Tutorial 3

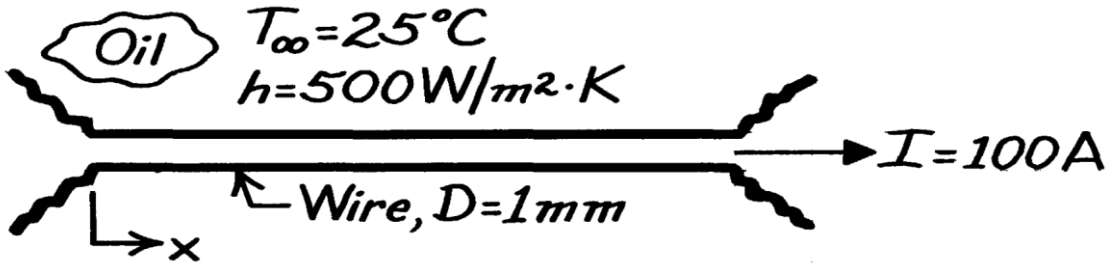
ME346-S3 Fall 2023

Question 1

A long wire of diameter D = 1 mm is submerged in an oil bath of temperature T_∞ = 25°C. The wire has an electrical resistance per unit length of R'_e = 0.01 Ω/m. The properties of the wire are ρ = 8000 kg/m^3 , c = 500 J/kg · K, and k = 20 W/m · K.

If a current of I = 100 A flows through the wire and the convection coefficient is h = 500 W/m^2 · K, what is the steady-state temperature of the wire?

From the time the current is applied, how long does it take for the wire to reach a temperature that is within 1°C of the steady-state value?

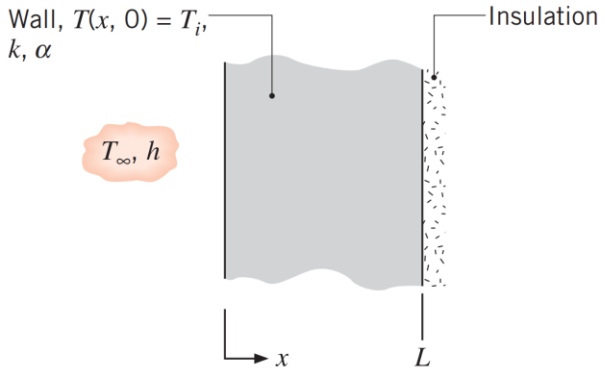


Question 2

Consider the one-dimensional wall shown in the sketch, which is initially at a uniform temperature T_i and is suddenly subjected to the convection boundary condition with a fluid at T_∞.

For a particular wall, case 1, the temperature at $x = L_1$ after $t_1 = 100$ s is $T_1(L_1, t_1) = 315°C$. Another wall, case 2, has different thickness and thermal conditions as shown.

How long will it take for the second wall to reach 28.5°C at the position $x = L_2$?



Case	L (m)	α (m^2/s)	k ($W/m \cdot K$)	T_i (°C)	T_∞ (°C)	h ($W/m^2 \cdot K$)
1	0.10	15×10^{-6}	50	300	400	200
2	0.40	25×10^{-6}	100	30	20	100