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Question Paper Code: 41762

B.E. / B.Tech. DEGREE EXAMINATION, MAY 2017

Sixth Semester

Mechanical Engineering

14UME602 - HEAT AND MASS TRANSFER

(Regulation 2014)

(HMT tables, Steam table, Mollier chart and Psychometric chart are permitted)

Duration: Three hours Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. A satellite in space exchanges heat with surroundings essentially essentially by

   (a) conduction (b) convection
   (c) radiation (d) conduction and convection put together

2. Fins are made as thin as possible to

   (a) reduce the total weight
   (b) accommodate more number of fins
   (c) increase the which for the same profile area
   (d) improve the flow of coolant around the fin

3. The free convection heat transfer is significantly affected by

   (a) Reynolds number (b) Grashoff number
   (c) Prandtl number (d) Stanton number

4. The convection heat transfer coefficient is laminar flow over a flat plate

   (a) increase with the distance
   (b) increase if a higher viscosity fluid is used
   (c) increase if a denser fluid is used
   (d) decrease with increase in free stream velocity

5. The steam condenser in a thermal power plant is heat exchanger of the type

(a) direct contact (b) regenerator
(c) recuperator (d) none of these

6. In a heat exchanger with one fluid evaporating or condensing, the surface area required is least in

(a) parallel flow (b) counter flow
(c) cross flow (d) all the above

7. What is the basic equation of radiation from which all other equations of radiation equations can be derived

(a) Stefan-Boltzman equation (b) Plancks equation
(c) Wiens equation (d) Rayleigh-Jeans formula

8. A radiation shield should

(a) Have high transmissivity
(b) absorb all the radiations
(c) Have high reflective power
(d) partly absorb and partly transmit the incident radiation

9. In a mass transfer process of diffusion of hot smoke in cold air in a power plant, the temperature profile and concentration profile will become identical when

(a) Prandtl number = 1 (b) Nusset number = 1
(c) Lewins number = 1 (d) Schmidt number = 2

10. If heat and mass transfer takes place simultaneously then the ratio of heat transfer coefficient to mass transfer coefficient is a function of the radio of

(a) Schmidt and Reynolds numbers (b) Schmidt and Prandtl numbers
(c) Nusselt and Lewis numbers (d) Reynolds and Lewis numbers

PART - B (5 x 2 = 10 Marks)

11. What are the factors affecting thermal conductivity?

12. Define free and forced convection.

13. How the filmwise condensation is different from dropwise condensation?

14. What is emissive power?

15. State Ficks first law of diffusion.

PART - C (5 x 16 = 80 Marks)

16. (a) A furnace wall is made up of three layers one is fire brick, one is insulating layer and one is red brick. The inner and outer surfaces temperature are at 870º *C* and 40º *C* respectively. The respective conductive heat transfer coefficient of the layers are 1.163, 0.14 and 0.872 *W/mºC* and the thickness are 22 *cm*, 7.5 *cm* and 11 *cm*. Find the rate of the loss per sq.m. and interface temperature. (16)

Or

(b) A large plane wall 40 *cm* thick and 8 m^2 area is heated from one side and temperature distribution at a certain time instant is approximately prescribed by the relation $t = 80 - 60X + 12X^2 + 25X^2 - 20X^4$ where temperature t is in degree celsius and the distance *X* is in meters. Make calculations for the

(i) heat energy stored in the wall in unit time

(ii) rate of temperature change at 20 *cm* distance from the side being heated and

(iii) location where the rate of heating or cooling is maximum

For the wall material, thermal conductivity $k = 6$ *W/mk* and thermal diffusivity $\alpha = 0.02$ m^2/hr. (16)

17. (a) Air at 8 KN/m^2 and 242º *C* flows over a flat plate of 0.3 *m* wide and 1 *m* long at a velocity of 8 *m/sec*. If the plate is maintained at a temperature of 75º *C*. Estimate the heat to be removed continuously from the plate. (16)

Or

(b) A vertical plate $L = 5$ *m* high and $w = 1.5$ *m* wide has one of its surface insulated. The other surface maintained at a uniform temperature 400 *K* is exposed to quiescent atmospheric air at 300 *k*. Calculate the total rate of heat loss from the plate. (16)

18. (a) Air at 120º *C* is cooled to 50º *C* by passing through the counter flow that exchanger tubes of 12 *mm* ID surrounded by water which enters the cooler at 10º *C* and leaves at 25º *C*. Find the LMTD. If the air velocity in the tube is limited to 6 *m/s*, find the length of the tube required. Tube inside heat transfer coefficient is 65 W/m^2K and tube water side heat transfer coefficient is 200 W/m^2K, density of air = 2.85 kg/m^3, for air *Cp* = 1.005 *KJ/KgK*. (16)

Or

(b) An air craft counter flow heat exchanger for liquid metal and air is designed and got the following temperatures. T_1 = 800º *C*, T_2 = 500º *C*, t_1 = 300º *C* and t_2 = 700º *C*. The flow rate of air is 110 *kg/*s and Cp_c - 1100 *J/Kgk* and average flow rate of the metal is 160 *kg/s* and Cp_h = 800 *J/Kgk*. the overall heat transfer coefficient based on air side area is 610 W/m^2K. Find the area required for the above mentioned heat transfer use NTU method. (16)

19. (a) Three cylinders of thin wall 150 *mm*, 200 *mm* and 250 *mm* in diameters are arranged concentrically. The temperature of the surfaces of 150 *mm* diameter cylinder and 250 *mm* diameter cylinder are maintained at 800 *k* and 200 *k* respectively. Assuming vacuum between the annular spaces, find out the steady state temperature attained by the surfaces of the cylinder whose diameter is 200 *mm*. Take $\varepsilon_1=\varepsilon_2$ - ε_2 = 0.005. Also find the heat loss per m length of the composite cylinder. (16)

Or

(b) Two very large parallel plates are maintained at uniform temperature of T_1 = 1000 *K*, T_2 = 800 *K* and have emissivity of $\varepsilon_1=\varepsilon_2$ = 0.2 respectively. It desired to reduce the net rate of radiation heat transfer between the two plants to one-fifth by placing thin aluminum sheets with an emissivity of 0.15. Determine numbers of sheets that need to be inserted. (16)

20. (a) A vessel contains binary mixture of O_2 and N_2 with partial pressure in the ratio 0.21 and 0.79 at 15º *C*. The total pressure of the mixture is 1.1 bar. Calculate the following

(i) Molar concentrations

(ii) Mass densities

(iii) Mass factions and

(iv) Molar fractions of each species. (16)

Or

(b) Dry air at 27*º C* and 1 bar flows over a wet plate of 50 *cm* at 50 *m/sec*. Calculate the mass transfer coefficient of water vapour in air at the end of the plate. (16)
