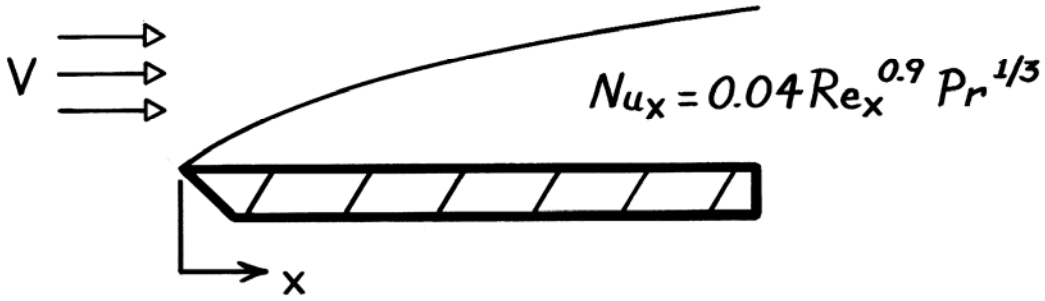
PROBLEM 6.32

KNOWN: Local Nusselt number correlation for flow over a roughened surface.

FIND: Ratio of average heat transfer coefficient to local coefficient.

SCHEMATIC:



ANALYSIS: The local convection coefficient is obtained from the prescribed correlation,

$$h_x = Nu_x \frac{k}{x} = 0.04 \frac{k}{x} Re_x^{0.9} Pr^{1/3}$$

$$h_x = 0.04\, k \left[\frac{V}{\nu}\right]^{0.9} Pr^{1/3} \frac{x^{0.9}}{x} \equiv C_1 x^{-0.1}.$$

To determine the average heat transfer coefficient for the length zero to x,

$$\bar{h}_x \equiv \frac{1}{x}\int_0^x h_x\, dx = \frac{1}{x} C_1 \int_0^x x^{-0.1} dx$$

$$\bar{h}_x = \frac{C_1}{x}\frac{x^{0.9}}{0.9} = 1.11\, C_1\, x^{-0.1}.$$

Hence, the ratio of the average to local coefficient is

$$\frac{\bar{h}_x}{h_x} = \frac{1.11\, C_1\, x^{-0.1}}{C_1\, x^{-0.1}} = 1.11. \quad <$$

COMMENTS: Note that $\overline{Nu}_x / Nu_x$ is also equal to 1.11. Note, however, that $\overline{Nu}_x \neq \frac{1}{x}\int_0^x Nu_x\, dx$.