

S.E. (Mechanical)(First Semester) EXAMINATION, 2010**APPLIED THERMODYNAMICS****(2008 COURSE)****Time : Three Hours****Maximum Marks : 100**

- N.B. :—**
- (i) Answer *three* questions from each Section.
 - (ii) Answers to the two Sections should be written in separate answer-books.
 - (iii) Neat diagrams must be drawn wherever necessary.
 - (iv) Figures to the right indicate full marks.
 - (v) Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.
 - (vi) Assume suitable data, if necessary.

SECTION I

1. (a) Obtain an expression for entropy change in the form :

$$S_2 - S_1 = c_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}. \quad [8]$$

- (b) What are statements of second law of thermodynamics ?
How is second law applicable to compressors and air receiver tanks ? [8]

Or

2. (a) Air is compressed from 100 kPa and 17°C to 600 kPa and 57°C. What will be entropy change ? Now if this process is carried out in isentropic way by maintaining initial conditions and pressure ratio, what will be final temperature of air ? [8]
- (b) Explain Clausius inequality. [8]
3. (a) Carbon steel balls of density 7833 kg/m³ and C_p 0.465 kJ/kgK, diameter 8 mm are annealed by heating to 900°C and then by slow cooling at 100°C in the air. Air temperature is 35°C. If 1200 balls are to be processed per hour, determine total rate of heat transfer and lost work. [10]
- (b) Derive expression for polytropic specific heat capacity. [6]

Or

4. (a) 0.1 m³ of a gas is compressed from 120 kPa and 25°C to 1.2 MN/m² according to a law $PV^{1.2} = C$. Calculate work done, change of internal energy, heat transfer. Also state direction of heat transfer. [8]
- (b) Obtain expression for non-flow energy. [8]

5. (a) Explain with sketch working of separating and throttling calorimeter. [8]
- (b) What is throttling process ? Steam at 1.5 MPa and 0.7 dry is throttled to 0.10 MPa. Find out dryness fraction after throttle. [6]
- (c) Explain significance of specific steam consumption and work ratio. [4]

Or

6. (a) Show Rankine cycle of P-V and T-S diagram when steam is superheated. Also discuss whether efficiency of cycle will change if reheat is employed. Show this process of reheat in two stages on Mollier chart. [8]
- (b) A steam turbine plant working on Rankine cycle uses steam at 15 bar and condenses at 0.3 bar. Determine Rankine efficiency if :
- (i) steam is dry saturated
 - (ii) superheated at 400°C .
- Also find specific steam consumption in second case. Neglect feed pump work in both cases. [10]

SECTION II

7. (a) Distinguish between :

(i) Mass fraction and mole fraction

(ii) Lean mixture and rich mixture. [4]

(b) Explain NDIR method of gas analysis in brief. [4]

(c) The following data was obtained during experimental determination of calorific value of fuel by Bomb calorimeter :

Mass of coal = 0.78 gm

Mass of fuse wire = 0.032 gm

Calorific value of fuse wire = 7 kJ/gm

Mass of water in calorimeter = 2 kg

Water equivalent of calorimeter = 0.4 kg

Rise in temperature of calorimeter water = 3.2°C

Cooling correction = 0.01°C .

Determine HCV and LCV of coal at NTP conditions. Given the coal contains 90% of carbon and 5% of hydrogen. [8]

Or

8. (a) With the help of neat sketch discuss the method of determining calorific value of gaseous fuel. [8]

(b) The composition of dry flue gas as obtained by using Orsat apparatus was $\text{CO}_2 = 9.8\%$, $\text{CO} = 7.2\%$, $\text{H}_2 = 3.4\%$, $\text{CH}_4 = 0.3\%$, $\text{N}_2 = 79.3\%$. Calculate :

(i) Air fuel ratio

(ii) Stoichiometric air

(iii) Mixture strength.

[8]

9. (a) What are the advantages of multistaging in reciprocating air compressor ? [4]

(b) Differentiate between reciprocating and rotary compressors. [4]

(c) A single stage, single acting reciprocating air compressor delivers 0.7 kg of air per min at 6 bar. The suction temperature and pressure are 25°C and 1 bar. The bore and stroke of the compressor are 100 mm and 150 mm respectively. The clearance is 3% of swept volume. Assuming index of compression and expansion to be 1.3. Find :

(i) Volumetric efficiency of the compressor

(ii) Power supplied to drive the compressor if mechanical efficiency is 85%

(iii) Speed of the compressor (RPM).

[10]

Or

10. (a) Discuss the factors those influence the volumetric efficiency of a reciprocating air compressor. [6]
- (b) A two-stage reciprocating air compressor takes in air at 1 bar and 27°C. Air is delivered at 10 bar. The intermediate pressure is deal and intercooling is perfect. The law for compression is $PV^{1.35} = C$. The rate of discharge is 0.1 kg/s. Find :
- (i) Power required to drive the compressor
 - (ii) Saving in work compared to single stage
 - (iii) Isothermal efficiency for multistage
 - (iv) Heat rejected in intercooler.

Take $R = 0.287 \text{ kJ/kg K}$ and $C_p = 1 \text{ kJ/kg K}$. [12]

11. (a) Differentiate between mountings and accessories of the boiler. [4]
- (b) Write a short note on artificial draught. [4]
- (c) During the boiler trial the following data were obtained :
- Duration of trial = 8 hrs.
- Pressure of steam = 1400 kPa
- Dryness fraction = 0.973
- Feed water evaporated = 26700 kg
- Hot well temperature = 50°C

Coal used = 4260 kg

CV of coal = 28900 kJ/kg

Air used per kg of fuel = 17 kg

Temperature of flue gases = 344°C

Boiler house temperature = 21°C

C_p of flue gases = 1.1 kJ/kg K.

Determine :

(i) Boiler efficiency

(ii) Equivalent evaporation

(iii) Heat lost to flue gases.

[8]

Or

12. (a) Explain the term boiler efficiency and equivalent evaporation by writing its significance. [6]
- (b) Explain how it is an advantageous using an economizer and superheater in steam power plant. [4]
- (c) A 32 m high chimney is used to discharge hot gases at 297°C to the atmosphere which is at 27°C. Find the mass of air actually used per kg of fuel, if the draught produced is 12 mm of water. Also calculate draught measured in terms of hot gas column. [6]