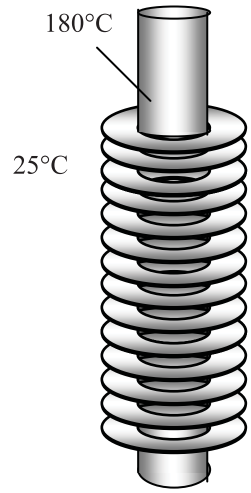
10-117 Circular aluminum fins are to be attached to the tubes of a heating system. The increase in heat transfer from the tubes per unit length as a result of adding fins is to be determined.

Assumptions **1** Steady operating conditions exist. **2** The heat transfer coefficient is constant and uniform over the entire fin surfaces. **3** Thermal conductivity is constant. **4** Heat transfer by radiation is negligible.

Properties The thermal conductivity of the fins is given to be k = 186 W/m·°C.

Analysis In case of no fins, heat transfer from the tube per meter of its length is



$$A_{\text{no fin}} = \pi D_1 L = \pi(0.05\text{ m})(1\text{ m}) = 0.1571\text{ m}^2$$

$$\dot{Q}_{\text{no fin}} = hA_{\text{no fin}}(T_b - T_\infty) = (40\text{ W/m}^2.°\text{C})(0.1571\text{ m}^2)(180-25)°\text{C} = 974\text{ W}$$

The efficiency of these circular fins is, from the efficiency curve, Fig. 10-43

$$\left.\begin{aligned} L &= (D_2 - D_1)/2 = (0.06-0.05)/2 = 0.005\text{ m} \\ \frac{r_2 + (t/2)}{r_1} &= \frac{0.03+(0.001/2)}{0.025} = 1.22 \\ L_c^{3/2}\left(\frac{h}{kA_p}\right)^{1/2} &= \left(L+\frac{t}{2}\right)\sqrt{\frac{h}{kt}} \\ &= \left(0.005+\frac{0.001}{2}\right)\sqrt{\frac{40\text{ W/m}^2\,{}^\circ\text{C}}{(186\text{ W/m}^\circ\text{C})(0.001\text{ m})}} = 0.08 \end{aligned}\right\}\eta_{\text{fin}} = 0.97$$

Heat transfer from a single fin is

$$A_{\text{fin}} = 2\pi(r_2^{\,2} - r_1^{\,2}) + 2\pi r_2 t = 2\pi(0.03^2 - 0.025^2) + 2\pi(0.03)(0.001) = 0.001916\text{ m}^2$$

$$\begin{aligned} \dot{Q}_{\text{fin}} &= \eta_{\text{fin}}\dot{Q}_{\text{fin,max}} = \eta_{\text{fin}} hA_{\text{fin}}(T_b - T_\infty) \\ &= 0.97(40\text{ W/m}^2.°\text{C})(0.001916\text{ m}^2)(180-25)°\text{C} \\ &= 11.53\text{ W} \end{aligned}$$

Heat transfer from a single unfinned portion of the tube is

$$A_{\text{unfin}} = \pi D_1 s = \pi(0.05\text{ m})(0.003\text{ m}) = 0.0004712\text{ m}^2$$

$$\dot{Q}_{\text{unfin}} = hA_{\text{unfin}}(T_b - T_\infty) = (40\text{ W/m}^2.°\text{C})(0.0004712\text{ m}^2)(180-25)°\text{C} = 2.92\text{ W}$$

There are 250 fins and thus 250 interfin spacings per meter length of the tube. The total heat transfer from the finned tube is then determined from

$$\dot{Q}_{\text{total,fin}} = n(\dot{Q}_{\text{fin}} + \dot{Q}_{\text{unfin}}) = 250(11.53+2.92) = 3613\text{ W}$$

Therefore the increase in heat transfer from the tube per meter of its length as a result of the addition of the fins is

$$\dot{Q}_{\text{increase}} = \dot{Q}_{\text{total,fin}} - \dot{Q}_{\text{no fin}} = 3613 - 974 = \mathbf{2639\text{ W}}$$

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