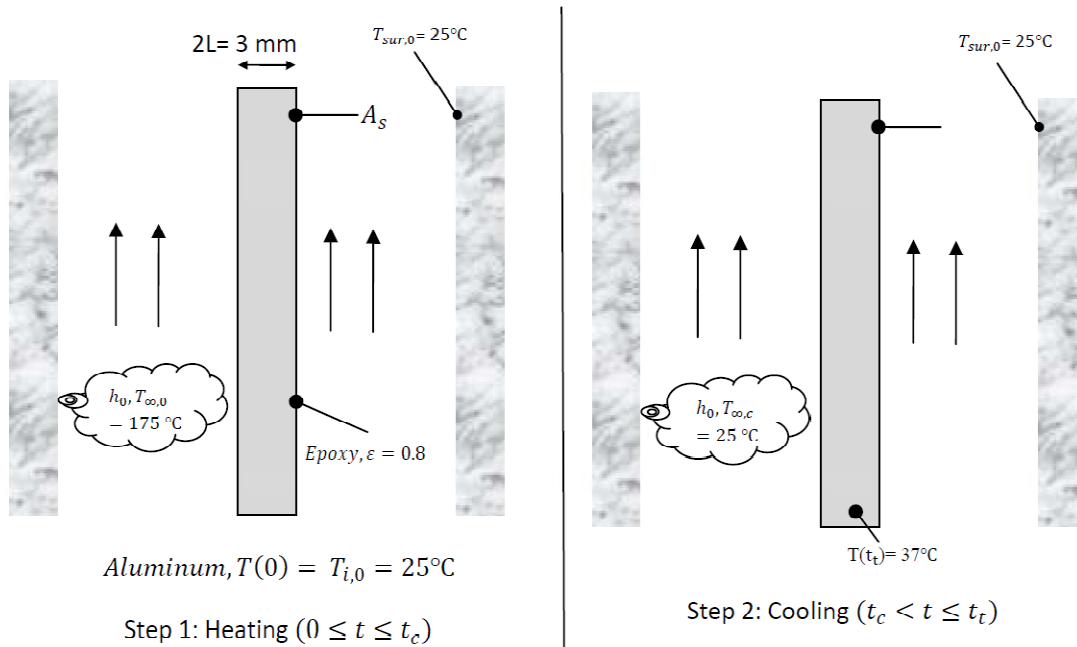# ENSC 388

Assignment #8

Assignment date: Wednesday Nov. 18, 2009

Due date: Wednesday Nov. 25, 2009

Problem 1

A 3-*mm*-thick panel of aluminum alloy ($k = 177$ $W/m{\cdot}K$, $c = 875$ $J/kg{\cdot}K$, and $\rho = 2770$ kg/m^3) is finished on both sides with an epoxy coating that must be cured at or above $T_c = 150°C$ for at least 5 min. The production line for the curing operation involves two steps: (1) heating in a large oven with air at $T_{\infty,o} = 175°C$ and a convection coefficient of $h_o = 40$ $W/m^2{\cdot}K$, and (2) cooling in a large chamber with air a $T_{\infty,c} = 25°C$ and a convection coefficient of $h_c = 10$ $W/m^2{\cdot}K$. The heating portion of the process is conducted over a time interval t_e, which exceeds the time t_c required to reach $150°C$ by 5 min ($t_e = t_c + 300$ s). The coating has an emissivity of $\varepsilon = 0.8$, and the temperatures of the oven and chamber walls are $175°C$ and $25°C$, respectively. If the panel is placed in the oven at an initial temperature of $25°C$ and removed from the chamber at a *safe-to-touch* temperature of $37°C$, what is the total elapsed time for the two-step curing operation?

2L= 3 mm $T_{sur,0}= 25°C$ $T_{sur,0}= 25°C$

A_s

$h_0, T_{\infty,0}$
$- 175\ °C$

$h_0, T_{\infty,c}$
$= 25\ °C$

$Epoxy, \varepsilon = 0.8$

$Aluminum, T(0) = T_{i,0} = 25°C$

Step 1: Heating ($0 \le t \le t_c$)

$T(t_t)= 37°C$

Step 2: Cooling ($t_c < t \le t_t$)

Problem 2

Consider a steel pipeline (AISI 1010) that is 1 *m* in diameter and has a wall thickness of 40 *mm*. The pipe is heavily insulated on the outside, and before the initiation of flow, the walls of the pipe are at a uniform temperature of -*20°C*. With the initiation of flow, hot oil at *60°C* is pumped through the pipe, creating a convective surface condition corresponding to h = 500 *W/m²·K* at the inner surface of the pipe.

l. What are the appropriate Biot and Fourier numbers 8 min after the initiation of flow?

2. At t = 8 min, what is the temperature of the exterior pipe surface covered by the insulation?

3. What is the heat flux q'' (W/m²) to the pipe from the oil at t = *8* min?

4. How much energy per meter of pipe length has been transferred from the oil to the pipe at t = 8 min?

$T(x, 0)$= T_i = −20°C

$T(L, t)$

$T(0, t)$

T_∞ = 60°C, h = 500$W/m^2.K$

Insulation

Steel, AISI 1010

$T(L, t)$

L=40 mm

x