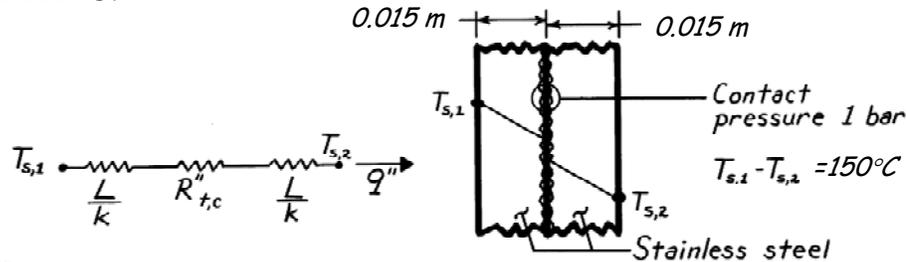


PROBLEM 3.28

KNOWN: Thickness, overall temperature difference, and pressure for two stainless steel plates.

FIND: (a) Heat flux and (b) Contact plane temperature drop.

SCHEMATIC:



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

PROPERTIES: Table A-1, Stainless Steel ($T \approx 400\text{K}$): $k = 16.6 \text{ W/m}\cdot\text{K}$.

ANALYSIS: (a) With $R''_{t,c} \approx 15 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$ from Table 3.1 and

$$\frac{L}{k} = \frac{0.015\text{m}}{16.6 \text{ W/m}\cdot\text{K}} = 9.04 \times 10^{-4} \text{ m}^2 \cdot \text{K/W},$$

it follows that

$$R''_{\text{tot}} = 2(L/k) + R''_{t,c} \approx 33.1 \times 10^{-4} \text{ m}^2 \cdot \text{K/W};$$

hence

$$q'' = \frac{\Delta T}{R''_{\text{tot}}} = \frac{150^\circ\text{C}}{33.1 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}} = 4.54 \times 10^4 \text{ W/m}^2. \quad <$$

(b) From the thermal circuit,

$$\frac{\Delta T_c}{T_{s,1} - T_{s,2}} = \frac{R''_{t,c}}{R''_{\text{tot}}} = \frac{15 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}}{33.1 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}} = 0.453.$$

Hence,

$$\Delta T_c = 0.453(T_{s,1} - T_{s,2}) = 0.453(150^\circ\text{C}) = 68^\circ\text{C}. \quad <$$

COMMENTS: The contact resistance is significant relative to the conduction resistances. The value of $R''_{t,c}$ would diminish, however, with increasing pressure. Note that there is considerable uncertainty in the answer since the thermal contact resistance can take on a wide range of values.