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EX/PROD/T/212/2017(S)

BACHELOR OF PRODUCTION ENGINEERING EXAMINATION, 2017

(2nd Year 1st Semester Supplementary)

THERMAL ENGINEERING

Time: **Three hours** Full Marks: **100**

All parts of a question *(a, b, c* etc) should be answered at one place.
Assume any missing data with proper justification.

Answer any **FIVE** questions.

1.(a) State the Fourier law of heat conduction.

(b) What do you mean by heat flux? What is the thermal resistance?

(c) A hollow sphere with inner and outer radii of 7.5 cm and 12.5 cm respectively is made of a material of thermal conductivity 52 W/m-K and carrying saturated steam. If the heat conducted out from the sphere is 2165 W and the inside temperature of the sphere is 425° C then determine the outside wall temperature of the sphere. Estimate the critical thickness of insulation when the sphere is insulated with a thickness of asbestos of thermal conductivity of 2 W/m-K and the convective heat transfer co-efficient from the surface of asbestos to the ambient air is 12 W/m^2-K. Also, calculate the outside temperature of insulation. Neglect radiation.

3+(3+2)+12

2.(a) Define the fin effectiveness.

(b) A 10 cm OD steam pipe is covered with asbestos of thickness 20 cm having thermal conductivity of 1.0 W/m-°C. The inside surface temperature of the asbestos is 130° C and the outside air temperature 35° C. The heat transfer coefficient for convection at the outer surface of the heat insulation is 25 W/m^2-°C. Calculate the rate of heat loss from the pipe per 1-m length of the pipe.

(c) An iron rod of length 30 cm and thermal conductivity 65 W/m-°K is attached horizontally to a large tank at a temperature of 200° C. The rod is dissipating heat by convection into the ambient air at 20° C with heat transfer coefficient 15 W/m^2-°K. Determine: (i) rate of heat transfer from the tip of the rod and (ii) efficiency of the rod and (iii) the temperature of the rod at 20 cm from the tank when it is considered as a fin. Assume no heat loss from tip of the rod.

3+7+10

3.(a) Explain about the free and forced convections.

(b) Explain the following terms:
(i) Nusselt No., (ii) Reynold No., (iii) Prandlt No.

(c) What is the Buckingham π-theorem?

(d) An engine oil at 30° C flows over a flat plate at a speed of 0.08 m/s. The length of the plates is 5 m. The plate is uniformly heated and maintained at 90° C. Estimate the rate of heat transfer. The properties of oil at 60° C are as follows:

Density, $\rho = 956.8$ kg/m^3; Thermal conductivity, k = 0.213 W/m-K,

Thermal diffusivity, $\alpha = 7.2 \times 10^{-8}$ m^2/s, Kinematic viscosity, $\upsilon = 0.65 \times 10^{-3}$ m^2/s.

4+6+3+7

4.(a) State the Kirchoff's law applied to radiation heat transfer.

(b) What is meant by absorptivity, reflectivity and transmitivity?

(c) What do you understand by the following terms with respect to radiation heat transfer?
(i) Black body surface, (ii) Gray body surface

(d) Derive an expression for thermal radiation heat transfer between two black body surfaces.

(e) Two parallel, infinite gray surfaces are maintained at temperatures of 127° C and 227° C respectively. If the temperature of the hot surface is increased to 327° C, by what factor is the net radiation exchange per unit area increased? Assume the emissivity for the colder and hotter surfaces to be 0.9 and 0.7 respectively.

2+3+3+6+6

5.(a) Define the fin effectiveness.

(b) Distinguish between parallel flow and counter flow heat exchangers with respect to the following points:
(i) Direction of flow, (ii) Temperature variation.

(c) An oil cooler consists of a straight tube of 20 mm outside diameter and 16 mm inside diameter enclosed within a pipe and concentric with it. The external pipe is well insulated. Oil flows through a tube at the rate of 180 kg/h (c_p = 2000 J/kg-K) and the cooling liquid flows in the annulus in the opposite direction at the rate of 6 kg/min (c_p = 4000 J/kg-K). The oil enters the cooler at 180° C and leaves at 80° C, while the cooling liquid enters at 30° C. Estimate (i) the exit temperature of cooling liquid, (ii) heat transfer rate, (iii) the effectiveness, (iv) NTU and (v) the length of the tube if the heat transfer coefficient from the oil to the tube surface is 2000 W/m^2-K and from the surface to the water is 4000 W/m^2-K. Thermal conductivity of the tube material is 48 W/m-K. Neglect the resistance due to the fouling.

2+4+14

6.(a) For an air standard Otto cycle show that thermal efficiency, $\eta = 1 - \frac{1}{r_k^{\gamma-1}}$.

Where, r_k = Compression Ratio.

(b) Compare the efficiency of Otto, Diesel and Dual cycles for the same maximum pressure and temperature and the same heat rejection.

(c) The compression ratio of an air-standard Dual cycle is 12 and the maximum pressure in the cycle is limited to 70 bar. The pressure and temperature of cycle at beginning of compression process are 1 bar and 23°C respectively. Heat is added during constant pressure process up to 3% of the stroke. Assuming diameter as 25 cm and stroke as 30 cm calculate the thermal efficiency of the cycle. Take c_p = 1.005 kJ/kg-K; c_v = 0.718 kJ/kg-K and γ=1.4. Also, draw the **p-V**and **T-s** diagrams of the cycle.

5+5+10

7.(a) Define the calorific value (CV) of a fuel. Differentiate between higher calorific value (HCV) and lower calorific value (LCV) of a fuel.

(b) The ultimate analysis by mass of a sample of petrol was 85.5% C and 14.5% H. Calculate (i) the stoichiometric air-fuel ratio, (ii) actual air-fuel ratio when the mixture strength is 90%

and (iii) determine the percentage of wet products of combustion by mass.

6+14

8.(a) Discuss briefly the working principle of 4-stroke diesel engine with the aid of sectional view and the valve timing diagram.

(b) A four cylinder four stroke SI petrol engine gave the following particulars:

Bore: 65 mm; Stroke: 95 mm; Speed: 3000 rpm; Clearance volume: 65 cm^3; Relative efficiency based on brake power, $\eta_{B.thermal}$: 50%; Heating value of fuel used: 46000 kJ/kg and when tested on load it developed 70 Nm torque. Determine: (i) break mean effective pressure, (ii) indicated mean effective pressure and (iii) indicated thermal efficiency. Assume γ= 1.4 for air and mechanical efficiency of 80%.

10+10

9.(a) Compare the fire tube boiler and water tube boiler.

(b) Differentiate between the boiler accessories and mountings with examples?

(c) Describe the working of Cochran boiler with neat sketch.

5+5+10

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