Exam Date & Time: 10-Mar-2021 (02:00 PM - 05:00 PM)

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

III Semester End Semester Examination< B.Tech. Aeronautical/ B.Tech. Automobile> Engineering Thermodynamics (AAE 2158)

THERMODYNAMICS [AAE 2158]

Marks: 50 **Duration: 180 mins.**

Descriptive Questions

Answer all the questions. Section Duration: 180 mins

1) A) Distinguish between a path function and a point function. (2)

B) A closed system undergoes heating process at constant pressure. Derive the expression for the heat transfer during the process. (4)

C) An electric motor consists of copper windings having a resistance of 100 Ω at room temperature of 30ºC. The motor is switched ON, operated for an hour before switching OFF. The resistance is immediately measured and found to be 123 Ω. The resistance of the windings is found to vary with temperature as per the relation $R=R_0(1+0.00395t)$, at temperature 't' in ºC. Find out the temperature of the windings when the motor is switched OFF. (4)

2) A) A refrigerator needs to make ice cubes out of a tray of 0.5 kg liquid water at 10ºC. Assume the refrigerator works in a Carnot cycle between −5ºC and 35ºC with a motor-compressor of 750 W. How much time does it take if this is the only cooling load? Given: Specific heat of water is 4.187 kJ/kgK and latent heat of fusion of ice is 335 kJ/kg. (3)

B) In a closed-cycle gas turbine unit (with a pressure ratio 7:1), the maximum and minimum operating temperatures are 760ºC and 20ºC respectively. Determine the ideal cycle efficiency and the work ratio. (3)

C) Prove that the efficiency of a reversible engine operating between two thermal energy reservoirs at different temperatures is maximum compared to irreversible engines. (4)

3) A) A homogeneous mixture of air and petrol, in the ratio 15:1 by mass, enters the suction manifold of a spark ignition engine at a temperature of 30ºC and leaves as combustion productions at a temperature of 800ºC. The engine has a specific fuel consumption of 0.3 kg/kWh. The net heat transfer rate from the combustion chamber to the cylinder walls is around 35 kW. The shaft power delivered by the engine is 30 kW. Determine the increase in the specific enthalpy of the fuel-air mixture, assuming that the changes in the kinetic energy and potential energy are negligible. (3)

B) Define triple point for a substance. Show its location on a pressure-temperature plot. (3)

C) (4)

Oxygen (c_p=0.92 kJ/kgK) at 1.05 bar and 15ºC is compressed reversibly and polytropically inside a cylinder such that one-third of the work input is rejected as heat to the surroundings. What is the final temperature of oxygen after the compression process?

4) Show that entropy is a property of the system. (3)

A)

B) The products of combustion are flowing through a heat exchanger with 13% carbon dioxide, 13% water, and 74% nitrogen on a volume basis at the rate 0.1 kg/s and 100 kPa. What is the dew-point temperature? If the mixture is cooled 10ºC below the dew-point temperature, how long will it take to collect 10 kg of liquid water? (3)

C) A rigid container with volume 200 litres is divided into two equal volumes by a partition. Both sides contain nitrogen; one side is at 2 MPa, 250ºC, and the other is at 1 MPa, 50ºC. The partition ruptures, and the nitrogen comes to a uniform state at 100ºC. Assuming the surroundings are at 25ºC, find the actual heat transfer in the process and the final pressure of nitrogen at the uniform state. Take 'c_p' of nitrogen as 1.04 kJ/kgK. (4)

5) In an insulated chamber, 80 kg of water at 100ºC is mixed with 50 kg of water at 50ºC. The ambient temperature is 20ºC. What is the decrease in exergy due to the mixing? (3)

A)

B) What is meant by adiabatic saturation temperature? When does the adiabatic saturation attain a steady state? Illustrate with the help of a P-v plot. (2)

C) The displacement volume of an internal combustion engine is 5.6 litres. The processes within each cylinder of the engine, are modelled as an air-standard Diesel cycle with a cut-off ratio of 2.4. The state of the air at the beginning of compression is fixed by p_1=95 kPa, T_1=27ºC, and V_1=6.0 litres. Determine the net work output per cycle, in kJ, the power developed by the engine, in kW, and the thermal efficiency, if the cycle is executed 1500 times per min. (5)

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