Register Number: ……………….

M.E DEGREE EXAMINATIONS: JUNE 2016

(Regulation 2015)

Second Semester

ENERGY ENGINEERING

P15EETE07: Design of Heat Exchangers

[Use of HMT data hand book, approved data hand books are permitted]

COURSE OUTCOMES

CO1: Discuss the components of heat exchangers
CO2: Analyze the heat exchanger for flow and strength
CO3: Appraise the design aspects of different heat exchangers
CO4: Design and develop a solution for compact and plate heat exchanger
CO5: Predict the performance characteristics of condensers and cooling towers

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Consider the following steps to find shell side heat transfer coefficient by using Bell-Delaware method. CO3 [K_2]
   1. Find the shell side properties of the fluid based on the type of fluid.
   2. Find the cross flow area at the shell diameter.
   3. Find the coulborn j-factor (j_i) for an ideal tube bank.
   4. Substitute the properties and j_i to find heat transfer coefficient.

   The correct sequence for calculating the length of the shell and tube heat exchanger is

   a) 3-2-1-4 b) 2-1-4-3
   c) 3-1-4-2 d) 1-2-3-4

2. A heat exchanger having a surface area density greater than about 700 m^2/m^3 is referred to as CO4 [K_2]

   a) Compact heat exchanger b) Micro heat exchanger
   c) Double pipe heat exchanger d) Plate heat exchanger

3. The accumulation of solid particles suspended in the process stream onto the heat transfer surface results in CO1 [K_2]

   a) Crystallization fouling b) Particulate fouling
   c) Corrosion fouling d) Biofouling

4. Match list I (material for plate heat exchanger) with list II (Application) and select the correct answer using the codes given below. CO4 [K_3]

List I	List II
A. Stainless steel 316	i. Demineralized water
B. Incoloy	ii. Cooling hydrogen gas saturated with water vapor and mercury carry over in electrolysis plants.
C. Titanium	iii. Caustic solutions (50 to 70%)
D. Nickel	iv. Sea or brackish water

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	1	2	4	3
(c)	2	1	3	4
(d)	1	2	3	4

a) a　　b) c

c) d　　d) b

5. The following type of baffle is frequently used in shell and tube heat exchanger CO1 [K_2]

a) Single and double segmental baffle　　b) Doughnut baffle

c) Rod or grid baffle　　d) Orifice baffle

6. Pressure drop calculation using Bell Delaware method involves CO3 [K_3]

a) Pressure drop in window　　b) Pressure drop in the interior cross flow section

c) Pressure drop in entrance and exit sections　　d) All the above (option a + b + c)

7. The following item consists of two statements, one labeled as the “Assertion (A)” and the other as “Reason (R). CO4 [K_2]

Assertion (A): A gasketed plate heat exchanger can be easily opened for inspection, mechanical cleaning.

Reason (R) : Fouling is more in gasketed plate heat exchanger than tubular heat exchangers.

a) both A and R are individually true and R is the correct explanation of A　　b) both A and R are individually true but R is not the correct explanation of A

c) A is true but R is false　　d) A is false but R is true.

8. Consider the following steps to find length of the shell and tube heat exchanger with one shell pass and multiples of two tube passes CO1 [K_2]

1. Find the value of correction factor from LMTD correction factor chart for shell and tube heat exchanger with one shell pass and multiples of two tube passes Write the given data and convert all the units to S.I units.
2. Find the area of the heat exchanger.
3. Write the given data and convert all the units to S.I units.
4. Find the value of “P” (Temperature effectiveness of the heat exchanger on the cold fluid side) and “R” (heat capacity rate ratio).

The correct sequence for calculating the length of the shell and tube heat exchanger is

	a) 3-4-1-2	b) 2-1-3-4		
	c) 3-1-4-2	d) 3-2-1-4		
9.	Consider the following statements. 1. Tube to tube joint is preferable compared to tube to header joint. 2. Tube to header joint is preferable compared to tube to tube joint. 3. Column type supports are used for thin walled pressure vessels. 4. Colum type supports are used for thick walled pressure vessels. Which of these statements are correct?		CO2	[K_2]
	a) 1,2	b) 1,3		
	c) 2,4	d) 1,4		
10.	TEMA class (Tubular exchanger of mechanical association) for chemical process application is		CO1	[K_2]
	a) Class A	b) Class R		
	c) Class C	d) Class B		

PART B (10 x 2 = 20 Marks)

