B.E. 6th Semester (Mech. Engg.)

Examination, May–2012

HEAT TRANSFER

Paper–ME–306-E

Time allowed : 3 hours] *[Maximum marks : 100*

*Note : Attempt any **five** questions.*

1. (a) A black metal plate, 1 m in diameter and 1 cm thick, is exposed to sun's rays. The plate heats up to such a temperature that rate at which it receives solar energy on one face equals the rate at which it loses heat by radiation and by convection from both surfaces. Presuming the following data calculate the heat transfer by convection

   Solar energy flux = 200 W/m^2, Net radiation sheat flux leaving the plate = 80 W/m^2, Plate temperature = 310 K and surrounding air temperature = 300 K. 10

   (b) A black metal plate (k = 32 W/mK) at 305°C is exposed to surroundings air at 32°C. It convects

and radiates heat to surroundings. If the convection coefficient is 29 W/m^2K what is the temperature gradient in the plate ? 10

2. (a) Derive the general heat diffusion (conduction) equation in cylindrical coordinates. 10

(b) An exterior wall of a house may be approximated by 10 cm layer of common brick (k = 0.75 W/m-deg) followed by 4 cm layer of gypsum plaster (k = 0.5 W/m-deg). What thickness of loosely packed rock wool insulation (k = 0.065 W/m-deg) should be added to reduce the heat gain or loss through the wall by 75%. 10

3. (a) A flat plate fuel element for a nuclear reactor is 6 mm thick and is clad on each face with aluminium 2 mm thick. The rate of heat generation is uniform within element and has magnitude of 5.6×10^8 W/m^3. If the coolant temperature is 140°C, make calculations for the temperature at the free surface of the aluminium, the aluminium interface and at centre of fuel element. 14

(b) Define effectiveness of the fin and describe some ways to enhance the effectiveness of fins. 6

4. Prove that for a body whose thermal resistance is zero, the temperature required for heating or cooling can be obtained from relation $\frac{t - t_a}{t_i - t_a} = \exp\left[-\frac{hA}{wc_p}\right]$, where t is the temperature of a body at any time τ, t_i is the initial temperature of the body, t_a is the ambient temperature, A is surface area and w is the weight of body, c_p is the specific heat of the body material and h is heat transfer coefficient on the surface of the body.

Estimate the time required to cook a carrot in boiling water at atmospheric pressure. The carrot is initially at the room temperature 25°C and the cooking requirement stipulates that a minimum temperature of 90°C is reached at the centre of carrot. Treat the carrot as a long cylinder of 20 mm diameter and having the following thermo physical properties :

$\rho = 1025$ kg/m^3, $c_p = 4000$ J/kgK, $k = 0.48$ W/mK, $h = 2000$ W/m^{2}K. 20

5. (a) Derive the energy equation

$$u\frac{\partial t}{\partial x}+v\frac{\partial t}{\partial y}=\alpha\frac{\partial^2 t}{\partial y^2}$$ 12

(b) A plate 0.5 m × 0.2 m has been placed longitudinally in a stream of crude oil which flows with undisturbed velocity of 6 m/s. Given that oil has a specific gravity 0.9 and kinematic viscosity 1 stoke, calculate the boundary layer thickness and shear at the middle of plate. 8

6. (a) State and explain Planck's law and Stefan Boltzman's law. 8

(b) Two parallel square plates, each 4 m^2 area, are large compared to a gap of 4 mm separating them. One plate has a temperature of 790 K and surface emissivity of 0.5 while the other has a temperature of 290 K and surface emissivity of 0.88. Find the net energy exchange by radiation between them. 12

7. (a) What is meant by fouling factor ? How does it affect the performance of heat exchanger ? 5

(b) A tube type heat exchanger is used to cool hot water from 90°C to 70°C. The task is accomplished by transferring heat to cold water that enters the heat exchanger at 30°C and leaves at 45°C. Should this heat exchanger operate under counter flow or parallel flow conditions ? Also determine the exit temperatures if the flow rates of fluids are doubled. 15

8. What is condensation and when does it occur ? Distinguish between mechanism of film wise condensation and drop wise condensation. Which types has the highest heat transfer film coefficient and explain why this is so ? In the design of condensers, which of the two types of condensation is usually selected and why ? 20