Q. P. Code: 24252

(Time: 3 Hours) **[Total Marks: 80]**

N. B. : (1) Question No. **1** is **compulsory**.
(2) Solve any **three** out of the remaining **five** questions.
(3) Assume suitable data if required and state it clearly.
(4) Use of Steam Table and Mollier diagram is permitted.

1. Attempt any **four** out of the following **20**

(a) Define heat engine, refrigerator and heat pump.

(b) Draw a neat diagram of vane type blower and explain its working.

(c) Define i) wet steam, ii) superheated steam, iii) dryness fraction, iv) saturation temperature

(d) What do you understand by mean temperature of heat addition? For a given temperature of heat rejection show how the Rankine cycle efficiency depends on the mean temperature of heat addition.

(e) State the first law for a closed system undergoing a change of state.

2. (a) A reciprocating air compressor takes in 2 m^3/min at 0.11 MPa, 20^0C, which it delivers at 1.5 MPa, 111^0C to an aftercooler where the air is cooled at constant pressure to 25^0C. The power absorbed by the compressor is 4.15 kW. Determine the heat transfer in the compressor and the aftercooler. **10**

(b) Derive the first and second Tds equations. **5**

(c) A lump of 800 kg of steel at 1250 K is to be cooled 500 K. If it is desired to use the steel as source of energy, calculate the available and unavailable energies. Take specific heat of steel as 0.5 kJ/kg K and ambient temperature 300 K. **5**

3. (a) A heat pump working on a Carnot cycle takes in heat from a reservoir at 5^0C and delivers heat to a reservoir at 60^0C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840^0C and rejects heat to a reservoir at 60^0C. The reversible heat engine also drives a machine that absorbs 30 kW. If the pump extracts 17 kJ/s from the 5^0C reservoir, determine i) the rate of heat supply from 840^0C source, and ii) the rate of heat rejection to the 60^0C sink. **10**

(b) Determine entropy change of universe, if two copper blocks of 1 kg & 0.5 kg at 150^0C and 0^0C are joined together. Specific heats for copper at 150^0C and 0^0C are 0.393 kJ/kg K and 0.381 kJ/kg K respectively. **5**

(c) Determine the maximum work obtainable by using one finite body at temperature T and a thermal energy reservoir at temperature T_0, $T > T_0$ **5**

4. (a) A cyclic steam power plant is to be designed for a steam temperature at turbine inlet of 360^0C and an exhaust pressure of 0.08 bar. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet and calculate the Rankine cycle efficiency for these steam conditions. Estimate also the mean temperature of heat addition. **10**

   (b) Derive an expression of air standard efficiency for Otto cycle. **5**

   (c) Define volumetric efficiency of a compressor. On what factors does it depend? **5**

5. (a) A mass of air is initially at 260^0C and 700 kPa and occupies 0.028 m^3. The air is expanded at constant pressure to 0.084 m^3. A polytropic process with n = 1.50 is then carried out, followed by a constant temperature process which completes the cycle. All the processes are reversible. i) sketch the cycle on p-V and T-s plane, ii) find the heat received and heat rejected in the cycle, and iii) find the efficiency of the cycle. **10**

   (b) Show that energy is property of a system. **5**

   (c) Write Maxwell's equations. **5**

6. (a) An air standard limited pressure cycle has a compression ratio of 15 and compression begins at 0.1 MPa, 40^0C. The maximum pressure is limited to 6 MPa and the heat added is 1.675 MJ/kg. Compute i) the heat supplied at constant volume in kJ/kg, ii) the heat supplied at constant pressure in kJ/kg, iii) the work done per kg of air, iv) the cycle efficiency and v) the m.e.p. of the cycle. **10**

   (b) A single stage, double acting air compressor is required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15^0C. The deliver pressure is 7 bar and the speed 300 rev/min. Take the clearance volume as 5% of the swept volume with a compression and re-expansion index of n = 1.3. Calculate the swept volume of the cylinder, the delivery temperature and the indicated power. **10**

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