Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH (TSES) END SEMESTER EXAMINATIONS,

APRIL 2018

SUBJECT: DESIGN OF HEAT EXCHANGERS [MME 5271]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Heat transfer, Heat exchanger design and thermodynamics data book are permitted.
- Missing data may be suitably assumed.

1. Design an oil cooler with sea water using external finned double pipe heat exchanger (refer specifications below). Annulus fluid is engine oil with 4 kg/s mass flow rate and entry and exit temperatures as 65°C and 55°C respectively. Tube side fluid is sea water with inlet temperature 15°C and outlet temperature 25°C. Tubes are made of cast iron.

Length of the hair pin	=	3 m
Annulus (short length) nominal diameter	=	3" (Schedule 40)
Nominal diameter of the inner tube	=	¾" (Schedule 40)
Fin height	=	3 mm
Fin thickness	=	0.9 mm
Number of fins	=	18
Number of tubes inside the annulus	=	3

Calculate the outside overall heat transfer coefficient under fouled condition and number of hair pins. Neglect tube wall resistance. Consider short length with constant wall temperature condition for annulus side flow. **(10)**

2. A heat exchanger is available to heat raw water by the use of condensed water at 67ºC which flows in the shell side with a mass flow rate of 50000 kg/h. Shell side dimensions are as follows:

Shell diameter = 19.25", Tube pitch = 1.25" (square) and baffle spacing = 0.3m.

The raw water enters the tubes at 17ºC with a mass flow rate of 30000 kg/h. Tube outer diameter is 1" with 18 BWG. The allowable length of the heat exchanger is 6 m with two passes. Sea water outlet temperature should not be less than 40ºC. Calculate:

(i) Outlet temperatures
(ii) Heat load of the heat exchanger
(iii) Required length of the heat exchanger under fouled condition **(10)**

3. A plate heat exchanger will be used for heating city water using the waste water available at 90°C. The vertical distance between the ports of the plate is 1.60 m and width of the plate is 0.50 m with a gap of 6 mm between the plates. The Chevron

angle and enhancement factor are 50° and 1.17 respectively. The plates are made of titanium (k = 20 W/mK) with a thickness of 6 x10^{-4} m. The port diameter is 0.15 m. The cold water enters the plate heat exchanger at 15°C and leaves at 45°C at a rate of 6 kg/s. It will be heated by the hot water available at 90°C, flowing at a rate of 12 kg/s. By considering single pass arrangement for both streams, calculate the effective surface area and the number of plates. Neglect wall and fouling resistance. Consider least Re case for the correlation. **(10)**

4. Calculate the overall heat transfer coefficient and outlet temperature of fluids for the heat exchanger as shown in Figure 1. The inlet conditions are:
Hot side = flue gas at 20 kg/s at 500°C
Cold side = air at 25 kg/s at 150°C
The fins used are plain fin of 19.86 type on both sides. The plate thickness is 0.5 mm on both sides with thermal conductivity of 90 W/mK. Assume mean temperature as 400°C for hot side and 200°C for cold side.

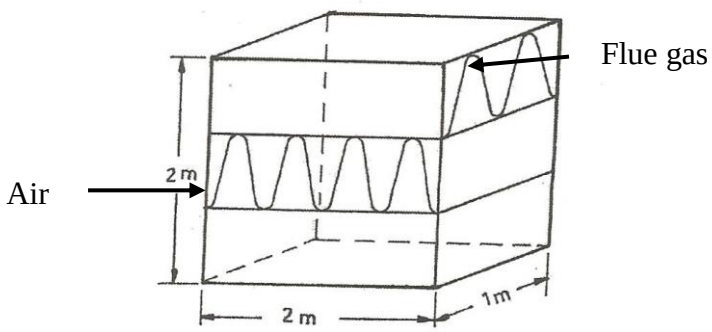

Figure 1 **(10)**

5. A water cooled, shell and tube Freon condenser with in-tube condensation will be designed to satisfy the following specifications:
Cooling load of the condenser: 125 kW,
Refrigerant: R-22,
Condensing temperature: 37°C,
Cooling water: City water with inlet and outlet temperature of 18°C and 26°C.
Tube material: Brass
It is proposed that the following heat exchanger parameters are fixed:
One tube pass with shell diameter 15¼", Baffle spacing of 350 mm, Tube of size 20 BWG and 1" square pitch.
Find the length of the unit under fouled condition using Cavallini & Zecchin co-relation.
R-22 properties are:

p_{sat}	=	14.17 bar	μ_l	=	1.86 x10^{-4} Pa.s
Cp_l	=	1.305 kJ/kgK	μ_g	=	1.39 x10^{-5} Pa.s
v_l	=	8.734x10^{-4} m^3/kg	k_l	=	0.082 W/mK
v_g	=	0.0164 m^3/kg	Pr	=	2.96
hfg	=	169 kJ/kg			

(10)