Ex/Prod/T/221/2017 (Old)

B. PRODUCTION ENGINEERING 2ND YEAR 2ND SEMESTER (Old) EXAMINATION, 2017

THERMODYNAMICS AND HEAT TRANSFER

Time: Three hours **Full Marks: 100**

Answer **FIVE** questions, taking any **THREE** from **Group A** and any **TWO** from **Group B.**
All parts of a question (a, b, c etc) should be answered at one place.

GROUP A

1.(a) What do you mean by thermodynamic property? Mention the various types of thermodynamic property with examples.

2+3

(b) What is the thermodynamic equilibrium?

3

(c) At the inlet of a certain nozzle the specific enthalpy of the fluid is 3025 kJ/kg and the velocity is 60 m/s. At the exit from the nozzle the specific enthalpy is 2790 kJ/kg. The nozzle is horizontal and there is a negligible heat loss from it. Calculate (i) the velocity of the fluid at exit, (ii) the rate of flow of fluid when the inlet area is 0.1 m^2 and the specific volume at inlet is 0.19 m^3/kg and (iii) the exit area of the nozzle when the specific volume at the nozzle exit is 0.5 m^3/kg.

12

2.(a) State the Kelvin-Plank statement of second law thermodynamics.

2

(b) Illustrate about the Carnot cycle with the aid of **T-s** diagram and derive the expression of thermal efficiency in terms of temperature.

8

(c) Two identical finite bodies of constant heat capacity (C_p= 8.4 kJ/K) are initially at temperatures 500° C and 30° C respectively. If a heat engine is operated in cycle between these two bodies calculate the maximum work obtained from the engine by using the entropy principle. Deduce an expression for maximum work you have used.

10

3.(a) What do you mean by the following terms?
(i) Degree of superheating and (ii) Triple point.

4

(b) Explain the working principle of Refrigerator operating on Vapour Compression refrigeration cycle with the help of flow diagram and **p-h** diagram.

8

(c) A refrigerator uses R-12 as the working fluid and operates on an ideal Vapour compression refrigeration cycle between 0.14 MPa and 0.8 MPa. If the mass flow rate is 216 kg/h. Calculate (i) the rate heat extracted from the cold chamber and power input to the compressor, (ii) the COP and (iii) the heat rejected to the environment. The compression is considered as dry compression. The enthalpy of refrigerant after compression is 208 kJ/kg. The properties of saturated R-12 are given as below: 8

Pressure (MPa)	Sp. enthalpy (kJ/kg-K)	
	h_f	h_g
0.14	16	178
0.8	67	200

4.(a) Explain the following terms:
(i) Relative humidity, (ii) Psychometric chart.

4

(b) Discuss the working principle of Rankine cycle with the aid of flow and **T-s** diagrams.

8

(c) In a thermal power plant steam is supplied as dry saturated at 40 bar to a turbine and the condenser pressure is 0.03 bar. If the plant operates on the Rankine cycle calculate per

[Turn over

kilogram of steam (i) the work output and (ii) the Rankine cycle efficiency. Neglect the pump work. 8

5.(a) Show that the entropy change between states 1 and 2 in a polytropic process **pV^n= C** is given by $s_2 - s_1 = \left(\frac{n-\gamma}{n-1}\right) c_v \log_e\left(\frac{T_2}{T_1}\right)$. 5

(b) For an air standard Otto cycle show that thermal efficiency

$\eta = 1 - \frac{1}{r_k^{\gamma-1}}$ where, r_k = compression ratio. 5

(c) The compression ratio of an air-standard Dual cycle is 12 and the maximum pressure in the cycle is limited to 70 bar. The pressure and temperature of cycle at beginning of compression process are 1 bar and 23°C respectively. Heat is added during constant pressure process upto 3% of the stroke. Assuming diameter as 25 cm and stroke as 30 cm calculate the thermal efficiency of the cycle. Take c_p = 1.005 kJ/kg-K; c_v = 0.718 kJ/kg-K and γ=1.4. Also, draw the **p-V**and **T-s** diagrams of the cycle. 10

GROUP B

6.(a) State the Newton's law of cooling. 3

(b) Derive an expression for critical radius of insulation on sphere. 5

(c) A furnace wall consists of 125 mm wide refractory brick and 125 mm wide insulating firebrick separated by an air gap. The outside wall is covered with a 12 mm thickness of plaster. The temperature of the hot gas inside the furnace is at 1100°C and outside air temperature is 25°C. The heat transfer co-efficient of hot gas and the outside wall surface to the air in the room are 25 W/m^2-K and 17 W/m^2-K respectively and the thermal resistance to heat flow of air gap is 0.16 K/W. The thermal conductivities of refractory brick, insulating firebrick and plaster are 1.6, 0.3 and 0.14 W/m-K respectively. Estimate (i) the rate of heat loss per unit area of wall surface and (ii) the temperature at the outside surface of furnace wall. Neglect heat loss by radiation. 12

7.(a) Define the fin effectiveness. 3

(b) Distinguish between parallel flow and counter flow heat exchangers with respect to the following points:
(i) Direction of flow, (ii) Temperature variation. 4

(c) Water with specific heat of 4.2 kJ/kg-K is heated in a counter-flow heat exchanger from 35°C to 85° C by oil with specific heat of 1.5 kJ/kg-K and mass flow rate of 60 kg/min. The oil is cooled from 215° C to 185° C. The overall heat transfer co-efficient is 450 W/m^2-K. Determine (i) mass flow rate of water, (ii) surface area of heat exchanger and (iii) effectiveness of the heat exchanger. 8

(d) An Aluminium rod 2.5 cm in diameter and 15 cm long protrudes from a wall, which is maintained at 260° C. The rod is exposed to an environment at 16° C. The convection heat transfer coefficient is 15 W/m^2-K. Calculate the heat lost by the rod. Assume thermal conductivity k= 200 W/m-K for aluminium. 5

8.(a) Explain the importance of Grasoff No. in convection. 4

(b) Explain about the free and forced convections. 4

(c) State the Stefan-Boltzman law of radiation heat transfer. 3

(d) What do you mean by absorptivity, reflectivity and transmitivity? 3

(e) Derive the expression of thermal radiation heat transfer between two black surfaces. 6