Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH (TSES) END SEMESTER EXAMINATIONS, APRIL/MAY 2019

SUBJECT: DESIGN OF HEAT EXCHANGERS [MME 5271]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- ❖ Answer **ALL** the questions.
- ❖ Missing data may be suitably assumed.
- ❖ Use of Thermodynamics, Heat and mass transfer, and Heat exchanger data book is permitted

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. Crude oil at a flow rate of 63.77 kg/s enters the shell side of a heat exchanger at 102ºC and leaves at 65ºC. The heat will be transferred to 45 kg/s flow of sea water coming from a supply at 21ºC. The heat exchanger data are given below:
¾" OD, 18 BWG Carbon steel (0.5 % C) tubes on a 1" square pitch. Shell diameter of 35". Baffle spacing is 275 mm. Heat exchanger arrangement is 1-2. Consider the shell side condition as tube banks with 20 or more rows. Neglect the property variation effect. Calculate the length of the heat exchanger under fouled surfaces and shell side pressure drop (f = 0.185).

Particulars	Shell side	Tube side
Specific heat (J/kgK)	2177	4186.8
Dynamic viscosity (Ns/m^2)	0.00189	0.00072
Thermal conductivity (W/mK)	0.122	0.605
Density (kg/m^3)	786.4	995
Prandtl Number	33.73	6.29

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3. A Condenser is to be designed to condense 163 kg/h of steam at atmospheric pressure. A staggered triangular array of 100, 10 mm outside diameter tubes are available for the design and the wall temperature of the tube maintained at 98°C.

(a) Estimate the length of the tube required if the condenser is to be installed in the horizontal position.

(b) If the above condenser is by mistake installed in the vertical position, will there be any change in the condensation rate? Calculate the condensation rate.

The arrangement of tubes in each row is as follows:

- 1^{st} and 11^{th} row 7 tubes
- 2^{nd} and 10^{th} row 8 tubes
- 3^{rd} and 9^{th} row 9 tubes
- 4^{th}, 6^{th} and 8^{th} row 10 tubes
- 5^{th} and 7^{th} row 11 tubes

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4. A gasketed 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 1.6 m and the width of the plate is 0.50 m with a gap between the plates of 6 mm. The enlargement factor is given by the manufacturer as 1.17 and the chevron angle is 40°. The plates are made of titanium (k = 20 W/mK) with a thickness of 0.0006 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 and it will be heated by the hot water available at 90°C, flowing at a rate of 12 kg/s. Considering single-pass arrangements for both streams, calculate the effective surface area and the number of plates of this heat exchanger. Consider least Re case in the correlation.

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5. An air to water compact heat exchanger is to be designed to serve as an intercooler in a gas turbine plant. Geometrical details of the proposed surface for the air side (surface 11.32-0.737-S-R) are given in Figure 6 and Table 5 of 'design of heat exchanger data book'. Hot air at 2 bar and 403 K with a flow rate of 18.75 kg/s flows across the matrix. The outlet temperature of air is 303 K. Water at 17ºC and a flow rate of 50 kg/s flows inside the flat tubes. Water velocity is 1.5 m/s. Waterside geometrical details are:

D_h = 0.373 cm, σ_w = 0.129, $\frac{\text{Waterside heat transfer area}}{\text{total volume}} = 138\ \text{m}^2/\text{m}^3$

Thermal conductivity of fin material = 170 W/mK, Fin height = 0.572 cm.
Consider properties of water at 20ºC. Find:

(i) Volume of the heat exchanger

(ii) Air side based overall heat transfer coefficient

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