = 1.08558 * Re^{-0.128025}$
- $\Delta P_t = N_p \left(8 J_f \frac{L}{d_i}\left(\frac{\mu}{\mu_w}\right)^{-m} + 2.5\right)\frac{\rho u_t^2}{2}$
- $\Delta P_s = \frac{f G_s^2 L_p}{D_{ev}\rho}\left(\frac{D_{ev}}{S_T}\right)^{0.4}\left(\frac{S_L}{S_T}\right)^{0.6}$

Q.5 10900 kg/hr Methyl ethyl ketone vapour at 13.73 kPa g pressure and 83.87°C temperature is to be condensed and cooled to 60°C by cooling water available at 32°C. Consider pressure drop of 13.7 kPa for vapour and 86.7 kPa for the water as permissible. Design the condenser for given heat duty. **14**

Data : Shell side : Methyl ethyl ketone Tube side: Water form cooling tower Latent heat of methyl ethyl ketone at 83.87°C is 440 kJ/sec. Take overall coefficient for condensation is 800W/m^2°C, overall coefficient for sub cooling is 200 W/m^2°C. Db= do *(Nt/k1)1/n1 , pt/do= 1.25 triangular pitch

No of tube side pass	1	2	4	6
K1	0.319	0.249	0.175	0.0743
n 1	2.142	2.207	2.285	2.499`

Tube OD 19.05 mm, length 1.83 m

$Nu = 0.023 Re^{0.8} Pr^{0.33}$

Tube wall temperature is 58.5 °C. h_{co} = 1500 W/(m^2 ^{0}C)

Shell side condensation coefficient with horizontal position used below equation

$$h_{co} = 0.95 * kL\{\rho L(\rho L - \rho V)g/(\mu L * \tau h)\}^{1/3} * N_r^{-1/6}$$

h_{osub} = 283.77 W/(m^{20}C)

organic vapours, h_{od} = 10000 W/(m^{20}C)

cooling water h_{id} =4000 W/(m^{20}C)

thermal conductivity of SS-304 material, k_w = 16.3 W/(m^0C).

OR

Q.5 (a) Analyze different modes of heat transfer and differentiate between them along with examples and governing laws of each. **07**

(b) Discuss the design steps of thermo siphon reboiler. **07**

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