Seat No.: ________ Enrolment No.______________

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – II • EXAMINATION – WINTER • 2013

Subject code: 1723903 **Date: 31-12-2013**

Subject Name: Thermal 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 Property tables, steam tables and refrigeration tables are permitted.**

Q.1 **(a)** State the assumptions made in LMTD method. Explain LMTD method for parallel flow heat exchanger. **07**

(b) Steam at atmospheric pressure enters the shell of a surface condenser in which the water flows through a bundle of tubes of diameter 25mm at the rate of 0.05 kg/s. The inlet and outlet temp. of water are 15^0C and 70^0C resp. The condensation of steam takes place on the outside surface of the tube. If the overall heat transfer co-efficient is 230 W/m^{20}C,calculate using NTU method, (i)Effectiveness of heat exchanger (ii)length of the tube (iii)rate of steam condensation **07**

Q.2 **(a)** Give the complete classification of heat exchanger with schematic diagram. **07**

(b) Distilled water with a flow rate of 50kg/s enters a baffled shell and tube type heat exchanger at 32^0C and leaves at 25^0C. heat will be transferred to 150 kg/s of raw water coming from supply at 20^0C. Estimate using Kern method, LMTD, shell diameter, equivalent diameter using 1 inch square pitch and heat transfer co-efficient. A single shell and single tube pass is preferable. The tube diameter is 19mm OD and 16mm ID.max. flow velocity through the tube is 2 kg/s. Baffle spacing is 0.5m. **07**

OR

(b) Using Kern method, Determine the shell side and tube side heat transfer co-efficient for 2-P shell and tube type heat exchanger for the given data: Shell internal diameter = 0.39m, Nos. of tubes = 124, Tube parameters –OD=19mm, ID = 16mm, K_{tube} = 60 W/m^2K, baffle spacing =0.25m and cut = 25%, fouling resistance of 0.000176m^2.K/W on both side, Pitch size = 0.024m, μ_w=6.04 x 10^{-4} Ns/m^2.Mass flow rate = 13.88Kg/s. Assume Th_1=67^0C,Th_2= 53.2^0C, Tc_1=17^0C, Tc_2=40^0C. m_t = 8.33kg/s **07**

Q.3 **(a)** Write a short note on evaporative condenser. **07**

(b) A double pipe heat exchanger is employed to heat raw water ($\dot{m}_c$ =5 kg/s) from 15^0 to 65^0C using waste hot water ($\dot{m}_h$ = 4.83 Kg/s) cooled in the process from 95^0 to 75^0C.The hot water flows in the inner tube (ID = 40mm, OD = 48mm) in counter flow to the raw water which flows in annulus (ID = 75mm, OD = 90mm). Calculate the total length of heat exchanger. Consider K_W = 60 W/m ^{0}K. **07**

OR

Q.3 **(a)** Explain double pipe type evaporator. **07**

(b) Write a explain design procedure for condenser. **07**

Q.4 **(a)** Explain Plate-Fin Heat Exchanger and Tube-Fin Heat exchanger **07**

(b) Air enters the core of a finned –tube heat exchanger of the type shown in FIGURE 1 at 1 atm and 30^0 C.The air flows at a rate of 1500 Kg/h perpendicular to the tubes and exits with a mean temperature of 100^0 C. The core is 0.5 m long with a 0.25 m^2 frontal area. Calculate the total pressure drop between the air inlet and outlet and the average heat transfer coefficient on the air side. **07**

OR

Q.4 **(a)** List out the assumptions made for Regenerator heat transfer analysis **07**

(b) Determine the effectiveness and the outlet temperatures of the hot and cold fluids of a two-disk (in parallel) counterflow rotary regenerator for a vehicular gas turbine using the following data: **07**

Operating conditions	Disk geometry (exclusive of rim)
Airflow rate = 2.029 kg/s	Disk diameter = 0.683 m
Gas flow rate = 2.094 kg/s	Hub diameter = 0.076 m
Disk speed = 15 rpm	Seal face coverage = 7%
Air inlet temperature = 480^0 C	Matrix effective mass (two disks) = 34.93 kg
Gas inlet temperature = 960^0 C	Matrix compactness β = 5250 m^2/m^3
Flow length = 0.0715 m	Flow split, gas : air = 50:50
Heat transfer coefficients	Physical properties
h_{air}= 220.5 W/m^2 K	$Cp_{;air}$ = 1.050 kJ/kg K
h_{gas}= 240.5 W/m^2 K	Cp_{gas} = 1.130 kJ/kg K

