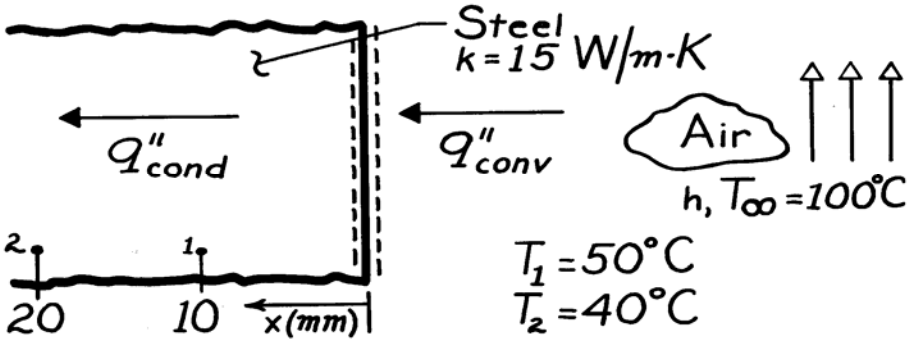
PROBLEM 1.77

KNOWN: Temperatures at 10 mm and 20 mm from the surface and in the adjoining airflow for a thick stainless steel casting.

FIND: Surface convection coefficient, h.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state, (2) One-dimensional conduction in the x-direction, (3) Constant properties, (4) Negligible generation.

ANALYSIS: From a surface energy balance, it follows that

$$q''_{cond} = q''_{conv}$$

where the convection rate equation has the form

$$q''_{conv} = h\left(T_\infty - T_0\right),$$

and q''_{cond} can be evaluated from the temperatures prescribed at surfaces 1 and 2. That is, from Fourier's law,

$$q''_{cond} = k\frac{T_1 - T_2}{x_2 - x_1}$$

$$q''_{cond} = 15\frac{W}{m\cdot K}\frac{(50-40)^\circ C}{(20\text{-}10)\times 10^{-3} m} = 15{,}000\ W/m^2.$$

Since the temperature gradient in the solid must be linear for the prescribed conditions, it follows that

$$T_o = 60°C.$$

Hence, the convection coefficient is

$$h = \frac{q''_{cond}}{T_\infty - T_0}$$

$$h = \frac{15{,}000\ W/m^2}{40^\circ C} = 375\ W/m^2\cdot K. \quad <$$

COMMENTS: The accuracy of this procedure for measuring h depends strongly on the validity of the assumed conditions.