B.E. (ME) Part-II 4th Semester Examination, 2010

Applied Thermodynamics
(ME-402)

Time : 3 hours Full Marks : 70

Use separate answerscript for each half.
Answer SIX questions, taking THREE from each half.
The questions are of equal value.
Use of steam table allowed.

FIRST HALF

1. a) Explain the vapour compression refrigeration cycle with the help of schematic, T-s and p-h diagrams.
Can this cycle be reversible? If not, why?

b) A simple saturated mechanical vapour compression refrigeration cycle works between -10°C and 38°C. The refrigerant used is ammonice and there is no sub-cooling of liquid ammonia. Determine theoretical piston displacement and power per ton of refrigeration (TR). Also calculate the C.O.P.of the system.
Take, Cp for liquid ammonia = 4.75 kJ/kg-K
and Cp for ammonia vapour = 3.00 kJ/kg-K.
Other properties can be obtained from the table given below:
Properties of **NH3**

Temperature	Enthalpy, kj/kg		Entropy, kJ/kg-K		Specific volume, m^3/kg
°C	hf	$_{h}$g	Sf	$_{s}$g	$_{v}$g
-10	-808.71	487.76	5.5257	10.4539	0.41949
38	-581.57	526.77	6.3111	9.8472	0.08817

2. a) With the help of a neat sketch explain the working of a La Mont boiler.

b) The following data were recorded during a boiler trial :
Feed water = 680 kg/hr
Temperature of feed water - 20°C
Steam pressure = 1.5 MPa
Steam temperature = 300°C
Coal consumption = 95 kg/hr
Calorific value of coal = 26500 kj/hr
Ash and unburned coal in ashpit = 4kg/hr

Calorific value of ash and unburned coal = 2200 kJ/Kg
Flue gas formed = 18 kg/kg of coal supplied.
Exhaust Flue gas temperature = 300°C
Ambient temperature = 28°C
Mean specific heat of exhaust gas = 1.025 kJ/kg-K.
Determine
(i) boiler efficiency
(ii) equivalent evaporation from and at 100°C
(iii) percentage of heat unaccounted for.

3. a) What factors limit the delivery pressure in a reciprocating compressor?

b) Show that the volumetric efficiency of a single stage compressor is given by

$$\eta_v = 1 - \frac{v_c}{v_s}\left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{n}} - 1\right]$$

where the symbols have their usual meanings.

c) Air is compressed from 0.95 bar and 25°C to a pressure of 5 bar in a single stage double acting air compressor of 40 cm bore and 30 cm stroke running at 250 RPM. The clearance volume is 6% of the swept.volume. The index for compression and expansion is 1.30. Determine the theoretical power requirement and the mass of air compressed per second.

4. a) The COP of an air refrigeration cycle is very low, even then why air-refrigeration system is most common in the air craft?

b) Deduce expression for the COP of Bell-Coleman Air refrigeration cycle in terms of pressure ratio.

c) A Bell-Coleman cycle works between 1 and 6 bar pressure limits. The compression and expansion indices are 1.25 and 1.3 respectively. Obtain COP and tonnage of the unit for an air flow rate of 0.5 kg/s. Neglect the clearance volume and take temperatures at the beginning of compression and expansion to be 7°C and 37°C respectively.

5. Write short notes (<u>any three</u>) :

a) Benefits of multi-stage compression
b) Benson boiler
c) Heat balance of a boiler plant
d) Isothermal efficiency of compressor.

SECOND HALF

6. a) With the help of p-v diagram, explain in brief the meaning of the Mean Effective Pressure (MEP) of a gas power cycle. With the help of p-v and T-s diagrams, also prove that for same compression ratio and heat rejection.

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b) In a diesel cycle, the compressor ratio is 15. Pressure and temperature of air at inlet to compression are 0.1 MPa and 17°C respectively. The temperature of working fluid after combustion is 2300°C. Estimate pressure and temperature of working fluid at all the state points of the cycle. Also estimate MEP in bar.

Assume that Cp, C_v and y of working fluid are 1.005 kJ/kg-K, 0.718 kJ/kg-K and 1.4 respectively

7. a) With the help of p-v, T-s and flow diagrams, explain in brief the different processes and the working of a closed Brayton cycle used for a Gas Turbine Power Plant. Also deduce the expression of efficiency of the cycle.

b) A gas turbine power plant operates through an air standard Brayton cycle. The pr. and temperature of working fluid at the inlet of compressor are 1 bar and 18°C. The working fluid leaves the compressor at 6.2 bar. If the heat transfer to the working fluid is 750 kJ/kg, calculate (i) specific work done on the compressor, (ii) specific work done by the turbine, and (iii) specific heat rejected by the working fluid.

If the plant capacity is 2 MW. find out mass flow rate of the working fluid in Tons/hr.

C_p, C_v and ***y*** of working fluid are 1.005 kJ/kg-K, 0.718 kJ/kg-K and 1.4 respectively.

8. a) In case of vapour power cycle actually used in steam power plant, explain in brief the significance of specific steam consumption, heat rate, and mean temperature of heat addition of the cycle. Also in brief, discuss the relating and regenerative feed heating methodologies used for the enhancement of mean temperature of heat addition of the cycle.

b) In a steam power plant, operating on an ideal Rankine cycle, steam enters the turbine at 480°C and 100 bar. After isentropic expansion, the steam leaves the turbine at the pressure of 0.1 bar. Using steam table, estimate, (i) dryness fraction of steam at the exhaust of turbine, (ii) cycle efficiency, and (iii) specific steam consumption. Pump work is to be considered.

9. a) What do you mean by mass defect and binding energy? Discuss in brief the various radio active radiations discharged during a nuclear reaction. Also classify the nuclear reactors.

   b) A 2 MW nuclear power plant using natural uranium as fuel, is having an overall efficiency of 30%. Find the amount of natural uranium required for 10 years if the average energy release per fission of this fuel is 190 MeV.

10. Write short notes on any three of the following :

    a) Ericsson cycle,

    b) Nuclear fission,

    c) Dual combustion cycle,

    d) Critical mass, multiplication factor and Neutron flux of a nuclear reactor.