Seat No.: ________ Enrolment No.______________

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – II • EXAMINATION – WINTER • 2014

Subject code: 1723903 **Date: 04-12-2014**

Subject Name: Thermal Equipment Design (Mechanical)

Time: 02:30 pm - 05:00 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)** What is NTU? Explain NTU method for counter flow type heat exchanger. **07**

(b) In a double pipe counter flow heat exchanger, water is heated from 25^0C to 65^0C by an oil with a specific heat of 1.45 KJ/KgK and mass flow rate of 0.9 kg/s. The oil is cooled from 230^0C to 160^0C. If the overall heat transfer co-efficient is 420 $W/m^{2 0}C$, calculate (i)Rate of Heat transfer(ii)The mass flow rate of water (iii)the surface area of heat exchanger. **07**

Q.2 **(a)** State the advantages of double pipe heat exchangers. **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 ($\dot{m}_h$ = 4.8 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

(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 ($\dot{m}_h$ = 4.83Kg/s) cooled in the process from 95 to 75^0C.The hot water flows in the inner tube (ID = 40.94mm, OD = 48.3mm)with 32 nos of longitudinal carbon steel fins (Fin Width = 0.89mm, Fin Height = 12.7mm & Root Width W_r = 4.02mm) in counter flow to the raw water which flows in annulus (ID = 75mm,OD = 89mm). Calculate the efficiency of the fin. Consider $K_{fin\ material}$ = 60 W/m ^{0}K. **07**

Q.3 **(a)** Explain shell and coil type condenser. **07**

(b) A single pass shell & tube heat exchanger is to be designed to heat raw water at 17^0C ($\dot{m}_c$ =8.33 kg/s, Cp = 4184 J/kgK) by use of condensed water ($\dot{m}_h$ = 13.89 Kg/s) at 67^0C and 0.2bar which will flow in the shell side. A fouling resistance of $0.000176m^2$.K/W is suggested and the surface over design should not be over 35%.A max. coolant velocity of 1.5 m/s is suggested to prevent erosion. Tube material is carbon steel (K = 60 W/mK, ID=16mm, OD = 19mm, L_{max} = 5m) laid out of square pitch with pitch ratio of 1.25. The baffle spacing is approx. by 0.6 of shell diameter and baffle cut is set to 25%.The permissible max. **07**

pressure drop on the shell side is 0.5 psi. The water outlet temp, should not be less than 40^0C.Assume h_i = 4000 W/m^2K and h_o= 5000 W/m^2K. Estimate shell diameter and no. of tubes. Assume F = 0.9 & L = 3m

OR

Q.3 **(a)** Explain plate type evaporator with neat sketch. **07**

(b) The following are the values measured on a shell-and-tube ammonia condenser: **07**

Velocity of water flowing through the tubes, V m/s	1.22	0.61
Overall heat transfer co-efficient , U_0 W/m^2K	2300	1570

Water flowed inside the tubes while refrigerant condensed outside the tubes (OD-51mm, ID-46mm, K = 60 W/mK.). Using the concept of Wilson s plot, determine the condensing heat transfer coefficient. What is the value of overall heat transfer coefficient when the velocity of water is 0.244 m/s?

Q.4 **(a)** Explain measurements and observations involved in the performance assessment of the cooling towers. **07**

(b) The findings of one typical trial pertaining to the Cooling Towers of a Thermal Power Plant 3 x 200 MW is given below: **07**

* Unit Load 1 & 3 of the Station = 398 MW
* Mains Frequency = 49.3
* Inlet Cooling Water Temperature °C = 44 (Rated 43°C)
* Outlet Cooling Water Temperature °C = 37.6 (Rated 33°C)
* Air Wet Bulb Temperature near Cell °C = 29.3 (Rated 27.5°C)
* Air Dry Bulb Temperature near Cell °C = 40.8°C
* Number of CT Cells on line with water flow = 45 (Total 48)
* Total Measured Cooling Water Flow m3/hr = 70426.76
* Measured CT Fan Flow m3/hr = 989544

Analyze the cooling tower and comment on the results obtained in the analysis.

