Abdelhafid Boussouf University Center – Mila
Institute of Science & Technology
Process Engineering – E2
Heat Transfer

Academic year: **2024-2025** Instructor: **Dr. Mohamed BOUTI**

In-Class Exercises n°02

Exercise 2.1

The temperature distribution across a wall **1 m thick** at a certain instant of time is given a

$$T(x) = a + bx + cx^2$$

Where

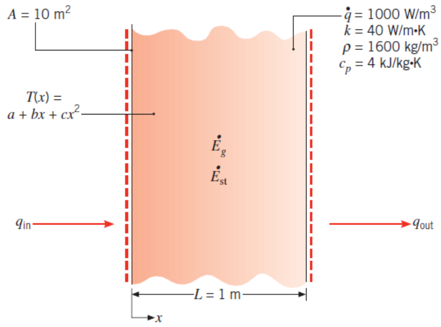
T is in degrees Celsius and **x** is in meters

While

$a = 900°C$, $b = -300°C/m$, and $c = -50°C/m^2$

A uniform heat generation, $\dot{g} = 1000\ W/m^3$, is present in the wall of area **10 m²** having the properties

$\rho = 1600\ kg/m^3$, $k = 40\ W/m{\cdot}K$, and $c_p = 4\ kJ/kg{\cdot}K$



(Figure 2.1)

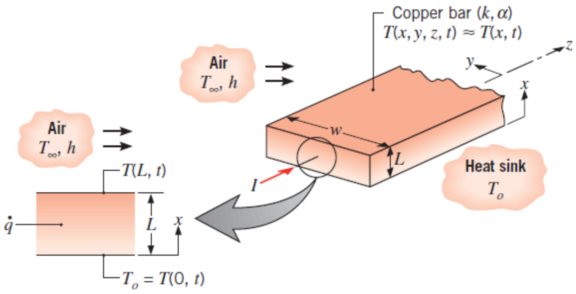
1. Determine the rate of heat transfer entering the wall (**x = 0**) and leaving the wall (**x = 1 m**).

2. Determine the rate of change of energy storage in the wall.

3. Determine the time rate of temperature change at **x = 0, 0.25**, and **0.5 m**.

Exercise 2.2

A long copper bar of rectangular cross section, whose width w is much greater than its thickness **L**, is maintained in contact with a heat sink at its lower surface, and the temperature throughout the bar is approximately equal to that of the sink, T_o. Suddenly, an electric current is passed through the bar and an airstream of temperature T_∞ is passed over the top surface, while the bottom surface continues to be maintained at T_o.



(Figure 2.2)

Obtain the differential equation and the boundary and initial conditions that could be solved to determine the temperature as a function of position and time in the bar.

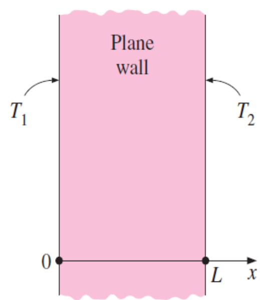
Exercise 2.3

Consider a large plane wall of thickness **L = 0.2 m**, thermal conductivity $k = 1.2\ W/m{\cdot}°C$, and surface area $A = 15\ m^2$. The two sides of the wall are maintained at constant temperatures of $T_1 = 120°C$ and $T_2 = 50°C$, respectively, as shown in **Figure 2–3**.

Determine

a) the variation of temperature within the wall and the value of temperature at **x = 0.1 m**

b) the rate of heat conduction through the wall under steady conditions.

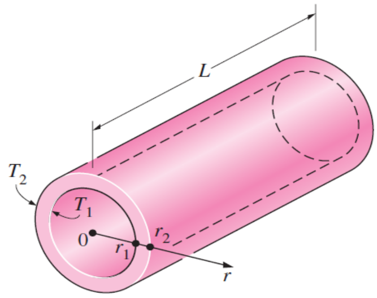


(Figure 2.3)

Exercise 2.4

Consider a steam pipe of length **L = 20 m**, inner radius $\mathbf{r_1}$ **= 6 cm**, outer radius $\mathbf{r_2}$ **= 8 cm**, and thermal conductivity **k = 20 W/m·°C**, as shown in **Figure 2–4**. The inner and outer surfaces of the pipe are maintained at average temperatures of $\mathbf{T_1}$ **= 150 °C** and $\mathbf{T_2}$ **= 60 °C**, respectively.

Obtain a general relation for the temperature distribution inside the pipe under steady conditions, and determine the rate of heat loss from the steam through the pipe.

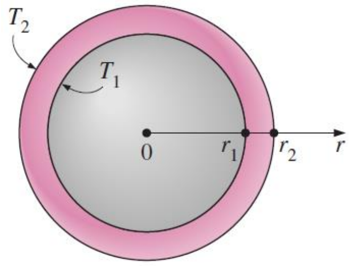


(Figure 2.4)

Exercise 2.5

Consider a spherical container of inner radius $\mathbf{r_1}$ **= 8 cm**, outer radius $\mathbf{r_2}$ **= 10 cm**, and thermal conductivity **k = 45 W/m·°C**, as shown in **Figure 2–5**. The inner and outer surfaces of the container are maintained at constant temperatures of $\mathbf{T_1}$ **= 200 °C** and $\mathbf{T_2}$ **= 80 °C**, respectively, as a result of some chemical reactions occurring inside.

Obtain a general relation for the temperature distribution inside the shell under steady conditions, and determine the rate of heat loss from the container.



(Figure 2.5)

Exercise 2.6

Consider, for each situation, a medium in which the heat conduction equation is given in its simplest form as

Situation 1	Situation 2	Situation 3
$\frac{\partial^2 T}{\partial x^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$	$\frac{1}{r}\frac{d}{dr}\left(rk\frac{dT}{dr}\right) + \dot{g} = 0$	$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{dT}{dr}\right) = \frac{1}{\alpha}\frac{\partial T}{\partial t}$

a) Is heat transfer steady or transient?
b) Is heat transfer one-, two-, or three-dimensional?
c) Is there heat generation in the medium?
d) Is the thermal conductivity of the medium constant or variable?

Exercise 2.7

Beginning with a differential control volume in the form of a cylindrical shell, derive the heat diffusion equation for a one-dimensional, cylindrical, radial coordinate system with internal heat generation. Compare your result with Equation (**Eq.02**).

Exercise 2.8

Beginning with a differential control volume in the form of a spherical shell, derive the heat diffusion equation for a one-dimensional, spherical, radial coordinate system with internal heat generation. Compare your result with Equation (**Eq.03**).