RM-7849/100

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B. E. IV (Sem. VIII) (Mech.) Examination

May / June – 2010

Design of Heat Exchangers

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :
☛ **B. E. 4 (Sem. 8) (Mech.)**

Name of the Subject :
☛ **Design of Heat Exchangers**

☛ Subject Code No. : **7 8 4 9** ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Answer **all** questions.

(3) Use **separate** answer book for each section.

(4) Figures to the **right** indicates full marks.

(5) Use of design of heat exchanger data book is permitted.

(6) Assume suitable data, if **necessary**.

SECTION – I

Q-1 Explain giving the precise reasons weather the following statements are true or false: 10

(1) In pull through tube bundles pressure drop on the shell side is reduced substantially by the leakage and by pass streams
(2) NTU values for most heat exchangers are limited to 5
(3) The square lay out is more effective in heat transfer than the triangular layout of tubes.
(4) For flow over fin tubes, the entrance and exit pressure loss coefficients are neglected
(5) Plate heat exchangers are widely used in milk pasteurizing

Q-2 (1) Draw single, double and triple segmented baffles. 10
(2) Draw Tinker's shell side flow model.

Q-3 **Attempt any two** 30

(a) Consider the following data to design a water cooled shell and tube Freon condenser for the given heat duty:

Cooling load of the condenser	125 kW
Refrigerant	R-22 Condensing temperature, 37°C in tube condensation
Coolant	City water Inlet temperature, 18°C Outlet temperature, 26°C Mean pressure, 0.4 Mpa
Heat transfer matrix	¾ in OD, 20 BWG Brass tube

Value for shell and tube condenser are

Np – 1 tube pass

Ds = 0387 m

Nt = 137 tubes

$P_{T-1''}$ square pitch

Properties of shell side coolant fluid

Tc1 = 18°C

Tc2 = 26°C

Do = 0.75 in = 0.01905 m

Properties at saturation temperature

Psat = 14.17 bar

$V_l = 8.734\times10^{-4}$ m^3/kg

$\mu_l = 0.082$ Pa-s

$i_{fg} = 169$ kJ/kg

Cpl = 1.305 kJ/kg-K

Vg = 0.01643 m^3/kg

$\mu_g = 0.0000139$ Pa-s

Pr = 2.96

Use following correlations

Shell side

$$\frac{h_o \cdot D_e}{k} = 0.35 \cdot Re_s^{0.55} \cdot Pr_s^{(1/3)} \cdot \left[\frac{\mu_b}{\mu_w}\right]^{0.14}$$

Tube side :

$$h_{TP} = 0.05 \cdot Re_{eq}^{0.8} \cdot Pr^{(1/3)} \cdot \frac{k_L}{d_i}$$

Where

$$Re_{eq} = Re_v \cdot \frac{\mu_v}{\mu_L} \cdot \left[\frac{\rho_L}{\rho_v}\right]^{0.5} + Re_L$$

Determine overall heat transfer coefficient, LMTD, heat transfer surface are and length of tube.

(b) A split backing ring floating head type heat exchanger is proposed for the following process conditions. Verify whether the proposed design will meet the process requirement or not?

Tube OD = 19.05 mm Tube ID = 14.83 mm Pitch = 25.4 mm ×30° No of tubes in shell = 744 No of tube pass = 4 Shell side nozzle ID = 254.5 mm Shell ID = 889 mm Central baffle spacing = 275 mm No of baffles = 14	Overall tube length = 5 m Effective tube length = 4.764 m No of shells = 1 No of velocity head lost in shell side nozzle = 4 No of velocity head lost in tube side nozzle = 1.8 Tube side nozzle iD = 202.7 Correction factor for MTD = 0.92 End baffle spacing = 550 mm

Use appropriate correlations for tube side from the data book

Item	Tube-side	Shell-side	Unit
Fluid name	Water	Oil	-----
Flow rate	45	63.77	Kg/s
Inlet temp	21	102	C
Outlet temp	49	64	C
Cp	4.187	2.177	kJ/kg-K
μ	0.00072	0.00189	N-s/m^2
K	0.64	0122	W/m-K
ρ	995	786.4	Kg/m^3
Pr	4.8	33.73	--------
Fouling factor	0.00026	0.000018	M^2-K/W
Max.Pr loss	50000	70000	Pa
Wall resistance	0.00004		M^2-K/W

