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Total No. of Questions - 8] **[Total No. of Printed Pages-5**

B.E. III - Semester Examination

BE-III/11 (A)

247029

MECHANICAL ENGINEERING

Thermodynamics

Course No. : PME - 302

Time Allowed- 3 Hours *Maximum Marks-100*

Note: 1. Question Paper will be of 3 hours duration.

2. There will be 8 questions in all, Four from Section - A and Four from Section - B.

3. Students are required to attempt Five questions in all at least two questions from each section.

Section - A

1. a) A steam turbine operates under steady flow conditions receiving steam at the following state: pressure 15 bar; internal energy 2700 kJ/kg; specific volume 0.17 m^3/kg and velocity 100 m/s. The exhaust of steam from the turbine is at 0.1 bar with internal energy 2175 kJ/kg, specific volume 15 m^3/kg and velocity 300 m/s. The intake is 3 meters above the exhaust. The turbine develops 35 kW and heat loss over the surface of turbine is 20 kJ/kg. Determine the steam flow rate through the turbine.

b) $0.2\ m^3$ of an ideal gas at a pressure of 2 MPa and 600 K is expanded isothermally to 5 times the initial volume. It is then cooled to 360 K at constant volume and then compressed back polytropically to its initial state. Determine the net work done and heat transfer during the cycle. **(5)**

c) State and prove the Carnot theorem and its corollaries. **(10)**

2. a) A reversible heat pump is required to maintain a temperature of 0^0C in a refrigerator while rejecting heat to the surroundings at 300 K. If the heat removed rate from the refrigerator is 25kW, determine the COP of the machine and work input required. Proceed to determine the overall COP of the system if the power required to run the machine is developed by a reversible engine which operates between higher and lower temperature limits of 650 K and 300 K respectively.**(10)**

b) Derive an expression for a steady flow energy equation and point out the significance of various terms involved. **(10)**

3. a) A steam turbine working on the Rankine cycle is supplied with dry saturated steam at 25 bar and the exhaust takes place at 0.2 bar. For a steam flow rate of 10 kg/s, determine:

i. Quality of steam at end of the expansion
ii. Turbine shaft work
iii. Power required to drive the pump
iv. Work ratio
v. Rankine efficiency
vi. Heat flow in the condenser.

b) Differentiate between Otto, Diesel and Dual cycles of internal combustion engines. **(10)**

4. a) 3 kg of air at 150 kPa pressure and 360 K temperature is compressed polytropically to pressure 750 kPa according to the law $PV^{1.2}$ = constant. Subsequently, the air is cooled to the initial temperature at constant pressure. This is followed by expansion at constant temperature till the original pressure of 150 kPa is reached. Sketch the cycle on P-V and T-S plots and determine the work done, heat transfer and entropy change for each process. **(10)**

b) Show that the work done per kg of a perfect gas during an adiabatic expansion for which PV^{γ} = constant is given by:

$$W_{1-2} = \frac{R(T_1 - T_2)}{\gamma - 1}$$

(10)

SECTION - B

5. a) A vapour compression refrigerator uses R-12 as refrigerant and the liquid evaporates in the evaporator at -15°C. The temperature of this refrigerant at the delivery from the compressor is 15°C when vapour is condensed at 10°C. Find the COP

   i. There is no under-cooling and

   ii. The liquid is cooled by 5°C before expansion by throttling.

   Take specific heat at constant pressure for the superheated vapour as 0.64 kJ/kg K and that for liquid as 0.94 kJ/kg K.

   (10)

b) Write short note on the following:

i. Dew point

ii. Wet bulb

iii. Dry bulb temperature

iv. By-pass factor of heating and cooling coil **(4×2.5)**

6. a) The following data refer to air conditioning of public hall:

Outdoor conditions = 40°C DBT, 20°C WBT;

Required comfort conditions = 20°C DBT, 50% RH;

seating capacity of hall = 1000;

Amount of outdoor air supplied = 0.3 m^3/min/person.

If the required condition is achieved first by adiabatic humidifying and then cooling, find:

i. The capacity of the cooling coil and surface temperature of the coil if the BPF of coil is 0.25

ii. Capacity of the humidifier and its efficiency.

(10)

b) Give the chemical formula of these refrigerants:

i. R - 12 ii. R - 22

iii. R - 404 iv. R - 600

v. R - 40

(5×2)

7. a) Give major classification of reciprocating compressors.

(8)

b) Why intercoolers are required for multi-stage reciprocating compressors.

(6)

c) Differentiate between single acting and double acting compressor.

(6)

8. The shaft power input to a single cylinder double acting compressor is 6.93 kW. The mechanical and volumetric efficiencies are 82% and 87% respectively. The cylinder diameter is 12 cm and the stroke is 15 cm. On the crank side, the cross-sectional area of the piston rod is 10% of the total cylinder area. The crank speed is 500 revolutions per minute. Determine

i) The rate of delivery of air from the compressor

ii) The delivery pressure and

iii) The index of compression and expansion.

Assume the clearance to be 1/32 of the swept volume. Assume the suction conditions to be 1 atm and 300 K. **(20)**