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SE-6863

B. E. - III (Sem. V) (Mech.) Examination

April / May – 2011

Heat and Mass Transfer

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ **B. E. - 3 (Sem. 5) (Mech.)**

Name of the Subject :

☛ **Heat & Mass Transfer**

☛Subject Code No. : **6 8 6 3** ☛Section No. (1, 2,.....) : **Nil**

Seat No. :

Student's Signature

(2) Answer all questions.
(3) Figures to the right inidcate full marks.
(4) Assume suitable data, if necessary.
(5) Use of steam table, molier diagram, refrigeration charts are permitted.

1 (a) Attempt any six : **12**

(i) Define heat transfer and what are the modes of heat transfer ?
(ii) Define Fourier's law of conduction.
(iii) Define Newton's law of cooling.
(iv) Differentiate between isotropic and anisotropic material.
(v) Define black, white and grey body.
(vi) Define Emissivity and Emissive power.
(vii) Explain Wien's law of displacement.

2 Attempt the following questions : (any three) **18**

(i) Derive an expression for three dimensional heat conduction equation in Cartesian coordinates.
(ii) What is critical radius of insulation ? Derive the expression for long hollow cylinder with one layer of insulation.

(iii) What is composite wall ? Derive an expression overall heat transfer coefficient and thermal resistance with two layer of insulation.

(iv) What is composite cylinder ? Derive an expression for overall heat transfer coefficient and thermal resistance with two layer of insulation.

3 Answer the following : (any three) **20**

(i) A pane wall of fireclay brick. 25 cm thick is having temperature $1350^{o}C$ and $50^{o}C$ on two sides. The thermal conductivity of fireclay varies as : k=0.838[1+0.0007T] where T is in degree celsius. Calculate the heat loss per square meter through the wall. Q/A = -k dT/dx where k is thermal conductivity.

(ii) An industrial freezer is designed to operate with an internal air temperature of $-20^{o}C$, when the external air temperature is $25^{o}C$. The internal and external heat transfer coefficients are 12 W/m^2K and 8 W/m^2K respectively. The wall of the freezer consists of an inner layer of plastic k = 1 w/mK, 3 mm thick and an outer layer of stainless steel with k=16 W/mK, 1 mm thick. A layer of insulation material (k=0.07 W/mK) is sandwiched between these two layers. Find the thickness of insulation required to reduce the convective heat loss (q) to 15 W/m^2.

(iii) The walls of house in cold region consists of three layers and outer brick work 15 cm thick, an inner wooden panel, the intermediate layer is made of an insulating material, 7 cm thick. The thermal conductivities of brick and wood used are 0.7 and 0.18 W/mK respectively. The inside and outside wall are $21^{o}C$ and $-15^{o}C$, respectively. If the layer of insulation offers twice the thermal resistance ($R_2 = 2R_1$) of the brick wall calculate (a) the rate of heat loss (q) per unit area of the wall and (b) thermal conductivity of insulating material.

(iv) A copper pipe carrying the refrigerant at $-20^{o}C$ is 10 mm in outer diameter and is exposed to ambient at $-25^{o}C$ with convective coefficient of 50 W/m^2K. It is proposed to apply the insulation of material having thermal conductivity of 0.5 W/mK. Determine the thickness beyond which the heat gain will be reduced. Calculate the heat losses for 2.5 mm thick layer of insulation over 1 m length.

4 (a) Attempt any five : **10**

(i) Define laminar and turbulent flow. What is Reynolds number ?

(ii) Explain velocity and thermal boundary layer.

(iii) What is critical Reynolds number ?

(iv) What is heat exchanger ? Where are they used ?

(v) What do you mean by fouling factor ?

(vi) What is direct contact type heat exchanger ?

(vii) Define 'Prandtl number' related to convection heat transfer.

(b) Explain Fick's law of diffusion. What is mass diffusivity ? **4**

(c) A steel rectangular container having wall 16 mm thick is used to store gaseous hydrogen at elevated pressure. The molar concentrations of hydrogen in the steel at the inside and outside surfaces are 1.2 kg mol/ m3 and zero respectively. Assuming the diffusion co-efficient for hydrogen in steel as $0.248\times10^{-12}\,m^2/s$, calculate the molar diffusion flux for hydrogen through the steel. **6**

5 (a) Explain Reynolds analogy for turbulent flow over a flat plate. **5**

(b) Air at 27^oC and 1 atm flows over a heated plate with a velocity 2 m/s. The plate is at temperature of 60^oC. Calculate the heat transfer rate from first 0.2 m of the plate. Take properties of air as given below : **10**

$v=17.36\times10^{-6}\,m^2/s$, k_f \0.02749 W/mK,

Pr=0.7, $C_p=1.006\,kJ/kgK$.

OR

(b) A tube 5 m long is maintained at 100^oC by steam jacketing. A fluid flows through the tube with velocity 3 m/s and at the temperature of 30^oC. The diameter of the tube is 2 cm. Find out the rate of heat transfer. Take the following properties of the fluid.

$\rho=850\,kg/m^3$, $C_p=2000\,J/kgK$, $v=5.1\times10^{-6}m^2/s$,

k=0.12 W/mK.

6 (a) Compare parallel flow. Counter flow and flow heat exchanger. **5**

(b) In a counter flow double pipe heat exchanger, water is heated from 25^oC to 65^oC by an oil with a specific heat of 1.45 kJ/kgK and mass flow rate 0.9 kg/s. The oil is cooled from 230^oC to 160^oC. If the overall heat transfer coefficient is $420\ W/m^2K$, calculate the rate of heat transfer and heat transfer area required. **10**

OR

(b) A horizontal 40 W fluorescent tube which is 3.8 cm in diameter and 120 cm long stands in still air at 1 atm and 20^oC. If the surface temperature is 40^oC and convection ? Take properties of air as follows : **10**

$v = 16.19 \times 10^6\ m^2/s$, $k_f = 0.2652\ W/mK$, Pr=0.706.