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17ME43

Fourth Semester B.E. Degree Examination, Dec.2019/Jan.2020

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 hand book is permitted.

Module-1

1 a. Show the compression ratio (r_c) for maximum work should be per kg of air in an Otto cycle between upper and lower limits of absolute temperature T_3 and T_3 is given $r_C = \left(\frac{T_3}{T_1}\right)^{\frac{1}{2(\gamma-1)}}$ and also show that $T_2 . T_4 = (T_1\ T_3)^{1/2}$ **(10 Marks)**

b. Compression ratio of diesel cycle is 14 and cut off ratio is 2.2 at beginning of cycle, air is 0.98 bar and 100°C. Find: (i) The temperature and pressure at salient points (ii) Air standard efficiency. **(10 Marks)**

OR

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

b. In an open cycle gas turbine plant, air enters the compressor at 1 bar and 27°C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and the compressor are 85% and 80% respectively. Air fuel ratio is 80:1 calorific value of the fuel used is 42000 kJ/kg. Mass flow rate of air is 2.5 kg/sec. Determine the power output from the plant and the cycle efficiency. Assume the value of Cp = 1.005 kJ/kgK and $\gamma = 1.4$. **(10 Marks)**

Module-2

3 a. Discuss with the help of T-S diagram the effect of Boiler pressure, condenser pressure and super heat on the performance of a Rankine cycle. **(10 Marks)**

b. A 40 MW steam power plant working on Rankine cycle operator between boiler pressure of 40 bar and condenser pressure of 0.1 bar. Steam leaves the boiler and enters the turbine at 400°C. The isentropic efficiency of steam turbine is 84%. Determine:
i) Efficiency ii) Quality of exhaust iii) Steam flow rate in kg/hr. **(10 Marks)**

OR

4 a. 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 T-S and h-s diagrams. Find:
(i) Quality of steam at turbine exhaust
(ii) Cycle efficiency
(iii) Steam rate in kg/KWh. **(10 Marks)**

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

Module-3

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

b. Methane (CH_4) is burned with atmospheric air. The analysis of the products on a dry basis is as follows: $CO_2 = 10\%$, $O_2 = 2.37\%$, $CO = 0.53\%$, $N_2 = 87.10\%$.
   (i) Determine the combustion equation
   (ii) Calculate the air-fuel ratio
   (iii) Percent theoretical air **(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 give the following results while running on full load, area of indicator diagram = 300 mm^2, length of diagram = 40 mm. The spring constant = 1 bar/mm, speed of the engine = 400 rpm, load on the brake = 370 N, spring balance reading = 50 N, diameter of brake drum = 1.2 m, fuel consumption = 2.8 kg/hr, calorific value fuel = 41800 kJ/kg, diameter of cylinder = 160 mm, stroke = 200 mm. Calculate IP, BP, Brake mean effective pressure, brake specific fuel consumption, brake thermal efficiency, indicator thermal efficiency. **(10 Marks)**

Module-4

7 a. With a neat sketch, describe clearly the working of a Bell-Coleman cycle. **(06 Marks)**

b. Write a brief note on properties of refrigerants. **(04 Marks)**

c. For food-storage purpose, a refrigeration plant of 10.5 TR is required at an evaporation temperature of −12°C and condenser temperature of 27°C. The refrigerant is ammonia. It is sub-cooled by 6°C before entering the expansion valve. The vapour is 0.95 dry as it leaves the evaporator coil. The compression is adiabatic using p-h chart. Calculate:
   (i) Condition of vapour at outlet of the compressor
   (ii) Condition of vapour at entrance to evaporator
   (iii) CoP
   (iv) Power required in KW.
   Neglect throttling and clearance effect. **(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. An air-conditioning plant is to be designed for a small office for winter conditions. Outdoor condition = 10°C DBT and 8°C WBT. Required indoor conditions = 20°C DBT and 60% RH. Amount of air circulation = 0.3 m^3/min/person seating capacity of the office = 50. The required condition is achieved first by heating and then by adiabatic humidifying. Find the followings:
   (i) Heating capacity of the coil in KW and the surface temperature required if the bypass factor of the coil is 0.32
   (ii) The capacity of the humidifier. **(10 Marks)**

Module-5

9 a. Define the following with respect to a compressor:
i) Isothermal efficiency ii) Adiabatic efficiency iii) Mechanical efficiency
iv) Overall efficiency v) Volumetric efficiency **(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 the 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/kgK. **(10 Marks)**

OR

10 a. Prove the 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 $P_2 / P_1 = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ 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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