



SF-7849

B. E. - IV (Sem. - VIII) (Mechanical) Examination

May/June - 2011

Design of Heat Exchangers

Time : 3 Hours]

[Total Marks : 100

Instruction :

(1)

नीचे दर्शायेव निशानीवाणी विगतो उत्तरवडी पर अवश्य वपनी. Fillup strictly the details of signs on your answer book.	Seat No. :
Name of the Examination :	<input type="text"/>
<b>B. E. - 4 (SEM. - 8) (MECHANICAL)</b>	<input type="text"/>
Name of the Subject :	<input type="text"/>
<b>DESIGN OF HEAT EXCHANGERS</b>	<input type="text"/>
Subject Code No. : <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	Student's Signature
Section No. (1, 2,.....): <input type="text"/> <b>Nil</b>	

- (2) Attempt all question.
- (3) Use separate answer book for each section.
- (4) Figures to the **right** indicate full marks.
- (5) Use of design of heat exchangers data book is permitted.
- (6) Assume suitable data, if necessary.

Q-1 **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

$N_p = 1$  tube pass

$D_s = 0.387$  m

$N_t = 137$  tubes

$P_T = 1"$  square pitch

Properties of shell side coolant fluid

$T_{c1} = 18^\circ\text{C}$

$T_{c2} = 26^\circ\text{C}$

$D_o = 0.75$  in = 0.01905 m

Properties at saturation temperature

$P_{sat} = 14.17 \text{ bar}$   
 $V_l = 8.734 \times 10^{-4} \text{ m}^3/\text{kg}$   
 $\mu_l = 0.082 \text{ Pa}\cdot\text{s}$   
 $i_{fg} = 169 \text{ kJ/kg}$   
 $C_{pl} = 1.305 \text{ kJ/kg}\cdot\text{K}$   
 $V_g = 0.01643 \text{ m}^3/\text{kg}$   
 $\mu_g = 0.0000139 \text{ Pa}\cdot\text{s}$

$Pr = 2.96$

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 area and length of tube.

- (b) A fixed tube sheet type heat exchanger is proposed for the following process conditions. Verify whether the proposed design will meet the process requirement or not?

Tube OD = 25.4 mm	Overall tube length = 7.5 m
Tube ID = 21.18 mm	Effective tube length = 7.211 m
Pitch = 31.75 mm $\times 30^\circ$	No of shells = 1
No of tubes in shell = 460	No of velocity head lost in shell side nozzle = 4
No of tube pass = 2	No of velocity head lost in tube side nozzle = 1.8
Shell side nozzle ID = 336.6 mm	Tube side nozzle ID = 336.6
Shell ID = 787 mm	Correction factor for MTD = 0.97
Central baffle spacing = 275 mm	End baffle spacing = 787 mm
No of baffles = 8	

Use appropriate correlations for tube side from the data book

Item	Tube-side	Shell-side	Unit
Fluid name	Water	Oil	-----
Flow rate	244.8	200	Kg/s
Inlet temp	25	145	C
Outlet temp	50	100	C
Cp	4.187	2.847	kJ/kg-K
$\mu$	0.00069	0.0004	N-s/m <sup>2</sup>
K	0.64	0.086	W/m-K
$\rho$	994	900	Kg/m <sup>3</sup>
Pr	4.8	13.24	-----
Fouling factor	0.000088	0.000088	M <sup>2</sup> -K/W
Max.Pr loss	100 000	135 000	Pa
Wall resistance	0.000068		M <sup>2</sup> -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 –  $325 \text{ W/m}^2$   
 Dimension of combustion chamber:  $4.5 \times 9 \times 12 \text{ m}$   
 Tube centre to centre spacing:  $2.5 \text{ cm}$   
 Tube OD:  $12 \text{ cm}$   
 Number of tubes arranged in single row:  $90$   
 Circumferential tube surface:  $450 \text{ m}^2$   
 Total wall area (At):  $400 \text{ m}^2$   
 Fuel oil atomization medium :  $0.14 \text{ kg steam/kg oil}$   
 Heating value of fuel (LHV) :  $40160 \text{ kJ/kg}$   
 Excess air :  $26\%$   
 Estimated tube temperature:  $550^\circ\text{C}$   
 Partial pressure of  $\text{CO}_2$ :  $0.1084$   
 Partial pressure of  $\text{H}_2\text{O}$ :  $0.1248$

