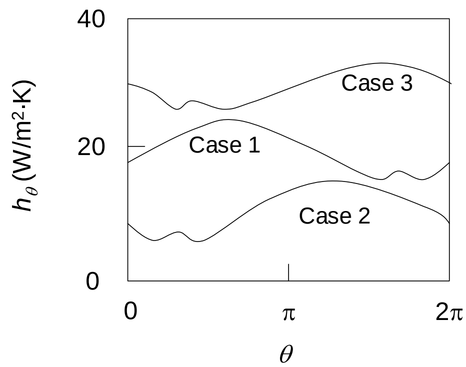
PROBLEM 6.11

KNOWN: Variation of local heat transfer coefficient around a circular collector tube.

FIND: (a) Estimate the average heat transfer coefficient, (b) Case with highest collector efficiency.

SCHEMATIC:

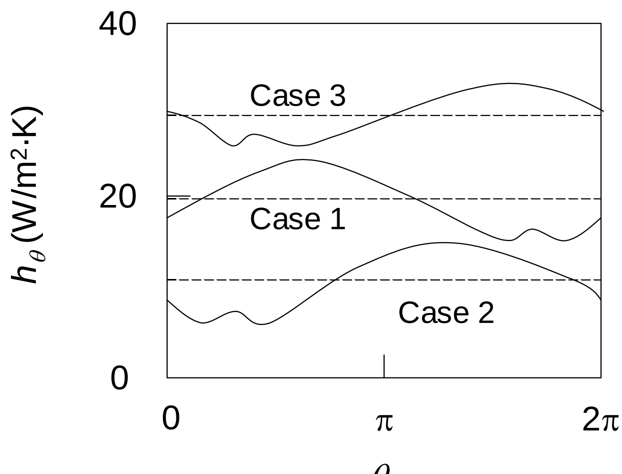


ASSUMPTIONS: Solar irradiation is independent of the reflector orientation.

ANALYSIS: (a) From Eq. 6.9,

$$\bar{h} = \frac{1}{A_s}\int_{A_s} h dA_s = \frac{1}{\pi DL}\int_{\theta=0}^{2\pi} h_\theta (D/2) L d\theta = \frac{1}{2\pi}\int_{\theta=0}^{2\pi} h_\theta d\theta$$

where L is the collector tube length. Hence, the average heat transfer coefficient may be estimated as the average value of the local heat transfer coefficient. Approximate values of the average heat transfer coefficient are shown in the sketch below.



For Case 1, $\bar{h} \approx 20$ W/m^2·K; for Case 2, $\bar{h} \approx 10$ W/m^2·K, for Case 3, $\bar{h} \approx 30$ W/m^2·K <

(b) The collector tube will be hotter than the ambient air. Hence, convective losses from the collector tube will diminish the overall collector efficiency. Therefore, Case 2 will have the highest collector efficiency. <

COMMENTS: (1) For case 2, the parabolic reflector partially "shields" the collector tube from the wind, resulting in reduced heat transfer coefficients. The flow adjacent to the tube also experiences a change in direction for case 2, with a large recirculation pattern established behind the reflector. (2) None of the cases experiences symmetrical flow over the collector tube, as would be expected without the reflector in place. (3) See Naeeni and Yaghoubi, "Analysis of Wind Flow Around a Parabolic Collector (2) Heat Transfer from Receiver Tube," *Renewable Energy*, Vol. 32, pp. 1259 – 1272, 2007, for additional discussion.