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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Third Semester

Aerospace Engineering

AE 3351 – AERO ENGINEERING THERMODYNAMICS

(Common to : Aeronautical Engineering)

(Regulations – 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define intensive and extensive properties with examples.

2. Give the similarities and dissimilarities between work and heat.

3. A reversible power cycle operates between a reservoir at temperature T and a lower temperature reservoir at 200 K. At steady state, the cycle develops 40 kW of power while rejecting 1000 kJ/min of energy by heat transfer to the cold reservoir. Determine the value of T.

4. What is meant by irreversibility? What are the various causes of irreversibility?

5. What are the assumptions that are taken when air is considered as a working fluid in an air standard cycle?

6. Show that the efficiency of Otto cycle is greater than diesel cycle.

7. Define dryness fraction.

8. Suggest suitable methods to improve Rankine cycle efficiency.

9. Give the advantages and disadvantages of Turbofan engine.

10. What is meant by free convection and forced convection?

PART B — ($5 \times 13 = 65$ marks)

11. (a) (i) A cylinder fitted with a piston has an initial volume of $0.1 m^3$ and contains nitrogen at 150 kPa, 25°C. The piston is moved, compressing the nitrogen until the pressure is 1 MPa and the temperature is 150°C. During this compression process heat is transferred from the nitrogen and the work done on the nitrogen is 20 kJ. Determine the amount of this heat transfer. (7)

(ii) Show that the polytropic process having an equation of $pv^n =$constant. For different values of 'n' deduce it for various thermodynamics processes involved. (6)

Or

(b) Explain about the thermodynamic system with suitable practical examples.

12. (a) (i) A steady state refrigerator who's COP is 2.5 removes energy by heat transfer from a freezer cabinet at 0°C at the rate of 8000 kJ/h and discharges energy by heat transfer to the surroundings, which is at 20°C. Determine the power input to the refrigerator and compare with the power required by a reversible refrigerator cycle operating between reservoirs at these two reservoirs. (7)

(ii) An inventor claims to have developed an engine that takes in 105 MJ at a temperature of 400K, rejects heat at a temperature of 200K, and delivers 17.5 kWh of mechanical work. Would you advise investing money to put this engine in market. (6)

Or

(b) Explain about Carnot cycle with all processes. (13)

13. (a) An ideal Otto cycle has compression ratio of 8. At the beginning of the compression process air is at 100 kPa and 18°C and 800 kJ/kg of heat is transferred to air the constant volume heat addition process. Assuming cold air standard assumption, determine (i) the maximum pressure and temperature that occur during the cycle, (ii) the net work done, (iii) thermal efficiency. (8)

Or

(b) Derive the efficacy of Dual cycle. Indicate all processes in P-V and T-S diagrams.

14. (a) (i) Using steam tables, determine the specified property data from each of the following states. Show the location of each state with respect to the saturation lines. (1) 3 bar, 240 °C, find specific volume and internal energy (2) 3 bar, 0.3 m^3/kg, find temperature and internal energy; (3) 10 bar, 400 °C find specific volume and enthalpy (4) 320 °C, 0.026 m^3/kg find pressure and specific internal energy. (7)

(ii) Explain in detail about the formation of superheated steam from -20°C of ice with T-v diagram. Also explain various processes involved in it. (6)

Or

(b) (i) In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. Determine the pump work, the turbine work, the Rankine efficiency, the condenser heat flow and the dryness at the end of expansion. Assume flow rate of 9.5 kg/s. (8)

(ii) Give the advantages and disadvantages of Regenerative cycle over simple Rankine cycle. (5)

15. (a) Derive an expression for the generalized three dimensional heat conduction equation in Cartesian coordinates and hence deduce it to a steady one dimensional heat equation with heat generation.

Or

(b) Explain briefly about the convective and radiation heat transfer in jet propulsion system .

PART C — (1 × 15 = 15 marks)

16. (a) A turbojet aircraft flies at sea level at a Mach number of 1.5 at an altitude where ambient pressure and ambient temperature are 11.6 kPa and 205 K respectively, Mass flow rate is 50 kg/s, compressor pressure ratio is 1.2, temperature in combustion chamber is 1400 K. Assume the turbojet operates on ideal Brayton cycle. Take calorific value of fuel used as 45 MJ/kg, y1 .4, Cp= 1 kJ/kg-K. Calculate the thrust developed by the engine by assuming the nozzle exit pressure is equal to the ambient pressure.

Or

(b) (i) Air enters a compressor operating at steady state at a pressure of 1 bar, a temperature of 290 K and a velocity of 6 m/s through an inlet with an area of 0.1 m^2. At the exit, the pressure is 8 bar, the temperature is 450 K and the velocity is 2 m/s. Heat transfer from the compressor to the surroundings occurs at the rate of 180 kJ/min. Employing the ideal gas model, calculate the power input to the compressor. (8)

(ii) Determine the quantity of heat required to produce 1 kg of steam at a pressure of 6 bar at a temperature of 25°C under the following conditions.

(1) When the steam is wet having a dryness fraction 0.9.

(2) When the steam is dry saturated.

When the steam is superheated at a constant pressure at 250°C assuming the mean specific heat of superheated steam to be 2.3 kJ/kg-K. (7)