- Q-2 Explain giving the precise reasons whether the following 10  
 statements are true or false:
- (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-3 (1) Draw static and dynamic type regenerators. 10  
 (2) Draw different type of shell and tube heat exchangers
- Q-4 (a) Answer the following: (**any three**) 6
1. What is difference between boiling and evaporation?
  2. Compare Compact Heat Exchanger and Shell and Tube Heat Exchanger.
  3. Why compact heat exchangers are more suitable for gaseous fluid?
  4. Draw various fins used in plate type compact heat exchanger.
- (b) Saturated steam at atmospheric pressure condenses on 2 m high and 3 m wide vertical plate that is maintained at  $80^\circ\text{C}$  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  $100^\circ\text{C}$  are  
 $h_{fg} = 2257 \times 10^3 \text{ J/kg}$

$$\rho_v = 0.6 \text{ kg/m}^3$$

The properties of water at the film temperature are

$$\rho_l = 965.3 \text{ kg/m}^3$$

$$C_{p_l} = 4206 \text{ J/kg}^\circ\text{C}$$

$$\mu_l = 0.315 \times 10^{-3} \text{ kg m/s}$$

$$k_l = 0.675 \text{ W/m}^\circ\text{C}$$

$$\nu_l = 0.326 \times 10^{-6} \text{ m}^2/\text{s}$$

OR

- (b) The Condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surface of the horizontal tubes through which cooling water circulates. The outer diameter of the pipe is 3 cm and the outer surface of the tube is maintained at 30°C. Determine the rate of heat transfer to the cooling water and rate of condensation of steam per unit length of a horizontal tube. 10

The properties of water at saturation pressure of 7.38 kPa are

$$h_{fg} = 2407 \times 10^3 \text{ J/kg}$$

$$\rho_v = 0.05 \text{ kg/m}^3$$

The properties of water at film temperature

$$\rho_l = 994 \text{ kg/m}^3$$

$$C_{p_l} = 4178 \text{ J/kg}^\circ\text{C}$$

$$\mu_l = 0.720 \times 10^{-3} \text{ kg m/s}$$

$$k_l = 0.623 \text{ W/m}^\circ\text{C}$$

- Q-5 (a) Describe various pool boiling regimes stating how they defer from each other. 8

- (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<sup>2</sup>. 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<sup>2</sup>°C. Calculate the exit temperature of air and water as well as the total heat transfer rate. 10

- Q-6 (a) Describe step wise procedure of sizing of heat exchanger. 04

- (b) 12

Following data is given for a rating of compact heat exchanger

	Hot fluid	Cold Fluid
Fluid	Air	Water
Entry temperature	147°C	15°C
Location	Finned flat tube matrix	Inside flat tube

Mass flow rate	10kg/s	40kg/s
Hydraulic diameter	0.0.351 cm	0.373
Free flow area	0.234 m <sup>2</sup>	0.03096 m <sup>2</sup>
Total heat transfer area	886 m <sup>2</sup>	138 m <sup>2</sup>
$\sigma$	$\sigma_a = 0.78$	$\sigma_w = 0.129$
Physical properties		
Viscosity	$\mu_a = 2.075 \times 10^{-5}$ kg/(m s)	$\mu_w = 1 \times 10^{-6}$ m <sup>2</sup> /s
$\rho$	1.996 kg/m <sup>3</sup>	10000 kg/m <sup>3</sup>
$C_p$	1009 J/kg°C	4182 J/kg°C
Pr	0.697	7.02

Re	Air Side		Re	Water Side	
	j	F		J	F
6000	0.00525	0.0205	4000	0.0060	0.0024
7000	0.00500	0.0200	5000	0.0055	0.0022
8000	0.00480	0.0158	6000	0.0053	0.0021

Calculate

1. Heat transfer coefficient for the air and water sides
2. Overall heat transfer coefficient.
3. Total heat transfer rate
4. Outlet temperature for both the fluids.