Reg. No. : E N G G T R E E . C O M

Question Paper Code : 30014

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

Third Semester

Aeronautical Engineering

AE 3351 – AERO ENGINEERING THERMODYNAMICS

(Common to: Aerospace Engineering)

(Regulations 2021)

Time : Three hours | Maximum : 100 marks

Approved Steam table may by Permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the difference between the classical and the statistical approaches to thermodynamics?

2. Define quasi-static process.

3. What are the characteristics of all heat engines?

4. Is it possible for a heat engine to operate without rejecting any heat loss to a low-temperature reservoir?

5. Define increase of entropy.

6. Does a cycle for which $\oint \delta Q > 0$ violate the Clausius inequality? Why?

7. What is open feed water heater in ideal regenerative Rankine cycle?

8. What is sensible heat of water?

9. How do the following quantities change when a simple ideal Rankine cycle is modified with reheating? Assume the mass flow rate is maintained the same.

10. Draw Subsonic Ramjet engine.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Air enters a 28-cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5 m/s. Air is heated as it flows, and leaves the pipe at 180 kPa and 40°C. Determine (1) the volume flow rate of air at the inlet, (2) the mass flow rate of air, and (3) the velocity and volume flow rate at the exit. (5)

(ii) Explain Nozzles and diffusers with sketch. (4)

(iii) What is the Difference Between Macroscopic and Microscopic in Thermodynamics? (4)

Or

(b) (i) Explain steady flow energy equation of gas turbine with sketch. (5)

(ii) What is difference between homogeneous system and heterogeneous system? (4)

(iii) Explain clearly the difference between a non-flow and a steady flow process. (4)

12. (a) Explain Carnot cycle with sketch. (13)

Or

(b) (i) Air is compressed by a 15-kW compressor from P1 to P2. The air temperature is maintained constant at 25°C during this process as a result of heat transfer to the surrounding medium at 20°C. Determine the rate of entropy change of the air. State the assumptions made in solving this problem. (6)

(ii) A completely reversible heat pump produces heat at a rate of 300 kW to warm a house maintained at 24°C. The exterior air, which is at 7°C, serves as the source. Calculate the rate of entropy change of the two reservoirs and determine if this heat pump satisfies the second law according to the increase of entropy principle. (7)

13. (a) Explain Joule cycle with sketch. (13)

Or

(b) (i) In a Stirling cycle the volume varies between 0.03 and 0.06m^3, the maximum pressure is 0.2 MPa and the temperature varies between 540°C and 270°C. The working fluid is air (an ideal gas). (5)

(1) Find the efficiency and the work done per cycle for the simple cycle.

(2) Find the efficiency and the work done per cycle for the cycle with an ideal regenerator, and compare with the Carnot cycle having the same isothermal heat supply process and the same temperature range.

(ii) Two engines are to operate on Otto and Diesel cycles with the following data: Maximum temperature 1400 K, exhaust temperature 700 K State of air at the beginning of compression 0.1 MPa. 300 K. Estimate the compression ratios, the maximum pressures, efficiencies, and rate of work outputs (for 1 kg/min of air) of the respective cycles. (8)

14. (a) (i) A steam power plant operates on a simple ideal Rankine cycle between the pressure limits of 3 MPa and 50 kPa. The temperature of the steam at the turbine inlet is 300°C, and the mass flow rate of steam through the cycle is 35 kg/s. Show the cycle on a T-s diagram with respect to saturation lines, and determine (8)

(1) the thermal efficiency of the cycle and

(2) the net power output of the power plant.

(ii) Show the ideal Rankine cycle with three stages of reheating on a T-s diagram. Assume the turbine inlet temperature is the same for all stages. How does the cycle efficiency vary with the number of reheat stages? (5)

Or

(b) (i) A vessel having a volume of 0.6 m^3 contains 3.0 kg of liquid water and water vapour mixture in equilibrium at a pressure of 0.5 MPa. Calculate: (4)

(1) Mass and volume of liquid

(2) Mass and volume of vapour.

(ii) Using steam tables, determine the mean specific heat for superheated steam: (2)

(1) at 0.75 bar, between 100°C and 150°C;

(2) at 0.5 bar, between 300°C and 400°C.