(c) Using the lobo-Evans method, calculate the fuel required in a furnace, having the following characteristics:
Heat transfer in average radiant section – 325 W/m^2
Dimension of combustion chamber: 4.5×9×12 m
Tube centre to centre spacing: 2.5 cm
Tube OD: 12 cm
Number of tubes arranged in single row: 90
Circumferential tube surface: 450 m^2
Total wall area (At): 400 m^2
Fuel oil atomization medium : 0.14 kg steam/kg oil
Heating value of fuel (LHV) : 40160 kJ/kg
Excess air : 26%
Estimated tube temperature: 550°C
Partial pressure of CO2:0.1084
Partial pressure of H2O: 0.1248

SECTION – II

Q-4 (a) Explain various regimes of forced convection boiling inside a vertical tube subjected to uniform wall temperature. 05

(b) Hot oil is to be cooled in a double tube counter flow heat exchanger. The copper inner tube has a diameter of 2cm and negligible thickness. The inner diameter of outer tube is 3cm. Water flows through the copper tube at the flow rate of 0.5kg/s, and the oil passes through outer tube at a flow rate of 0.8kg/s. Temperature of water and oil are 45C and 80C, respectively, Calculate the overall heat transfer coefficient. 10

Properties of water at 45 °C
$\rho = 990$ kg/m^3
Pr= 3.91
k = 0.637W/m°C
$\upsilon = 0.602326 \times 10^{-6}$ m^2/ s
Properties of oil at 80C
$\rho = 852$ kg/m^3
Pr= 490
k = 0.138W/m°C
$\upsilon = 37.5 \times 10^{-6}$ m^2/ s

Q-5 (a) Explain various regimes of forced convection boiling inside a vertical tube subjected to uniform wall temperature. 05

(b) Saturated steam at atmospheric pressure condenses on 2 m high and 3 m wide vertical plate that is maintained at 80°C by circulating water through the other side. Determine the rate of heat transfer by condensation to the plate and the rate at which the condensate drips off the plate at the bottom. 10

The properties of water at 100°C are
hfg =2257 X 10^3 J/kg
$\rho_v = 0.6$ kg/m^3
The properties of water at the film temperature are
$\rho_l = 965.3$ kg/m^3
$Cp_l = 4206$ J/kg°C
$\mu_l = 0.315 \times 10^{-3}$ kg m/ s
$k_l = 0.675$W/m°C
$\upsilon_l = 0.326 \times 10^{-6}$ m^2/ s

OR

(b) A cross flow heat exchanger is used for heat transfer between air and water. Both fluids are remaining unmixed. It is having heat transfer area of $8.4m^2$ Air enters at 15°C and its mass flow rate is 2 kg/s, while water enters at 90°C and its mass flow rate is 0.25 kg/s. Specific heat of air is 1005 J/kg°C and that of water is 4180 J/kg°C. The overall heat transfer coefficient is 250 W/m^2°C. Calculate the exit temperature of air and water as well as the total heat transfer rate. 10

Q-6 (a) Answer the following 06

1. Compare Compact Heat Exchanger and Shell and Tube Heat Exchanger.
2. Why dropwise condensation is more favorable than filmwise condensation?
3. What are the limitations of LMTD method in heat exchanger?

(b) It is required to size the compact heat exchanger based on the following data for gas to air compact heat exchanger 14

Fluid	Air	Gas
Entry temperature	175°C	429°C
Mass flow rate	24.31kg/s	24.69kg/s
A	$400m^2/m^3$	$574m^2/m^3$
B	256	367
Fin type	Louvered plate fin	Plain plate fin
Fin Pitch	2.38 fins/cm	4.37 fin/cm
Fin length	0.9525 cm	-
Hydraulic radius	1.112mm	0.771mm
Hydraulic diameter	4.448mm	3.084mm
Fin effectiveness	0.786	0.877
Inlet pressure of fluid	1.02bar	1.02bar
Effectiveness of heat exchanger	75%	
Physical properties		
Viscosity	$\mu_a = 28.52X\ 10^{-6}$ kg /(m - s)	$30.17\ X\ 10^{-6}$ kg/(m - s)
P	$1.996\ kg/m^3$	$10000\ kg/m^3$
C_p	1037 J/kg°C	1049 J/kg°C
Pr	0.67	0.67

	Air Side			Gas Side	
Re	j	F	Re	J	F
4000	0.00738	0.0375	1500	0.00444	0.0149
4030	0.00736	0.0374	1365	0.00456	0.0158
4060	0.00734	0.0373	1200	0.00471	0.0169

Calculate the core dimensions of the heat exchanger.