CBCS SCHEME

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18ME42

Fourth Semester B.E. Degree Examination, Dec.2024/Jan.2025
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 steam tables / Molar circuit / Psychrometric chart permitted.

Module-1

1 a. Obtain an expression for the mean effector pressure for an engine operation based on air standard Otto cycle. **(08 Marks)**

b. The volume of air at the beginning of compression in a single cylinder engine operated on dual cycle is 0.0168 m^3. The maximum pressure in the cycle is limited to 60 bar. The pressure and temperature of the air at the beginning of the cycle are 1 bar and 27°C. Heat is added during constant pressure process upto 3% of the stroke. Assuming cylinder diameter as 25 cm and stroke as 30 cm find the following :

(i) Work done per cycle
(ii) Air standard efficiency of the cycle.
(iii) Power developed if the number of working cycles are 200 per minute. **(12 Marks)**

OR

2 a. Describe the phenomenon of detoxation or knocking in S.I. Engine. How can it be controlled? **(06 Marks)**

b. The following observations were made during a trial of a single cylinder four stroke gas engine having cylinder diameter of 18 cm and stroke of 24 cm.

Duration of trial = 30 min; Total N = 9000; Total number of explosion=4200;
1 m.c.p = 5 bar ; Net load = 390 N ;
Effective diameter of brake wheel = 1 m ;
Calorific value of gaseous fuel at NTP = 19 MJ/m^3 ;
Total fuel used at NTP = 2.4 m^3 ; Total air used = 36 m^3 ;
Pressure of air = 720 mm of mercury ; Density of air at NTP = 1.29 kg/m^3 ;
Temperature of air =17°C ; Temperature of exhaust gases = 350°C ;
Sp.Heat of exhaust gases = 1 kJ/kgK ; Room temperature = 17°C ;
Cooling water circulated = 80 kg ; Rise in temperature of cooling water=30°C

Draw up a heat balance sheet and estimate the mechanical and indicated thermal efficiencies of the engine take R = 287 kJ/kgK. **(14 Marks)**

Module-2

3 a. Sketch the flow diagram and corresponding temperature entropy diagram of a gas turbine plant having 2 stage compression with intercooling, a regenerator and a 2 stage expansion with reheating in between the stages. Mark the state points clearly on both the diagrams. (Also description is necessary) **(06 Marks)**

b. In an open cycle gas turbine plant air enters the compressor at 1 bar and 27°C. The pressure of air after compression is 4 bar. The isentropic efficiency of the turbine and compressor are 85% and 80% respectively. Air fuel ratio is 80 : 1. Calorific value of 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 that C_P and V to be same for both air and products of combustion. **(14 Marks)**

OR

4 a. Explain briefly the methods used to increase the thermal efficiency and work output of a gas turbine power plant. **(08 Marks)**

b. In a gas turbine plant, the air at 10°C and 1 bar is compressed to 4 bar with compression efficiency of 80%. The air is heated in the regenerator and combustion chamber till the temperature is raised to 700°C and during the process, the pressure falls by 0.14 bar. The air is then expanded in the turbine and passes to regenerator which has 75% effectiveness and causes a pressure drop of 0.14 bar. If the isentropic efficiency of the turbine is 85%, determine the thermal efficiency of the plant. **(12 Marks)**

Module-3

5 a. Explain with the help of TS diagrams the effect of varying the boiler pressure and condenser pressure on the performance of a simple Rankine cycle. **(10 Marks)**

b. Steam enters the turbine of a steam power plant operating on Rankine cycle at 10 bar, 300°C. The condenser pressure is 0.1 bar. The steam leaving the turbine is 90% dry. Calculate the adiabatic efficiency of the turbine and also the cycle efficiency neglecting pump work. **(10 Marks)**

OR

6 a. Why is Carnot cycle not practicable for steam power plant? Explain briefly. **(06 Marks)**

b. Steam at 30 bar and 350°C is supplied to a steam turbine in a practical regenerative cycle and the steam is bled at 4 bar. The bled steam comes out as dry saturated steam and heats the feed water in an open type feed water, heater to its saturated liquid state. Rest of the steam in the turbine expands to a condenser pressure of 0.1 bar. Assuming the turbine efficiency to be same before and after bleeding determine,

(i) The turbine efficiency.
(ii) Steam quality at inlet to the condenser.
(iii) Mass flow rate of bled steam per unit mass flow rate at turbine inlet.
(iv) Cycle efficiency. **(14 Marks)**

Module-4

7 a. With the help of a neat sketch, elucidate the working of a vapour compression refrigeration system with the help of TS and hs diagram. Obtain the expression for the C.O.P. and capacity of refrigeration system. **(08 Marks)**

b. In a Bell-Coleman cycle, environment temperature is 302 K and the refrigerant temperature is 282 K. The pressure in the refrigerator is 1 bar and that in the cooler is 8 bar, Find the following :

(i) Maximum pressure and temperature in the cycle.
(ii) Refrigerant effect and heat rejected per kg of air.
(iii) Net work required per kg of air
(iv) Compressor and expander swept volume per kg of air
(v) C.O.P of the cycle.
(vi) η_e (relative efficiency)

Assume compression and expansion follow the Law $PV^{1.35} = C$. **(12 Marks)**

OR

8 a. Define the following terms with respect to air conditioning :
   (i) Dry bulb temperature
   (ii) Wet bulb temperature
   (iii) Dew point temperature
   (iv) Specific humidity
   (v) Relative humidity **(10 Marks)**

b. The sling psychrometer in a laboratory test recorded the following readings:
   (i) Dry bulb temperature = 35°C
   (ii) Wet bulb temperature = 25°C

   Calculate the following :
   (i) Specific humidity (ii) Relative humidity
   (iii) Vapour density in air. (iv) Dew point temperature
   (v) Enthalpy of mixture per kg dry air.
   Take atmospheric pressure = 1.0132 bar. **(10 Marks)**

Module-5

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

b. The following data refer to a single stage air compressor :
   Atmospheric conditions = 1 bar and 25°C
   Receiver pressure = 10 bar,
   Cylinder diameter = 12 cm,
   Stroke to Bore ratio is unity,
   Clearance volume is $\frac{1}{25}^{th}$ of the stroke volume.
   Index for both the compression and expansion = 1.25,
   Mechanical efficiency = 80%, if the receiver capacity is 600 liters and it takes 8 minutes to fill the receiver till its pressure is 10 bar starting from 1 bar, determine
   (i) Actual volumetric efficiency.
   (ii) Mass of air compressed per second
   (iii) Speed of compressor
   (iv) Power input.
   Assume that receiver temperature to remain at 25°C throughout the filling process.
   (10 Marks)

OR

10 a. What are the disadvantages of a single stage compressor? Obtain an expression for optimum pressure ratio in case of a 2 stage reciprocating air compressor with perfect inter cooling. Also derive an expression for minimum work for the same. **(10 Marks)**

b. A single acting two stage air compressor with complete inter cooling delivers 6 kg/min of air at 15 bars pressure. Assuming an intake state of 1 bar and 15°C and that of compression and expansion processes are polytropic with n = 1.3. Calculate the power required and isothermal efficiency if the speed is 410 rpm. Assuming the clearance volume of L.P. and H.P. cylinders to be 4% and 5% of the respective cylinder swept volumes, calculate the swept and clearance volumes for the cylinder. **(10 Marks)**

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