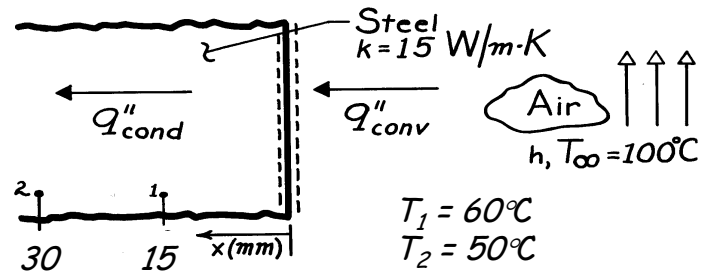


PROBLEM 1.58

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

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

where the convection rate equation has the form

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

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

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

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

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

$$T_0 = 70^{\circ}\text{C}.$$

Hence, the convection coefficient is

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

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

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