

S.E. (Mechanical) (I Semester) EXAMINATION, 2010

APPLIED THERMODYNAMICS

(2008 PATTERN)

Time : Three Hours

Maximum Marks : 100

- N.B. :—** (i) Answer any *three* questions from Section I and any *three* questions from Section II.
- (ii) Answer 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

Unit I

1. (a) What are the principal reasons of irreversibility ? Give *three* examples. [8]
- (b) An insulated vessel of 0.5 m^3 capacity is divided by a rigid conducting diaphragm into two chambers A and B each having capacity of 0.25 m^3 . Chamber A contains air at 1.4 bar pressure

and 290 K temperature and the corresponding parameters for air in chamber B are 4.2 bar and 440 K. Calculate :

- (i) Final equilibrium temperature
- (ii) Final pressure on each side of the diaphragm and
- (iii) Entropy change of system.

For air take $C_v = 0.715 \text{ kJ/kg K}$ and $R = 0.287 \text{ kJ/kg [8]}$

Or

2. (a) Show that entropy change in polytropic process is given by:

$$S_2 - S_1 = \frac{\gamma - n}{n} C_v \ln \frac{P_1}{P_2} \quad [8]$$

- (b) An ice plant working on a reversed Carnot cycle heat pump produces 15 tonnes of ice per day. The ice is formed from water at 0°C and the formed ice is maintained at 0°C. The heat is rejected to the atmosphere at 25°C. The heat pump is used to run the ice plant is coupled to a Carnot engine which absorbs heat from a source which is maintained at 220°C by burning liquid fuel of 44500 kJ/kg calorific value and rejects heat to the atmosphere. Determine :

- (i) Power developed by the engine,
- (ii) Fuel consumed per hour.

Take enthalpy of fusion of ice = 334.5 kJ/kg [8]

Unit II

3. (a) Explain the concept of available and unavailable energy. When does the system becomes dead ? [4]
- (b) Define the following :
- (i) Effectiveness
- (ii) Gibbs function [4]
- (c) Calculate the decrease in available energy when 20 kg of water at 90°C mixes with 30 kg of water at 30°C , the pressure being taken as constant and the temperature of the surroundings being 10°C .
- Take C_p of water as 4.18 kJ/kg K . [8]

Or

4. (a) Derive equation of state and state its significance. [8]
- (b) 1 kg of air at a pressure of 8 bar and a temperature of 100°C undergoes a reversible polytropic process following the law $PV^{1.2} = \text{Constant}$. If the final pressure is 1.8 bar, determine :
- (i) The final specific volume, temperature and increase of entropy;
- (ii) The work done and the heat transfer.
- Assume $R = 0.287 \text{ kJ/kg K}$ and $\gamma = 1.4$ [8]

Unit III

5. (a) Explain the following terms :
- (i) Critical point
 - (ii) Dryness fraction [4]
- (b) With the help of a neat sketch explain the working of separating and throttling calorimeter. [6]
- (c) Steam at 7 bar and 250°C has a volume of 0.5046 m^3 . In a frictionless constant volume process, pressure changes to 3.5 bar. Find the final temperature and the heat transferred. Also determine the change in entropy. [8]

Or

6. (a) Explain with a neat sketch a regenerative cycle. State its advantages. [6]
- (b) State various methods of improving efficiency of a Rankine cycle. [2]
- (c) A Rankine cycle operates between pressure of 80 bar and 0.1 bar. The maximum cycle temperature is 600°C . If the steam turbine and condensate pump efficiencies are 0.9 and 0.8 respectively, calculate the specific work and thermal efficiency. [10]

SECTION II

Unit IV

7. (a) Derive an expression for minimum quantity of air required for complete combustion of 1 kg of fuel assuming that fuel contains carbon, hydrogen, sulphur and oxygen as constituents. [6]

- (b) During a boiler trial a sample of coal gave the following analysis by mass :

Carbon = 89%, Hydrogen = 4%, Oxygen = 3%, Sulphur = 1%, the remaining being incombustible. Determine stoichiometric air required per kg of coal. If 60% excess air is supplied, estimate the percentage analysis by mass of the dry flue gas. Convert it into volumetric analysis. [10]

Or

8. (a) Discuss the method of determining volumetric analysis of dry flue gases with neat sketch. [8]

- (b) During Bomb calorimeter test on diesel oil, the following data were recorded :

Room temperature = 25°C

Weight of crucible = 8.231 gm

Weight of crucible and diesel oil = 8.803 gm

Weight of calorimeter vessel = 1.05 kg

Weight of water and calorimeter vessel = 3.5 kg

Water equivalent of calorimeter = 0.56 kg

Rise in temperature of water and calorimeter = 2.35°C

Cooling correction = 0.02°C

Find the HCV and LCV when mass of condensate is 0.32 gm.

The partial pressure of water vapour is 8 kPa. [8]

Unit V

9. (a) Explain the factors which affect volumetric efficiency of a reciprocating air compressor. [6]
- (b) Explain the functions of intercooler and aftercooler in case of a reciprocating air compressor. [4]
- (c) A single stage, single acting air compressor has a bore of 200 mm and stroke 300 mm. It runs at 420 rpm and has a clearance ratio of 0.065. The index of compression can be assumed as 1.3. The intake pressure is 1 bar and intake temperature is 27°C . Delivery pressure is 500 kPa. Determine :
- (i) FAD at NTP in m^3/hr
 - (ii) Volumetric efficiency
 - (iii) Delivery air temperature
 - (iv) Power required and
 - (v) Isothermal efficiency. [8]

Or

10. (a) Explain with a neat sketch any *one* of rotary compressor. [5]
- (b) Discuss various methods of increasing isothermal efficiency of the compressor. [5]

- (c) A two stage, double acting air compressor runs at 120 rpm. It draws in air at 1 bar and 293 K and compresses it with a total pressure ratio of 10. The intercooler used in between the stages works at a pressure of 3 bar and the air is cooled in it up to a temperature of 302 K. Determine the shaft power of the compressor having mechanical efficiency and volumetric efficiency of 90% and 82% respectively. The diameter of LP cylinder is 25 cm and stroke is 37.5 cm. The index of compression for each stage is 1.3. [8]

Unit VI

11. (a) Obtain an expression for chimney draught. [6]
- (b) Explain the term boiler efficiency and equivalent evaporation in relation with the boiler. [4]
- (c) Determine the air-fuel ratio for an oil fired steam with the following data :
- Chimney height = 40 m
- Draught = 25 mm of water column
- Mean chimney gas temperature = 367°C
- Ambient outside temperature = 20°C
- Also calculate velocity of the flue gases. [6]

Or

12. (a) Give the function and location of the following related to the boiler :

(i) Fusible plug

(ii) Superheater

[4]

(b) Write a short note on the classification of boiler. [6]

(c) The equivalent evaporation of a boiler from and at 100°C is 10.6 kg/kg of fuel. The calorific value of the fuel is 29800 kJ/kg . Determine the efficiency of the boiler. If the boiler produces 15000 kg/hr of steam at 24 bar from feed water at 39°C and the fuel consumption is 1650 kg/hr , determine the condition of steam produced. [6]