CBCS SCHEME

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17ME43

Fourth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note : 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of thermodynamics data handbook is permitted.***

Module-1

1 a. Derive an expression of Air – Standard efficiency of Otto cycle with neat sketch of P – V and T – S diagrams. **(10 Marks)**

b. Compression ratio of an Air – Standard dual cycle is 8. Air is at 100 Kpa, 300K at the beginning of compression process. The temperature of air at the end of constant heat addition process is 1300K. the net heat transfer to the cycle is 480 kJ/kg. Determine
i) Heat added during constant volume per kg of air.
ii) Air – Standard cycle efficiency
iii) Mean effective pressure. **(10 Marks)**

OR

2 a. With a neat sketch, explain the working of Ramjet. **(10 Marks)**

b. Determine the network output and thermal efficiency of an ideal gas turbine cycle having two stages of compression with perfect inter cooling , two stages of expansion with perfect reheating between the stages and an ideal regenerator. The overall pressure ratio of the cycle is 4 and the maximum temperature of the cycle is 900°C. Assume that the atmospheric temperature is 15°C and the cycle is designed for maximum work output. Draw the schematic and T – S diagrams for the cycle. **(10 Marks)**

Module-2

3 a. With the help of neat diagram, explain the working of regenerative Rankine cycle and derive the efficiency of the cycle. **(10 Marks)**

b. A simple Rankine cycle works between the boiler pressure of 30 bar and condenser pressure of 0.04 bar. The supply steam to the turbine is dry saturated. Determine Rankine cycle efficiency. If the supply steam to the turbine is superheated by 66°C. What is the effect on the Rankine cycle efficiency? **(10 Marks)**

OR

4 a. With the help of flow and h – s diagram, derive an expression for cycle efficiency and also for mass of steam bled in a practical regenerative steam cycle with one feed water heater. **(10 Marks)**

b. A steam power plant operates on a theoretical reheat cycle. Steam at boiler outlet 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw h – s diagram and find :
i) Quality of steam at turbine exit
ii) Cycle efficiency
iii) Steam rate in kg/kW – h. **(10 Marks)**

Module-3

5 a. Explain the following terms with reference to a combustion process :
i) Adiabatic flame temperature ii) Enthalpy of formation
iii) Stoichiometric Air iv) Enthalpy of combustion
v) Combustion efficiency. **(10 Marks)**

b. The products of combustion of an unknown hydrocarbon Cx Hy have the following composition as measured by an Orsat apparatus $CO_2 = 8.0\%$, $CO = 0.9\%$, $O_2 = 8.8\%$ and rest is N_2. Determine
i) Composition of the fuel
ii) The air – fuel ratio
iii) Percentage of excess air
iv) Dew point temperature of the products, if the total pressure is 1.0 bar. **(10 Marks)**

OR

6 a. Explain the following : i) Heat balance sheet ii) Morse test. **(10 Marks)**

b. A single cylinder 4 – stroke diesel engine gave the following results while running on full load. Area of indicator diagram = $300mm^2$, Length of diagram = 40mm. The spring constant = 1 bar/mm , Speed of engine = 400 rpm , Load on the brake = 370N , Spring balance reading = 50N , Diameter of brake drum = 1.2m , Fuel consumption = 2.8kg/hr , Calorific value of fuel = 41800kJ/kg , Diameter of cylinder = 160mm , Stroke = 200mm. Calculate IP , BP , Brake mean effective pressure , Brake specific fuel consumption , Brake thermal efficiency and indicated thermal efficiency. **(10 Marks)**

Module-4

7 a. With a neat sketch, explain the working of Bell Coleman cycle. **(10 Marks)**

b. A vapour compression plant uses R – 12 and is to develop 5 tonnes of refrigeration. The condenser and evaporator temperatures are to be 40°C and -10°C respectively. Determine
i) The refrigerant flow rate in kg/s
ii) Heat rejected in the condenser
iii) COP
iv) Power required to drive the compressor. **(10 Marks)**

OR

8 a. Define the following :
i) Dry Bulb temperature
ii) Dew point temperature
iii) Relative humidity
iv) Specific humidity
v) Degree of saturation. **(10 Marks)**

b. It is required to design an air conditioning plant for a office room with the following conditions : Outdoor conditions : 14°C DBT and 10°C WBT.
Required conditions : 20°C DBT and 60% RH ;
Amount of air circulation = $0.3m^3$ / min / person ; Seating capacity of office = 60.
The required condition is achieved first by heating and then by adiabatic humidifying.
Determine : i) Heating capacity of the coil in kW and surface temperature required, if the by – pass factor of the coil is 0.4
ii) The capacity of the humidifier. **(10 Marks)**

Module-5

9 a. Obtain an expression for the volumetric efficiency of a single stage air compressor , in terms of pressure ratio, clearance ratio and 'n' the exponent of expansion and compression. **(10 Marks)**

b. An air compressor takes in air at 1 bar and 20°C and compresses the same according to the law $PV^{1.2} = C$. It is delivered to a receiver at a constant pressure of 10 bar. Determine

   i) Temperature at the end of compression.

   ii) Work done and heat transferred during compression per kg of air , R = 0.287 kJ/kg – K. **(10 Marks)**

OR

10 a. Prove that maximum flow rate of steam per unit area through a nozzle occurs when the ratio of pressure at throat to the inlet pressure is equal to

$$\frac{P_2}{P_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

, where n is polytropic index of expansion. **(10 Marks)**

b. Dry – saturated steam at a pressure of 11 bar enters a convergent divergent nozzle and leaves at a pressure of 2 bar. If the flow is adiabatic frictionless, determine

   i) Exit velocity of steam.

   ii) Ratio of cross – section area at exit and at throat. Assume the index of adiabatic expansion to be 1.135. **(10 Marks)**

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