

L6 ADVANCED THERMO - LECTURE 9 Ex: 2

①

$$\dot{Q}_{\text{base}} = h \cdot A \cdot (T_b - T_{\infty}) \text{ where } A = 2\pi r_1 \times H$$

$$\begin{aligned} \therefore \dot{Q}_{\text{base}} &= h \cdot (2\pi r_1 H) (T_b - T_{\infty}) \\ &= 50 (2\pi \times 0.025 \times 0.15) (500 - 300) \end{aligned}$$

$$\text{So, } \dot{Q}_{\text{base}} = 235.62 \text{ W.}$$

To find $\dot{Q}$ with fins attached, then

$$\dot{Q}_t = h \cdot A_t \left[1 - \frac{N A_F}{A_t} (1 - \eta_F) \right] \cdot (T_b - T_{\infty})$$

$$\text{Now, } A_F = 2\pi (r_2^2 - r_1^2) = 2\pi [(r_2 + \frac{t}{2})^2 - r_1^2]$$

$$\text{(fin area)} \quad \therefore A_F = 2\pi [(0.045 + 0.003)^2 - (0.025)^2]$$

$$\text{So, } A_F = 0.01055 \text{ m}^2$$

$$\text{Now, } A_t = N \cdot A_F + A_b \text{ where } A_b \text{ is the prime area (i.e. 'visible' area of base).}$$

$$\therefore A_b = 2\pi r_1 (H - Nt) = 2\pi \times 0.025 \cdot (0.15 - (5 \times 0.006))$$

$$\text{So, } A_b = 0.01885 \text{ m}^2$$

$$\text{Hence, } A_t = (5 \times 0.01055) + 0.01885 = 0.0716 \text{ m}^2$$

To find an individual fin efficiency, η_F , we must determine the parameter;

$$L_c^{\frac{3}{2}} \left(\frac{h}{k \cdot A_p} \right)^{\frac{1}{2}}$$

$$\text{where, } L_c = L + \frac{t}{2} = 0.02 + \frac{0.006}{2}$$

$$\therefore L_c = 0.023 \text{ m}$$

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$$A_p = L_c t = 0.023 \times 0.006 = 0.138 \times 10^{-3} \text{ m}^2$$

(from graph of rectangular annular fin).

$$\text{So, } L_c^{\frac{3}{2}} \left(\frac{h}{k A_p} \right)^{\frac{1}{2}} = (0.023)^{\frac{3}{2}} \sqrt{\frac{50}{186 \times 0.138 \times 10^{-3}}}$$

$$= 0.15394 \text{ (i.e. } 0.154)$$

→ this is the x-axis value.

$$\text{Now, } r_{2c}/r_1 = \frac{0.048}{0.025} = 1.92$$

Hence, from graph provided;

$$\eta_f \approx 95\% \Rightarrow \therefore \eta_f \approx 0.95$$

To find overall surface efficiency;

$$\eta_o = \left[1 - \frac{N A_f}{A_t} (1 - \eta_f) \right]$$

$$\therefore \eta_o = \left[1 - \frac{(5 \times 0.01055)}{0.0716} (1 - 0.95) \right]$$

$$\eta_o = 0.963 \text{ (i.e. } \eta_o = 96.3\%)$$

$$\text{So, } \dot{Q}_t = h A_t \eta_o (T_b - T_\infty)$$

$$= 50 \times 0.0716 \times 0.963 (500 - 300)$$

$$\therefore \dot{Q}_t = 689.63 \text{ W (increase of } 454.01 \text{ W)}$$