AU – 2647

Fifth Semester B. E. (Mechanical Engineering) (CGS) Examination

HEAT TRANSFER

Paper – 5 ME 02

(USC – 10850)

P. Pages : 5

Time : Three Hours] [Max. Marks : 80

Note : (1) Separate answer book must be used for each section in the subject Geology, Engineering material of Civil branch and separate answer book must be used for Section A and B in pharmacy and Cosmetic Tech.

(2) Answer **Three** questions from Section A and **Three** questions from Section B.

(3) Due credit will be given to neatness and adequate dimensions.

(4) Assume suitable data wherever necessary.

(5) Diagrams and chemical equations should be given wherever necessary.

(6) Illustrate your answer wherever necessary with the help of neat sketches.

(7) Use pen of Blue / Black ink / refill only for writing book.

http://www.sgbauonline.com

SECTION A

1. (a) Show that heat transfer through a composite layer consisting of n number of layer is given by

$$Q = \frac{T_{h+1} - T_1}{\sum_{h=1}^{h} \frac{L}{AK}}$$

6

(b) A brick wall (10cm thick, k=0.7 W/mK) has plaster on one side of the wall (thickness 4 cm, K=0.48 W/mK). The temperature on inside and outside surfaces are 725^{0}C and 110^{0}C resp. The contact resistance is 0.0035 K / W, calculate heat transfer and temperature drop at the contact. 7

OR

2. (a) Show that the maximum temperature at the centre of a solid cylinder of radius R and surface temperature T_W with internal heat generation per unit

http://www.sgbauonline.com

volume q_g is given by

$$T_{max} = T_w + \frac{q_g R^2}{4K}$$ 6

(b) A copper cable (K=395 W/mK). 30 mm in diameter carries a current of 300 A, when exposed to air at 30^0C with convection coefficient of $20 W/m^2K$. The cable resistance is $5 \times 10^{-3} \Omega/m$. Determine the surface and centre temperature of the cable. 7

3. (a) Define critical radius of insulation and derive an expression for it for pipe. 6

(b) A C. I. fin on an engine cylinder is 0.3 m wide 3 mm thick and 5 cm long. The base temperature of the fin is 150^0C when operating at an ambient temperature of 20^0C. If thermal conductivity of the fin is 52 W/mK and heat transfer coefficient is $50 W/m^2K$. Find the temperature at the tip and at a distance half way along the fin. Determine also the power dissipated by 40 such fins in kW. Heat loss from fin tip may be neglected. 7

OR

4. (a) Prove that for a body whose thermal resistance is zero, the temperature required for cooling or heating can be obtained from the relation

$$\frac{T - Ta}{Ti - Ta} = EXP\left[\frac{-hA}{\rho V C p} T\right]$$

where T is the temperature of the body at any time T and Ti is the initial temperature of the body. 6

(b) A pipe of outside diameter 20 mm is to be insulated with asbestos which has a mean thermal conductivty of $0.1 W/m^0C$. The local coeff. of convective heat to surrounding is $5 W/m^2\,{}^0C$. Comment upon the utility of asbestos as insulating material.

What should be the minimum value of thermal conductivity of insulating material to reduce heat transfer. 7

5. State and explain any four laws of radiation heat transfer. 14

OR

6. (a) The Sun may be considered to be a black body with a surface temperature of 5780 K. Calculate

   (i) The wave length for maximum spectral emissive power

   (ii) The frequency of maximum spectral emissive power if velocity of light $C = 2.998 \times 10^8 m/s$.

   (iii) Maximum spectral emissive power

   (iv) The hemispherical total emissive power. 8

   (b) Assuming the Sun to be a black body emitting radiation with maximum intensity at $\lambda = 0.46\ \mu m$, calculate the following :—

   (i) The surface temperature of the Sun

   (ii) The heat flux at the surface of the Sun. 6

http://www.sgbauonline.com

SECTION B

7. (a) Define the following dimensionless numbers and give their physical significance

   (i) Reynold number

   (ii) Prandtle number

   (iii) Nusselt number

   (iv) Grashhoffs number. 6

   (b) Air at 10^0C is flowing over a plate at a velocity of $3 m/s$. If the plate is 30 cm wide and at a temperature of 60^0C. Calculate the following quantities at $x = 0.3 m$

   (1) Boundary layer thickness

   (2) Thickness of thermal boundary layer

   (3) Local heat transfer coefficent

   (4) Heat transfer from the plate

http://www.sgbauonline.com

Assume the following properties of air at mean temperature of 35 ^{0}C.

