Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

II SEMESTER M.TECH. (TSES)

END SEMESTER EXAMINATIONS, APRIL / MAY 2017

SUBJECT: DESIGN OF HEAT EXCHANGERS (MME 5271)

REVISED CREDIT SYSTEM

(22/04/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer ALL the questions.
- Thermodynamics, Heat transfer and Heat exchanger design data book are permitted.
- Missing data, if any, 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. 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 is1-2. 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

(10)

3. A vertical 4 tube- 1 shell pass condenser with 25 X 2 mm tube having benzene vapor condensing at a rate of 4 t/h in the shell side while cooling water is flowing in the tube side. The water temperature is 15°C and 35°C. The benzene vapor is saturated and condensing at atmospheric pressure. The height of the condenser should not exceed 3.5 m and tube side velocity is limited to 0.77 m/s. Tube material is carbon steel (1% C). Neglect the fouling effect. Is the design acceptable? if so give shell and tube specification.

Benzene properties are:

T_{sat}	=	80°C	*hfg*	=	400.125 kJ/kg
ρ_l	=	815 kg/m^3	μ_l	=	3.3x10^{-4} kg/ms
ρ_g	=	2.7 kg/m^3	μ_g	=	9x10^{-4} kg/ms
k_l	=	0.132 W/mK			

Water properties are:

Pr	=	6.35	μ	=	917.83x10^{-6} kg/ms
ρ	=	999 kg/m^3	*k*	=	0.605 W/mK

(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.

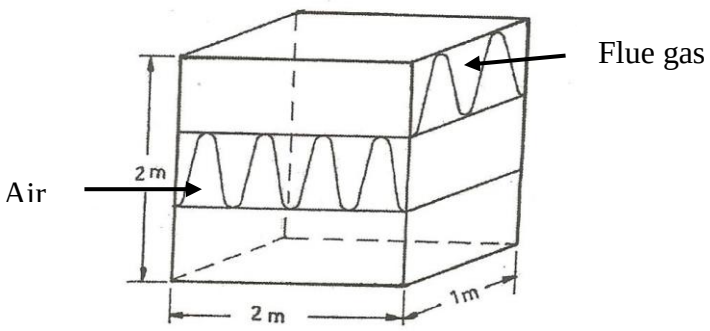

Figure 1

(10)

5. A heat exchanger is required to heat treated cooling water with a flow rate of 60 kg/s from 10°C to 50°C using the waste heat from water, cooling from 60°C to 20°C with same flow rate as the cold water. A gasketed plate heat exchanger (β = 45°) with 301 plates having horizontal port distance of 500 mm, a port diameter of 0.15 m and a vertical distance between ports of 1.5 m is proposed and the plate pitch is 0.0035 m with an enlargement factor of 1.25. The spacing between the plates is 0.6 mm. plates are made of SS 316 (k = 16.5 W/mK). For a two-pass/two-pass arrangement, analyze the area requirement. Could this heat exchanger be smaller or larger? Find also the hot water side pressure drop. Take waste water fouling resistance as 0.00005 m^{2}K/W. Neglect the effect of fluid property in Nusselt number and pressure drop.

(10)