PROBLEM 2.45

KNOWN: Steady-state data are provided for a composite wall formed from a steel layer and a brick layer.

FIND: Determine the minimum thickness of the brick layer to keep the outer surface temperature of the brick $\leq 105°F$.

SCHEMATIC & GIVEN DATA:

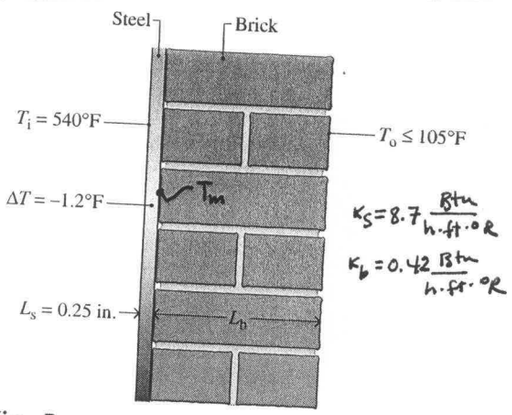

Fig. P2.45

ENGR. MODEL:

1. The wall is at steady state.
2. The temperature varies linearly through each layer.

ANALYSIS:

Using Eq. 2.31 together with assumption 2

$$\left(\frac{\dot{Q}}{A}\right)_{steel} = -k_s\left[\frac{T_m - T_i}{L_s}\right]$$

$$\left(\frac{\dot{Q}}{A}\right)_{brick} = -k_b\left[\frac{T_o - T_m}{L_b}\right]$$

where T_m denotes the temperature at the steel-brick interface.

At steady state, the rate of conduction to the steel-brick interface must equal the rate of conduction from that interface. Thus

$$\left(\frac{\dot{Q}}{A}\right)_{steel} = \left(\frac{\dot{Q}}{A}\right)_{brick}$$

$$-k_s\left[\frac{T_m - T_i}{L_s}\right] = -k_b\left[\frac{T_o - T_m}{L_b}\right]$$

$(540 - 1.2) = 538.8°F$

Solving

$$L_b = \frac{k_b}{k_s}\left[\frac{T_o - T_m}{\underbrace{T_m - T_i}_{=-1.2°F}}\right]L_s$$

$$L_b = \left(\frac{0.42\ Btu/h \cdot ft \cdot °R}{8.7\ Btu/h \cdot ft \cdot °R}\right)\left[\frac{538.8 - T_o}{1.2°F}\right](0.25in)$$

Since $T_o \leq 105°F$,

$$L_b \geq \left(\frac{0.42}{8.7}\right)\left[\frac{538.8 - 105}{1.2°F}\right](0.25in)$$

$$L_b \geq 4.36\ in.$$ ←