VIT
Vellore Institute of Technology

Final Assessment Test – November 2019

Course: MEE2005 - Heat Transfer

Class NBR(s): 0826 / 1337 / 1869 Slot: A2+TA2+V3

Time: Three Hours Max. Marks: 100

KEEPING MOBILE PHONE/SMART WATCH, EVEN IN 'OFF' POSITION, IS EXAM MALPRACTICE

General Instructions: i) Assume suitable data if required.
ii) Heat and Mass Transfer data book is permitted.

Answer any TEN Questions
(10 X 10 = 100 Marks)

1. With neat sketch derive the general three-dimensional conduction equation with heat generation for cubical element. Deduce the heat conduction equation for the following special cases from the general heat conduction equation: (i) steady state, (ii) Transient & no heat generation, (iii) steady-state, no heat generation. [10]

2. A square plate heater (15 cm × 15 cm) is inserted between two slabs as shown in Fig. 1. Slab A is 2 cm thick (k = 50 W/mK) and slab B is 1 cm thick (k = 0.2 W/mK). [10]

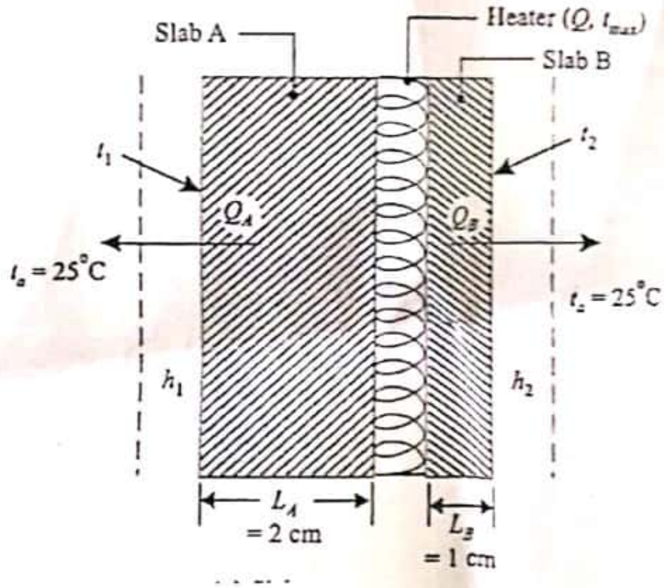

Fig. 1

The outside heat transfer coefficient on side A and side B are 200 W/mK and 50 W/mK respectively. The temperature of surrounding air is 25°C. if rating of heater is 1 kW, find:

(i) Maximum temperature in the system
(ii) Outer surface temperature of two slabs
(iii) Draw an equivalent electrical circuit

3. A short aluminum cylinder 5.0 cm in diameter and 10.0 cm long is initially at a uniform temperature of 200°C. It is suddenly subjected to a convection environment at 70°C, and h = 525 W/m^2°C. Calculate the temperature at a radial position of 1.25 cm and a distance of 0.625 cm from one end of the cylinder 1 min after exposure to the environment. [10]

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4. The initial uniform temperature of a thick concrete wall ($\alpha = 1.6 \times 10^{-3}$, $k = 0.94$ W/mK) of a jet engine test cell is 25°C. The surface temperature of the wall suddenly rises to 340°C when the combination of exhaust gases from the turbojet and spray cooling water occurs. [10]

Determine:

(i) The temperature at a point 80 mm from the surface after 8 hr.

(ii) The instantaneous heat flow rate at the specified plane and at the surface itself at the instant method at (i)

Use the solution for semi-infinite solid.

5. Air at 27°C and 1 atm flows over a flat plate at a speed of 2 m/s. Calculate the boundary-layer thickness at distances of 20 cm and 40 cm from the leading edge of the plate. [10]

For the flow system assume that the plate is heated over its entire length to a temperature of 60°C. Calculate the heat transferred in (a) the first 20 cm of the plate and (b) the first 40 cm of the plate.

