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Your Roll No. .....

8455 **A**

B.Tech. (M)/II

Paper EME–204—THERMAL ENGINEERING–I

Time : 3 *Hours* *Maximum Marks* : 70

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any ***five*** *questions.*

Assume missing data suitably, if any.

Use of steam tables and Mollier charts permitted.

1. (a) State and explain the first law of TD for a cycle and a process. Show that the work done of a perfect gas during isentropic expansion is given by

$$W_{12} = \frac{R(T_1 - T_2)}{r - 1}$$

(b) 0.2 m^3 of an ideal gas at a pressure of 2 MPa and 600 K is expanded isothermally to 5 times the initial volume. It is then cooled to 300 K at constant volume and then compressed back polytropically to its initial state. Determine the net WD and heat transfer during each process and cycle. Draw *pv* diagram of the processes. 5,9

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2. (a) Air at 290 K temperature passes through a heat exchanger at 30 m/s and its temperature gets raised to 1100 K. Subsequently the heated air enters a turbine with the same velocity and its expansion continues till the temperature drops to 900 K. After exit from the turbine at 45 m/s, further expansion occurs in a nozzle and temperature falls to 790 K. If the mass flow rate of air is 2 kg/s, determine,

(i) rate of heat transfer to air in the heat exchanger

(ii) power output from the turbine

(iii) velocity at exit from the nozzle.

(b) Explain the establishment of a thermodynamic temperature scale. 10,4

3. (a) Three Carnot heat engines have same thermal efficiency and are connected in series. The first engine absorbs 2400 KJ of heat from a thermal reservoir at 1250 K and the third engine rejects 300 KJ of heat to a sink at 150 K. Determine the work output from the each engine.

(b) Determine the entropy of a gas at 30 bar and 800 K temperature. Given that entropy of gas at 1 bar and 273 K is zero and specific heats of the gas vary linearly with absolute temperature according to the following correlations :

$C_p = (0.94 + 0.0002\,T)$ & $C_v = (0.65 + 0.0002T)$ KJ/KgK 9,5

4. In a test on single cylinder oil engine with bore 30 cm and strok 45 cm and working on 4s cycle, the following data were obtained :

Net brake load and effective drum diameter = 1650 N and 150 cm

Engine speed and duration of test = 200 rpm and 1 hr

Fuel consumption = 7.5 kg with CV of 42 MJ/Kg

Inlet and outlet temperatures of cooling water = 15°C and 60°C

Total mass jacket cooling water = 450 kg

Total air consumption = 350 kg

Inlet air and exhaust gas temp = 20°C and 300°C

Mean S_p heat δ exhaust gases = 1.025 kJ/Kg K

Mean effective pressure = 6 bar

Determine indicated power, Brake power, mechanical efficiency, thermal efficiencies and prepare a heat balance chart for the engine trial. 14

5. (a) Explain the methods adopted for improving the performance of the Rankine cycle.

(b) In a reheat cycle the initial steam pressure and temperature are 150 bar and 500°C respectively. If the condenser pressure is 0.1 bar and the moisture at condenser inlet is 15% and assuming ideal processes, determine (i) Reheat pressure (ii) the cycle efficiency and (iii) the steam rate. 5, 9

6. (a) Show that critical pr ratio for maximum discharge of steam through nozzle $\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ and hence show that maximum discharge through nozzle

$$M_{max} = A\sqrt{\frac{2n}{n+1}\ \frac{p_1}{v_1}\left(\frac{2}{n+1}\right)^{\frac{2}{n-1}}}$$

(b) What is the optimum velocity ratio for an impulse stage and 50% reaction stage ? Compare the diagram efficiencies of impulse and 50% reaction stage turbines. 10,4

7. (a) What do you mean by High pr boiler ? Explain the working principle of forced circulation boiler with a heat sketch.

(b) What do you mean by Boiler Mountings ? What is the difference between Boiler Mountings and Boiler Accessories ?

Explain any one of the Boiler Accessories with neat sketch. 6,8

8. Explain any ***three*** of the following :

(i) Principle of increase of Entropy

(ii) Surface condensers

(iii) Knocking tendency in IC Engines

(iv) Governing of steam turbines. 14