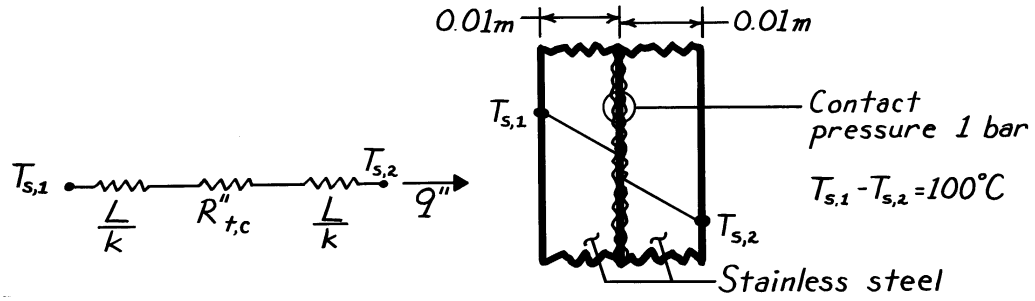
PROBLEM 05

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 ≈ 400K): k = 16.6 W/m·K.

ANALYSIS: (a) With $R''_{t,c} \approx 15\times10^{-4}\ m^2\cdot K/W$ from Table 3.1 and

$$\frac{L}{k}=\frac{0.01m}{16.6\ W/m\cdot K}=6.02\times10^{-4}m^2\cdot K/W,$$

it follows that

$$R''_{tot}=2\left(L/k\right)+R''_{t,c}\approx 27\times10^{-4}m^2\cdot K/W;$$

hence

$$q''=\frac{\Delta T}{R''_{tot}}=\frac{100^\circ C}{27\times10^{-4}m^2\cdot K/W}=3.70\times10^4 W/m^2. \quad <$$

(b) From the thermal circuit,

$$\frac{\Delta T_c}{T_{s,1}-T_{s,2}}=\frac{R''_{t,c}}{R''_{tot}}=\frac{15\times10^{-4}m^2\cdot K/W}{27\times10^{-4}m^2\cdot K/W}=0.556.$$

Hence,

$$\Delta T_c=0.556\left(T_{s,1}-T_{s,2}\right)=0.556\left(100^\circ C\right)=55.6^\circ C. \quad <$$

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.