This question paper contains 8+3 printed pages]

HPAS (M)—2015

MECHANICAL ENGINEERING

Paper II

Time : 3 *Hours* *Maximum Marks :* 150

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

(2) Question No. 8 is compulsory.

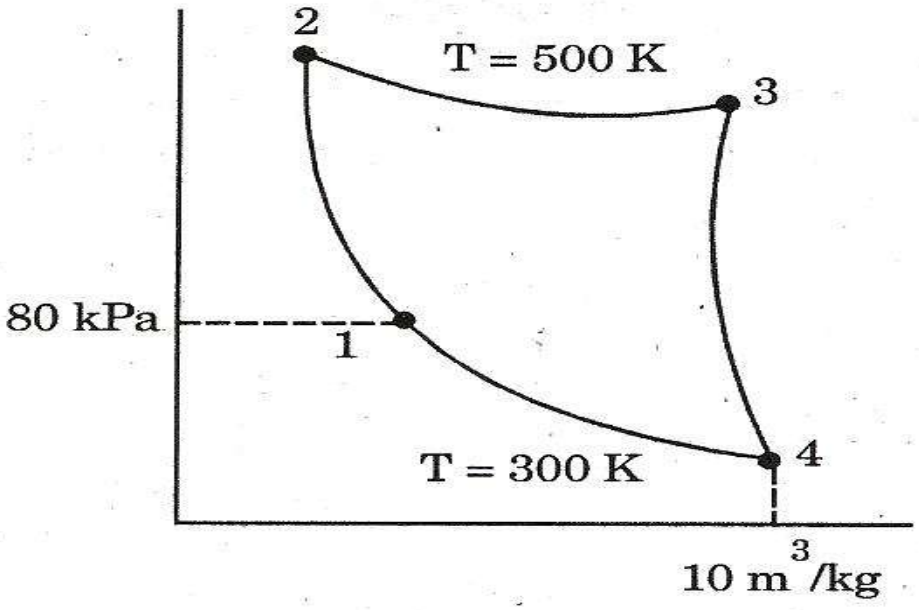
(3) Use of non-programmable calculator, steam tables, Mollier diagram, Psychometric charts and Refrigerant property table is permitted.

(4) Suitably assume missing data, if any.

1. (*a*) A Carnot engine operates with in using the cycle shown in Fig. Determine the thermal

P.T.O.

efficiency and the work output for each cycle of operation. 10



(*b*) Find the thickness of the boundary layer at the trailing edge of a smooth plate of length 5 m and a width 1.2 m, when the plate is moving with 5 m/s in stationary air. Take kinematic viscosity of air as 0.11 stokes. 10

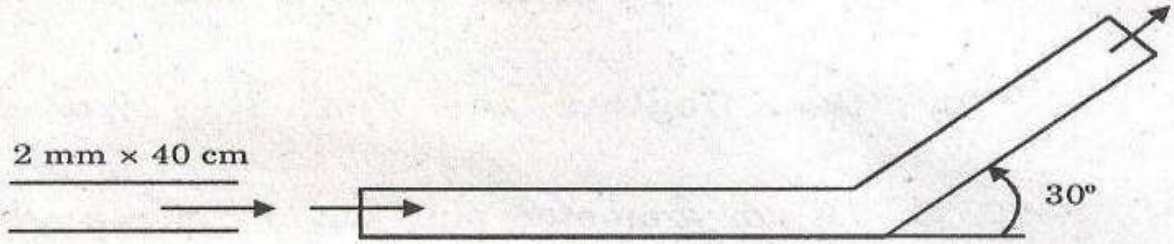
(c) Calculate the critical radius of insulation for asbestos [k = 0.17 W/m.°C] surrounding a pipe and exposed to room air at 20°C with h = 3.0 W/m^2.°C. Calculate the heat loss from a 200°C, 5.0 cm diameter pipe when covered with the critical radius of insulation and without insulation. 10

2. (a) The deflector shown in figure moves to the right at 30 m/s while nozzle remains stationary. Determine :

(i) the force components needed to support the deflector,

(ii) V_2 as observed from a fixed observer, and

(*iii*) the power by the vane. The jet velocity is 80 m/s. 15



(*b*) Engine oil at 20°C is forced over a 20 cm square plate at a velocity of 1.2 m/s. The plate is heated to a uniform temperature of 60°C. Calculate the heat lost by the plate. 15

