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HPAS (Main)—2016

MECHANICAL ENGINEERING

Paper II

Time : 3 *Hours* *Maximum Marks :* 100

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

(2) Question No. 8 is compulsory.

(3) Use of Steam Tables, Mollier Diagram, Psychometric Charts, Refrigerant property Table, Non-Programmable Calculator, Graph sheet allowed.

(4) Assume missing data, suitably if any.

1. (*a*) Iron is required to melt at 4.8 tonnes/hour from a charge at 18°C to molten metal at 1648°C. Melting point of Iron is 1530°C and the latent

P.T.O.

heat is 268 kJ/kg. In solid state the specific heat is 0.507 and in liquid state 0.54 kJ/kg K. If an electric furnace has 68% efficiency, find the kW rating required. If the density in molten state is 6885 kg/m^3 and bath volume is three times the hourly melting rate, find the dimensions of the cylindrical furnace having length to diameter ratio as 2. 12

(*b*) Explain with diagram working of a throttling calorimeter which takes in wet steam and changes to steam in the superheated region after throttling. Also depict throttling process on T-s and h-s plots. 8

2. (*a*) With diagram explain the effect of intercooling and reheating on Brayton cycle. Show T-s and P-V diagrams in these cases. 10

(*b*) A ship of weight 29580 kN has a time period of rolling in sea water is 9 secs. Let the specific weight of sea water be 10050 N/m^3. The MOI of the ship at the water line about Fore and Aft-Axis is 990 m^4. The centre of buoyancy of the ship is 1.48 m below the entre of gravity. Find the Radius of Gyration of the ship. 10

3. (*a*) A pump has a tapering pipe running full of water. The pipe is placed vertically with the diameters at the base and the base and top being 1.2 m and 0.6 m respectively. The pressure at the upper end is 240 mm of Hg vacuum, while the pressure at the lower end is 15 kN/m^2. Assume the head loss to be 20 percent of difference of velocity head. Calculate the discharge, the flow is

vertically upwards and difference of elevation is 3.9 m. 10

(*b*) Two parallel plates kept at 11 cm apart have laminar flow of oil between them. The maximum velocity of flow is 140 cm/s. Calculate : (*i*) Discharge per meter width, (*ii*) Shear stress at the plates, (*iii*) Pressure difference between two points 1900 cm apart, (*iv*) Velocity gradient at the plates, (*v*) Velocity at 2 cm from the plate. Take velocity of oil as 2.45 pa-s. 10

4. (*a*) A jet of liquid metal of 3 mm diameter at 2000°C pours from a crucible. A 5 cm diameter cylindrical radiation shield surrounds the jet through an angle of 330° but there is a 30° slit in it. The jet is otherwise surrounded by a large

cubic room at 30°C. How much radiant energy reaches the room per meter length of the shield, if it is legitimate to assume that the jet and the shield are both black under these conditions ? (Assume that heat transfer from the inside of the shield to the room is negligible). 10

(*b*) Explain :

(*i*) Buckingham Pi-Theorem,

(*ii*) Fourier's Law of heat conduction. 10

5. (*a*) A four cylinder, two-stroke internal combustion engine has the following particulars :

engine speed = 3000 rpm, bore = 12 cm, crank radius = 6 cm, mechanical efficiency = 90% and the engine develops 75 bhp.

Calculate the swept volume and mean effective pressure (MEP). 10

(*b*) Define Breaking Jet. Derive the expression for efficiency of the jet striking the vane in case of Pelton wheel. 10

6. (*a*) An impellar of inside diameter 150 mm and outside diameter 400 mm having width at inlet 40 mm and width at outlet 20 mm is running at 1440 RPM. The inlet and outlet blade angles are 25 degrees and 15 degrees respectively. The whirl velocity at inlet is zero. Find : (*i*) flow rate (litres/min), (*ii*) power of impeller, (*iii*) absolute velocity at outlet. 10

(*b*) 38 cubic meter of air per minute at 31°C DBT and 18.5°C WBT is passed over the cooling coil whose surface temperature is 4.4°C. The coil cooling capacity is 3.56 tons of refrigeration under

the given condition of air. Determine DBT and WBT of the air leaving the cooling coil. 10

7. (*a*) A cold wave of two weeks duration causes a temperature drop of 23°C at the surface and the temperature variation follows sinusoidal waveform. Determine the drop in temperature at a depth of 115 cm and time lag for a soil having thermal diffusivity = 0.0017 m^2/hour. If the base temprature is 6°C, calculate the minimum burial depth you would recommend in laying water mains to avoid freezing of water. 10

(*b*) Calculate the internal energy per kg of superheated steam at a pressure of 10 bar and temperature of 300 degree centigrade. Also find the change in internal energy if this steam is expanded to 1.4 bar and dryness fraction 0.8. 10

8. Explain the following : 5×4=20

(*i*) Viscous flow of incompressible fluids

(*ii*) Boiling and condensation heat transfer

(*iii*) Brayton cycle with regeneration and reheat

(*iv*) Knocking and detonation control in IC engines