B.E. (Mechanical Engineering / Power Engineering) Semester Fifth (C.B.S.)

Heat Transfer Paper - I

P. Pages : 4 **KNT/KW/16/7341/7368**

Time : Three Hours * 0 6 7 2 * Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
3. Solve Question 3 OR Questions No. 4.
4. Solve Question 5 OR Questions No. 6.
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Assume suitable data whenever necessary.
9. Illustrate your answers whenever necessary with the help of neat sketches.
10. Use of non programmable calculator is permitted.
11. Heat transfer data book & steam table is allowed.

1. a) Derive generalized one dimensional Heat conduction equation for cylinder. **6**

b) A wall of a furnace is made up of inside layer of silica brick 120 mm thick covered with a layer of magnesite brick 240 mm thick. Temperature at the inside surface of silica brick wall and outside surface of magnesite brick wall are 725ºC and 110ºC respectively. The thermal contact resistance between the two wall interface is $0.0035°C/W$ per unit area of wall. If the thermal conductivity of silica & magnesite bricks are $1.7 w/m°C$ and $5.8 w/m°C$. **7**

Calculate :
i) Rate of Heat loss per unit area of the wall.
ii) Temperature drop at the wall interface.

OR

2. a) A Hollow sphere of inside and outside diameters of 25 cm and 30 cm respection, is heated by means of 15Ω coil placed inside the sphere. Find out the current required to maintain the temperature difference of 50ºC between inner & outer surface of the sphere. Take the conductivity of sphere material is 40 w/mk. **6**

b) A electrical cable of 12 mm diameter is insulated to increase the current capacity. Due to the insulation the current carrying capacity is increased by 15% without increasing cable surface temperature above 70ºC. The environmental temperature is 30ºC. Assume that the heat transfer coefficient from bare & insulated cable is $14 w/m^2k$. Calculate the conductivity of insulating material. **7**

3. a) Define : **6**
i) Fin effectiveness and its significance?
ii) Fin efficiency of insulated tip and long tin.
iii) Biot no.
iv) Fourier's no.

b) A stainless steel rod 20 mm rod dia. is carrying an electrical current of 100 Amp. The thermal and electrical conductivity are 20 w/mk and $1.25\times10^{4}\,\Omega\text{cm}^{-1}$. What is the temperature at the centre of the rod if its surface temperature should not exceeded 400ºC. **8**

OR

4. a) The handle of saucepan 30 cm long and 2 cm in diameter is partially immersed in boiling water at 100ºC. The average unit conductance over the handle surface is $7.35\,\text{w/m}^2\,^{o}\text{C}$ in the kitchen air at 24ºC. The cook is likely grasp the last 10 cm of the handle and hence, the temperature of the portion should be not exceeded 32ºC. What would be the material conductivity of handle material. Handle may be treated as fin insulated at the tip. **7**

b) An ordinary egg can be approximated as 5 cm dia. sphere. The egg is initially at a uniform temperature of 5ºC and is dropped into boiling water at 95ºC. Taking the convection coefficient to be $1200\,\text{w/m}^2\text{k}$. determine how long it will take for centre of egg to reach 70ºC. **7**

Take properties of egg as

$$K = 0.627\,\text{w/m}^2\text{k} \quad \alpha = {}^{k}\!/_{ecp} = 0.151\times10^{-6}\ \text{m}^2/\text{s}$$

5. Air $(T_a = 20^{o}\text{C})$ flowing over the flat square plate $280\,\text{mm}\times280\,\text{mm}$ in size, at a velocity of 3 m/sec. The plate surface is maintained at a temperature of 56ºC. Calculate ; **13**

1) Boundary layer thickness at 280 mm from leading edge.
2) Local and average heat transfer coefficient.
3) Local and average coefficient of friction.
4) Total Heat transported from the plate.
5) Total drag force on the plate.

