Reg. No.										

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MANIPAL INSTITUTE OF TECHNOLOGY

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

MAY 2016

SUBJECT: DESIGN OF HEAT EXCHANGER EQUIPMENTS [MME 593]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE** questions.
- Thermodynamics, Heat transfer and Heat exchanger design data books are permitted.
- Missing data, if any, may be suitably assumed.

1. A counterflow double-pipe heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of oil through the annulus is 0.4 kg/s and is fully developed. The oil and treated water enter at temperatures of 60°C and 30°C respectively. The heat transfer coefficient in the inner tube is calculated to be 3000 W/m^{2}K. The inner tube diameter is 25 mm and the inside diameter of the outer tube is 45 mm. The outlet temperature of oil and water are 40°C and 50°C respectively. The tube wall resistance and the curvature of the wall are neglected. Assume the length of the double pipe heat exchanger is 14 m and by considering appropriate fouling resistances, calculate:

(i) The heat transfer coefficient in the annulus

(ii) The heat transfer area and number of hairpins **10**

2. A heat exchanger is available to heat sea water by the use of condensed clean water at 67ºC which flows in the shell side with a mass flow rate of 50000 kg/h. The seawater enters the tubes at 20ºC with a mass flow rate of 30000 kg/h. Tube (Carbon steel (0.5% C)) outer diameter is 1” with 18 BWG. The allowable length of the heat exchanger is 6 m with two passes. Water outlet temperature should not be less than 40ºC.

Shell side dimensions are as follows:

Ds = 19.25”, P_T = 1.25” (square) and baffle spacing = 0.3m.

Calculate:

(i) Outlet temperature

(ii) Heat load of the heat exchanger

(iii) Required length of the heat exchanger under fouled condition **10**

3. Design a vertical 4 tube-1 shell pass heat condenser with 25X2 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. Tube side velocity is limited to 0.77 m/s. Use general expression from HMT data book for condensation. Tube material is carbon steel (1%C). Neglect fouling effect. What is the final height of the heat exchanger?

Benzene properties are:

T_{sat}	=	80°C	*hfg*	=	400.125 kJ/kg	k_L	=	0.132 W/mK
ρ_L	=	815 kg/m^3	μ_L	=	3.3x10^{-4} kg/ms	R_e	=	$4\dot{m}/\pi d_o \mu N_t$
ρ_g	=	2.7 kg/m^3	μ_g	=	9x10^{-4} kg/ms			

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4. 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 heat exchanger
(ii) Air based overall heat transfer coefficient

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5. A gasketed plate heat exchanger will be used for heating city water (R_f = 0.00006 m^{2}K/W) 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 0.5 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 arrangement for both streams, calculate the effective surface area and the number of plates of this heat exchanger. Consider least 'Re' case for correlation.

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6. Estimate the size of the vertical cylinder fired heater and the number of tubes in the radiant section for a total heat load of 7.5 MW and tube size 135 mm diameter and 225 mm spacing. The furnace will be fired with natural gas and will use 10 % excess air. Assume that radiant section will be designed for 22000 W/m^2 and the 60 % heat of the total heat is used in the radiant section. The stack gas temperature is 250°C. Consider H/D = 3.

In convective section, there are 5 rows of plain tubes of length 2.5 m, diameter 235 mm and pitch of 350 mm. Find also the convective coefficient in convective section by incorporating flue gas temperature as 627°C.

Value of specific heat:

CO_2	1.055 kJ/kgK	O_2	0.997 kJ/kgK
H_2O	2.014 kJ/kgK	N_2	1.057 kJ/kgK

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