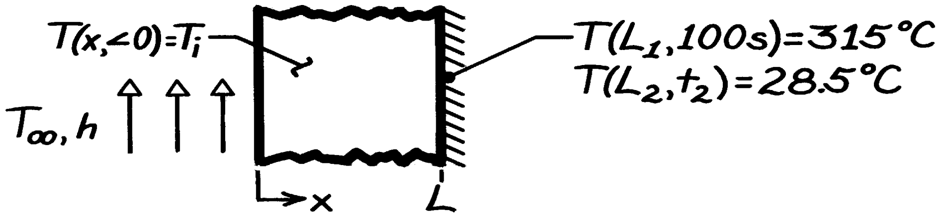
PROBLEM 5.44

KNOWN: One-dimensional wall, initially at a uniform temperature, T_i, is suddenly exposed to a convection process (T_∞, h). For wall #1, the time (t_1 = 100s) required to reach a specified temperature at x = L is prescribed, $T(L_1, t_1)$ = 315°C.

FIND: For wall #2 of different thickness and thermal conditions, the time, t_2, required for $T(L_2, t_2)$ = 28°C.

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction, (2) Constant properties.

ANALYSIS: The properties, thickness and thermal conditions for the two walls are:

Wall	L(m)	$\alpha(m^2/s)$	k(W/m·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

The dimensionless functional dependence for the one-dimensional, transient temperature distribution, Eq. 5.38, is

$$\theta^* = \frac{T(x,t) - T_\infty}{T_i - T_\infty} = f\left(x^*,\ Bi,\ Fo\right)$$

where

$$x^* = x/L \qquad Bi = hL/k \qquad Fo = \alpha t/L^2.$$

If the parameters x*, Bi, and Fo are the same for both walls, then $\theta_1^* = \theta_2^*$. Evaluate these parameters:

Wall	x*	Bi	Fo	θ*
1	1	0.40	0.150	0.85
2	1	0.40	$1.563\times10^{-4}\ t_2$	0.85

where

$$\theta_1^* = \frac{315-400}{300-400} = 0.85 \qquad \theta_2^* = \frac{28.5-20}{30-20} = 0.85.$$

It follows that

$$Fo_2 = Fo_1 \qquad 1.563\times10^{-4} t_2 = 0.150$$

$$t_2 = 960s.$$

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