OR

6. a) A water heater consists of 25 mm diameter tube inside a coaxial tube. Water at 10ºC enters the inner tube at 0.8 kg/s. condensing steam in outer pipe maintains the inner tube surface temperature at 90ºC. **7**

i) Determine the exit temperature of water and the heat transfer rate from 10 m long tube.

ii) What should be the length of the tube for exit temperature of water to be 70ºC.

b) Liquid Mercury flows at a rate of 1.6 kg/s through a copper tube of 20 mm diameter. The Mercury enters the tube at 15ºC and after setting heated it leaves the tube at 35ºC. Calculate the tube length for constant heat flux at the wall is maintained at an average temperature of 50ºC. **6**

Use $\overline{Nu} = 7 + 0.025(Pe)^{0.8}$

Pe = Peclet Number = Pr Re

Take properties of Mercury at mean bulk temperature.

$$P = 13582\,\text{kg/m}^3;\quad K = 8.69\,\text{w/m}^{o}\text{C};\quad Cp = 140\,\text{J/kg}^{o}\text{C}$$

$$\nu = 1.5\times10^{-7}\ \text{m}^3/\text{sec}.\ \text{Pr} = 0.0248$$

7. a) Explain with neat sketch pool boiling curve. **4**

b) An Air Flow through a long rectangular duct $(30\,cm \times 65\,cm)$ air – conditioning duct outer surface maintained at the temperature at 15ºC. If the duct is insulated and exposed to the air at 25ºC. Calculate the heat gained by the duct per meter length. assuming it to be horizontal. Use following correlations. **9**

$Nu_L = 0.59(Ra_L)^{\frac{1}{4}} \Leftarrow$ Vertical Surface

upper surface heated = $Nu = 0.54(Ra_L)^{\frac{1}{4}}$

lower surface heated = $Nu = 0.27(Ra_L)^{\frac{1}{4}}$

where $\underline{Ra_L = Gr\,Pr}$

OR

8. a) A steam at 0.08132 bar is to condensed over a 60 cm x 60 cm square vertical plate. The surface temperature maintained at 28ºC. **9**

Calculate :

a) Film thickness, local Heat transfer coefficient, and mean flow velocity at 20 cm from the bottom of the plate.

b) Average Heat transfer coefficient and total heat transfer rate from the plate.

c) Steam condensation rate.

b) Differentiate between film wise and dropwise condensation. **4**

9. a) State following : **7**

1) Stefan's Boltzmann Law.

2) Lambert cosine law.

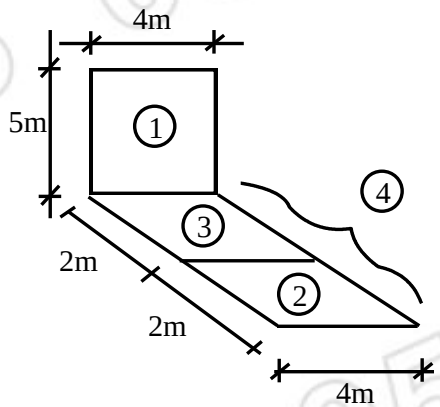
3) Wein displacement law.

4) Kirchoff's law.

b) An encloser measure $1.5\,m * 1.7\,m$ with height of 2 m. The wall and ceiling are maintained at 250ºC and floor at 130ºC. The walls and ceiling having an emissivity of 0.82 and floor 0.7. Determine net radiation to the floor. **7**

OR

10. a) What is shape factor? Calculate shape factor for given geometry (F_{12}). **6**



b) Two identical circular plates each with area $1m^2$ and emissivity 0.5 are arranged facing each other in a long room. The emissive power of the plates are $30 kw/m^2$ and $3 kw/m^2$ respectively. The temperature of the surrounding is 27ºC. The surface of the plate facing each other only radiating energy. **8**

Find :

1) Distance between the two plates.
2) Temperature of the plates.

Assume shape factor between the plates as 0.6

11. a) Derive the expression for effectiveness of parallel flow Heat exchanger. **6**

b) A flow rate of hot and cold water streams running through the parallel flow Heat exchanger are 0.2 kg/sec. and 0.5 kg/s respectively. The inlet temperature of hot and cold side are 75ºC and 20ºC respectively. The exit temperature of hot water is 45ºC. Heat transfer coefficient on both side is $650 CN/m^2 {}^oC$; Calculate Area of Heat exchanger. **7**

OR

12. Find the length of the Counter Flow Heat exchanger to heat 4000 kg/hr of oil from 10ºC to 20ºC using hot water at 70ºC. The hot water flows with a velocity 75 cm/s through a copper pipe of internal diameter 1.8 cm and outer diameter 2.1 cm (conductivity of pipe material $K_{pipe} = 386 w/mk$). The oil flows through annulus of internal diameter 3 cm. The fouling factor's at inside & outside surface of inner tube are as, **13**

$F_i = 0.000088 m^2 {}^oC/w$ & $F_0 = 0.00088 m^2 {}^oC/w$.

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