MECH-420
Heat Transfer
FINS/THERMAL Circuits
STUDY AID

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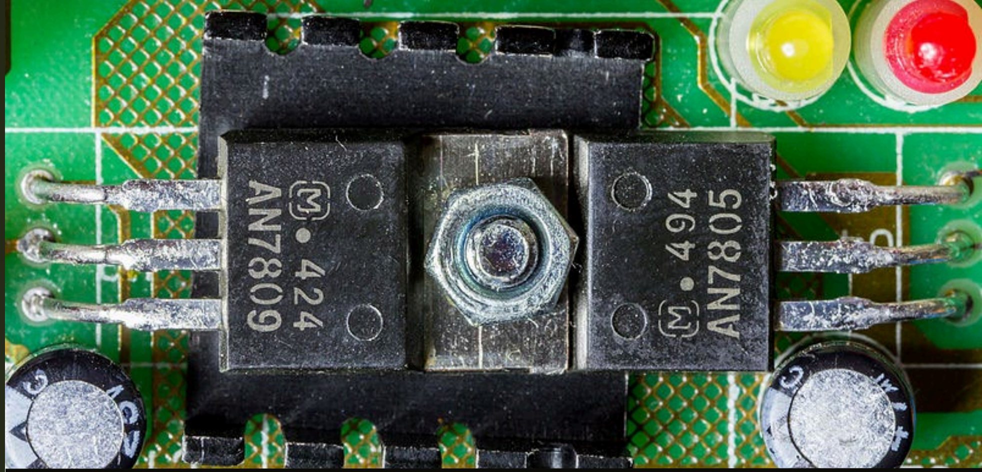
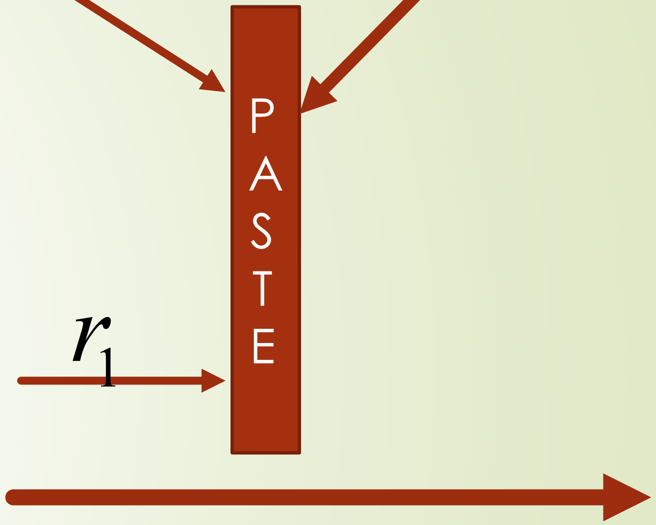


Annular aluminum fins of rectangular profile (k=240 W/m-K) are attached to a circular tube (Height H = 2.5m) at 250C with a thermal paste (w=thickness 1.0E-3 m) with a contact resistance of R″ = 1.0E-6 m2-W/K with an outside tube diameter of 25 mm. (It may help for you to draw a picture).



$$q_{heatTOTAL} = 3kW$$

The fins are 1 mm thick and 10 mm long. The convection coefficient is 25 W/m^2-K with an ambient fluid temperature of 25C.

a. What is the temperature of the fin base, fin efficiency, effectiveness, and the heat loss from the fin, W.

b. If the desired total heat transfer is 3.0 kW, what is the required number of fins per unit length of tube (i.e. N')

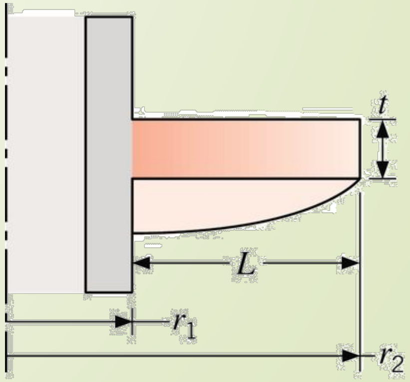
Thermal Circuits

$$q=\frac{T_w - T_b}{\frac{R_c'' \frac{m^2 - W}{K}}{2\pi r_1 t[m^2]}}, T_w = 250C$$

$$T_b = T_w - q \bullet \frac{R_c'' \frac{m^2 - W}{K}}{2\pi r_1 t[m^2]}, r_1 = \frac{25}{2} mm = 0.0125m, t = 0.001$$

$$= 250C - 38.2$$

$$= 211.8C$$



FIN CALCULATIONS

FIN EFFICIENCY

$r_1 = 0.0125m, t = 0.001m, L = 0.01m$

$r_2 = r_1 + L = 0.0225$

$r_{2c} = r_2 + t/2 = 0.0023$

$L_c = L + t/2 = 0.0105$

$A_p = L_c t = 1.05E-05$

$h = 25W/m2-K, k = 240W/m-K$

$$\left(\frac{h}{kA_p}\right)^{1/2} = 99.602$$

$$L_c\left(\frac{h}{kA_p}\right)^{1/2} = 0.11$$

$\eta_{fin} \approx 98\% (Figure\ 3.2)$

FIN HEAT TRANSFER (each fin)

$r_1 = 0.0125m, t = 0.001m$

$r_2 = r_1 + L = 0.0225$

$$\eta = \frac{q_{fin}}{q_{\max}} = \frac{q_{fin}}{hA_{finTOTAL}\theta_b}$$

$q_{fin} = \eta \bullet hA_{finTOTAL}\theta_b$

$\theta_b = 211.8C - 25C = 186.8C$

$A_{finTOTAL} = 2\pi(r_2^2 - r_1^2) + 2\pi r_2 t = 2.3405E-03m^2$

$q_{fin} = 10.7W$ per FIN

FIN EFFECTIVENESS

$\theta_b = 211.8C - 25C = 186.8C$

$r_1 = 0.0125m, t = 0.001m$

$r_2 = r_1 + L = 0.0225$

$$\varepsilon = \frac{q_{fin}}{q_{base}} = \frac{q_{fin}}{h\left[A_{base}\right]\theta_b}$$

$$= \frac{q_{fin}}{h\left[2\pi r_1 t\right]\theta_b} = 29.2$$

$\rightarrow$ A mighty good fin

TOTAL FINS NEEDED

$$q_{\text{TOTAL}}[W] = Nq_{fin} + hA_0\theta_b$$

$$A_0 = 2\pi r_1 H - 2\pi r_1 \bullet t \bullet N$$

$$\frac{q_{\text{TOTAL}}[W]}{H} = \frac{N}{H} q_{fin} + h\theta_b \left[2\pi r_1 \frac{H}{H} - [2\pi r_1 \bullet t] \bullet \frac{N}{H} \right]$$

$$\frac{q_{\text{TOTAL}}[W]}{H} - h\theta_b 2\pi r_1 = \frac{N}{H} \left\{ q_{fin} - h\theta_b [2\pi r_1 \bullet t] \right\}$$

$$\frac{\frac{q_{\text{TOTAL}}[W]}{H} - h\left[\frac{W}{m^2 - K}\right]\theta_b[K] 2\pi r_1[m]}{q_{fin}[W] - h\theta_b [2\pi r_1 \bullet t]} = \left[\frac{1}{m}\right] = \frac{N}{H}$$

$$\frac{\frac{3{,}000W}{2.5m} - 25x186.8x2x\pi x r_1}{10.7 - 25x186.8x r_1 x0.001} = \frac{N}{H}$$

$$\frac{833.2}{10.64} = 78.3\,fins/m$$