This question paper contains 8+2 printed pages]

H.P.A.S. (Main)—2013

MECHANICAL ENGINEERING

Paper II

Time : 3 Hours *Maximum Marks* : 150

Note :— (1) Attempt total *Five* questions.

(2) Question No. 8 is compulsory.

(3) Use of non-programmable calculator, steam tables, Mollier diagram, psychometric chart and Refrigerant property table is permitted.

(4) Assume missing data, if any, suitably.

1. (*a*) A centrifugal compressor has a pressure ratio 4/1 with an isentropic efficiency of 80% when running at 1500 rev/min and inducing air

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at 20°C. Guide vanes at inlet give the air a pre-whirl of 25° to the axial direction all radii and the mean diameter of eye is 250 mm; the absolute air velocity at inlet is 150 m/s. At exit the blades are radially inclined and the impeller tip diameter is 590 mm. Calculate the slip factor of the compressor. 14

(*b*) Bernoulli's equation, looks very much like the energy equation developed in thermodynamics for control volume. Discuss the differences between the two equations. 8

(*c*) Show that, for $t_o = -15°C$ and $t_k = 30°C$, for isobutane the suction state for maximum COP lies in the superheat region. 8

2. (*a*) A hot copper coin at 60°C is cooled by an air stream at 20°C with convective heat transfer coefficient 50 $W/m^2.K$. The coin has thickness of 0.13 cm and a diameter of 1.95 cm.

(*i*) Can the lumped capacitance assumption be used ?

(*ii*) Determine how long will it take the coin to cool to 25°C.

(For copper K = 401 W/mK, C = 385 J/kg K, and ρ = 8933 kg/m^3.) 12

(*b*) A large diesel engine runs on four stroke cycle at 2000 rpm. The engine has a displacement of 25 litres and brake mean effective pressure of 0.6 MN/m^2. It consumes 0.018 kg/s of fuel (Calorific value = 42000 kJ/kg). Determine the brake power and brake thermal efficiency. 10

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(c) Show that for Turbulent flow in pipes, ratio of maximum velocity to average velocity is given by : 8

$$\frac{u_m}{u_o} = 1.33\sqrt{f} + 1.$$

3. (a) A jet of water diameter 12 cm and having a velocity of 6 m/s strikes tangentially at inlet of a curved vane moving with 6 m/s in the same direction as the jet. If the jet gets deflected through 130°, and vane is smooth, find :

(i) Force

(ii) Power

(iii) Efficiency of vane.

Assume β acute. 15

(b) Steam used in a reheat cycle for working of a steam engine. The steam leaves the boiler and enters the turbine at 3 MPa, 350°C. After expansion in the turbine to 500 kPa, the steam is reheated to 500°C and then expanded in the low pressure turbine to 20 kPa.

Determine the efficiency of the reheat cycle. 15

4. (a) Propane is burned with theoretical air, both are at 25°C and 1 atm in a steady flow combustion chamber. Predict the adiabatic flame temperature. 8

(b) A Carnot engine operates with air, using the cycle shown in Fig. 1. Determine the thermal efficiency and the work output for each cycle of operation. 12

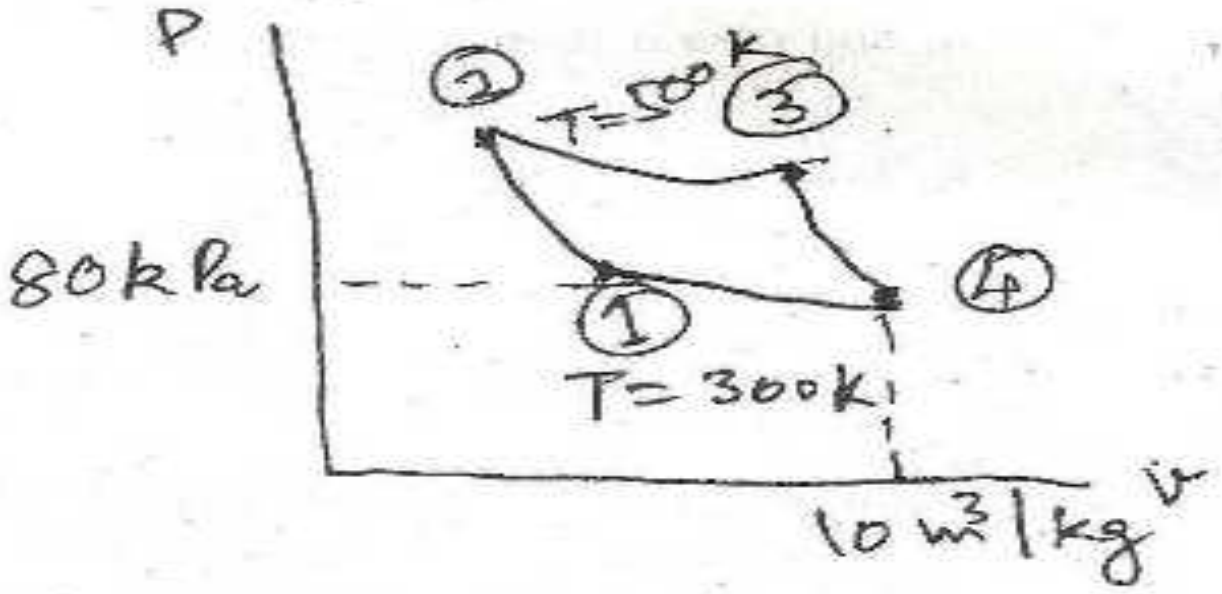

Fig. 1

(c) What do you mean by compounding of steam turbines ? Briefly, discuss various methods of compounding. 10

5. (a) Find the rate of heat transfor from a 2m(L) square plate maintained at temperature of 210°C (T_w) in ambient air 30°C (T_0) in horizontal position. 15

(b) Air enters a window air conditioner at 1 atm, 30°C, and 80 percent relative humidity at a rate of 10 m^3/min, and it leaves as saturated air 14°C. Part of the moisture in the air that condenses during the process is also removed at 14°C. Determine the rates of heat and moisture removal from the air. 15

6. (*a*) Determine the enthalpy change and the entropy change of oxygen per unit mole as it undergoes a change of state from 220 K and 5 MPa to 300 K and 10 MPa :

(*i*) by assuming ideal-gas behaviour, and

(*ii*) by accounting for deviation from ideal-gas behaviour. 15

(*b*) A cubical room of side 3 m is heated from the floor by maintaining it a uniform temperature of 300 K, heat transfer takes place to the ceiling and side walls; which are maintained at 200 K. The

floor has emissivity of 0.9, the ceiling has an emissivity of 0.6, and side walls having emissivity of 0.5. Determine heat transfer. 15

7. (*a*) A cylinder of 1.2 dia and length = 10 m, is rotated at 2000 rpm with its axis normal to air stream of V_0 = 10 m/s. Find circulation around cylinder, lift force, coefficient of lift and stagnation points. ρ_{air} = 1.2 kg/m^3. 15

(*b*) For the same compression ratio and heat rejection, which cycle is most efficient—Otto, Diesel or Dual ? 15

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8. Write short notes on : 6×5=30

(a) Effect and control of Nox emission

(b) Diesel knock

(c) Shock wave

(d) Cavitation

(e) Vapour absorption system

(f) Clausius's theorem.