Con. 8541-13. **LJ-10519**

(3 Hours) **[Total Marks : 100**

N.B. : (1) Question No. **1** is **compulsory**.
(2) Answer any **four** out of remaining **six** questions.
(3) **Assumptions** made should be **clearly** stated.
(4) Assume suitable **data** wherever **required**. but **justify** the **same**.
(5) Use of **Mollier Chart, Steam Table permitted**.

Q-1. Answer any **four** of the following : [20]

(a) Define volumetric efficiency of compressor .Discuss in brief the factors affecting volumetric efficiency.
(b) Define adiabatic flame temperature and explain its practical significance.
(c) Define equivalent evaporation of boiler. Distinguish between boiler mountings and accessories with examples.
(d) With reference to steam turbine what do you understand by compounding? Write a note on any one method of compounding.
(e) Enlist the various sources of air leakage in a condenser and discuss its effect on the performance of condenser.
(f) Explain in brief the effect of pressure ratio on the performance of a simple gas turbine.

Q-2. a) A single stage , single acting air compressor has a bore of 20 cm and a stroke of 30 cm. The compressor runs at 600 rpm. The clearance volume is 4 % of swept volume and the index of expansion and compression is 1.3. The suction conditions are 0.97 bar , 27° C and the delivery pressure is 5.6 bar. The atmospheric conditions are at 1.01 bar and 17 ° C. Determine : [12]

i) The volumetric efficiency

ii) The free air delivered in m^3 /min.

iii) The indicated power.

b) In an internal combustion engine the liquid fuel C_8H_{18} is supplied under steady flow conditions at the rate of 0.03 kg/s with stoichiometric air at 25^0 C and 1 atmosphere pressure. The products of combustion leave at 900 K and engine develops 400 kW of power. Determine the rate of heat transfer from the engine. The following data is applicable : [8]

Substance	h_f^0 (kJ/kgmole)	h_{298K} (kJ/kgmole)	h_{900K} (kJ/kgmole)
C_8H_{18} (l)	-249950	0	-
O_2 (g)	0	8624	27903
N_2 (g)	0	8660	26911
CO_2 (g)	-241830	8769	37434

Q-3. a) Why fire tube boilers are not suitable for high pressure applications. Explain with a neat sketch the operation of any one natural circulation water tube boiler. [8]

b) Following observations were made during a test on steam boiler: [12]

Boiler pressure = 10 bar; Calorific value of fuel used = 33000 kJ / kg; Feed water temperature entering the economizer = 25°C and leaving the economizer = 80°C; Condition of steam leaving the superheater = 250°C; Steam condition leaving the boiler = 0.95; Amount of water evaporated = 6000 kg / hr Amount of fuel burnt = 600 kg / hr.

Find the equivalent evaporation with and without superheater, boiler efficiency and the percentage heat utilized in the boiler, economizer and the superheater.

Q-4. a) What are the advantages of multistage compression. Derive the condition for optimum pressure ratio for a two stage compressor with perfect intercooling and minimum work input. [10]

b) In a simple impulse turbine, the nozzles are inclined at 20° to the direction of motion of moving blades. The steam leaves the nozzles at 375 m/s. The blade speed is 165 m/s. Find suitable inlet and outlet angles for the blades in order that the axial thrust is zero. The relative velocity of steam as it flows over the blades is reduced by 15% by friction. Determine also the power developed for a flow rate of 10 kg/s. [10]

Q-5. a) Following observations were made on a steam condensing plant : [10]

Barometer reading = 76 cm of Hg; Recorded condenser vacuum = 70 cm of Hg; Mean temperature of condensate = 35° C; Condensate collected = 16.75 kg/min.; Cooling water = 39600 kg/hr; Rise in temperature of cooling water = 14°C; Inlet temperature of cooling water = 25° C.

Calculate : (i) Mass of air present per m^3 of condenser volume.

(ii) Dryness fraction of steam at entry to condenser.

(iii) The vacuum efficiency.

(iv) The efficiency of condenser.

b) Derive the condition for optimum speed ratio in a 50% reaction turbine and obtain an expression for maximum efficiency with usual notations. [10]

Q-6. a) At a particular stage of reaction turbine, the mean blade speed is 60 m/s and the steam pressure is 3.5 bar with a temperature of 175°C. The identical fixed and moving blades have inlet angles of 30° and outlet angles of 20°. [12]

Determine : (i) The blade height if it is 1/8th of the blade ring diameter, for flow rate of 13.5kg/s. (ii) The power developed by a pair.

b) Discuss with T-s diagrams the effect of inter-cooling, reheating and regeneration on the performance of gas turbine system [8]

Q-7. a) A constant pressure open cycle gas turbine has a pressure ratio of 6:1 and a maximum cycle temperature of 600°C. The isentropic efficiencies of the compressor and turbine are 82% and 85% respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine and the overall efficiency of the plant when the air enters the compressor at 15°C at the rate of 15 kg/s. Take : c_p= 1.005 kJ/kg K and γ = 1.4 throughout the cycle , mechanical and transmission efficiency of the turbine = 90%, generator efficiency = 90 % and combustion efficiency = 95 %. Neglect mass of fuel. [12]

b) What is the effect of friction in nozzle. With usual notations show that the critical pressure ratio for a nozzle under maximum mass flow rate per unit area is given by : [8]

$$p_c / p_1 = [2 / (n+1)]^{(n/n-1)}$$