Reg. No. :

Question Paper Code : X 10027

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2020
Third Semester
Aeronautical Engineering
AE8301 – AERO ENGINEERING THERMODYNAMICS
(Common to Aerospace Engineering)
(Regulations 2017)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. How the properties are classified ?
2. What is meant by quasi-equilibrium process ?
3. Define reversibilities.
4. State Clausius inequality for a cyclic process.
5. State the assumptions that are made in the analysis of air standard cycles.
6. What is meant by mean effective pressure ?
7. Draw the P-v and T-s diagram of Otto cycle.
8. Bring out the differences between Rankine cycle and Carnot cycle.
9. What is meant by TSFC ?
10. Define thermal conductivity of a materials.

PART – B **(5×13=65 Marks)**

11. a) i) One kg of air is expanded in piston-cylinder system from a specific volume of v = 0.2 m^3/kg and temperature of 580 K to a specific volume of v = 0.8 m^3/kg and a temperature of 290 K. The expansion process is given by $pv^{1.5}$ = 0.75 (p in bar and v in m^3/kg). Determine the work and heat interaction. **(8)**

ii) Give the expression for work done during the following reversible expansion processes, isothermal and adiabatic. **(5)**

(OR)

b) i) An adiabatic air compressor compresses 10 lit/s of air at 120 KPa and 20°C to 1000 KPa and 300°C. Determine the work required by the compressor in kJ/kg, and the power required to drive the air compressor in kW. **(8)**

ii) Nitrogen gas flows into a convergent nozzle at 200 kPa, 400 K and very low velocity. It flows out of the nozzle at 100 kPa, 330 K. If the nozzle is insulated, find the exit velocity. **(5)**

12. a) i) A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 15 kW and rejects the waste heat to the ambient air at 25°C. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at 10°C and transfers it to the same ambient air at 25°C. Determine the maximum rate of heat removal from the refrigerated space. **(8)**

ii) With necessary sketches, demonstrate the equivalence of the Clausius and Kelvin-Planck statements of the second law. **(5)**

(OR)

b) i) Show that thermal efficiency of an irreversible power cycle is always less than the thermal efficiency of a reversible power cycle when each operates between the same two thermal reservoirs. **(7)**

ii) 2kg of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process of 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.

(Take C_p of water = 4.187 kJ/kgK). **(6)**

13. a) An ideal Diesel cycle with air as the working fluid has a compression ratio of 18 and a cut-off ratio of 2. At the beginning of compression process, the working fluid is at 100 KPa, 27°C and 1917 cm^3. Determine :

a) the temperature and pressure of air at the end of each process

b) network output

c) thermal efficiency and

d) the mean effective pressure.

(OR)

b) An air standard dual cycle has a compression ratio of 16 and compression begins at 1 bar, 50°C. The maximum pressure is 70 bar. The heat transferred to air at constant pressure is equal to that at constant volume. Estimate :

a) the pressures and temperatures at the cardinal points of the cycle,

b) the cycle efficiency and

c) the MEP of the cycle. Take C_v = 0.718 kJ/kg K and C_p = 1.005 KJ/kg K.

14. a) What is meant by property diagram ? With neat sketches, explain the six different types of commonly encountered property diagrams in brief. **(13)**

(OR)

b) Steam is the working fluid in an ideal Rankine cycle. Saturated vapor enters the turbine at 8.0 MPa and saturated liquid exits the condenser at a pressure of 0.008 MPa. The net power output of the cycle is 100 MW. Determine for the cycle : **(13)**

a) the thermal efficiency

b) the back work ratio

c) the mass flow rate of the steam, in kg/h

d) the rate of heat transfer, Q_{in}, into the working fluid as it passes through the boiler, in MW

e) the rate of heat transfer Q_{out}, from the condensing steam as it passes through the condenser, in MW, if cooling water enters the condenser at 15°C and exits at 35°C.

15. a) What are the various classification of jet engines ? Explain them with neat sketches. **(13)**

(OR)

b) i) A slab 0.2 m thick with thermal conductivity of 45 W/mK receives heat from a furnace at 500 K both by convection and radiation. The convection coefficient has a value of 50 W/m^{2}K. The surface temperature is 400 K on this side. The heat is transferred to surroundings at T_∞ both by convection and radiation. The convection coefficient on this side being 60 W/m^{2}K. Determine the surrounding temperature. Consider 1m^2 area and shape factor as 1 for radiation. **(7)**

ii) A solid sphere of 0.09 m radius generates heat at 5×10^6 W/m^3. The conductivity of the material is 30 W/m–K. The heat generated is convected over the outer surface to a fluid at 160°C, with a convective heat transfer coefficient of 750 W/m^{2}K. Determine the maximum temperature in the material and the temperature at radius = 0.06 m. **(6)**

PART – C **(1×15=15 Marks)**

16. a) i) An insulated piston-cylinder device contains 5 litres of saturated liquid water at a constant pressure of 150 KPa. An electric resistance heater inside by the cylinder is now turned on and 2200 kJ of energy is transferred to the steam. Determine the entropy change of the water during this process. **(10)**

ii) An inventor claims to have developed an engine that takes in 105 MJ at a temperature of 400 K, rejects heat at a temperature of 200 K and delivers 17.5 KWh of mechanical work. Would you advise investing money to put this engine in market ? **(5)**

(OR)

b) Consider a steam power plant that operates on ideal reheat Rankine cycle. The plant maintains the boiler at 7000 KPa, the reheat section at 800 KPa and the condenser at 10 KPa. The mixture quality at the exit of both turbines is 93%. Determine the temperature at the inlet of high pressure and low pressure turbine respectively.
