- Resistencias serie, paralelo
- Aislante crítico en tuberías
- Resistencias de contacto.

$$q = UA\Delta T \qquad q = \frac{\Delta T}{R_{eq}} \qquad R_{eq} = \frac{1}{UA}$$

$$q = hA\,\Delta T \qquad UA = \frac{1}{R_{eq}}$$

$$U = h \qquad U = \frac{1}{AR_{eq}}$$

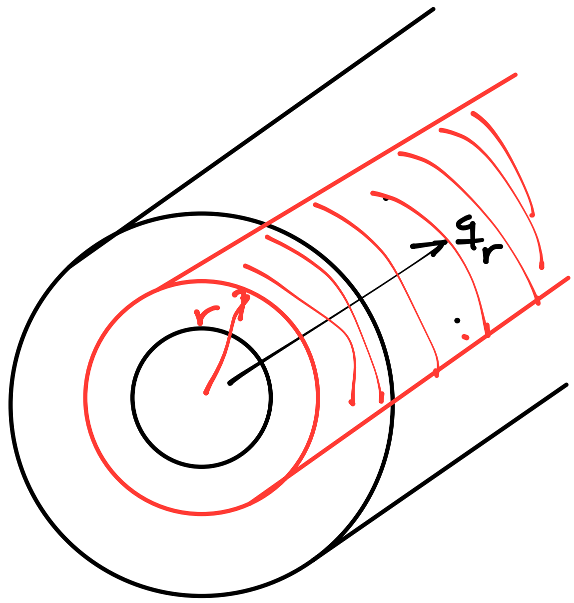
$$R = \frac{1}{hA}$$

$$q = KA\frac{\Delta T}{L} \qquad U = \frac{K}{L} \qquad R = \frac{L}{KA}$$

$$q = -k(T)A(x)\frac{dT}{dx}$$

$$\int_{T_0}^{T_L} \frac{-k(T)\,dT}{q} = \int_0^L \frac{dx}{A(x)}$$

$$-\frac{1}{q}\int_{T_0}^{T_L} k(T)\,dT = \int_0^L \frac{dx}{A(x)}$$



$$q = \frac{-\int_{T_0}^{T_L} k(T)\,dT}{\int_0^L \frac{dx}{A(x)}}$$

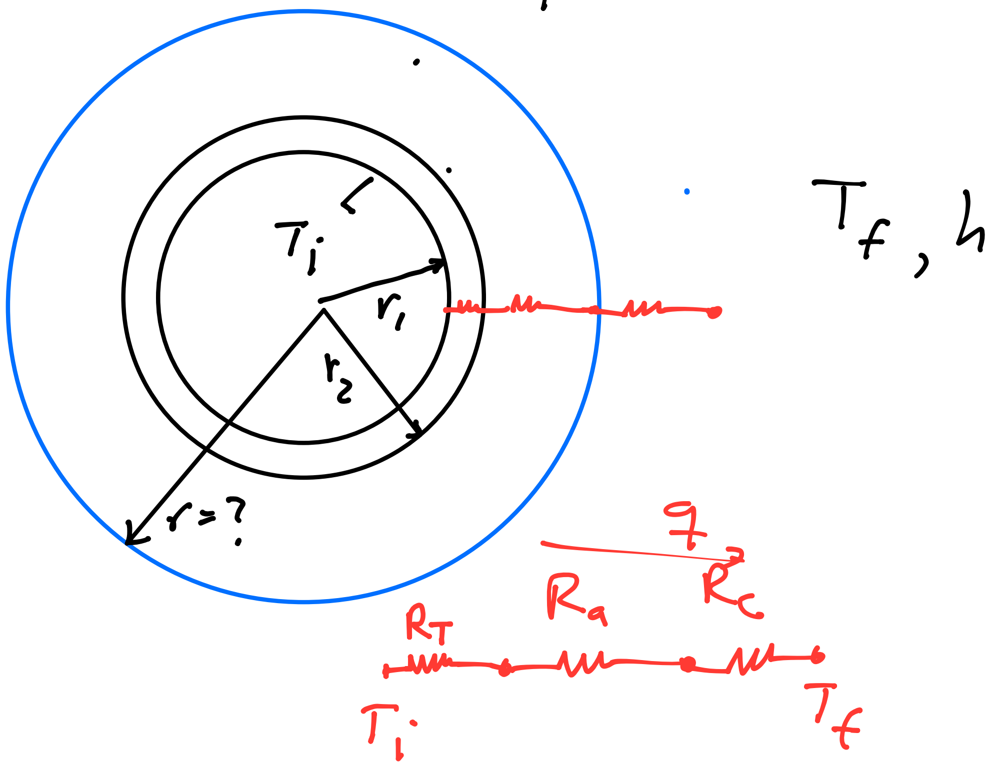
$$A(r) = 2\pi r L$$

$$q = \frac{-\int_{T_0}^{T_L} k(T)\,dT}{\int_{r_i}^{r_0} \frac{dr}{2\pi r L}} = \frac{-\int_{T_i}^{T_0} k(T)\,dT}{\frac{1}{2\pi L}\ln\left(\frac{r_0}{r_i}\right)}$$

