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Solution Manual Convective Heat Transfer Kays

PROBLEM 11

KNOWN: Heat rate, q , through one-dimensional wall of area A , thickness L , thermal conductivity k and inner temperature, T_1 .

FIND: The outer temperature of the wall, T_2 .

SCHEMATIC:

$k = 0.2 \text{ W/m}\cdot\text{K}$
 $A = 10 \text{ m}^2$
 $T_1 = 415^\circ\text{C}$
 $L = 2.5 \text{ cm}$
 $q_{\text{cond}} = 5 \text{ kW}$

ASSUMPTIONS: (1) One-dimensional conduction in the x -direction, (2) Steady-state conditions, (3) Constant properties.

ANALYSIS: The rate equation for conduction through the wall is given by Fourier's law,

$$q_{\text{cond}} = q_1 = q_2 = k \frac{dT}{dx} = kA \frac{T_1 - T_2}{L}$$

Solving for T_2 gives

$$T_2 = T_1 - \frac{q_{\text{cond}} L}{kA}$$

Substituting numerical values, find

$$T_2 = 415^\circ\text{C} - \frac{5000 \text{ W} \times 0.025 \text{ m}}{0.2 \text{ W/m}\cdot\text{K} \times 10 \text{ m}^2}$$
$$T_2 = 415^\circ\text{C} - 37.5^\circ\text{C}$$
$$T_2 = 378^\circ\text{C}$$

COMMENTS: Note direction of heat flow and fact that T_2 must be less than T_1 .