$\rho = 1.137 kg/m^3$, $Pr = 0.7$

$K = 0.0272 W/MK$, $C_p = 1.006 KJ/kg\ K$

and $\mu = 19 \times 10^{-6} kg/m.s.$ 7

OR

8. (a) Water flows over a flat plate measuring 1 m x 1 m with a velocity of 2 m/s. The plate is at uniform temperature of 90^{0}C and the water temperature is 10^{0}C. Estimate the length of the plate over which the flow is laminar and rate of heat transfer from entire plate.
The properties of water at 50^{0}C are

$\rho = 988.1 kg/m^3$, $\nu = 0.556 \times 10^{-6} m^2/s$

$Pr = 3.54$ and $K = 0.648 W/mK$ 6

(b) Cold air at 5^{0}C is carried by a rectangular duct 30 cm x 20 cm in size and it is maintained at 15^{0}C over the whole surface. The velocity of air is 10 m/s.
Taking the following properties of air at mean temperature at 10^{0}C, find the heat gained by air when it is passed through 10 m length of duct.

$\rho = 1.25 kg/m^3$, $Cp = 1005\ J/kg\ K$

$K = 0.025 W/mK$ and $\nu = 14.16 \times 10^{-6} m^2/s$

Use the relation $N_u = 0.023\ R_C^{0.8}\ P_r^{0.33}$. 7

9. (a) What is condensation ? Distinguish between filmwise and dropwise condensation. 6

(b) A vertical cylindrical body of 300 mm diameter and 1.6 m height is maintained at a constant temperature of 36.5^{0}C. The surrounding temperature is 13.5^{0}C. Find out the amount of the heat to be dissipated by the body per hour if

$\rho = 1.025 kg/m^3$, $Cp = 0.96\ kJ/kg\ ^0C$

$\nu = 15.06 \times 10^{-6} m^2/s$,

$K = 0.0247 W/mK$ and $\beta = \dfrac{1}{298}\ K^{-1}$

7

http://www.sgbauonline.com
http://www.sgbauonline.com

OR

10. (a) Explain with neat sketches, how is the boundary developed for natural convection on a vertical plate which is maintained at a temperature

(a) higher and (b) lower, than the surrounding fluid. 6

(b) A horizontal 50 W flourescent tube which is 4 cm in diameter and 100 cm long stands in still air at 1 atm. and 20^0C. If the surface temperature is 40^0C and radiation is neglected, what percentage of power is being dissipated by convection ?

Take for air

$K = 0.0265$ W/mk , $\nu = 16.19 \times 10^{-6}$ m²/s

$\beta = \frac{1}{303}$ K^{-1} and $P_r = 0.706$

Use the relation $Nu = 0.53\ (G_r.\ P_r)^{1/4}$. 7

11. (a) Derive an expression for LMTD for parallel flow heat exchanger. 6

(b) In a food processing plant, a brine solution is heated from -12^0C to -6.5^0C in a double pipe parallel flow heat exchanger by water entering at 35^0C and leaving at 20.5^0C at the rate of 9 kg/min. Determine heat exchanger area for an overall heat transfer coefficient of 860 w/m²K. For water $Cp = 4.186 \times 10^3$ J/kg K. 8

http://www.sgbauonline.com

OR

12. (a) What is fouling ? Discuss the fouling mechanisms that gives rise to fouling problems in H. E. How fouling is taken into account while designing heat exchanges ? 4

(b) Exhaust gases (Cp = 1120 J/kg K) flowing through a tubular heat exchanger at the rate of 1200 kg/hr are cooled from 400^0C to 120^0C by water (Cp = 4180 J/kg K) that enters the system at 10^0C at the rate of 1500 kg/hr. If the overall heat transfer coefficient is 138.8 w/m²K, what heat exchanger area is required for

(i) Parallel flow arrangement ? (ii) Counter flow arrangement ? 10

http://www.sgbauonline.com