Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VII SEMESTER B. TECH (MECHANICAL/IP ENGG.) END SEMESTER EXAMINATIONS, NOVEMBER 2018

SUBJECT: DESIGN OF THERMAL POWER PLANT SYSTEMS [MME 4010]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of heat exchanger data sheet, thermodynamics and heat transfer data book are permitted

1A. Sketch and explain natural, forced and assisted draught cooling towers. Also define various energy parameters related to cooling tower. **05**

1B. E-type shell and tube heat exchanger is to be designed with the following specifications:

Shell side	=	Engine oil, 10000 kg/h, 100°C to 60°C
Tube side	=	Ethylene glycol, 56417 kg/h, 20°C, 1.5 m/s, 1” OD, 1¼” Square pitch, 11 BWG
Tube side coefficient	=	47.2 W/m^{2}K
Material	=	Nickel steel (20 % Ni)
Flow condition	=	Single shell pass / Single tube pass

Allowable maximum length is 50 m. Baffle spacing is 0.5 times shell diameter.
Neglect boundary layer effect.
Is the proposed design is feasible? **05**

2A. With a neat sketch explain the furnace based natural loop steam generating unit taking into account various heat exchangers. **05**

2B. Calculate overall heat transfer coefficient, outlet temperatures and air side pressure drop for the heat exchanger with following dimensions and flow conditions:
Hot side = Exhaust gas at 30 kg/s, 600°C, Frontal area = 2 m x 2 m
Cold side = Air at 30 kg/s, 200°C, Frontal area = 2 m x 4 m
The fins used are plain fin of 19.86 type on both sides. The plate thickness is 0.4 mm with thermal conductivity 100 W/mK. Take Ke = 0.2 and Kc = 1.4. **05**

3A. Explain with neat sketches the different zones of condensation in horizontal tube. **05**

3B. Find The change in length of DPHX when the two inner tubes are inside finned and unfinned with following specifications:

Annulus size	=	3½ ” nominal, 40 schedule
Inner tube	=	1” nominal, 80 schedule
Material	=	Carbon steel (0.5 % C)
Tube side	=	Engine oil, 80°C to 40°C, 2 kg/s
Annulus side	=	Water, 20°C to 60°C
Fin height	=	4 mm
Fin thickness	=	1 mm
Fin number	=	30

Assume overall fin efficiency as 0.85
Neglect fouling resistance **05**

4A. With schematic, explain the hot fluid series/cold fluid parallel and cold fluid series/ hot fluid parallel arrangements in double pipe heat exchanger. State its necessity. **05**

4B. 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?

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
Properties of saturated water and steam are:
$\rho_l = 961 kg/m^3$ $k_l = 0.6804$ W/mK $\mu_l = 2.81 \times 10^{-4}$ Pa.s $h_{fg} = 2257$ kJ/kg **05**

5A. In a cooling tower performance test, the following readings are noted in case of Forced mode.

Water entry temperature	=	45°C	DBT at entry	=	33°C
Water exit temperature	=	40°C	DBT at exit	=	37°C
WBT at entry	=	25°C	Water flow rate	=	10 lpm
WBT at exit	=	30°C	Duration of test	=	300 s

Find:

(a) Cooling tower duty
(b) Cooling tower efficiency
(c) Mass flow rate of air
(d) Rate of make-up water **05**

5B. Fired heater is used to heat the process fluid having flow rate of 200000 kg/h from 200°C to 350°C. Assume the stack gas temperature to be 100°C more than the process fluid inlet temperature. Propane (M= 44.1) is used as the fuel with 15 % excess air. Take radiation loss as 4 % and other losses (excluding dry gas loss) as 10 %. Specific heat of process fluid is 2500 J/kgK. Specific heat of CO_2, H_2O, O_2 and N_2 are 1.055, 2.014, 0.997 and 1.057 kJ/kg K respectively. Consider 55 % load in radiant section. Allowable maximum radiation heat flux is 30 kW/m^2. Tube diameter = 210 mm, pitch = 250 mm, H/D = 1.5. Find:

(a) Furnace efficiency (b) Radiant zone load
(c) Height and diameter of the furnace, (d) Number of tubes in radiant zone **05**