Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME - SEMESTER– II(Old course) • EXAMINATION (Remedial) – WINTER- 2015

Subject Code: 1722101 **Date: 09/12/2015**

Subject Name: Design of Heat Exchange Equipments

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.**

Q.1 **(a)** When one of the two fluids undergoes phase change, Derive an equation for effectiveness in counter flow heat exchanger using ÚNTU method. **07**

(b) Classify heat exchangers according to flow type and explain the characteristics of each type. **07**

Q.2 **(a)** Explain how the charts provided by Kays and London are useful in the design of heat exchangers. **07**

(b) List and Explain the basic principles of heat transfer in detail. **07**

OR

(b) 1. In a gas to liquid heat exchanger, why are fins provided on the gas side? **07**

2. In the definition of effectiveness, explain why minimum heat capacity value (C_{min}) is used for the maximum possible rate of heat transfer?

Q.3 **(a)** Explain the method of Plate heat exchanger design. **07**

(b) Compare óplate and frame heat exchangerô and ówelded plate heat exchangerô. **07**

OR

Q.3 **(a)** Explain giving precious reason why fouling fluids are not used in compact heat exchangers **07**

(b) Explain double pipe heat exchanger and derive the expression for hydraulic diameter and equivalent diameter for hairpin heat exchanger. **07**

Q.4 **(a)** Explain various óTEMA-Standardô available for shell designs in the shell and tube heat exchangers. **07**

(b) Distilled water with a flow rate of 50 kg/s enters a baffled shell and tube heat exchanger at 32 C and leaves at 25 C. Heat will be transferred to 150 kg/s of raw water coming from a supply at 20 C. You are informed to design the heat exchanger for this purpose. A single shell and tube is preferable. The tube O.D. and I.D. is 19 mm and 16 mm. Tubes are laid out on 2.54 cm square pitch. Maximum length of the heat exchanger is 8 m is required because of space limitations. Assume K_{tube} = 42.3 W/m K and maximum flow velocity through the tube is to be 2 m/s to prevent erosion. Also perform thermal analysis of the heat exchanger using Bell-Delaware method using correction factor of 60%. The following correlations and properties may be used; **07**

	Tube side fluid	Shell side fluid
ρ (kg/m^3)	998.2	995.9
μ (Ns/m^2)	10.02×10^{-4}	8.15×10^{-4}
k (W/m.K)	0.598	0.612
c_p (J/kg.K)	4182	4179
Pr	7.01	5.75

	Tube side fluid	Shell side fluid
Corelations used	$Nu_b = \dfrac{(f/2)\mathrm{Re}_b\,\mathrm{Pr}_b}{1.07+12.7(f/2)^{1/2}\left(\mathrm{Pr}_b^{1/2}-1\right)}$ $f=(158\ln \mathrm{Re}_b-3.28)^{-2}$	$h_{id}=j_i c_p\left(\dfrac{\dot{m}_s}{A_s}\right)\left(\dfrac{k_s}{c_p\mu_s}\right)^{2/3}$ $j_i=0.185\,\mathrm{Re}_s^{-0.324}$

OR

Q.4 (a) Name and explain the various leakages and bypass streams taken in to account in determination of shell side heat transfer coefficient and pressure drop in Bell-Delaware method. **07**

(b) A shell and tube condenser of a large steam power plant consisting of a single shell and 30,000 tubes, each executing two passes. The tubes are of thin wall construction with 25 mm diameter and steam condenses on their outer surface with an associated convection coefficient of 11,000 W/m^2.K. The heat transfer rate that must be affected by the exchanger is 2 × 10^9 W, and this is accomplished by passing cooling water through the tubes at a rate of 3 × 10^4 kg/s. The water enters at 20 °C, while the steam condenses at 50 °C. What is the temperature of the cooling water emerging from the condenser? What is the required tube length L per pass? Take properties of water are: ρ = 997 kg/m^3, C_p = 4179 J/kg, μ = 855×10^{-6} N.s/m^2, k = 0.613 W/m.K, Pr = 5.83. **07**

Use an internal flow correlation as $Nu_D = 0.023\,\mathrm{Re}_D^{4/5}\,\mathrm{Pr}^{0.4}$

Q.5 (a) State design and operational considerations while selecting of condensers. **07**

(b) A double pipe heat exchanger is used to condense steam at a rate of 120 kg/h at 45 °C. Seawater enters through the inner tube at a rate of 1.2 kg/s at 15 °C. The tube with 25.4 mm O.D. and 22.1 mm I.D. is made of mild steel, k = 45 W/m.K. The heat transfer coefficient on the steam side, h_o is 7000 W/m^{2}K Calculate the overall heat transfer coefficient under clean and fouled conditions. C_p = 4.18 kJ/kg K for water and h_{fg} = 2392 kJ/kg. At the mean temperature the properties of water are ρ = 997.207 kg/m^3, k = 0.605 W/m K, μ = 9.09×10^{-4} Pa.s and Pr =6.29, Fouling factor for sea water and condensate are 0.088 m^2 K/kW. Use following correlation for inside of tube; **07**

$$Nu_b = \frac{(f/2)(\mathrm{Re}_b-1000)\mathrm{Pr}_b}{1+2.7(f/2)^{1/2}\left(\mathrm{Pr}_b^{2/3}-1\right)}$$

$$f=(1.58\ln \mathrm{Re}-3.28)^{-2}$$

OR

Q.5 (a) State design considerations for a coal based furnace. **07**

(b) Water at a flow rate of 5000 kg/h will be heated from 20 to 35 °C by hot water at 140 °C. A 15 °C hot water temperature drop is allowed. A number of 3.5 m long hairpins of I.D. = 0.0779 m by I.D. = 0.0525 m and O.D. = 0.0603 m double pipe heat exchangers with annuli and pipes each connected in series will be used. Hot water flows through the inner tube. Inside and outside fouling factors are 0.000176 m^{2}K/W and 0.000352 m^2 K/W. Assume that the pipe is made of carbon steel (k = 54 W/m K). The heat exchanger is insulated against heat losses. Calculate the number of hairpins. Take properties of hot and cold water in a following manner: **07**

	Hot water	Cold water
ρ (kg/m^3)	932.53	996.4
μ (Pa.s)	0.207×10^{-3}	0.841×10^{-3}
k (W/m.K)	0.687	0.609
c_p (kJ/kg.K)	4.268	4.179

Pr	1.28	5.77
	$f = \left(1.58 \ln \mathrm{Re} - 3.28\right)^{-2}$	$f = \left(3.64 \log_{10} \mathrm{Re} - 3.28\right)^{-2}$
Use : $Nu_b = \dfrac{\left(f/2\right)\mathrm{Re}_b \, \mathrm{Pr}_b}{1 + 8.7\left(f/2\right)^{1/2}\left(\mathrm{Pr}_b - 1\right)}$ for both fluids		

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