Q.5 **(a)** What is cooling tower performance? List the factors affecting it **07**

(b) A chiller system with capacity 500kW and COP 4.5 is designed with a cooling tower, the designed temperatures for water entering and leaving condenser of the cooling tower are 37°C and 32°C respectively, the design wet bulb temperature of the outdoor air is 28°C, what are: **07**

a) the cooling tower coefficient

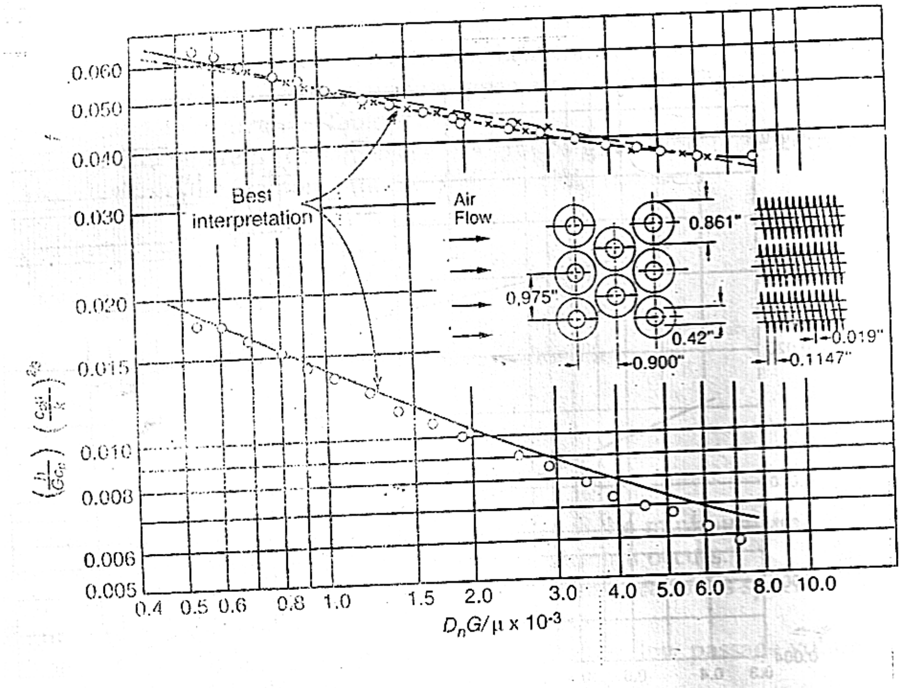
b) the required condenser water and air mass rate (in kg/s) in the cooling tower

c) the required height of the fill

OR

Q.5 **(a)** Write a short note on forced draft cooling tower **07**

(b) Describe the main elements of cooling tower with neat sketch. **07**



Heat transfer and friction factor for flow across circular finned-tube matrix. Surface CF-8.72(c): tube OD = 1.07 cm; fin pitch = 3.43/cm; fin thickness = 0.048 cm; fin area/total area = 0.876; air-passage hydraulic diameter, d_h = 0.443 cm; free-flow area/frontal area, σ = 0.494; heat transfer area/total volume = 446 m^2/m^3.

