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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

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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 kJ/kg K and R = 0.287 kJ/kg [8]

Or

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

$$S_2 - S_1 = \frac{\gamma - n}{n} C_v \ln \frac{P_1}{P_2}$$ [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 $PV^{1.2}$ = 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 kJ/kg K and γ = 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 :

Carban = 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 clorimeter 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 next 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 mechnical 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]