11.	What is the significance of Strouhal number?	CO2	[K_2]
12.	Enumerate the types of failures in pressure vessels?	CO2	[K_2]
13.	What are the benefits of finned tubes in heat exchangers?	CO2	[K_2]
14.	For a cylindrical tube if the differential pressure across the wall is 100 MPa, internal diameter is 20 mm; wall thickness is 5 mm. calculate the hoop stress in the wall.	CO2	[K_3]
15.	What are the functions of baffles in shell and tube heat exchangers?	CO3	[K_2]
16.	Illustrate the various techniques for heat transfer enhancement in compact heat exchangers.	CO4	[K_2]
17.	List any two reasons for failure of condenser operation.	CO5	[K_2]
18.	What are the advantages of chevron angle in plate heat exchanger?	CO4	[K_2]
19.	Differentiate between regenerative and recuperative heat exchanger	CO1	[K_2]
20.	What is the function of tie rod in a shell and tube heat exchanger?	CO1	[K_2]

PART C (6 x 5 = 30 Marks)

21.	With a neat sketch explain the construction features of Shell and tube heat exchanger.	CO1	[K_2]
22.	Water enters a counter flow, double pipe heat exchanger at 15°C, flowing at the rate of 1300 kg/hr. It is heated by oil (C_p = 2000 J/kg-K) flowing at the rate of 550 kg/hr from the inlet temperature of 94°C. For an area of 1 m^2 and an overall heat transfer coefficient of 1075 w/m^2-K, determine the total heat transfer and the outlet temperatures of water and oil.	CO2	[K_3]
23.	In a staggered tube bank, water is passed through the tubes while the air is passed in cross flow over the tubes. There are seven rows of tubes in the air flow direction. The temperature of air is 15°C and the maximum velocity for staggered tube bank is 30 m/s. The longitudinal and transverse pitches are equal to 20.5 mm. The tube outside diameter is 16.4 mm and the tube surface temperature is 70°C. Calculate the pressure drop across the tube bundle.	CO2	[K_3]
24.	Differentiate between stationary head type and floating head type for a shell and tube heat exchanger.	CO3	[K_2]

25. With a neat sketch explain induced draft cooling tower. CO5 [K_2]

26. Enumerate the different process conditions to be considered for designing a cooling tower. CO5 [K_2]

Answer any FOUR Questions

PART D (4 x 10 = 40 Marks)

27. Illustrate the heat exchanger design methodology with a flow chart. CO1 [K_3]

28. Distilled water enters 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. A single shell and tube pass is preferable. The outer diameter and inner diameter of the tube is 19 mm and 16 mm respectively. The tubes are laid out in a 25.4mm square pitch. The maximum flow velocity through the tube is 2 m/s to prevent erosion. The cross flow area (A_s) at the shell diameter is 0.073 m^2. Find the shell side heat transfer coefficient using Bell-Delaware method. CO3 [K_3]

29. Consider a pipe circuit of a heat exchanger. In the circuit there are four 90° standard elbows, three close pattern return bends, two check valves (clear way swing type), two angle valves (with no obstruction in flat type seat), and three gate valves (conventional wedge type); the valves are fully open . The straight part of the circuit pipe is 150 m, and water at 50°C flows with a velocity of 4 m/s. The pressure drop through the heat exchanger is 12 kPa. Nominal pipe size is 0.0508m outer diameter (inner diameter = 0.052 m). Calculate the total pressure drop in the system. CO2 [K_3]

30. Water at a flow rate of 5000 kg/hr will be heated from 20°C to 35°C by hot water at 140°C. A 15°C hot water temperature drop is allowed. A number of 3.5 m hairpins of 0.0762m (Inner diameter = 0.0779 m) by 0.0508m (Inner diameter = 0.0525 m, Outer diameter = 0.0603 m) counter flow double pipe heat exchangers with annuli and pipes, each connected in series, will be used. Hot water flows through the inner tube. CO3 [K_3]
Fouling factors are: R_{fi} = 0.000176 m^2- K/W, R_{fo} = 0.000352 m^2-K/W.
Where R_{fi}= Fouling resistance of inner pipe and R_{fo} = fouling resistance of outer pipe. Assume that the pipe is made of carbon steel (k= 54 W/m-K). The heat exchanger is insulated against heat losses. Find the number of hair pins.

31. Air at 1 atmosphere and 400 K with a free stream velocity of 10 m/s flows across a circular tube continuous fin compact heat exchanger with surface designation as 8 - 3/8 T. Calculate the heat transfer coefficient h, and frictional pressure drop for the air side. The length of the matrix is 0.6 m. CO4 [K_3]

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