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B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Third Semester

Aeronautical Engineering

AE 8301 – AERO ENGINEERING THERMODYNAMICS

(Common to: Aerospace Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

(Use of steam table/HMT Data Book permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Derive the steady flow energy equation for a nozzle.
2. State the zeroth law of thermodynamics with suitable example.
3. State Kelvin Planck and Claussius statements of second law of thermodynamics.
4. Explain the difference between Efficiency and COP.
5. For the same maximum pressure and heat input which cycle (Otto, Diesel, Dual) is the most and least efficient. Give suitable explanation.
6. Draw the PV and TS diagram for a air standard Brayton cycle.
7. Define: One Tonne of refrigeration.
8. Define triple point and critical point.
9. What is the significance of specific impulse?
10. Define Plancks law of radiation.

PART B — (5 × 13 = 65 marks)

11. (a) Describe the steady flow energy equation for a flow system and derive the same for het engine components.

Or

(b) A mass of air is initially at 206°C at a pressure of 7 bar and having a volume of 0.03 m^3 The air is expanded at constant pressure to 0.09 m^3 , a polytropic process with n = 1.5 is carried out , followed by a constant temperature process which completes the cycle All processes are reversible. Sketch the cycle on pressure-volume and temperature entropy planes and find (i) change in entropy during each process. (ii) Heat received and rejected during each cycle and (iii) Efficiency of the cycle. Take R = 0.287 J/kgK and C_v =0.713 kJ/kgK.

12. (a) A heat pump working on a reversed carnot cycle takes in energy from a reservoir maintained at 5°C and delivers it to another reservoir where temperature is 77°C. The heat pump derives power for its operation from a reversible engine operating within the higher and lower temperatures of 1077°C and 77°C. For 100 kJ/kg of energy supplied to reservoir at 77°C, estimate the energy taken from the reservoir at 1077°C.

Or

(b) A reversible engine is supplied with heat from two constant temperature sources at 900K and 600K and rejects heat to a constant temperature sink at 300K . The engine develops work equivalent to 90 kJ/s and rejects heat at the rate of 56 kJ/s . Estimate (i) Heat supplied by each source and (ii) Thermal efficiency of the engine.

13. (a) In a compression ignition engine working on a dual combustion cycle, pressure and temperature at the start of compression are 1 bar and 300K respectively. At the end of compression the pressure reaches a value of 25 bar 420 kJ of heat is supplied per kg of air during the constant volume heating and pressure becomes 2.8 bar at the end of isentropic expansion. Estimate the ideal thermal efficiency. Take C_p = 1.005 kJ/kgK and C_v = 0.712kJ/kgK .

Or

(b) Derive the Mean effective pressure and Efficiency of an Engine operating on a air standard Diesel cycle. Draw suitable PV and TS diagram.

14. (a) In a Rankine cycle, the steam flows to turbine as saturated steam at a pressure of 35 bar and the exhaust pressure is 0.2 bar. Determine (using steam table only) (i) pump work (ii) the turbine work (iii) the rankine efficiency (iv) the condenser heat flow (v) the dryness fraction at the end of expansion. The mass flow rate of steam is 9.5 kg/s.

Or

(b) A turbine is supplied with steam at a pressure of 32 bar and a temperature of 410°C. The steam then expands isentropically to a pressure of 0.08 bar Find the dryness fraction at the end of expansion and thermal efficiency of the cycle. If the steam is reheated at 5.5 bar to a temperature of 395°C and then expanded isentropically to a pressure of 0.08 bar, what will be the dryness fraction and thermal efficiency of the cycle?

15. (a) Air at a temperature of 20°C passes through a heat exchanger at a velocity of 40 m/s where its temperature is raised to 820°C. It then enters a turbine with same velocity of 40 m/s and expands till the temperature falls to 620°C. On leaving the turbine, the air is taken at a velocity of 55 m/s to a nozzle where it expands until the temperature has fallen to 510°C. If the air flow rate is 2.5 kg/s, calculate (i) Rate of heat transfer to the air in the heat exchanger (ii) The power output from the turbine assuming no heat loss (iii) The velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as h = cpt, where cp is the specific heat equal to 1.005 kJ/kg°C and t the temperature.

Or

(b) An engine working on Otto cycle has a volume of 0.45 m^3, pressure 1 bar and temperature 30°C at the beginning of compression stroke. At the end of compression stroke, the pressure is 11 bar. 210 kJ of heat is added at constant volume. Determine (i) Pressures, temperatures and volumes at salient points in the cycle. (ii) Percentage clearance. (iii) Efficiency. (iv) Net work per cycle. (v) Mean effective pressure. (vi) Ideal power developed by the engine if the number of working cycles per minute is 210. Assume the cycle is reversible.

PART C — (1 × 15 = 15 marks)

16. (a) With neat sketch, explain the various parts of a basic jet propulsion engine.

Or

(b) A furnace wall is made up of three layers of thicknesses 250 mm. 100 mm and 150 mm with thermal conductivities of 1.65, k and 9.2 W/m°C respectively. The inside is exposed to gases at 1250°C with a convection coefficient of 25 W/m²°C and the inside surface is at 1100°C, the outside surface is exposed air at 25°C with convection coefficient of 12 W/m²°C. Determine:

(i) The unknown thermal conductivity 'k';

(ii) The overall heat transfer coefficient;

(iii) All surface temperatures.