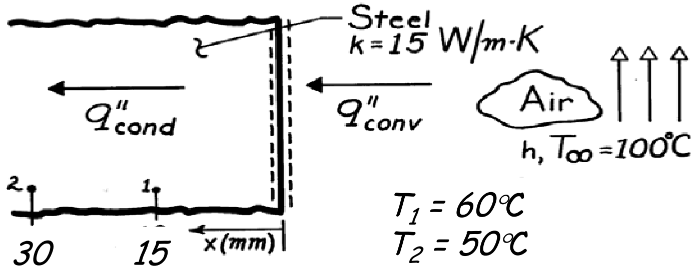
PROBLEM 1.77

KNOWN: Temperatures at 15 mm and 30 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,

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

$$q''_{cond} = 15\frac{W}{m \cdot K}\frac{\left(60-50\right)^\circ C}{\left(30\text{-}15\right)\times 10^{-3} m} = 10,000\ W/m^2.$$

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

$$T_o = 70°C.$$

Hence, the convection coefficient is

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

$$h = \frac{10,000\ W/m^2}{30°C} = 333\ W/m^2 \cdot K$$ <

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