[3862] – 311

S.E. (Mechnical) (Semester – I) Examination, 2010
APPLIED THERMODYNAMICS
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answers to the **two** Sections should be written in **separate** Answer books.*
*2) **Neat** diagrams must be drawn **wherever** necessary.*
*3) Figures to the **right** indicates **full** marks.*
*4) Use of Mollier chart, steam tables, electronic pocket calculator is **allowed**.*
*5) Assume suitable data, **if necessary**.*

SECTION – I

UNIT – I

1. a) Discuss equivalence of Clausius and Kelvin-Plank statement. **6**

   b) Explain "Principle of Increase of Entropy". **4**

   c) A house is to be maintained at a temperature of 20°C by means of a heat pump pumping heat from atmosphere. Heat losses through the walls of the house are estimated at 0.65 kW per unit of temperature difference between inside of the house and atmosphere.

      i) If the atmospheric temperature is –10°C, what is the minimum power required to drive the pump ?

      ii) It is proposed to use the same heat pump to cool the house in summer. For the same room temperature, the same heat loss rate and the same power input to the pump, what is the maximum permissible atmospheric temperature ? **6**

OR

2. a) State and explain Carnot theorem. Explain why Carnot cycle is not used as practical cycle. **8**

   b) One kg of water at 300 K is first heated to 400 K by bringing it in contact with an inter-mediate heat reservoir at 400 K and then to 500 K as before. What will be the entropy change of the universe in this case ? **8**

P.T.O.

UNIT – II

3. a) Derive characteristic equation of a perfect gas. 6

   b) Represent the following processes on P-V and T-S diagram for Ideal gas : 6

      i) Isothermal Compression

      ii) Adiabatic Expansion

      iii) Polytropic Compression.

   c) 0.5 kg of air is compressed reversibly and adiabatically from 80 KPa and 60°C to 0.4 MPa and is then expanded at constant pressure to the original volume. Sketch the process on P-V and T-S diagrams and compute the work transfer and heat transfer. Take R = 0.287 KJ/KgK and $\gamma = 1.4$. 6

OR

4. a) Derive an expression for Air standard efficiency of Diesel cycle. 8

   b) An amount of a perfect gas has initial conditions of volume 1 m^3, pressure 1 bar and temperature 18°C. It undergoes ideal diesel cycle operations, the pressure after isentropic compression being 50 bar and the volume after constant pressure expansion being 0.1 m^3. Calculate the temperatures at the major points of the cycle and evaluate the thermal efficiency of the cycle.

   Assume, $\gamma = 1.4$ for the gas. 10

UNIT – III

5. a) What are the limitations of separating calorimeter and throttling calorimeter ? 6

   b) Show the following processes on T-S & h-s diagram for steam : 4

      i) Isothermal Process

      ii) Irreversible Adiabatic Process

      iii) Reversible Adiabatic Process

      iv) Throttling Process.

   c) Determine the state of the steam in the following cases :

      i) Pressure 10 bar and specific volume 0.185 m^3/kg

      ii) Pressure 12 bar and temperature 200°C

      iii) Pressure 15 bar and 2500 KJ/Kg of heat is required to generate steam from water at 0°C. 6

OR

6. a) Explain with the help of T-S diagram, the effect of superheating, inlet pressure and condenser pressure on performance of Rankine cycle. 8

b) In a Rankine cycle, the turbine inlet pressure is 6 MPa and the condenser pressure is 0.08 bar. Determine :

i) Moisture content at the turbine outlet

ii) The cycle thermal efficiency

Determine above parameters for the turbine inlet temperature of :

1) Saturation temperature at 6 MPa and

2) 450°C

Neglect pump work. **8**

SECTION – II

UNIT – IV

7. a) Define the following terms for reciprocating air compressor :

i) Isothermal efficiency. **2**

ii) Volumetric efficiency. **2**

iii) Mechanical efficiency. **2**

iv) FAD. **2**

b) A two stage, single acting reciprocating air compressor draws in air at 1 bar and 300 K. The delivery pressure is 12 bar. The intermediate pressure is ideal for minimum work and the intercooling is perfect. The index of compression is 1.3. Flow rate of air through the compressor is 0.15 kg/sec. Determine :

i) Power required to drive the compressor. **2**

ii) Saving in power compared to single stage. **2**

iii) Isothermal efficiency for multistage and single stage. **2**

iv) Heat rejected in intercooler if C_p = 1 KJ/KgK and R = 0.287 KJ/KgK. **2**

OR

8. a) Deduce on expression for the optimum value of the intercooler pressure in a two stage compressor. Also state the assumptions made. **8**

b) A two stage air compressor compresses air from 1 bar and 20°C to 42 bar. If the law of compression is $PV^{1.35}$ = const. and the intercooling is complete to 20°C, find per kg of air :

i) The workdone in compressing

ii) The mass of water necessary for a abstracting the heat in the intercooler, if the temperature rise of the cooling water is 25°C. Take R = 287 J/KgK and C_p = 1 KJ/KgK. **8**

UNIT – V

9. a) With schematic diagram, explain the use of orsat apparatus used in determining the percentage of flue gases. **8**

   b) A sample of coal with C = 0.78; H_2 = 0.05; O_2 = 0.08; S = 0.02; N_2 = 0.02 and ash = 0.05 is burnt in a furnace with 50% excess air. The flue gases enter the chimney at 325°C and the atmospheric temperature is 15°C. Take Cp for O_2, N_2 and air = 1.008 KJ/KgK and Cp for CO_2 and SO_2 from the flue gas = 1.05 KJ/KgK. Assume that the heat carried away per Kg of moisture in flue gases is 2940 KJ. Calculate the quantity of heat carried away by the flue gases in KJ/Kg of coal. **8**

OR

10. a) Write short notes on the followings :
   i) Bom calorimeter. **4**
   ii) Alternative fuels. **4**

   b) A blast furnace gas has the following volumetric composition.
   CO_2 = 11%; CO = 27%; H_2 = 2% and N_2 = 60%. Find the theoretical volume of air required for the complete combustion of $1m^3$ of the gas. Find the percentage composition of dry flue gases by volume. Assume that air contains 21% of O_2 and 79% of N_2 by volume. **8**

UNIT – VI

11. a) Explain how it is advantageous using an economiser, air preheater and superheater in a steam power plant. **6**

   b) Explain the procedure to draw Heat balance sheet for a boiler plant. **6**

   c) A coal fired boiler plant consumes 400 Kg of coal per hour. The boiler evaporates 3200 kg of water at 44.S°C, into superheated steam at a pressure of 12 bar and 274.5°C. If the calorific value of fuel is 32760 KJ/Kg of coal; determine :
   i) Equivalent evaporation "from and at 100°C" and
   ii) Thermal efficiency of boiler. Assume spectre heat of superheated steam as 2.1 KJ/KgK. **6**

OR

12. a) Explain the concept of available and unavailable energy. **6**

   b) Derive an expression for availability in nonflow system. **6**

   c) 5 kg of air at 550 K and 4 bar is enclosed in a closed system :
   i) Determine the availability of the system if the surrounding pressure and temperatures are 1 bar and 290 K respectively.
   ii) If the air is cooled at constant pressure to the atmospheric temperature, determine the availability and effectiveness. **6**