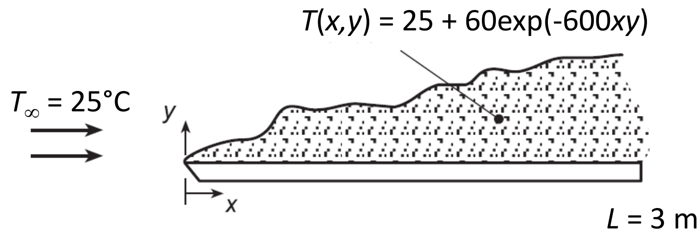
PROBLEM 6.11

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

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

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Uniform properties.

PROPERTIES: *Table A-4*, Helium (T_s = 85°C = 358 K), k = 0.173 W/m·K.

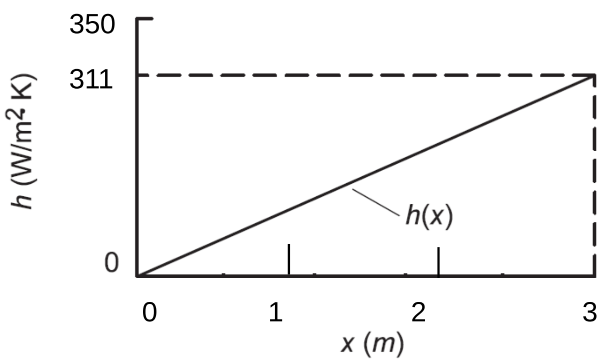
ANALYSIS: From Eq. 6.5,

$$h = -\frac{k\,\partial T/\partial y|_{y=0}}{(T_s - T_\infty)} = +\frac{k(60\times 600x)}{(T_s - T_\infty)}$$

where k is evaluated at y= 0 and T_s = T(x,0) = 85°C. Hence, with T_s - T_∞ = 60°C = 60 K,

$$h = \frac{0.173\,W/m\cdot K(36,000x)K/m}{60\,K} = 104x\left(W/m^2\cdot K\right)$$ <

and the convection coefficient increases linearly with x.



The average coefficient over the range 0 ≤ x ≤ 3 m is

$$\bar{h} = \frac{1}{L}\int_0^L h dx = \frac{104}{3}\int_0^3 x dx = \frac{104}{3}\left.\frac{x^2}{2}\right|_0^3 = 155\,W/m^2\cdot K$$ <