SE/Sem III/CBCGS/AUTO/ND-19 18/11/19

Paper / Subject Code: 50402 / THERMODYNAMICS

(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) State and prove Carnot Theorem.

(b) Explain the working principle of Roots blower. Also draw P-V diagram for it.

(c) What is the difference between heat and internal energy?

(d) Why is Carnot cycle not practicable for a steam power plant?

(e) Calculate the state of steam (i.e. whether it is dry, wet or superheated), when steam has a pressure of 15 bar and specific volume of 0.12 m^3/kg.

2. (a) In a gas turbine unit, the gases flow through the turbine is 15 kg/s and the power developed by the turbine is 12000 kW. The enthalpies of gases at the inlet and outlet are 1260 kJ/kg and 400 kJ/kg respectively, and the velocity of gases at the inlet and outlet are 50 m/s and 110 m/s respectively. Calculate : — 10
(i) The rate at which heat is rejected to the turbine, and
(ii) The area of the inlet pipe, given that the specific volume of the gases at the inlet is 0.45 m^3/kg.

(b) Show that the heat transfer through a finite temperature difference is irreversible. — 5

(c) A system at 500 K receives 7200 kJ/min from a source at 1000 K. The temperature of atmosphere is 300 K. Assuming that the temperatures of system and source remain constant during heat transfer find out : — 5
(i) The entropy produced during heat transfer ;
(ii) The decrease in available energy after heat transfer.

3. (a) Three reversible engines of Carnot type are operating in series between the limiting temperatures of 1100 K and 300 K. Determine the intermediate temperatures if the work output from engines is in proportion of 3 : 2 : 1. — 10

(b) Explain the principle of increase of entropy. — 5

(c) Derive the first and second T-dS equations. — 5

4. (a) In a thermal power plant operating on an ideal Rankine cycle, superheated steam produced at 5 MPa and 500^0C is fed to a turbine where it expands to the condenser pressure of 10 kPa. If the net power output of the plant is to be 20 MW, determine: i) heat added in boiler, in kJ/kg ii) the thermal efficiency. iii) the mass flow rate of steam in kg/sec. — 10

(b) Show that the efficiency of the Otto cycle depends only on the compression ratio. — 5

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

5. (a) One kg of air at 1 bar and 300 K is compressed adiabatically till its pressure becomes 5 times the original pressure. Subsequently it is expanded at constant pressure and finally cooled at constant volume to return to its original state. Calculate the heat and work interactions and change in internal energy for each process and for the cycle. **10**

(b) State the Zeroth law of thermodynamics. What is it's significance? **5**

(c) Deduce the expression for available energy from a finite energy source at temperature T when the ambient temperature is T_o. **5**

6. (a) An oil engine takes in air at 1.01 bar, 20^0C and the maximum cycle pressure is 69 bar. The compression ratio is 18. Calculate the air standard thermal efficiency based on the dual combustion cycle. Assume that the heat added at constant volume is equal to the heat added at constant pressure. **10**

(b) A single stage, single acting air compressor running at 1000 rev/min delivers air at 25 bar. For this purpose the induction and free air conditions can be taken as 1.013 bar and 15^0C, and the FAD as 0.25 m^3/min. The clearance volume is 3% of the swept volume and the bore/stroke ratio is 1.2/1. Calculate: **10**

(i) the bore and stroke;
(ii) the volumetric efficiency;
(iii) the indicated power;
(iv) the isothermal efficiency;

Take the index of compression and re-expansion as 1.3.
