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B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Third Semester

Aeronautical Engineering

AE 6301 — AERO ENGINEERING THERMODYNAMICS

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define: Internal energy.

2. Write the steady flow energy equation for steam turbine by considering heat lost to the surrounding.

3. State Carnot theorem.

4. What is principle of entropy?

5. Differentiate between energy and energy.

6. Draw the PV and TS diagram for Brayton cycle.

7. Draw and explain a p-T (pressure-temperature) diagram for a pure substance.

8. State the advantages of regenerative cycle/simple Rankine cycle.

9. What is specific impulse? Also state its significance.

10. Mention some applications of radiation heat transfer.

PART B — ($5 \times 13 = 65$ marks)

11. (a) 85 kJ of heat are supplied to a system at constant volume. The system rejects 90 kJ of heat at constant pressure and 20 kJ of work is done on it. The system is brought to its original state by adiabatic process. Determine the adiabatic work. Determine also the value of internal energy at all end states if initial value is 100 kJ. (13)

Or

(b) Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg, and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of air leaving is 88 kJ/g greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 kJ/s. Calculate the power required to drive the compressor and the inlet and outlet pipe cross-sectional areas. (13)

12. (a) A fish freezing plant requires 50 tons of refrigeration. The freezing temperature is –40°C while the ambient temperature is 35°C. If the performance of the plant is 15% of the theoretical reversed Carnot cycle working within the same temperature limits, calculate the power required. Take 1 ton = 210 kJ/min. (13)

Or

(b) A rigid cylinder containing 0.006 m^3 of nitrogen (molecular weight 28) at 1.04 bar, 15°C, is heated reversibly until the temperature is 90°C. Calculate the change of entropy and the heat supplied. Sketch the process on T-s diagram. Take the isentropic index, γ, for nitrogen as 1.4, and assume that nitrogen is a perfect gas. (13)

13. (a) 1 kg of ice at 0°C is mixed with 10 kg of water at 30°C. Determine the net increase in the entropy and unavailable energy when the system reaches common temperature. Assume that surrounding temperature is 10°C. Take, specific heat of water 4.18 kJ/kg K specific heat of ice = 2.1 kJ/kg K; latent heat of ice 333.5 kJ/kg. (13)

Or

(b) An air-standard Diesel cycle has a compression ratio of 18, and the heat transferred to the working fluid per cycle is 1800 kJ/kg. At the beginning of the compression stroke, the pressure is I bar and the temperature is 300 K. Calculate: (i) Thermal efficiency, (ii) The mean effective pressure. (13)

14. (a) (i) A pressure cooker contains 1.5 kg of steam at 5 bar and 0.9 dryness when the gas was switched off. Determine the quantity of heat rejected by the pressure cooker when the pressure in the cooker falls to 1 bar. (7)

(ii) Steam at 19 bar is throttled to 1 bar and the temperature after throttling is found to be 150°C. Calculate the initial dryness fraction of the steam. (6)

Or

(b) In a regenerative cycle the inlet conditions are 40 bar and 400°C. Steam is bled at 10 bar in regenerative heating. The exit pressure is 0.8 bar. Neglecting pump work. Determine the efficiency of the cycle. (13)

15. (a) An aircraft flies at 90 km/hr. One of its turbojet engines takes in 40 kg/s of air and expands the gases to the ambient pressure. The air-fuel ratio is 50 and the lower calorific value of the fuel is 43 MJ/kg. For maximum thrust power, determine : jet velocity, thrust, specific thrust, thrust power, propulsive and thermal efficiencies. (13)

Or

(b) A cold storage room has walls made of 0.23 m of brick on the outside, 0.08 m of plastic foam, and finally 15 mm of wood on the inside. The outside and inside air temperatures are 22°C and –2°C respectively. If the inside and outside heat transfer co-efficients are respectively 29 and 12 W/m²K and the thermal conductivities of brick, foam and wood are 0.98, 0.02 and 0.17 W/mK respectively determine (i) the rate of heat removal by refrigeration if the total wall area is 90 m, and (ii) the temperature of the inside surface of the brick. (13)

PART C — (1 × 15 = 15 marks)

16. (a) A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and –20°C. The heat transfer to the heat engine is 2000 kJ and the network output for the combined engine v' refrigerator is 360 kJ. (i) Calculate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. (ii) Reconsider (i) given that the efficiency of the heat engine and the C.O.P. of the refrigerator are each 40 per cent of their maximum possible values. (15)

Or

(b) Calculate the heat flowing through a furnace wall 0.23 m thick, the inside and outside surface temperatures of which are 1000°C and 200°C respectively. Assume that the mean thermal conductivity of the wall material is 1.1 W/mK. Assuming that 7 mm of insulation (k = 0.075 W/mK) is added to the outside surface of the wall and reduces the heat loss 20%; calculate the outside surface temperature of the wall. If the cost of the insulation is Rs. 70 per sq m. What time will be required to pay for the insulation? Base the calculations on the 24 hours operation per day and 199 days per year. Heat energy may be valued at Rs. 10 per 1000 kWh. (15)

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