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Question Paper Code : 52523

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Third Semester

Aeronautical Engineering

AE 6301 — AERO ENGINEERING THERMODYNAMICS

(Regulation 2013)

Time : Three hours Maximum : 100 marks

Use of Thermodynamic tables, Mollier chart permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define the Perpetual Motion Machine of the first kind.

2. What is meant by a quasi-static process?

3. State the Carnot's theorem.

4. State thermodynamic advantage of heat pump over direct heating.

5. Distinguish between Exergy and Irreversibility.

6. Determine the entropy change for a reversible isochoric process.

7. Identify the features of a pure substance with examples.

8. What is meant by sublimation? Illustrate with an example.

9. Comment on critical thickness of insulation.

10. List the assumptions made for Fourier law of heat conduction.

PART B — (5 × 13 = 65 marks)

11. (a) A highly elastic ball released from rest from an initial height of 'z_0' m, bounces a large number of times on a rigid horizontal surface before coming to rest such that the height attained after each bounce is 'φ' times the height before the bounce ($\varphi < 1$). The surface of the plane is adiabatic and the ball is made of a diathermic material with mass 'm' and specific heat 'c'. Derive an expression for the temperature rise "ΔT" of the ball after "X" number of bounces.

Or

(b) A unit mass of Nitrogen gas undergoes an expansion process as per the relation $P = aV + bV^2$ where a =1. lbar/m^3 and b is a constant (bar/m^6), from an initial pressure of 15 bar and temperature 100°C to a final volume of 100 liters. Calculate the displacement work done by the gas and also the heat exchange with the surroundings if the container walls are not insulated. Given Specific heat at constant volume as 0.7kJ/kgK.

12. (a) Prove that the Kelvin Planck Statement of Second law of thermodynamics is equivalent to the Clausius statement.

Or

(b) A 50-kg block of iron block at a temperature of 500 K is cooled by dipping in a pool of water at a temperature of 285 K. The iron block eventually reaches thermal equilibrium with the pool water. Assuming an average specific heat of 0.45 kJ/kgK for the iron, determine (i) the entropy change of the iron block, (ii) the entropy change of the pool water, and (iii) the entropy generated during this process.

13. (a) Illustrate the working of an ideal dual combustion cycle with the use of P-v and T-s plots and Derive its thermal efficiency.

Or

(b) A heat engine receives 500 kW of heat from a source at 1200 K and rejects the waste heat to a medium at 300 K. The power generated by the heat engine is 480 MJ/hr. Determine the following :

(i) Exergy

(ii) Anergy

(iii) Heat engine efficiency

(iv) Rate of irreversibility.

14. (a) An unknown quantity of super-heated steam is throttled from 10 bar and 200°C to 8 bar. Sketch the process on a T-v diagram. Calculate the following: (i) Final state of steam (ii) Change in specific volume (iii) Increase in specific entropy. Given the specific heat at constant pressure of steam as 2.1 kJ/kgK.

Or

(b) Explain the P-v-T surface diagram for substances that expand on freezing with a neat labelled sketch.

15. (a) Derive an expression for the overall heat transfer coefficient between two fluids at different temperatures 'T_1' K and 'T_2' K respectively, separated by a plain wall of thermal conductivity 'K'. Assume that the convective heat transfer coefficient between the inner fluid and wall surface is 'h_1' and that between the outer fluid and wall surface is 'h_2' respectively.

Or

(b) Consider a composite wall that includes an 8 mm thick Oakwood siding (K = 0.36 W/mK), Glass fiber insulation (K = 0.062 W/mK), and a 12 mm layer of vermiculite wall board (K = 0.056 W/mK). The layers are held together by 20 mm diameter and 40 mm long 0.5% carbon steel studs (K = 40 W/mK) with 1 stud for every 1.5 m^2 area of the wall. What is the effective thermal resistance associated with a wall that is 2 m high by 3 m wide? Assume surfaces normal to the x-direction are isothermal. If the wall insulates a storehouse with inside temperature 40°C and outside temperature 15°C, find out the heat transfer across the wall.

PART C — (1 × 15 = 15 marks)

16. (a) Explain briefly the history of jet engines and show the working of Ram jet engine using relevant sketches.

Or

(b) In a Rankine cycle, steam enters the first stage turbine at 10 MPa and 500°C, expands to 0.1MPa. It is then reheated to 450°C before expansion in the LP turbine. It then expands to a condenser pressure of 0.01MPa. Net power developed is 100MW. Both the turbines have an efficiency of 80%. Calculate (i) Overall thermal efficiency of the cycle (ii) mass flow rate of steam.

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