



# CBCS SCHEME

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  $100^\circ\text{C}$ . 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  $27^\circ\text{C}$ . 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  $C_p = 1.005$  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  $400^\circ\text{C}$ . 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,  $550^\circ\text{C}$  expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to  $550^\circ\text{C}$  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:
- Adiabatic flame temperature
  - Enthalpy of formation
  - Stoichiometric air
  - Enthalpy of combustion
  - Combustion efficiency
- (10 Marks)
- b. Methane ( $\text{CH}_4$ ) is burned with atmospheric air. The analysis of the products on a dry basis is as follows:  $\text{CO}_2 = 10\%$ ,  $\text{O}_2 = 2.37\%$ ,  $\text{CO} = 0.53\%$ ,  $\text{N}_2 = 87.10\%$ .
- Determine the combustion equation
  - Calculate the air-fuel ratio
  - Percent theoretical air
- (10 Marks)

OR

- 6 a. Explain the following:
- Heat balance sheet
  - 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 =  $300 \text{ mm}^2$ , 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  $-12^\circ\text{C}$  and condenser temperature of  $27^\circ\text{C}$ . The refrigerant is ammonia. It is sub-cooled by  $6^\circ\text{C}$  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:
- Condition of vapour at outlet of the compressor
  - Condition of vapour at entrance to evaporator
  - CoP
  - 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 =  $10^\circ\text{C}$  DBT and  $8^\circ\text{C}$  WBT. Required indoor conditions =  $20^\circ\text{C}$  DBT and 60% RH. Amount of air circulation =  $0.3 \text{ m}^3/\text{min}/\text{person}$  seating capacity of the office = 50. The required condition is achieved first by heating and then by adiabatic humidifying. Find the followings:
- Heating capacity of the coil in KW and the surface temperature required if the bypass factor of the coil is 0.32
  - 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 delivered to a receiver at a constant pressure of 10 bar.
- Determine:
- Temperature at the end of compression.
  - 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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