Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VII SEMESTER B. TECH (MECHANICAL/IP ENGG.) END SEMESTER EXAMINATIONS, NOVEMBER 2019

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

1B. Flue gas at 300°C with a velocity of 20 m/s flow across a compact heat exchanger of type 9.1-0.737-S. Water at 40°C and flow rate of 40 kg/s flows through the conduit. Frontal length and height for gas flow is 0.60 m x 0.50 m. Flow length is 0.40 m. Neglect wall resistance. Find rate of heat transfer.

Water side cross-sectional porosity	:	0.15
Material	:	Al alloy 195
Height of the fin	:	1.5 mm
Water side area to core volume	:	150 m^2/m^3

05

2A. Explain with neat sketches the different models of film condensation in tube bundles. **05**

2B. 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^2K
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**

3A. Explain different methods used to cool process fluid in industrial applications. **05**

3B. The designed length of the DPHX is 24 m. However due to space constraint (2 m), hairpin configuration is suggested. If 3 hairpins are considered for each parallel flow stream, find the total HX length ratio between two cases.
Case I- Hot fluid series and Case II-Cold fluid series.
Inlet and outlet temperature of hot fluid : 100°C and 60°C
Inlet and outlet temperature of cold fluid : 30°C and 70°C **05**

4A. How tube and annulus side pressure drop can be reduced in case of double pipe heat exchangers? Explain with neat sketch. **05**

4B. 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/kgK 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**

5A. In a cooling tower (forced mode) performance test, the following readings are noted :

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. 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?

1st and 11th row 7 tubes, 2nd and 10th row 8 tubes
3rd and 9th row 9 tubes, 4th, 6th and 8th row 10 tubes, 5th and 7th row 11 tubes
Properties of saturated water and steam are:
ρ_l = 961kg/m^3 k_l = 0.6804 W/mK μ_l = 2.81x10^{-4} Pa.s h_{fg} = 2257 kJ/kg **05**