FIGURE 1

Properties of air at 1 atm pressure

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p, J/kg · K	Thermal Conductivity k, W/m · K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m · s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr
−150	2.866	983	0.01171	4.158×10^{-6}	8.636×10^{-6}	3.013×10^{-6}	0.7246
−100	2.038	966	0.01582	8.036×10^{-6}	1.189×10^{-5}	5.837×10^{-6}	0.7263
−50	1.582	999	0.01979	1.252×10^{-5}	1.474×10^{-5}	9.319×10^{-6}	0.7440
−40	1.514	1002	0.02057	1.356×10^{-5}	1.527×10^{-5}	1.008×10^{-5}	0.7436
−30	1.451	1004	0.02134	1.465×10^{-5}	1.579×10^{-5}	1.087×10^{-5}	0.7425
−20	1.394	1005	0.02211	1.578×10^{-5}	1.630×10^{-5}	1.169×10^{-5}	0.7408
−10	1.341	1006	0.02288	1.696×10^{-5}	1.680×10^{-5}	1.252×10^{-5}	0.7387
0	1.292	1006	0.02364	1.818×10^{-5}	1.729×10^{-5}	1.338×10^{-5}	0.7362
5	1.269	1006	0.02401	1.880×10^{-5}	1.754×10^{-5}	1.382×10^{-5}	0.7350
10	1.246	1006	0.02439	1.944×10^{-5}	1.778×10^{-5}	1.426×10^{-5}	0.7336
15	1.225	1007	0.02476	2.009×10^{-5}	1.802×10^{-5}	1.470×10^{-5}	0.7323
20	1.204	1007	0.02514	2.074×10^{-5}	1.825×10^{-5}	1.516×10^{-5}	0.7309
25	1.184	1007	0.02551	2.141×10^{-5}	1.849×10^{-5}	1.562×10^{-5}	0.7296
30	1.164	1007	0.02588	2.208×10^{-5}	1.872×10^{-5}	1.608×10^{-5}	0.7282
35	1.145	1007	0.02625	2.277×10^{-5}	1.895×10^{-5}	1.655×10^{-5}	0.7268
40	1.127	1007	0.02662	2.346×10^{-5}	1.918×10^{-5}	1.702×10^{-5}	0.7255
45	1.109	1007	0.02699	2.416×10^{-5}	1.941×10^{-5}	1.750×10^{-5}	0.7241
50	1.092	1007	0.02735	2.487×10^{-5}	1.963×10^{-5}	1.798×10^{-5}	0.7228
60	1.059	1007	0.02808	2.632×10^{-5}	2.008×10^{-5}	1.896×10^{-5}	0.7202
70	1.028	1007	0.02881	2.780×10^{-5}	2.052×10^{-5}	1.995×10^{-5}	0.7177
80	0.9994	1008	0.02953	2.931×10^{-5}	2.096×10^{-5}	2.097×10^{-5}	0.7154
90	0.9718	1008	0.03024	3.086×10^{-5}	2.139×10^{-5}	2.201×10^{-5}	0.7132
100	0.9458	1009	0.03095	3.243×10^{-5}	2.181×10^{-5}	2.306×10^{-5}	0.7111
120	0.8977	1011	0.03235	3.565×10^{-5}	2.264×10^{-5}	2.522×10^{-5}	0.7073
140	0.8542	1013	0.03374	3.898×10^{-5}	2.345×10^{-5}	2.745×10^{-5}	0.7041
160	0.8148	1016	0.03511	4.241×10^{-5}	2.420×10^{-5}	2.975×10^{-5}	0.7014
180	0.7788	1019	0.03646	4.593×10^{-5}	2.504×10^{-5}	3.212×10^{-5}	0.6992
200	0.7459	1023	0.03779	4.954×10^{-5}	2.577×10^{-5}	3.455×10^{-5}	0.6974
250	0.6746	1033	0.04104	5.890×10^{-5}	2.760×10^{-5}	4.091×10^{-5}	0.6946
300	0.6158	1044	0.04418	6.871×10^{-5}	2.934×10^{-5}	4.765×10^{-5}	0.6935
350	0.5664	1056	0.04721	7.892×10^{-5}	3.101×10^{-5}	5.475×10^{-5}	0.6937
400	0.5243	1069	0.05015	8.951×10^{-5}	3.261×10^{-5}	6.219×10^{-5}	0.6948
450	0.4880	1081	0.05298	1.004×10^{-4}	3.415×10^{-5}	6.997×10^{-5}	0.6965
500	0.4565	1093	0.05572	1.117×10^{-4}	3.563×10^{-5}	7.806×10^{-5}	0.6986
600	0.4042	1115	0.06093	1.352×10^{-4}	3.846×10^{-5}	9.515×10^{-5}	0.7037
700	0.3627	1135	0.06581	1.598×10^{-4}	4.111×10^{-5}	1.133×10^{-4}	0.7092
800	0.3289	1153	0.07037	1.855×10^{-4}	4.362×10^{-5}	1.326×10^{-4}	0.7149
900	0.3008	1169	0.07465	2.122×10^{-4}	4.600×10^{-5}	1.529×10^{-4}	0.7206
1000	0.2772	1184	0.07868	2.398×10^{-4}	4.826×10^{-5}	1.741×10^{-4}	0.7260
1500	0.1990	1234	0.09599	3.908×10^{-4}	5.817×10^{-5}	2.922×10^{-4}	0.7478
2000	0.1553	1264	0.11113	5.664×10^{-4}	6.630×10^{-5}	4.270×10^{-4}	0.7539

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