Exam Date & Time: 08-May-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

VI SEMESTER B.TECH END SEMESTER EXAMINATIONS, APRIL-MAY 2024

DESIGN OF THERMAL POWER PLANT SYSTEM [MME 4050]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions.
Use charts or tables for required data. Missing data may be suitably assumed.

1) A) The following readings are noted in a cooling tower performance test for forced cooling tower.
Derive an expression for calculating the mass flow rate of air required and obtain the same for the given cooling tower. (5)

Parameter	Forced	Units
Water entry temperature	*38*	°C
Water exit temperature	*34*	°C
Wet bulb entry temperature	*24.5*	°C
Wet bulb entry temperature	*29*	°C
Dry bulb entry temperature	*30.8*	°C
Dry bulb exit temperature	*33*	°C
Water flow rate	*4*	*Lpm*
Duration	*265*	*sec*

B) With a neat sketch, explain the components of a natural draft cooling tower. (5)

2) A) Water will cool hot oil in a 1-shell-pass and 8-tube-pass heat exchanger. The tubes are thin-walled and are made of copper with an internal diameter of 14 mm. The length of each tube pass in the heat exchanger is 5 m, and the overall heat transfer coefficient is 310 W/m2 °C. Water flows through the tubes at 0.2 kg/s, and the oil through the shell at 0.3 kg/s. The water and the oil enter at 20°C and 150°C, respectively. Determine the heat transfer rate in the heat exchanger. (5)

B) "It is required to determine the heat transfer rate and the outlet temperatures of the hot and cold fluids for prescribed fluid mass flow rates and inlet temperatures when the type and size of the heat exchanger are specified. In this case, the heat transfer surface area A of the heat exchanger is known, but the outlet temperatures are not."
As a designer, which method will you use? Derive and justify. (5)

3) Hot air at 1 atm and 147°C flows across a finned flat tube compact heat exchanger matrix at 10 kg/s. Water at 15 °C and a flow rate of 40 kg/s flows inside flat tubes. (5)

A) Frontal length and height for airflow are 0.6 m and 0.5 m, respectively. The flow length is 0.4 m. Use a suitable compact heat exchanger chart to obtain other data. Evaluate the heat transfer coefficient at air and waterside.

$$\sigma_w = 0.129;\ D_{hw} = 0.377\ cm;\ K_f = 170\ W/mK,\ A_f/A_t = 0.845;$$
$$thickness\ of\ fin\ (t) = 0.01\ cm;\ Height\ of\ fin\ (H_f) = 0.572\ cm;\ \beta_w = 138\ m^2/m^3$$

B) "Heat load of a heat exchanger depends upon its area density." Justify the above statement mathematically. Also, mention the advantages of compact heat exchangers. (5)

4) A) A condenser is designed to condense 163 kg of steam/hr at atm. pressure. A square array of 100, 10 mm outer diameter tubes are available for the design, and the wall temperature of the tube is to be maintained at 98°C. Estimate the length of the tube required if the condenser is to be installed in the horizontal position (KERN method). (5)

B) Explain the pool boiling regimes for water with the help of a boiling curve. (5)

5) A) A heat exchanger is designed to heat raw water using condensed water at 67 °C and 1 atm, which flows in the shell side with a mass flow rate of 50000 kg/h. The heat will be transferred to 30000 kg/hr of water required for process heating from a supply at 17 °C. The minimum temperature required for process heating is 40 °C. A fouling resistance of 0.000176 m2 K/W is suggested. Estimate the overall heat transfer coefficient for fouled surfaces and the tube length required for the fouling case. (5)

Tube side specifications	Shell side specifications
Outside diameter = 19 mm	Shell diameter = 0.39 m
Inside diameter = 16 mm	Pitch size = 0.024 m
No. of tubes = 124	Baffle spacing = 0.25 m
Layout of tubes: Square pitch	
k_{tube} = 60 W/m. K	
Shell side: $$Nu = 0.36 \left(\frac{D_e G_s}{\mu}\right)^{0.55} \left(\frac{\mu C}{k}\right)^{\frac{1}{3}} \left(\frac{\mu_b}{\mu_w}\right)^{0.14}$$ Where $\mu_w = 6.04 \times 10^{-4}$ Ns/m^2	
Tube Side: $h_i = 3586$ W/m^2. K	

Properties	Tube side	Shell side	Units
Density	997	983	kg/m^3
Specific heat capacity	4179	4184	J/kg. K
Dynamic viscosity	8.2×10^{-4}	4.7×10^{-4}	Ns/m^2
Thermal conductivity	0.610	0.652	N/mK
Prandtl number	5.65	3	-

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B) How does fouling impact the heat transfer characteristics of a heat exchanger? What are the factors on which it depends? What are the possible solutions to reduce its impact?5 (5)

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