

K 1086

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2004.

Third Semester

Electrical and Electronics Engineering

ME 251 — THERMODYNAMICS

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

Use of Steam Tables, Mollier chart, HMT Data book permitted.

PART A — (10 × 2 = 20 marks)

1. State second law of thermodynamics according to Kelvin-Planck and Clausius.
2. If $pv^n = C$ represents a general thermodynamic process, name the processes when n has values of 0, 1, γ and ∞ .
3. Sketch the ideal dual cycle on $p-v$ diagram and name all the processes.
4. If a 50% efficient Carnot engine rejects heat at 27°C , at what temperature, it should receive heat.
5. Group the following devices into boiler mountings and accessories 'Water level indicator', 'Superheater', 'Economiser', 'Safety valve'.
6. State the purpose of compounding and name various methods of compounding.
7. Name any four rotary compressors.
8. State the conditions of refrigerant, while entering and leaving the condenser in an ideal vapour compression refrigeration system.
9. What is the difference between free convection and forced convection?
10. Define reflectivity and absorptivity.

PART B — (5 × 16 = 80 marks)

11. (i) An all rigid walled leak proof tight container holds a gas at 2.5 bar and 127°C. Heat is supplied to this gas at constant rate for sometime. At the end of heating it is estimated that change in internal energy is 450 kJ. Volume of the container is 0.6 m³. $C_p = 1.005$ kJ/kgK; $C_v = 0.712$ kJ/kg K; $R = 0.287$ kJ/kg K.

Name the process carried on and sketch it on $p-v$ diagram

Find the mass of gas

What is the temperature at the end of the process

Determine the pressure at the end of process

Estimate change in enthalpy.

(5 × 2 = 10)

- (ii) Certain volume of gas at 57°C is expanded to three times its original volume according to $pv^{1.25} = \text{constant}$. Determine the temperature at the end and change in entropy per kg of gas. $c_p = 0.99$ kJ/kg K
 $C_v = 0.7$ kJ/kg K.

(6)

12. (a) (i) An engine is to operate between temperature limits of 1400°C and 327°C. It is claimed that its power output is 4.0 kW, fuel consumption is 0.45 kg/hour. Calorific value of fuel is 42,000 kJ/kg. State whether the claim is justified by comparing with Carnot cycle.

(6)

- (ii) In an air standard Otto cycle, compression begins at 1 bar and 40°C, with a compression ratio of 7.0. The heat added is 2500 kJ/kg. Find maximum temperature, maximum pressure of the cycle, work done per kg of air, cycle efficiency and mean effective pressure.

(10)

Or

- (b) (i) Draw sketches to illustrate, suction, compression, power and exhaust strokes of an ideal 4-stroke diesel engine, carefully indicating valve position and piston movement.

(8)

- (ii) Explain with the help of these sketches the working principle of a 4-stroke diesel engine.

(8)

13. (a) (i) Estimate the quantity of heat required to produce 5 kg of steam at 6 bar from water at 0°C, when the steam is 80% dry and when it is at 300°C. Take C_p of superheated steam as 2.3 kJ/kg K.

(6)

- (ii) Steam at 20 bar, with a degree of superheat of 88°C is supplied by a boiler at 1.5 kg/s to a turbine. It is expanded isentropically to 0.07 bar. Determine the quality of steam after expansion, heat supplied in the boiler in kW, heat rejected in the condenser in kW, power generated and thermal efficiency neglecting pump work. (10)

Or

- (b) (i) During a boiler testing 250 kg of coal is used to evaporate 2000 kg water to produce 0.95 dry steam at 11.5 bar. Feed water temperature is 34°C and calorific value of coal is 29,800 kJ/kg. Estimate the "equivalent evaporation from and at 100°C" per kg of coal and efficiency of the boiler. (8)
- (ii) Give a descriptive account of how steam turbines are classified and explain the working of a simple DeLaval impulse turbine. (8)
14. (a) The free air delivery of a single cylinder, single stage reciprocating air compressor is 2.5 m³ per minute. The ambient air is at STP conditions. The delivery pressure is 7 bars. The clearance volume is 5% of stroke volume. Both compression and expansion are according to $pv^{1.25} = C$. Stroke length is 20% more than the bore. Compressor runs at 150 rpm. Determine mass of air per second, indicated power, indicated mean effective pressure, bore and stroke of cylinder.

Or

- (b) Draw the theoretical vapour compression refrigeration cycle with dry saturated vapour after compression on temperature - entropy diagram and pressure - enthalpy diagram. Explain the various processes in detail and obtain an expression for COP.
15. (a) (i) A steel pipe line has inner diameter of 100 mm and outer diameter of 110 mm. Its thermal conductivity is 50 W/mk. It is covered with two layers of insulation each 50 mm thick. The thermal conductivity of inner insulation is 0.06 W/mk and that of outer insulation is 0.12 W/mk. Calculate the loss of heat per metre length of pipe and the inter face temperature between the two layers of insulation if the temperature of the inside surface of tube is 250°C and that of outside surface of insulation is 50°C. (10)
- (ii) If the outer insulation is made as inner insulation and inner insulation is made as outer insulation. Estimate the percentage increase or decrease in heat loss per metre length. (6)

Or

- (b) (i) One end of a very long aluminium rod is connected to a wall at 140°C ; the other end protrudes into a room where the air temperature is 15°C . The rod diameter is 3 mm and heat transfer coefficient between rod surface and environment is $300\text{ W/m}^2\text{K}$. The thermal conductivity of rod is 150 W/mK . Estimate the total heat dissipated by the rod. (8)
- (ii) Air at 20°C flows along a hot flat plate at 3 m/s . Calculate the thickness of hydrodynamic boundary layer and skin friction coefficient at 40 cm from the leading edge of the plate. The kinematic viscosity of air at 20°C is $15 \times 10^{-6}\text{ m}^2/\text{s}$. (8)