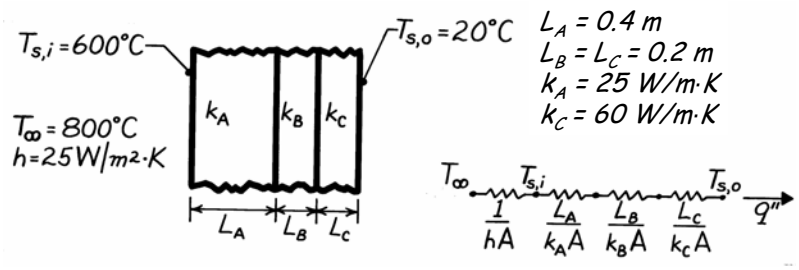
PROBLEM 3.18

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

$$q'' = \frac{T_{s,i} - T_{s,o}}{\frac{L_A}{k_A} + \frac{L_B}{k_B} + \frac{L_C}{k_C}} = \frac{(600 - 20)^\circ C}{\frac{0.4\ m}{25\ W/m \cdot K} + \frac{0.20\ m}{k_B} + \frac{0.20\ m}{60\ W/m \cdot K}}$$

$$q'' = \frac{580}{0.01933 + 0.20/k_B}\ W/m^2. \tag{1}$$

The heat flux may be obtained from

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

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

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

$$\frac{0.20}{k_B} = \frac{580}{q''} - 0.01933 = \frac{580}{5000} - 0.01933 = 0.0967$$

$$k_B = 2.07\ W/m \cdot K. \quad <$$

COMMENTS: Radiation effects might influence the net heat flux at the inner surface of the oven.