3. (*a*) Two large parallel planes are at $T_1 = 800$ K, $\varepsilon_1 = 0.3$, $T_2 = 400$ K, $\varepsilon_2 = 0.7$ and are separated by a gray gas having $\varepsilon_g = 0.2$, $\tau_g = 0.8$. Calculate the heat-transfer rate between the two plates and the temperature of the gas using a radiation network. Compare with the heat transfer without the pressure of the gas. 12

(*b*) Air enters the compressor of a gas turbine at 100 kPa and 25°C. For a pressure ratio of 5 and a maximum temperature of 850°C, determine the back work ratio (BWR) and the thermal efficiency for this Brayton cycle using the ideal gas equation. 10

(*c*) Discuss the properties of Ideal Refrigerant and Ideal Absorbent. 8

4. (*a*) Combustion in a diesel engine is assumed to begin at inner dead center and to be at constant pressure. The air fuel ratio is 27 : 1, the calorific value of the fuel is 43000 kJ/kg and the specific heat of the products of combustion is given by $C_V = 0.71 + 20 \times 10^{-5}$ T; R for the

products = 0.287 kJ/kg K. If the compression ratio is 15 : 1, and the temperature at the end of compression 870 K, find at what percentage of the stroke combustion is completed ? 9

(*b*) In an inward flow reaction turbine (vertical shaft) the sum of the pressure and kinetic head at entrance the spiral casing is 132 m and vertical distance between this section and the tail race level is 3.3 m. The peripherial velocity of the runner at entry is 33 m/s, discharge from the runner is without whirl. The hydraulic losses are :

(*i*) losses between turbine entrance and discharge from guide vanes = 4.95 m

(*ii*) losses in the runner = 8.8 m

(*iii*) losses in draft tube = 0.88 m

(*iv*) kinetic energy head rejected to tail race = 0.55 m.

Determine :

(*a*) the guide vane angle and the runner blade angle at inlet.

(*b*) the pressure heads at entry to and discharge from the runner. 12

(*c*) Steam is contained in a rigid contained at an initial pressure of 100 psi and 600°F. The pressure is reduced to 10 psi by removing energy via heat transfer. Calculate the change in entropy and the heat transfer and sketch a T-S diagram. 9

5. (*a*) Outside air at 5°C and 70% relative humidity is heated to 25°C, calculate the ratio of heat transfer needed if the incoming volume flow rate is 50 m^3/min. Also, find the final relative humidity. Assume p = 100 kPa. 10

(*b*) Bernoulli's equation, looks very much like the energy equation developed in thermodynamics for a control volume. Discuss the differences between the two equations. 10

(*c*) Show typical temperature distribution for idealized cases of heat exchangers. 10

6. (*a*) Write a note on boundary layer theory. Explain boundary layer with transition with the help of a line diagram. 10

(*b*) A 1 : 10 scale model of an automobile is used to measure the drag on a proposed design. It is to simulate a prototype speed of 90 km/h. What speed should be used in the wind tunnel if Reynolds numbers are equated ? For this condition, what is the ratio of drag forces ? 10

(*c*) In a single stage impulse turbine nozzle angle is 20° and blade angles are equal. The velocity co-efficient for blade is 0.85. Find maximum blade efficiency possible. If the actual blade efficiency is 92% of the maximum blade efficiency, find the possible ratio of blade speed to steam speed. 10

7. (*a*) Liquid octane, at 25°C, fuels a jet engine. Air, at 600 K, enters the insulated combustion chamber and the products leave at 1000 K. The pressure is assumed constant at 1 atm. Estimate the exit velocity using theoretical air. 15

(*b*) An 89 W refrigerating capacity 165 L Freon 12 domestic refrigerator operates on the standard cycle. Determine :

(*i*) Isentropic discharge temperature

(*ii*) Actual discharge temperature if experimental value of polytropic index n is found to be 1.032.

(*iii*) Motor watts (isentropic)

(*iv*) Heat rejected in the condenser

(*v*) Volumetric efficiency of the compressor if its cylinder volume is 4.33 cc and rpm of its motor is 2800. 15

8. Write notes on the following : 5×6=30

(*a*) Normal shock wave

(*b*) Caviation

(*c*) Tidal energy

(*d*) Effect of carbon-mono-oxide on human beings

(*e*) Supersaturated flow in nozzels

(*f*) Bleeding.