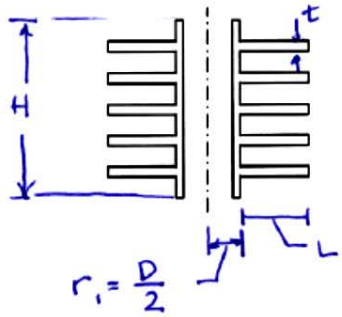
Example

A motorcycle *cylinder* is constructed from 2024-T6 aluminum alloy (k = 186 W/m-°C) and has a height of H = 0.15 m and an outer diameter of D = 50 mm. The temperature of the outer diameter of the cylinder is 500 K under typical conditions. The surrounding air has a temperature is T_{air} = 300 K with h_{air} = 50 W/m²-K. It is suggested that the heat transfer from the motorcycle can be enhanced by adding *annular* fins of length L = 20 mm and thickness t = 6 mm. Calculate the increase of heat transfer due to adding five such fins, all equally spaced.



$$\dot{Q} = (\varepsilon_{OVERALL})\,\dot{Q}_{NO\ FIN}$$

$$\dot{Q}_{NO\ FIN} = h A_{NO\ FIN} (T_b - T_\infty)$$

$$= h(\pi D H)(T_b - T_\infty)$$

$$= \left(50 \frac{W}{m^2 \cdot °C}\right)(\pi)(0.050\ m)(0.15\ m)(500 - 300)\ °C$$

$$= \underline{235.6\ W}$$

$$\varepsilon_{OVERALL} = \frac{A_{UNFIN} + \eta_{FIN} A_{FINS}}{A_{NO\ FIN}}$$

From figure in text

$$L_c = L + \frac{t}{2} = 0.020\ m + \frac{0.006\ m}{2} = 0.023\ m$$

$$A_p = L_c t = (0.023\ m)(0.006\ m) = 0.000138\ m^2$$

$$\xi = L_c^{3/2}\left[\frac{h}{kA_p}\right]^{1/2} = (0.023)^{3/2}\left[\frac{50}{(186)(0.000138)}\right]^{1/2} = \underline{0.154}$$

$$r_{2c} = r_2 + t/2 = (r_1 + L) + t/2 = \frac{D}{2} + L + \frac{t}{2} = \frac{0.050}{2} + 0.020 + \frac{0.006}{2}$$

$$= 0.048\ m$$

$$r_{2c}/r_1 = \frac{0.048\ m}{0.050/2\ m} = \underline{1.92} \Rightarrow \underline{\eta \approx 0.95}$$

$$A_{UNFIN} = \pi D H - 5\pi D t = \pi D(H - 5t) = (\pi)(0.050)[0.15 - (5)(0.006)]$$

$$= 0.0188\ m^2$$

$$A_{FIN} = (5)(2)\left[\pi\left(r_{2c}^2 - r_1^2\right)\right]$$ CORRECTED FIN LENGTH

(5) ← 5 FINS; (2) ← TOP & BOTTOM SURFACE

$$= (5)(2)\left[\pi(0.048)^2 - (0.050/2)^2\right] = 0.05274\ m^2$$

$$A_{NO\ FIN} = \pi DH = (\pi)(0.050)(0.150) = 0.0236\ m^2$$

$$\Rightarrow \varepsilon = \frac{(0.0188) + (0.95)(0.05274)}{0.0236} = 2.919$$

$$\dot{Q} = (2.919)(235.6) = \boxed{688\ W}$$

$$\dot{Q} - \dot{Q}_{NO\ FIN} = 688 - 236 = 451\ W$$

$\Rightarrow$ WOW!!