Reg. No. : | | | | | | | | | | |

Question Paper Code: 46702

B.E. / B.Tech. DEGREE EXAMINATION, MAY 2022

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. The conduction heat diffuses in a material when the material has:.

   (i) High thermal conductivity (ii)Low density

   (iii)High specific heat (iv)High viscosity

   (a) i) and ii) (b) ii) and iii) (c) iii) and iv) (d) iv) and i)

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. A dimensionless number that connects the link between velocity flow field and the temperature field is

   (a) Nusselt number (b) Prandtl number (c) Reynolds number (d) Grashof number

4. The characteristic length for computing Grashof number in the case of horizontal cylinder is

   (a) The length of the cylinder (b) The diameter of the cylinder

   (c) The perimeter of the cylinder (d) The radius of the cylinder

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. A counter flow shell and tube heat exchanger is used to heat water with hot exhaust gases. The water (C= 4180 J/kg-k) flows at the rate of 2 kg/s and the exhaust gases (C=1000 J/kg-K) flow at the rate of 5 kg/s. If the heat transfer surface area is 32 m^2 and the overall heat transfer coefficient is 200 W/ m^2K, the NTU of the heat exchanger is

(a) 4-5 (b) 2-4 (c) 8-6 (d) 1-28

7. If a body is at 200 K, the wave length at which the body emits maximum amount of radiation is.

(a) 1.45 μm (b) 1.45 cm (c) 0.345 cm (d) 0.345 μm

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. Eddy diffusion takes place when fluids are in

(a) Laminar motion (b) Turbulent motion
(c) Uniform motion (d) Unsteady motion

10. The dimensionless number related to mass transfer is

(a) Prandtl Number (b) Nusselt Number
(c) Sherwood Number (d) Reynolds number

PART - B (5 x 2 = 10 Marks)

11. Define thermal contact resistance.

12. What is Hydrodynamic boundary layer?

13. Distinguish LMTD and NTU Method.

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/m°C* 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 242° *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 75° *C*. Estimate the heat to be removed continuously from the plate. (16)

Or

(b) A thin 80cm long and 8cm wide horizontal plate is maintained at a temperature of 130^0C in large tank full of water at 70^0C. Estimate the rate of heat input into the plate Necessary to maintain the temperature of 130^0C. (16)

18. (a) Exhaust gases flowing through the tubular heat exchanger at the rate of 0.4 kg/s are cooled from 450 ^{o} C to 150 ^{o} C by water initially at 15 ^{o} C. The specific heats of exhaust gases and water may be taken as 1.13 and 4.19 kJ/kg/ ^{o} C respectively and the overall heat transfer coefficient from gases to water is 140 W/m^2/ ^{o} C. Calculate the surface area required for the following cases i) parallel flow ii) counter flow, when the cooling water flow rate is 0.5 kg/s. (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) A double-walled spherical vessel used for storing liquid oxygen consists of an inner sphere of 30 cm diameter and an outer sphere of 36 cm diameter. Both the surfaces are covered with a paint of emissivity 0.5. The temperature of liquid oxygen stored is -183^o C where as the temperature of the outer sphere is 20^o C. Calculate the radiation heat transfer through the walls into the vessel and the rate of evaporation of liquid oxygen if its latent heat of vaporizations is 213.54kJ/kg. (16)

Or

(b) Two parallel plates 2mx1m are placed 1m apart. The temperature and the emissivity of the plates are respectively 500^o C, 300^o C, 0.8 and 0.5. Calculate the net radiant heat exchange between them. If a third plate of a same size, but with an emissivity of 0.6 is introduced between the two plates, find the temperature of the third plate and the heat gained by the colder plate. (16)

20. (a) Dry air at 27^{0}C and 1 atm flows over a wet plate 50 cm long at a velocity of 50m/s.Calculate the mass transfer coefficient of water vapour in the air at the end of the plate. D = 0.26 cm^2/s. (16)

Or

(b) A 20 mm diameter solid cylinder of naphthalene is exposed to an air stream for which convective mass transfer coefficient has been found to be 0.05m/s. Estimate the mass sublimation rate per unit length of the cylinder, If the saturated vapour concentration of naphthalene is 5x10$^-$6Kmol/m^3.The Molecular weight of Naphthalene is 128 Kg/Kmol. (16)