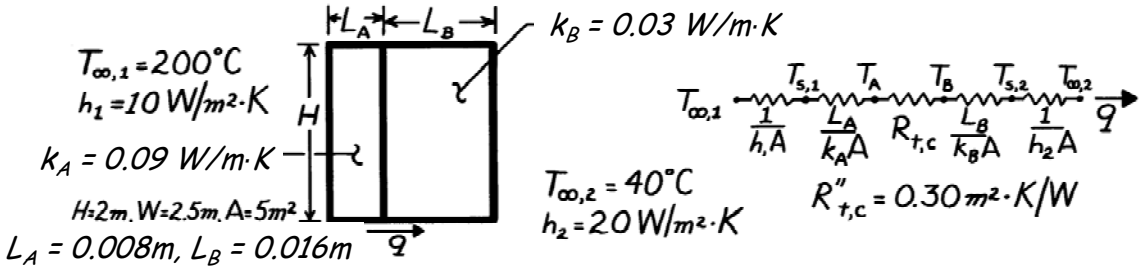
PROBLEM 3.29

KNOWN: Temperatures and convection coefficients associated with fluids at inner and outer surfaces of a composite wall. Contact resistance, dimensions, and thermal conductivities associated with wall materials.

FIND: (a) Rate of heat transfer through the wall, (b) Temperature distribution.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional heat transfer, (3) Negligible radiation, (4) Constant properties.

ANALYSIS: (a) Calculate the total resistance to find the heat rate,

$$R_{tot} = \frac{1}{h_1A} + \frac{L_A}{k_AA} + R_{t,c} + \frac{L_B}{k_BA} + \frac{1}{h_2A}$$

$$R_{tot} = \left[\frac{1}{10\times5} + \frac{0.008}{0.09\times5} + \frac{0.3}{5} + \frac{0.016}{0.03\times5} + \frac{1}{20\times5}\right]\frac{K}{W}$$

$$R_{tot} = \left[0.02 + 0.018 + 0.06 + 0.107 + 0.01\right]\frac{K}{W} = 0.214\,\frac{K}{W}$$

$$q = \frac{T_{\infty,1} - T_{\infty,2}}{R_{tot}} = \frac{(200-40)^\circ C}{0.214\ K/W} = 746\ W. \quad <$$

(b) It follows that

$$T_{s,1} = T_{\infty,1} - \frac{q}{h_1A} = 200^\circ C - \frac{746\ W}{50\ W/K} = 185.1^\circ C$$

$$T_A = T_{s,1} - \frac{qL_A}{k_AA} = 185^\circ C - \frac{746W\times0.008m}{0.09\frac{W}{m\cdot K}\times5m^2} = 171.8^\circ C$$

$$T_B = T_A - qR_{t,c} = 171.8^\circ C - 746W\times0.06\frac{K}{W} = 127.1^\circ C$$

$$T_{s,2} = T_B - \frac{qL_B}{k_BA} = 127.1^\circ C - \frac{746W\times0.016m}{0.03\frac{W}{m\cdot K}\times5m^2} = 47.5^\circ C$$

$$T_{\infty,2} = T_{s,2} - \frac{q}{h_2A} = 47.5^\circ C - \frac{746W}{100W/K} = 40^\circ C$$