6. In an industrial facility, air is to be preheated before entering a furnace by geothermal water at 120°C flowing through the tubes of a tube bank located in a duct. Air enters the duct at 20°C and 1 atm. with a mean velocity of 4.5 m/s, and flows over the tubes in normal direction. The outer diameter of the tubes is 1.5 cm, and the tubes are arranged in-line with longitudinal and transverse pitches of $S_L = S_T = 5$ cm. There are 6 rows in the flow direction with 10 tubes in each row, as shown in Fig. 2. Determine the rate of heat transfer per unit length of the tubes [10]

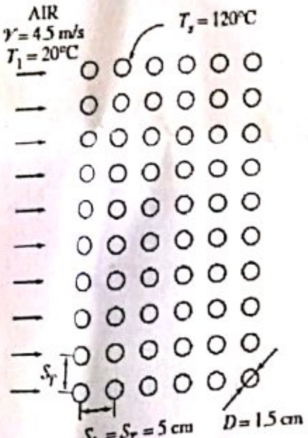

Fig.2

7. Hot air flows with a mass rate of 0.050 kg/s through an uninsulated sheet metal duct of diameter of 0.15m, which is in the crawlspace of a house. The hot air enters at 103°C and, after a distance of 5 m, cools to 85°C. The heat transfer coefficient between the duct outer surface and the ambient air at 0°C is known to be $h = 6$ W/m^{2}K. [10]

i) Calculate the heat loss (W) from the duct over the length

ii) Determine the heat flux and the duct surface temperature at length

8. In a plant location near a furnace, a net radiant energy flux of 800 W/m^2 is incident on a vertical metal surface 3.5 m high and 2 m wide. The metal is insulated on the back side and painted black so that all the incoming radiation is lost by free convection to the surrounding air at 30°C. What average temperature will be attained by the plate? [10]

9. Consider a 0.6 m x 0.6 m thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated, as shown in Fig. 3. Determine the rate of heat transfer from the plate by natural convection if the plate is (a) vertical, (b) horizontal with hot surface facing up [10]

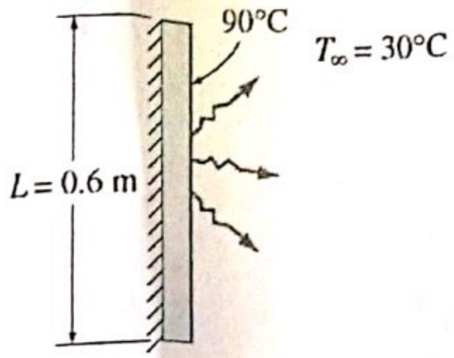

Fig. 3

10. Two large parallel planes are at $T_1 = 800$ K, $\varepsilon_1 = 0.3$, $T_2 = 400$ K, $\varepsilon_2 = 0.7$ and are separated by a gray gas having, $\varepsilon_g = 0.2$, $\tau_g = 0.8$. Calculate the heat-transfer rate between the two planes and the temperature of the gas using a radiation network. Compare with the heat transfer without presence of the gas. [10]

11. Three thin walled infinitely long hollow cylinders of radii 5 cm, 10 cm, and 15 cm are arranged concentrically as shown in Fig. 4. $T_1 = 1100$ K and $T_3 = 300$ K. [10]

Assuming $\varepsilon 1 = \varepsilon 2 = \varepsilon 3 = 0.05$ and vacuum in the spaces between the cylinders. Calculate the steady state temperature of cylinder surface 2 and heat flow per m^2 area of cylinder 1.

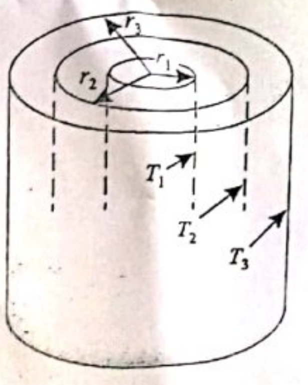

Fig. 4

12. Hot gases, which enter a finned tube, cross flow heat exchanger at 300°C and leave at 100°C, are used to heat pressurized water at a flow rate of 1 kg/s from 35 to 125°C. The exhaust gas specific heat is approximately 1000 J/kg K and the over all heat transfer coefficient based on the gas side surface area is $U_h = 100$ W/m^{2}K. Determine the required gas side area using NTU method. [10]

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