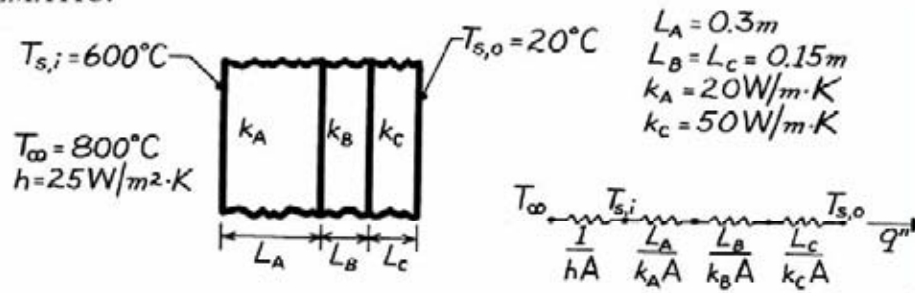


PROBLEM 3.9

KNOWN: Thicknesses of three materials which form a composite wall and thermal conductivities of two of the materials. Inner and outer surface temperatures of the composite; also, temperature and convection coefficient associated with adjoining gas.

FIND: Value of unknown thermal conductivity, k_B .

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional conduction, (3) Constant properties, (4) Negligible contact resistance, (5) Negligible radiation effects.

ANALYSIS: Referring to the thermal circuit, the heat flux may be expressed as

$$q'' = \frac{T_{s,i} - T_{s,o}}{\frac{L_A}{k_A} + \frac{L_B}{k_B} + \frac{L_C}{k_C}} = \frac{(600 - 20)^{\circ}\text{C}}{\frac{0.3\text{ m}}{20\text{ W/m}\cdot\text{K}} + \frac{0.15\text{ m}}{k_B} + \frac{0.15\text{ m}}{50\text{ W/m}\cdot\text{K}}}$$

$$q'' = \frac{580}{0.018 + 0.15/k_B} \text{ W/m}^2. \quad (1)$$

The heat flux may be obtained from

$$q'' = h(T_{\infty} - T_{s,i}) = 25\text{ W/m}^2 \cdot \text{K} (800 - 600)^{\circ}\text{C} \quad (2)$$

$$q'' = 5000\text{ W/m}^2.$$

Substituting for the heat flux from Eq. (2) into Eq. (1), find

$$\frac{0.15}{k_B} = \frac{580}{q''} - 0.018 = \frac{580}{5000} - 0.018 = 0.098$$

$$k_B = 1.53\text{ W/m}\cdot\text{K}. \quad <$$

COMMENTS: Radiation effects are likely to have a significant influence on the net heat flux at the inner surface of the oven.