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BIME-034

B.Tech. MECHANICAL ENGINEERING (BTMEVI)

Term-End Examination

December, 2013

BIME-034 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt* ***any five*** *questions.* ***All*** *questions carry* ***equal*** *marks. Use of scientific calculator is* ***permitted.***

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1. (a) Explain the electrical analogy of the heat transfer with the help of a neat diagram.

(b) The composite wall of an oven consists of three materials, two of the them are of known thermal conductivity $k_A = 20$ W/mk, and K_c 50 W/mk and Known thickness $L_A = 0.3$ and $L_c = 0.15$ m. The third material B, Which is Sandwiched between material A and C is of known thickness, $L_B = 0.15$ m, but of unknown thermal conductivity K_B. Under Steady state operating conditions, the measurement reveals an outer surface temperature of material C is 20°C and inner surface of A is 600°C and oven air temperature is 800°C. The inside convection coefficient is 25 $w/m^2 k$. What is the value of K_B ? **7+7=14**

2. (a) What is do you mean by critical radius of insulation ? Explain the concept with the help of material and surface of resistances.

(b) A furnace wall is made of three layers. First layer of insulation (k = 0.6 W/mk) is 12 cm thick. Its face is exposed to gases at 870°.C with convection cofficient of 110 W/m^2k. It is covered with (backed with) .a 10 cm thick layer of fire brick (k = 0.8 W/mk) with a contact resistance of $2.6x10^{-4}$ m^2 k/w between is first and second layer. the third layer is a plate of 10 cm thickness (k=4 w/mk) with a contact resistance between record and third layer of $1.5x10^{-4}$ m^2 k/w. The plate is exposed to air at 30°C with convetion coefficient of 1.5 w/m^2k. Determine the heat flow rate and overall heat transfer coefficient. **7+7=14**

3. (a) What is biot number ? What is its physical significance ? is the biot number more likely to be larger for highly conducting solids or insulator ones ? **7+7=14**

(b) A long cylindrical rod of radius 12 cm, consists of nuclear reacting material (k=2 bnw/mk) generating 30 kw/m^3 uniformly throughout its volume. the rod is encapsulated with another cylinder (k= 5 w /mk) whose outer radius is 24 cm and surface is surrounded by air at 30°C with heat transfer coefficient of 20 W/m^2 k. find the temperature at the interface between the two cylinders and at the outer surface.

4. (a) Determine the coefficient of heat transfer by free convection and maximum current density for a nichrom wire 0.5 mm in diameter. The surface of the wire is maintained at 300°C. The wire is exposed

to still air 20°C and resistance per metre length of the wire is 6 Ω / m. used relation

$N_0 = 1.18 (GrPr)^{1/8}$ use properties of air at 160°C ; K_f = 0.0361 W/mk; $\gamma = 30.35 \times 10^{-6}$ m^2/s; $P_r = 0.687$. **7+7=14**

(b) A central heating radiator has a surface temperature of 70°C and heats of room maintained at 20°C. Calculate the contribution of convection and radiation to heat transfer form the radiator.

Use following correlation for determination of natural convection coefficient $N_{uL} = 0.118(Gr_L \ P_r)^{1/3}$ the properties of fluid in the room are :

ρ = 1.2 kg/m^3, $\mu = 1.8 \times 10^{-5}$ kg/ms, K_f = 0.026 w/mk; $P_r = 0.71$

5. (a) Radiant energy with an intensity of 700 W/m^2 strikes a flat plate normally . The absorptivity is twice the transmissivity and 2.9 times its reflectivity Determine the rate of absorption, transmission and reflection of energy in W/m^2. **7+7=14**

(b) A black body is at 1000°C; Calculate.

(i) The wavelength at which the body has the maximum spectral emissive power, and the corresponding emissive power.

(ii) The total emissive power of the black body.

(iii) The fraction of total radiant energy emission between the wavelength 2.0 μm and 4.5 μm.

(iv) Hemispherical emissive power.

6. (a) Compare parallel flow and counter flow of heat exchanger. Define NTU of heat exchanger. Explain LMTD. **7+7=14**

(b) Hot oil with capacity rate 2500 W/k flows through a double pipe heat exchanger. It enters at 360^{o} C and leaves at 300^{o}C. Cold fluid enters at 30^{o} C and leaves at 200^{o}C. it the overall heat transfer coefficient is 800 W/m2 k, determine the heat exchanger area required for parallel and counter flow.

7. (a) Define and explain the physical significance of the following (Answer **any two**) : **7+7=14**

(i) Schmidt number

(ii) Lewis number

(iii) Sherwood number

(iv) Shape factor.

(b) Derive an expression for diffusion of one gas through a stagnant gas in terms of logarithmic mean partial pressures. Consider the pressure and temperature of the system to be constant.