CBCS SCHEME

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

Fourth Semester B.E. Degree Examination, July/August 2021
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: 1. *Answer any FIVE full questions.*
2. *Use of thermodynamic data hand book permitted.*
3. *Draw neat sketches, wherever necessary.*

1 a. Compare Otto, Diesel and Dual cycles for the same compression ratio and heat addition. Use P-V and T-S diagrams. **(06 Marks)**

b. What is an "Air Standard Cycle"? why are such cycles conceived? **(02 Marks)**

c. An engine working on the Otto cycle has an air standard efficiency of 56% and rejects 544 kJ/kg of heat. The pressure and temperature of air at the beginning of compression are 0.1 MPa and 60˚C respectively. Compute
(i) Compression ratio of the engine.
(ii) Work done per kg of air.
(iii) Pressure and temperature at the end of compression.
(iv) Maximum pressure of the cycle. **(08 Marks)**

2 a. Discuss the various methods employed to improve the thermal efficiency of an open cycle G.T. Plant. **(09 Marks)**

b. A simple Gas turbine unit consists of single stage compressor, regenerator, combustion chamber and single stage turbine. The initial pressure and temperature are 1.03 bar and 15.5˚C. The pressure ratio of the cycle is 5. The maximum temperature of the cycle is limited to 813 K. The isentropic efficiency of the compressor and turbine are 85% and 80% respectively. Take C_P = 1 kJ/kgK and γ = 1.4 for air and gases and find the air flow rate through the plant. If the power output of the turbine is 1560 kW. Neglect the mass of fuel. Take effectiveness of regenerator = 0.85. Compute the thermal efficiency of the plant. **(07 Marks)**

3 a. Compare Carnot and Rankine cycles for a steam power plant. Enumerate the importance of mean temperature of heat addition and explain the various methods employed to increase the mean temperature of heat addition. **(08 Marks)**

b. In a reheat cycle, steam at 500˚C expands in a HP turbine till it is saturated vapor. It is reheated at constant pressure to 400˚C and then expands in a L.P. turbine to 40˚C. If the maximum moisture content at the exhaust of the turbine is limited to 15% find (i) The reheat pressure (ii) Pressure at the inlet of the HP turbine. (iii) Net specific work output (iv) the efficiency (v) The steam rate
Assume all ideal processes. Use Mollier diagram. **(08 Marks)**

4 a. Obtain an expression for the thermal efficiency of a Regenerative Rankine cycle with single open heater. Obtain an expression for mass of steam bled. **(06 Marks)**

b. Discuss how of 'diminishing returns' with regard to efficiency of regenerative rankine cycle with 'n' heaters. **(04 Marks)**

c. A regenerative cycle operates with steam supplied at 30 bar and 300˚C and condenser pressure of 0.08 bar. The extraction points for two heaters (open type) are at 3.5 bar and 0.7 bar respectively. Calculate thermal efficiency. Neglect pump work. Use Mollier diagram. **(06 Marks)**

5 a. Define (i) Stoichiometric air (ii) Excess air (iii) Enthalpy of formation (iv) Combustion efficiency. **(06 Marks)**

b. With a neat sketch, explain the working principle of an Orsat apparatus. **(05 Marks)**

c. An S.I. Engine uses a hydrocarbon fuel of unknown composition and the volumetric analysis of the exhaust gas gives the following :
CO_2 – 14.4%, CO – 0.4%, O_2 – 5.5%, N_2 – 79.7%
Calculate on mass basis.
(i) Percentage theoretical air.
(ii) Air fuel ratio (actual)
(iii) Composition of the fuel on mass basis. **(05 Marks)**

6 a. Discuss the Willan's line methods employed to determine the fictional power of an I.C. Engine. **(04 Marks)**

b. With a P-θ diagram, explain the combustion phenomenon in C.I. Engines. **(06 Marks)**

c. The following data is from a trial on a 4-cylinder, 4-stroke petrol engine which is coupled to a hydraulic dynamometer at constant speed and full throttle:
B.P with all cylinders working : 14.7 kW
B.P with cylinder 1 cutoff : 10.4 kW
B.P with cylinder 2 cutoff : 10.3 kW
B.P. with cylinder 3 cutout : 10.4 kW
B.P. with cylinder 4 cutout : 10.2 kW
Petrol used = 5.44 kg/h, C.V. of the fuel = 42000 kJ/kg
Diameter and stroke of piston : 8 cm and 10 cms respectively,
Clearance volume = 100 cm^3
Find (i) the mechanical efficiency (ii) Relative efficiency on IP basis. **(06 Marks)**

7 a. Explain the following terms with regard to refrigeration :
(i) Refrigeration effect
(ii) Unit of refrigeration
(iii) Desirable properties of a refrigerant. **(06 Marks)**

b. A E12 vapor compression refrigeration system has a conducting temperature of 50˚C and evaporating temperature of 0˚C. The refrigeration capacity is 7 tons. The vapor leaving the evaporator is saturated and the liquid leaving the condenser is also saturated. Assuming isentropic compression. Determine
(i) Flow rate of refrigerant.
(ii) Power required to run the compressor.
(iii) Heat rejected in the plant.
(iv) COP of the system.
Use the following properties :

Temp ˚C	Pressure bar	h_f kJ/kg	h_g kJ/kg	S_f kJ/kg K	S_g kJ/kg K
50	12.199	84.864	206.298	03.34	0.6792
0	3.086	36.022	187.397	0.1418	0.696

(07 Marks)

c. Give a case study on Cold storage. **(03 Marks)**

8 a. Explain the following terms with regard to air conditioning :
   (i) Dry air
   (ii) Specific humidity
   (iii) Humidity ratio
   (iv) Degree of saturation. **(08 Marks)**

   b. The Sling psychrometer reads 40˚C DBT and 28˚WBT. Calculate :
   (i) Specific humidity
   (ii) Vapor density of an air.
   (iii) Dew point temperature
   (iv) Enthalpy of the mixture per kg of dry air.
   Assume atmospheric pressure to be 1.03 bar. **(08 Marks)**

9 a. Derive an expression for minimum work of compression for a 2-stage reciprocating air compressor with perfect intercooling. **(08 Marks)**

   b. A three stage compressor is used to compress H_2 from 1.04 bar to 35 bar. The compression in all stages follows the law $PV^{1.25} = C$. The temperature at the inlet of compressor is 288 K. Neglecting clearance and assuming perfect inter cooling find the power required to drive the compressor in kW to deliver 14 m^3/min of H_2 measured at inlet conditions. Also find the intermediate pressures. **(08 Marks)**

10 a. Derive an expression for optimum pressure ratio for maximum discharge and further obtain an expression for maximum discharge. **(07 Marks)**

   b. What do you understand by super saturated or metastable flow in nozzles? **(04 Marks)**

   c. The inlet conditions of steam to a convergent – divergent nozzle is 2.2 MN/m^2 and 260˚C. The exit pressure is 0.4 MN/m^2. Assuming frictionless flow upto the throat and a nozzle efficiency of 85 percent, determine (i) the flow rate for a throat area of 32.2 cm^2 (ii) exit area. **(05 Marks)**

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