INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY

B.E. (Mech) 4th Semester Final Examination, 2014

SUBJECT- APPLIED THERMODYNAMICS (ME-402)

Branch: **Mechanical Engineering**

Time: 3 Hours.

Full Marks: 70

FIRST HALF

Answer any three questions. All questions are of equal value.

1. (a) Discuss the effect of superheating refrigerant vapour before suction to compressor. Also discuss the effect of subcooling of the refrigerant of the refrigerants before its entry into the expansion valve. Use T-s and P-h diagrams and the expression for COP to explain it properly.

(b) In an aircraft cooling system, air enters the compressor at 1 bar and 4^0C and is compressed to 3 bar with an isentropic efficiency of 72%. The compressed air is cooled in a heat exchanger at constant pressure to 55^0C and expands in an expander to 1 bar with an isentropic efficiency of 78%. The low temperature air absorbs heat load of 3 Tons of refrigeration at constant pressure before re-entering the compressor. The compressor is driven by the air turbine. Determine the COP of the cooling system, the power required and the mass flow rate of air. Take C_p of air = 1.005 kJ/kg-K.

2. (a) In a single stage air compressor, the clearance volume puts a limit on the maximum pressure ratio developed. Explain the above statement. Prove that for Z stage reciprocating air compressor with perfect intercooling, work input is given by

$$W = \frac{Zn}{n-1} P_1 v_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{Zn}} - 1 \right]$$, where $\left(\frac{p_2}{p_1} \right)$ is the overall pressure ratio.

(b) A single stage double acting air compressor handles 17 m^3 of air per minute measured at 1 bar and 15^0C. The pressure and temperature at the end of the suction are 0.98 bar and 32^0C respectively. The air is delivered at 6.325 bar. Assuming a clearance volume as 5% of the swept volume and the compression and expansion following the polytropic law $pv^{1.32}$ = constant, determine the dimensions of the compressor. The piston is running at 5000 rpm and the L/D ratio is 1.2. Also calculate the indicated power in kW of the compressor. Take, R = 287 J/kg-K and neglect the effect of the piston rod.

3. (a) State the advantages of high pressure boiler. What do you mean by "Once through boiler"? Describe the working of such a boiler with the help of a neat sketch.

(b) The temperature limits of a vapour compression refrigeration cycle are -7^0C and 27^0C. If the gas is dry and saturated at the end of compression and there is no subcooling, find the coefficient of performance of the cycle. Use the following table for refrigerant properties.

Temp. (^{0}C)	h_f (kJ/kg)	h_g(kJ/kg)	s_f (kJ/kg-K)	s_g (kJ/kg-K)
27	117.23	1172.3	0.427	4.338
-7	-29.3	1297.9	-0.109	4.748

4. Write short notes (any three):

a) Refrigerants

b) Volumetric efficiency of compressor

c) Losses in boiler plant

d) Bell-Coleman cycle

SECOND HALF
(Attempt any THREE questions)

5 (a) Discuss in brief how the efficiency of an Otto cycle gets affected by its compression ratio.

(b) In an Otto cycle, at the inlet of compression process working fluid is at 1 bar and 18^0c. Estimate (i) thermal efficiency of the cycle and (ii) mean effective pressure in bar. The maximum cycle temperature is 1000^0c Choose compression ratio of the cycle as 7. Assume that C_p and R for the working fluid are 1.005 and 0.287 kJ/Kg.K respectively.

6 (a) Draw p-v and T-s diagrams of a Dual cycle. Discuss in brief the different processes of the cycle. Write the expressions for heat addition, heat rejection, and work ratio of the cycle.

(b) In a steam power plant operating under an ideal Rankine cycle, at the inlet of turbine the steam is at 95 bar and 470^0C. After isentropic expansion in the turbine, it enters the condenser at 0.15 bar. Calculate (i) thermal efficiency of the cycle considering the pump work, (ii) specific steam consumption (SSC), and (iii) heat rate. Use steam table.

7. (a) State the differences between a closed gas turbine and an open gas turbine power generating systems.

(b) In a gas turbine power plant operating under air standard Brayton cycle, the pressure and temperature of the working fluid at the inlet of the compressor are 1 bar and 17^0c respectively. The pressure ratio of the cycle is 6. Calculate (i) work ratio, (ii) ratio between specific heat addition and heat rejection, and (iii) cycle efficiency. The maximum cycle temperature is 1100^0c, Assume that C_p and R for the working fluid are 1.005 and 0.287 kJ/Kg.K respectively.

8. Write short notes on <u>any three</u> of the following:-

(a) Multiplication factor
(b) Ericsson cycle
(c) Mean Effective pressure
(d) Nuclear fission