(iii) A spherical vessel of 0.9 m^3 capacity contains steam at 8 bar and 0.9 dryness fraction. Steam is blown off until the pressure drops to 4 bar. The valve is then closed and the steam is allowed to cool until the pressure falls to 3 bar. Assuming that the enthalpy of steam in the vessel remains constant during blowing off periods, determine: (7)

(1) The mass of steam blown off;

(2) The dryness fraction of steam in the vessel after cooling;

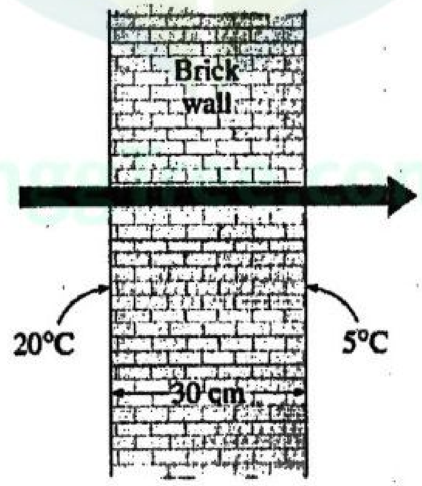
(3) The heat lost by steam per kg during cooling.

15. (a) (i) Classify and explain in brief the aerospace engines used. (4)

(ii) Explain any three basic jet propulsion engine with sketch. (9)

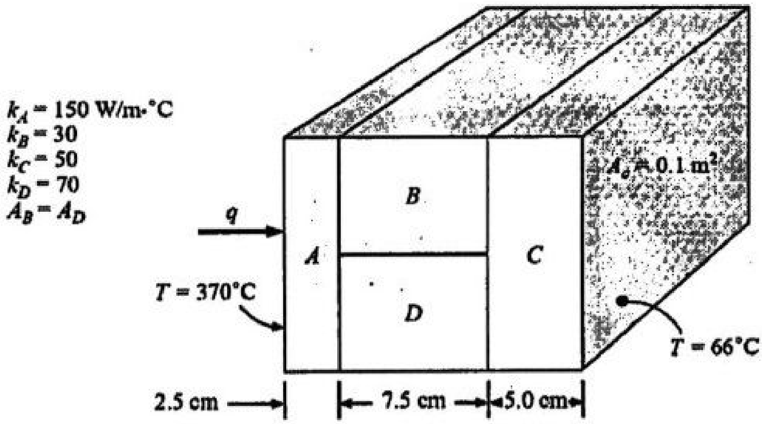
Or

(b) (i) The inner and outer surfaces of a 4-m × 7-m brick wall of thickness 30 cm and thermal conductivity 0.69 W/m.K are maintained at temperatures of 20°C and 5°C, respectively. Determine the rate of heat transfer through the wall in W for the system mentioned below. (4)



(ii) The inner and outer surfaces of a 0.5-cm thick 2-m × 2-m window glass in winter are 10°C and 3°C, respectively. If the thermal conductivity of the glass is 0.78 W/m.K, determine the amount of heat loss through the glass over a period of 5 h. What would your answer be if the glass were 1 cm thick? (4)

(iii) Find the heat transfer per unit area through the composite wall in Figure shown below. Assume one-dimensional heat flow. (5)



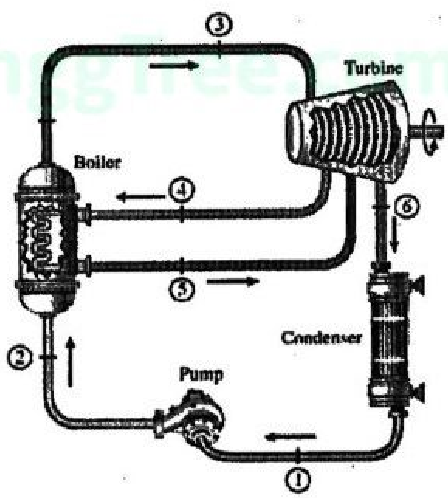
PART C — (1 × 15 = 15 marks)

16. (a) A steam power plant operates on the reheat Rankine cycle. Steam enters the high-pressure turbine at 12.5 MPa and 550°C at a rate of 7.7 kg/s and leaves at 2 MPa. Steam is then reheated at constant pressure to 450°C before it expands in the low-pressure turbine. The isentropic efficiencies of the turbine and the pump are 85 percent and 90 percent, respectively. Steam leaves the condenser as a saturated liquid. If the moisture content of the steam at the exit of the turbine is not to exceed 5 percent, determine

(i) the condenser pressure,

(ii) the net power output, and

(iii) the thermal efficiency.



Or

(b) Refrigerant-134a enters the condenser of a residential heat pump at 800 kPa and 35°C at a rate of 0.018 kg/s and leaves at 800 kPa as a saturated liquid. If the compressor consumes 1.2 kW of power, determine

(i) the COP of the heat pump and

(ii) the rate of heat absorption from the outside air.