OR

Q.4 **(a)** Write a short note on evaporative cooling tower. **07**

(b) Explain the components of cooling tower. **07**

Q.5 **(a)** What is a compact heat exchanger? Give the classification of compact heat exchanger. **07**

(b) Air at 1 atm and 400 K with a velocity of 10 m/s flows across a compact heat exchanger as shown in FIGURE 1 and exits with a mean temperature of 300 K. The core is 0.6 m long. Calculate the total frictional pressure drop between the air inlet and outlet and the average heat transfer coefficient on the air side. **07**

OR

Q.5 **(a)** Write short note on Rotary type regenerator. **07**

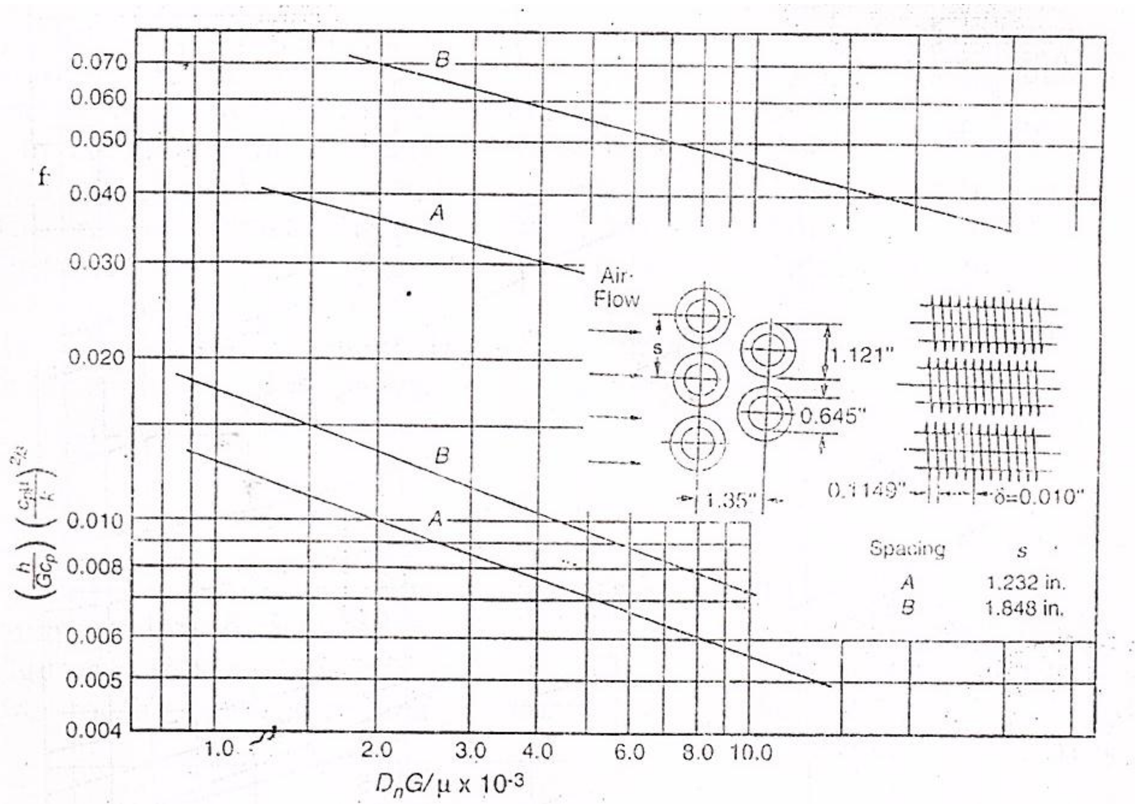
(b) A rotary regenerator, with a rotational speed of 10 rpm, is used to recover energy from a gas stream at 250^0C flowing at 10 kg/s. This heat is transferred to the airstream at 10^0C, also flowing at 10 kg/s. The wheel depth is 0.22 m and diameter 1.6 m, so that its face area is approximately 1.8 m^2. The mass of the matrix is 150 kg with a surface-to-volume ratio of 3000 m^2/m^3, and the mean specific heat of the matrix material is 0.8 kJ/kg.K. The heat transfer coefficient for both fluid streams is 30 W/m^2 ·K. The mean isobaric specific heat of the gas is 1.15 kJ/kg. K and that of air is 1.005 kJ/kg .K. The flow split gas : air = 50% : 50%. For a counterflow arrangement, calculate the following values: **07**

(a) The regenerator effectiveness

(b) The rate of heat recovery and the outlet temperatures of air and gas

(c) The rate of heat recovery and the outlet temperatures of air and gas if the rotational speed of the wheel is increased to 20 rpm

(d) The rate of heat recovery and the outlet temperatures of air and gas if the rotational speed of the wheel is reduced to 5 rpm



Heat transfer and friction factor for flow across finned-tube matrix. Surface CF-8.7-5/8 J: tube OD = 1.638 cm; fin pitch = 3.43/cm; fin thickness = 0.0254 cm; fin area/total area = 0.862; air-passage hydraulic diameter, D_h = 0.5477 cm (A), 1.1673 cm (B); free-flow area/frontal area, σ = 0.443 (A), 0.628 (B); heat transfer area/total volume = 323.8 m^2/m^3 (A), 215.6 m^2/m^3 (B).

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/s²	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^{-6}	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