CBCS SCHEME

USN | | | | | | | | | | 15ME43

Fourth Semester B.E. Degree Examination, Jan./Feb.2021
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 hand book permitted.*

Module-1

1 a. Derive an expression for mean effective pressure of an Otto cycle. **(08 Marks)**

b. The pressures on the compression curve of a diesel engine are at $\frac{1}{8}^{th}$ of stroke 1.4 bar and at $\frac{7}{8}^{th}$ stroke 14 bar. Estimate the compression ratio, calculate the air standard efficiency and mean effective pressure of the engine if the cut-off occurs at $\frac{1}{15}^{th}$ of the stroke. Assume initially air is at 1 bar and 27˚C. **(08 Marks)**

OR

2 a. For a gas turbine working on ideal Brayton cycle, show that the maximum network produced can be expressed in terms of maximum and minimum temperatures in the cycle as, $[W_{net}]_{max} = C_P\left(\sqrt{T_{max}} - \sqrt{T_{min}}\right)^2$. **(08 Marks)**

b. In a reheat gas turbine cycle comprising one compressor and two turbines, air is compressed from 1 bar 27˚C to 6 bar. The highest temperature in the cycle is 900˚C. The expansion in the first stage turbine is such that the work from it just equals the work required by the compressor. Air is reheated between the two stages of expansion to 850˚C. Assume that the isentropic efficiency of the compressor, the first stage and second stage turbines are 85% each and that working substance is air. Calculate the cycle efficiency. **(08 Marks)**

Module-2

3 a. Discuss the effect of, (i) Boiler pressure (ii) Condenser pressure (iii) Superheat on the performance of Rankine cycle. **(08 Marks)**

b. Steam at 20 bar, 360˚C is expanded in a steam turbine to a pressure of 0.08 bar. If then enters a condenser, where it is condensed to saturated liquid water. Assuming the turbine and feed pump efficiencies as 60% and 90% respectively, determine per kg of steam, the network, the heat transferred to the working fluid and the Rankine efficiency of the cycle. **(08 Marks)**

OR

4 a. With neat sketch, explain working of binary vapour cycle. **(08 Marks)**

b. In a reheat cycle, steam at 150 bar, 500˚C expands in HP turbine till it is saturated vapour. It is then reheated at constant pressure to 400˚C and then expanded in LP turbine to 40˚C. If the maximum moisture content at the turbine exhaust is limited to 15%, find (i) The Reheat pressure (ii) The pressure of steam at the inlet to HP turbine (iii) The cycle efficiency. **(08 Marks)**

Module-3

5 a. Define : (i) Stoichiometric air, (ii) Enthalpy of formation (iii) Enthalpy of reaction, (iv) Adiabatic flame temperature. **(08 Marks)**

b. The products of combustion of an unknown hydrocarbon C_xH_y have following composition as measured by an orset apparatus: CO_2 = 8%, O_2 = 8.8%, CO = 0.9%, N_2 = 82.3%, Determine (i) Composition of fuel (ii) Air fuel ratio (iii) Percentage of excess air used. **(08 Marks)**

OR

6 a. With a P-θ diagram, explain stages of combustion SI engine. **(08 Marks)**

b. Morse test is conducted on 4-S four cylinder petrol Engine at constant speed and the following power is measured: with all cylinders working = 15.6 kW. With number 1 cylinder cut-off = 11.1 kW, with number 2 cylinder cut off = 11.3 kW. With number 3 cylinder cut-off = 10.8 kW. With number 4 cylinder cut off = 11.0 kW. The bore and stroke of each cylinder is 75 mm and 100 mm respectively. The clearance volume of the cylinder is 100 cc. The fuel is consumed at the rate 6 kg/hr. If the calorific value of the fuel is 42000 kJ/kg. Determine (i) Indicated power (ii) Frictional power (iii) Mechanical efficiency (v) Relative efficiency with respect to brake thermal efficiency. **(08 Marks)**

Module-4

7 a. Sketch the flow diagram and the corresponding pressure volume diagram of an air refrigeration working on ideal Bell Colemen cycle and also derive an expression for COP of Bell Coleman cycle. **(08 Marks)**

b. An air refrigeration system is to be designed according to the following specifications:
Pressure of air at compressor inlet = 101 KPa.
Pressure of air at compressor outlet = 404 KPa.
Temperature of air at compressor inlet = -6°C
Temperature of air at turbine inlet = 27°C.
Isentropic efficiency of compressor = 85%
Isentropic efficiency of turbine = 85%
Determine:
(i) COP of the cycle
(ii) Power required to produce 1 ton of refrigeration (iii) Mass flow rate of air required for 1 ton refrigeration. **(08 Marks)**

OR

8 a. Define the following terms : (i) Wet Bulb Temperature (WBT). (ii) Specific Humidity (SH) (iii) Relative Humidity (RH) (iv) Degree of Saturation (DS). **(08 Marks)**

b. An air conditioning system is designed under the following conditions : Outdoor conditions : 30°C DBT, 75% RH. Required conditions : 22°C DBT, 70% RH, Amount of air circulated 3.33 m^3/sec. Coil Dew Point Temperature (DPT) = 14°C. The required conditions is achieved first by cooling and humidification and then by heating. Estimate (i) The capacity of the cooling coil in tones of refrigeration. (ii) Capacity of heating coil in kW (iii) The amount of water vapour removed in kg/hr. **(08 Marks)**

Module-5

9 a. Obtain an expression for the volumetric efficiency of a single stage air compressor in terms of pressure ratio, clearance and 'n' the exponent of compressions expansion. **(06 Marks)**

b. Why Intercooling is necessary in multistage compression? **(02 Marks)**

c. A single stage double acting air compressor is required to deliver 14 m^3 of air per minute measured at 1.013 bar is 15˚C. The delivery pressure is 7 bar and the speed is 300 rpm. Take the clearance volume is 5% of swept volume with a compression and re expansion index of n = 1.3. Calculates the swept volume of the cylinder, the delivery temperature and the indicated power. **(08 Marks)**

OR

10 a. With neat sketch, explain different shapes of nozzle. **(03 Marks)**

b. Derive an expression for exit velocity of nozzle in terms of pressure ratio and index of expansion. **(05 Marks)**

c. A multistage air compressor compresses air from 1 bar to 40 bar. The maximum temperature of air not to exceed 400 K in any stage. If the law of compression is $PV^{1.3} = C$ .Find number of stages for minimum power input, also find the actual intermediate pressure and temperatures. What will be minimum power input in kW required to compress and deliver 10 kg/min of air and the rate of heat rejection in each inter cooler. Assume ambient temperature = 27˚C and perfect inter cooling between stages. **(08 Marks)**

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