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Total Number of Pages: 02

Course: B.Tech/IDD  
Sub\_Code: MEPC2002

3<sup>rd</sup> Semester Regular Examination: 2024-25

SUBJECT: Engineering Thermodynamics

BRANCH(S): MMEAM, ME, MECH

Time: 3 Hours

Max Marks: 100

Q.Code: R589

Answer Question No.1 (Part-I) which is compulsory, any eight from Part-II and any two from Part-III.

The figures in the right hand margin indicate marks.

**Part-I**

**Q1 Answer the following questions:**

**(2 x 10)**

- Define the First Law of Thermodynamics for a closed system.
- What is entropy generation, and why does it occur?
- Differentiate between availability in non-flow and flow processes.
- Discuss the difference between exergy and energy?
- State the limitations of the Carnot vapor cycle for practical applications.
- What is the purpose of the reheat cycle in a steam power plant?
- Compare the Otto and Diesel cycles in terms of thermal efficiency and compression ratio.
- What is the main difference between the Brayton cycle and the Otto cycle?
- List the limitations of single-stage compression in reciprocating compressors.
- What factors affect the performance of a reciprocating compressor?

**Part-II**

**Q2 Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)**

**(6 x 8)**

- Compare and contrast the First Law and Second Law analyses for a steady-flow control volume. How does each provide different insights into system performance?
- Derive an expression for the change in entropy for a control volume undergoing a steady-state, steady-flow process with heat and work interactions.
- A heat engine operates between two reservoirs at temperatures  $T_H$  and  $T_L$ . Derive an expression for the maximum available energy and discuss the factors affecting it.
- Compare the concepts of energy conservation and exergy destruction. How do they complement each other in system analysis?
- Explain the Rankine cycle with a neat schematic and T-s diagram. Derive an expression for its thermal efficiency.
- Compare the Carnot vapor cycle, Rankine cycle, reheat cycle, and regenerative feed heating cycle in terms of efficiency and practicality.
- Derive the expression for the thermal efficiency of the Carnot vapor cycle and explain why it is not practical for real-world applications.

- h) An air-standard Otto cycle operates with a compression ratio of 8:1. The air enters the cylinder at 100 kPa and 300 K, and the maximum temperature during the cycle is 1200 K. Calculate the thermal efficiency of the cycle.
- i) A piston-cylinder device contains 2 kg of water at 200 kPa and 200°C. Using the Tds relations, calculate the change in entropy when the water is compressed isothermally to 500 kPa.
- j) Discuss the various uses of compressed air in industrial, automotive, and domestic applications.
- k) A single-stage reciprocating compressor has a clearance volume of 5% of the swept volume. If the pressure ratio is 6:1, calculate the volumetric efficiency assuming isentropic compression.
- l) Discuss the role of the Second Law of Thermodynamics in analyzing entropy generation in steady-flow systems. Provide examples.

### Part-III

#### Only Long Answer Type Questions (Answer Any Two out of Four)

- Q3** a) In an air compressor air enters at a 4 m/s, 1 bar, 0.5 m<sup>3</sup>/kg. The exit conditions are 7 m/s, 6 bar, 0.12 m<sup>3</sup>/kg. The internal energy of air is gained after compression process is 38 kJ/kg. The system loses 3000 kJ/min of heat to surroundings during process. Mass flow rate of air is 31 kg/min. Calculate (i) shaft work input, (ii) ratio of inlet to outlet areas. **(8+8)**
- b) 2 kg of water at 94 °C are mixed with 3 kg of water at 10 °C in an isolated system. Calculate the change of entropy due to mixing process.
- Q4** a) 1 kg of air is heated reversibly at constant pressure from 100 °C to 450 °C. The temperature of the surroundings is 27 °C, specific heat of air is 1.0055 kJ/kg K. Calculate (i) heat added (ii) available energy (iii) unavailable energy **(8+8)**
- b) 5 kg of air expands adiabatically in closed system from 6 bar at 90 °C to 1 bar at 40 °C. Calculate (i) maximum work, (ii) change of availability and (iii) irreversibility. Take,  $C_p = 1$  kJ / kg K,  $R = 0.287$  kJ / kg K,  $T_0 = 27$  °C,  $p_0 = 1$  bar.
- Q5** a) Explain the working principle of a simple Brayton cycle with the help of P-v and T-s diagrams. Derive an expression for its thermal efficiency. **(8+8)**
- b) A gas turbine operates on a simple Brayton cycle with an inlet temperature of 300 K and a maximum cycle temperature of 1300 K. The pressure ratio is 8. Calculate the cycle efficiency and the network output per kg of air if  $C_p = 1.005$  kJ/kgK.
- Q6** a) A two-stage compressor compresses air from 1 bar to 16 bar with perfect intercooling. The air enters at 27°C, and the intermediate pressure is optimized. Calculate the total work input per kg of air. Assume isentropic compression and  $\gamma$  (gamma) = 1.4. **(8+8)**
- b) A reciprocating compressor is designed to compress air from 100 kPa to 800 kPa with a volumetric efficiency of 85%. The swept volume is 0.1 m<sup>3</sup>, and the clearance volume is 5% of the swept volume. Calculate the mass of air compressed in one cycle.