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Heat & Mass Transfer
(1010)

P. Pages : 4

Time : Three Hours **Max. Marks : 100**

Instructions to Candidates :
1. Do not write anything on question paper except Seat No.
2. Answer sheet should be written with blue ink only. Graph or diagram should be drawn with the same pen being used for writing paper or black HB pencil.
3. Students should note, no supplement will be provided.
4. Attempt **any two** sub-questions out of a, b and c from each unit.
5. Use of heat transfer data book is allowed.
6. Figure to the right indicate full marks.
7. Assume suitable data if necessary.

UNIT – I

1. a) i) What are the three modes of heat transfer? Explain their potential for occurance. **6**

ii) Explain thermal contact resistance. **4**

b) A wall is constructed of several layers. The first layer consists of brick (K=0.66 W/m.k), 25 cm thick, the second layer 2.5 cm thick mortar (K = 0.7 W/m.k) the third layer 10 cm thick limestone (K = 0.66 W/mk) and outer layer of 1.25 cm thick plaster (K=0.7 W/mk). The heat transfer coefficients on interior and exterior of the wall fluid layers are 5.8 W/m^2k an 11.6 W/m^2-k, respectively. Find : **10**

i) Overall heat transfer coefficient,

ii) Overall thermal resistance per m^2,

iii) Rate of heat transfer per m^2, if the interior of the room is at 26ºC white outer air is at -7ºC,

iv) Temperature at the junction between mortar and limestone.

c) A solid cylinder, 100 mm in diameter generating heat at a uniform rate of $7 \times 10^6 W/m^3$. The thermal conductivity of solid is 190 W/m-k, and its surface temperature is maintained at 100 ºC. Calculate, **10**

i) Temperature at the centre of cylinder.

ii) Temperature at the distance 25mm from the centre.

iii) Temperature gradient at 25 mm radius.

iv) Heat flux at the surface.

UNIT – II

2. a) Explain : **10**

i) Fin selection.

ii) Fin effectiveness

iii) Absorptivity.

iv) Reflectivity.

v) Transmissivity.

b) A carbon steel pipe (k = 45 W/m.k), 78 mm in inner diameter and 5.5 mm thick has eight longitudinal fins 1.5 mm thick. Each fin extends 30 mm from the pipe wall. If the wall temperature, ambient temperature and surface heat transfer coefficient are 150 ^oC, 28 ^oC and 75 W/m^2k, respectively. Calculate the percentage increase in heat transfer rate for the finned tube over the plan tube. **10**

c) Calculate the following quantities for an industrial furnace (blackbody) emitting radiation at 2650 ^oC. **10**

i) Spectral emissive power at $\lambda = 1.2\mu m$,(Micro meter)

ii) Wavelength at which the emissive power is maximum.

iii) Maximum spectral emissive power.

iv) Total emissive power.

v) Total emissive power of the furnace, if it is treated as gray and diffuse body with an emissivity of 0.9.

UNIT – III

3. a) i) Define laminar and turbulent flows. What is Raynold's number ? **4**

ii) Water flows at 20^oC at 8 kg/s through the diffuser having 3 cm diameter at the entrance and 7.0 cm diameter at its exit. Calculate the fluid velocity and Reynold's number at the inlet and exit of the diffuser. **6**

b) Vertical door of a hot oven is 0.5 m high and is maintained at 200 ^oC. It is exposed to atmospheric air at 20^oC. Find : **10**

a) local heat transfer coefficient half way up the door;

b) average heat transfer coefficient for entire door;

c) thickness of free convection boundary layer at the top of the door.

The properties of atmospheric air at 110^oC from table are

$$\nu = 2.429 \times 10^{-5} m^2/s, K_f = 0.0332 W/m,k \ Pr = 0.687$$

$\beta = \frac{1}{383} K^{-1}, \ \rho = 0.922 \, kg/m^3, \ \mu = 2.24 \times 10^{-5} \, kg/ms$

You may use following correlation for local Nusselt number.

$N_{ux} = 0.508 \, P_r^{1/2} (0.952 + P_r)^{-1/4} \cdot Gr_x^{1/4}$

c) i) Define and explain principle of condensation. **4**

ii) The crank case of an automobile is approximated as 0.6m long, 0.2 m wide, and 0.1 m deep. Assuming that the surface temperature of the crank case is 350 k. Estimate the rate of heat flow from the crank case to atmosphere at 276 k at a road speed of 30 m/s. Assume that the vibration of the engine and chasis induce the transmission from laminar to turbulent flow very near to leading edge that for practical purposes the boundary layer is turbulent over the entire surface. Neglect the radiation and use for the front and rear surfaces, same heat transfer coefficient as for bottom and sides. **6**

UNIT – IV

4. a) i) What is heat Exchanger ? Explain shell and tube type heat exchanger ? Why baffles are used ? **5**

ii) Explain Fouling factor. **5**

b) A heat exchanger is used to cool the lubricating oil. Water flows at the rate of 0.3 kg/s through inner stainless steel tube (k=16 W/mk) of inner radius of 30 mm and wall thickness of 2 mm. The oil flows at a rate of 0.15 kg/s through outer tube of inner radius of 50 mm. The oil is cooled from 90 ^oC to 50 ^oC using water at 10 ^oC. Calculate, **10**

i) length of tube required for parallel flow.

ii) length of tube required for counter flow.

Take overall heat transfer coefficients based on inner radius as 21.9 W/m^2k and assume fully developed flow.

Take specific heat of water as 4178 J/kg.k and that of oil as 2131 J/kg.k.

c) i) Define NTU of a heat exchanger. **2**

ii) A concentric tube heat exchanger uses water which is available at 15 ^oC to cool ethylene glycol from 100 ^oC to 60 ^oC. The water and glycol flow rates are each 0.5 kg/s. What are the maximum possible heat transfer rate and effectiveness of the heat exchanger ? Which is preferred a parallel flow or a counter flow mode operation ? **8**

Take C_p of glycol = 2637 J/kg k, C_p of water = 4180 J/kgk.

UNIT – V

5. a) i) State the mode of mass transfer with suitable examples. **5**

ii) Explain similarities and differences in heat and mass transfer. **5**

b) The tyre tube of a vehicle has a surface area of 0.62 m^2 and wall thickness of 10 mm. The tube has air filled in it at a pressume of 2.2 bar. The air pressure drops to 2.18 bar in a period of 6 days. The solubility of air in the rubber is 0.075 m^3 of air/m^3 of rubber at 1 bar. The volume of air in the tube is 0.034 m^3 and operating temperature is 300 k. Calculate diffusivity of air in the rubber. **10**

c) i) Explain : **5**

i) Schmidt number

ii) Sherwood number

ii) Explain evaporation of water into air and its importance in engineering situations. **5**

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