CBCS Scheme

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15ME43

Fourth Semester B.E. Degree Examination, June/July 2018
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

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 for mean effective pressure in an air standard Otto cycle. **(08 Marks)**

b. Compression ratio of an air standard dual cycle is 8. Air is at 100 kPa, 300 K at the beginning of the compression process. The temperature of air at the end of constant pressure heat addition process is 1300 K. 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 and
iii) m.e.p. **(08 Marks)**

OR

2 a. For a simple gas turbine cycle, the optimum pressure ratio for maximum work output of cycle is given by

$$r_p = \left\{\eta_C \eta_T \frac{T_3}{T_1}\right\}^{\frac{\gamma}{2(\gamma-1)}}$$

where η_C and η_T are the isentropic efficiency of compressor and turbine respectively, T_3 and T_1 = maximum and minimum temperature of the cycle respectively. $\gamma = C_p/C_v$ **(08 Marks)**

b. Determine the network output and thermal efficiency of an ideal gas turbine cycle having two stages of compression with perfect intercooling, 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. **(08 Marks)**

Module-2

3 a. Why is Carnot cycle not practicable for steam power plant? Explain briefly with the help of T-S diagram. **(06 Marks)**

b. Discuss the effect of (i) Boiler pressure and (ii) Superheat on the performance of a Rankine cycle. **(06 Marks)**

c. A steam power plant operates on a theoretical reheat cycle. Steam at boiler with 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 **(04 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 open feed water heater. **(08 Marks)**

b. Steam at 30 bar, 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 direct contact type feed water heater to its saturated liquid state. The rest of the steam in the turbine expands to 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 the condenser inlet
iii) Mass of steam bled per kg of boiler steam
iv) Cycle efficiency. **(08 Marks)**

Module-3

5 a. With neat sketch, explain the Orsat's apparatus used for exhaust gas analysis. **(06 Marks)**

b. The products of combustion of an unknown hydrocarbon C_xH_y 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 principle of conducting Morse test on IC engines for determining frictional power. **(04 Marks)**

b. List the factors affecting the detonation. **(02 Marks)**

c. A 4-cylinder 2-stroke petrol engine has a bore of 57 mm and stroke of 90 mm. Its rated speed is 2800 rpm and is tested at this speed against a brake, which has a torque arm of 0.356 m. The net brake load is 155 N and the fuel consumption is 6.74 lit/h. The specific gravity of the petrol is 0.735 and it has a calorific value of 44200 kJ/kg. A Morse test is carried out and the cylinders are cut-out in order 1, 2, 3, 4 with corresponding brake loads 111, 106.5, 104.2 and 111.3 N respectively. Calculate for this speed :
i) The engine torque
ii) Brake mean effective pressure
iii) Brake thermal efficiency
iv) BSFC
v) Mechanical efficiency
vi) Indicated thermal efficiency. **(10 Marks)**

Module-4

7 a. 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 in KW
iii) COP
iv) Power required to drive the compressor **(06 Marks)**

b. An air refrigeration system working on Reversed Brayton Cycle with 15 tonnes capacity has its pressure range 1 bar to 10 bar. Air enters the compressor at −5°C and enters the expander at 25°C. Assuming the isentropic efficiency of expander and compressor each has 85%, find: i) COP ii) Air flow rate and iii) Power required. **(06 Marks)**

c. What are the desirable properties of good refrigerant? **(04 Marks)**

OR

8 a. With a neat sketch explain the working of air conditioning system for hot and dry summer condition. Show the processes on psychrometric chart. **(08 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 = 0.3 m^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. **(08 Marks)**

Module-5

9 a. Derive the condition for minimum work required by a two stage air compressor with perfect intercooling between stages. Assume the compression follows the law $PV^n = C$ for stage-1 and for the stage-2 follows $PV^m = C$. Reduce this equation when n = m. **(08 Marks)**

b. A single stage, double acting air compressor, required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15°C. The delivery pressure is 7 bar and speed is 300 rpm. Take the clearance volume as 5% of swept volume with the compression and expansion index, n = 1.3. Calculate:
i) the bore and stroke of the cylinder assuming L = 1.2 D
ii) Delivery temperature
iii) Indicated power required. **(08 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 $\left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ where n = isentropic index of expansion. **(08 Marks)**

b. An adiabatic steam nozzle is to be designed for a discharge rate of 10 kg/s of steam from 10 bar and 400°C to a back pressure of 1 bar. The nozzle efficiency is 0.92 and the frictional loss is assumed to take place in the diverging portion of the nozzle only. Calculate: i) Velocity of steam at throat and exit of the nozzle, ii) Throat and exit area. Assume index of expansion = 1.3. **(08 Marks)**

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