Reg. No. : | | | | | | | | | | | |

M 2495

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2008.

Third Semester

Mechanical Engineering

ME 231 — APPLIED THERMODYNAMICS

Time : Three hours

Maximum : 100 marks

Use of approved thermodynamic tables and charts permitted.

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is the effect of friction on the flow through steam nozzles?

2. What is meant by degree of super saturation and degree of under cooling?

3. What is meant by volumetric efficiency of a compressor?

4. What is meant by surging of compressors?

5. Draw the P-V and T-S diagrams for Otto and Diesel cycles.

6. Among Otto and Diesel cycles which one is the most efficient for the same maximum pressure.

7. What are the advantages of reheating the steam in high pressure steam plants?

8. What is meant by binary vapour cycle?

9. What is the difference between a refrigerator and heat pump?

10. What is the purpose of sub-cooling the refrigerant in vapour compression refrigeration cycle?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Show that the maximum discharge of steam through the nozzle takes place when the ratio of steam pressure at the throat to inlet pressure is given by

$$P_2/P_1 = \left(2/(n+1)\right)^{(n/n-1)}$$

Where 'n' is the index of expansion (8)

(ii) Dry saturated steam at 2.8 bar is expanded through a convergent nozzle to 1.7 bar. Estimate the exit velocity and the mass flow rate, assuming

(1) Isentropic expansion.

(2) Assuming superheated flow exists. (8)

Or

(b) A convergent-divergent nozzle required to discharge 2 kg of steam per second. The nozzle is supplied with steam at 7 bar and 180°C and discharge takes place against a back pressure of 1 bar. The expansion up to throat is isentropic and the frictional resistance between the throat and exit is equivalent to 63 kJ/kg of steam. Taking approach velocity of 75 m/s and throat pressure of 4 bar, estimate :

(i) Suitable areas for the throat and exit, and (8)

(ii) Overall efficiency of the nozzle based on the enthalpy drop between the actual inlet pressure and temperature and the exit pressure. (8)

12. (a) A two-stage single acting reciprocating compressor takes in air at the rate of 0.2 m³/s. The intake pressure and temperature of air are 0.1 MPa and 16°C. The air is compressed to a final pressure of 0.7 MPa. The intermediate pressure is ideal and inter cooling is perfect. The compression index in both the stages is 1.25 and the compressor runs at 600 rpm. Neglecting clearance, determine

(i) The intermediate pressure (4)

(ii) The total volume of each cylinder (4)

(iii) The power required to drive the compressor (4)

(iv) The rate of heat rejection in the inter cooler. Take $C_p = 1.005$ kJ/kg and $R = 287$ J/kg K. (4)

Or

(b) (i) Distinguish between the reciprocating and rotary air compressors? (8)

(ii) Explain about the roots blower compressor with neat sketch? (8)

13. (a) An engine works on Otto cycle. The pressure and temperature of the air at the beginning of the cycle are 1 bar and 40°C. The compression ratio is 6. Assuming the peak pressure is limited to 50 bar, and compression and expansion follow the law $PV^{1.25}$ = constant.

Find out the following:

(i) The thermal efficiency of the cycle. (4)

(ii) Mean effective pressure of the cycle. (6)

(iii) If the working cycles per minute are 300 and cylinder diameter and length of the stroke are 12 cm and 20 cm; find out the power developed by the engine in kW. Working fluid is air. (6)

Or

(b) A gas turbine works on an air standard Brayton cycle. The initial condition of air is 25°C and 1 bar. The maximum pressure and temperature are limited to 3 bar and 650°C. Determine the following :

(i) Cycle efficiency (4)

(ii) Heat supplied and heat rejected per kg of air (4)

(iii) Work output per kg of air (4)

(iv) Exhaust temperature. (4)

14. (a) In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 30 bar and the exhaust pressure is 0.25 bar. Determine

(i) The pump work (3)

(ii) Turbine power (3)

(iii) The Rankine efficiency (3)

(iv) The condenser heat flow (3)

(v) The dryness at the end of expansion. Assume flow rate of 10 kg/s. (4)

Or

(b) Steam is supplied to a two-stage turbine at 40 bar and 350° C. It expands in the first turbine until it is just dry saturated, then it re-heated to 350°C and expanded through second stage turbine. The condenser pressure is 0.035 bar. Calculate the work output and the heat supplied per kg of steam for the plant, assuming ideal process and neglecting the feed pump work. Calculate also the specific steam consumption and the cycle efficiency. (16)

15. (a) An air refrigerator working on Bell-Coleman cycle takes air from cold chamber at 1 bar and –5°C and compresses to 6 bar following the law $PV^{1.25} = C$. The compressor air is cooled to 37°C in the cooler before entering into the expander. The expansion is isentropic. Determine

(i) COP of the cycle (4)

(ii) Mass of air circulated per minute, if 500 kg of ice is produced per day at 0°C when the water is supplied at 20°C and (6)

(iii) Refrigeration capacity of the plant in tons. Neglect the clearance in compressor and expander, take $\gamma = 1.4$ and $C_p = 1$ kJ/kg K for air, latent heat of ice = 335 kJ/kg, C_p of water is 4.1868 kJ/kg K. (6)

Or

(b) Draw a neat sketch of ammonia absorption refrigeration system and explain it's working. (16)

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