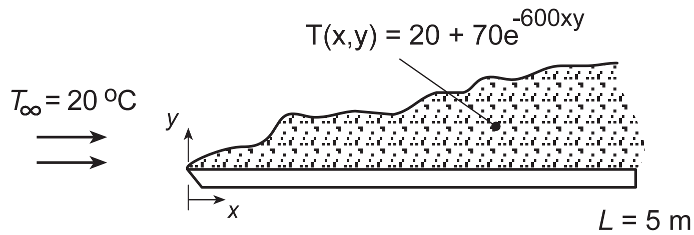
PROBLEM 6.12

KNOWN: Temperature distribution in boundary layer for air flow over a flat plate.

FIND: Variation of local convection coefficient along the plate and value of average coefficient.

SCHEMATIC:



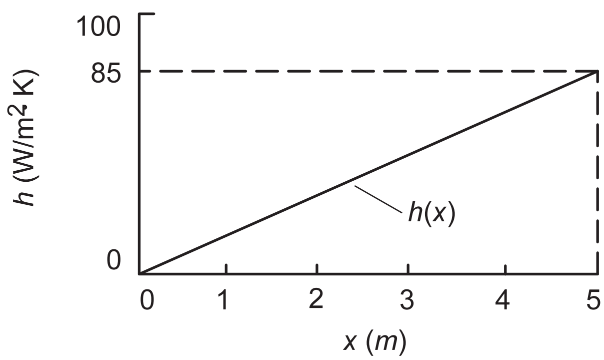
ANALYSIS: From Eq. 6.5,

$$h = -\frac{k\,\partial T/\partial y|_{y=0}}{(T_s - T_\infty)} = +\frac{k(70 \times 600x)}{(T_s - T_\infty)}$$

where $T_s = T(x,0) = 90°C$. Evaluating k at the arithmetic mean of the freestream and surface temperatures, $\bar{T}$ = (20 + 90)°C/2 = 55°C = 328 K, Table A.4 yields k = 0.0284 W/m·K. Hence, with $T_s - T_\infty$ = 70°C = 70 K,

$$h = \frac{0.0284\,\text{W/m}\cdot\text{K}(42{,}000x)\,\text{K/m}}{70\,\text{K}} = 17x\left(\text{W/m}^2\cdot\text{K}\right)$$ <

and the convection coefficient increases linearly with x.



The average coefficient over the range 0 ≤ x ≤ 5 m is

$$\bar{h} = \frac{1}{L}\int_0^L h\,dx = \frac{17}{5}\int_0^5 x\,dx = \frac{17}{5}\left.\frac{x^2}{2}\right|_0^5 = 42.5\,\text{W/m}^2\cdot\text{K}$$ <