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Question Paper Code : X10694

B.E./B.Tech. DEGREE EXAMINATIONS – NOV / DEC 2020 AND APRIL / MAY 2021

Third / Fourth Semester

Mechanical Engineering

ME8391 - ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering, Mechanical and Automation Engineering, Industrial Engineering and Plastic Technology)

(Regulations 2017)

Time: 3 Hours Answer ALL Questions Max. Marks 100

PART- A (10 x 2 = 20 Marks)

1. What is meant by intensive property in thermodynamics? Give two examples.
2. State the significance of Zeroth law of thermodynamics.
3. A reversible heat engine is operated with an efficiency of 25%. If it is operated as reversible refrigerator between the same temperature limits, what is its COP?
4. How does entropy of isolated system change? Why?
5. What is critical condition in phase change in thermodynamics?
6. What is the effect of reheating on network and efficiency of Rankine cycle?
7. What are the two distinct features of real gas?
8. What is the compressibility factor of Vander Walls' gas at critical point?
9. How does gas constant depend on molecular mass of the gas?
10. What is the need for dehumidification during summer air conditioning?

PART- B (5 x 13 = 65 Marks)

11. a) i) State first law of thermodynamics and list its limitations. **(2+3)**

ii) A fluid in a piston and cylinder executes 220+ cycles per min with four processes. The net heat transfer during a cycle is -300kJ. Complete the following table showing the method for each item, and compute the net rate of work output in kW. **(8)**

Process	Q(kJ/min)	W(kJ/min)	ΔE(kJ/min)
1-2	0	4350	?
2-3	42000	0	?
3-4	-4200	?	-73500
4-1	?	?	?

OR

b) i) Derive steady flow energy equation per unit mass and show that shaft work produced by a gas turbine is equal to the enthalpy drop across the gas turbine. **(3+2)**

ii) A blower handles 1 kg/s of air at 293 K and consumes a power of 15kW. The inlet and outlet velocities of the air are 100 m/s and 150 m/s respectively. Find the exit air temperature and the pressure ratio, assuming Adiabatic conditions. Take C_p = 1.005kJ/kg. **(5+3)**

12. a) i) State and derive Clausius inequality. **(2+3)**

ii) A reversible engine operates between a source at 972°C and two sinks, one at 127°C and another at 27°C. The energy rejected is same at both the sinks. Compute the engine efficiency. Also calculate the power and rate of heat supply if the rate of heat rejected to each sink is100 kW. **(4+4)**

OR

b) i) Draw the Carnot cycle on p-V and T-s diagram and derive the efficiency of Carnot cycle based on T-s diagram. **(2+3)**

ii) Air flows through an adiabatic compressor at 2 kg/s. The inlet conditions are 100 kPa and 310 K, and the exit conditions are 700 kPa and 560 K. Consider T_0 to be 298K. Determine the net rate of energy transfer and irreversibility. **(8)**

13. a) i) Explain the use of Throttling Calorimeter to determine dryness fraction. **(5)**

ii) Steam flows through a small turbine at the rate of 500 kg/h entering at 15 bar, 300°C and leaving gat 0.1 bar with 4% moisture. The steam enters at 80 m/s at a point 2 m above the discharge and leaves at 40 m/s. Compute the shaft power assuming that the device is adiabatic but considering kinetic and potential energy changes. Calculate the areas of the inlet and discharge tubes. **(8)**

OR

b) i) Draw Rankine Cycle on T-s and H-s diagram with steam at superheated condition at the entry of turbine and explain the effect of super heated steam on network and efficiency, compared to saturated steam based Rankine cycle. **(5)**

ii)Steam enters the turbine at 3 MPa and 400°C and is condensed at 10 KPa. Some quantity of steam leaves the turbine at 0.6 MPa and enters open feed water heater. Compute the fraction of the steam extracted per kg of steam and cycle thermal efficiency. **(8)**

14. a) i) Deduce the value of Van der Waals' constant in terms of critical properties. **(5)**

ii) Explain reduced properties and their uses in generalised compressibility chart. List the advantages of generalized compressibility chart. **(8)**

OR

b) i) Deduce the expression for the change in internal energy with respect to change in volume at constant temperature. **(5)**

ii) The latent heat of vaporization at 1 bar pressure is 2258kJ/kg and the saturation Temperature is 99.4°C. Calculate the saturation temperature at 2 bar pressure. Verify the same from the steam table data. **(8)**

15. a) i) State Amagat's Law and Dalton's Law. **(5)**

ii) A closed vessel has a capacity of 500 litres. It contains 20% nitrogen and 20% oxygen, 60% carbon di-oxide by volume at 100°C and 1 MPa. Calculate the molecular mass, gas constant, mass percentages and the mass of mixture. **(8)**

OR

b) i) Define relative humidity and show on the psychrometric chart how it changes during sensible heating, sensible cooling, humidification and dehumidification. **(5)**

ii) 120m^3 of air per minute at 35°C DBT and 50% relative humidity is cooled to 20°C DBT by passing through a cooling coil. Determine the following: **(2)**

i) Relative humidity of out coming air, **(2)**

ii) Wet bulb temperature of out coming air, **(4)**

iii) Capacity of cooling coil in tonnes of refrigeration, taking 14000 kJ/hr as one tonne of refrigeration.

PART- C (1 x 15 = 15 Marks)

16. a) The air speed of a turbo jet engine in flight is 270 m/s. Ambient Air temperature is -15°C. Gas temperature at the outlet of the nozzle is 600°C. Corresponding enthalpy values for air and gas are 260 and 912 kJ/kg respectively. Fuel-air ratio is 0.019. Chemical energy in the fuel is 44.5 MJ/kg. Owing to incomplete combustion 5% of the chemical energy is not released in the reaction. Heat loss from the engine is 21kJ/kg of air.

i) Draw the schematic diagram and indicate all the mass and energy interactions taking jet engine as a system. **(5)**

ii) Calculate the velocity of the exhaust jet. **(5)**

iii) Also calculate the thrust per unit mass flow rate of air, given that the thrust is the forward force on jet engine due to rate of change of momentum of working fluid. **(5)**

OR

b) It is required to design an air-conditioning system for an industrial process for the following hot and wet summer conditions with the use of psychometric chart:

Outdoor conditions……..32°C DBT and 65% R.H

Required air inlet conditions……25°C DBT and 60% R.H.

Coil dew point temperature……13°C

The required condition is achieved by first cooling and dehumidifying and then by heating. Hence, calculate the following:

i) The cooling capacity of the cooling coil and its by-pass factor. **(5)**

ii) Heating capacity of the heating coil in kW and surface temperature of the heating coil if the by-pass factor is 0.3. **(5)**

iii) The mass of water vapour removed per hour. **(5)**