$$q = \frac{-\bar{k}\,(T_0 - T_i)}{\frac{1}{2\pi L}\ln\left(\frac{r_0}{r_i}\right)} = \frac{T_i - T_0}{\frac{1}{2\pi k L}\ln\left(\frac{r_0}{r_i}\right)} = \frac{\Delta T}{R_{eq}}$$

$$R_{wall} = \frac{L}{KA} \qquad R_{cyl} = \frac{1}{2\pi K L} \ln\left(\frac{r_o}{r_i}\right)$$

$$q = \frac{\Delta T}{R_{eq}}$$



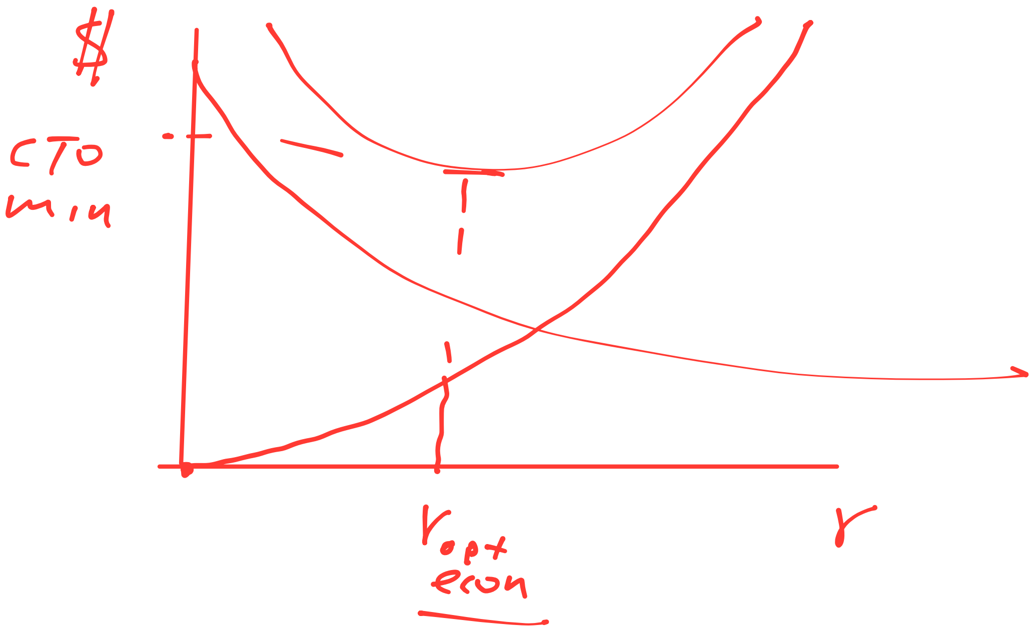
$$q = \frac{T_i - T_f}{R_T + R_a + R_c}$$

$$R_{TOT} = \frac{1}{2\pi K_T L} \ln\left(\frac{r_2}{r_1}\right) + \frac{1}{2\pi K_a L} \ln\left(\frac{r}{r_2}\right) + \frac{1}{h\,(2\pi r L)}$$

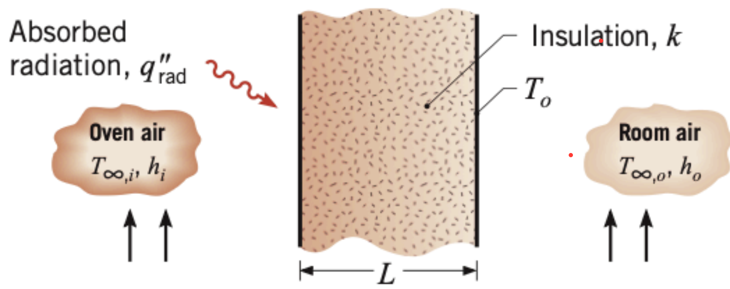
$$R_{TOT}\Big|_{max} \rightarrow \frac{d R_{TOT}}{d r} = 0$$

$$\frac{1}{\cancel{2\pi} K_a \cancel{L}} \frac{\cancel{r_2}}{\cancel{r}} \frac{1}{r_{\cancel{2}}} - \frac{1}{\cancel{2\pi} h \cancel{L} r^{\cancel{2}}} = 0$$

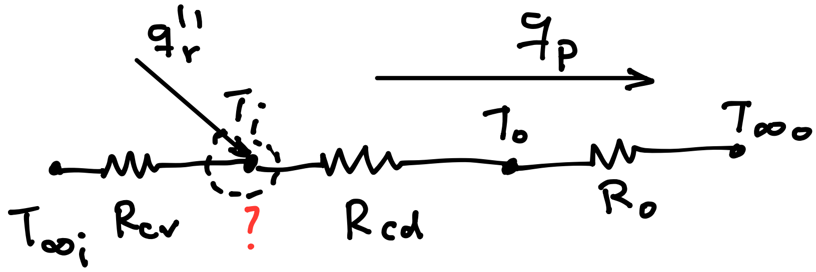
$$\frac{1}{Ka} = \frac{1}{hr} \qquad r_{cr} = \frac{Ka}{h}$$



3.19 The wall of a drying oven is constructed by sandwiching an insulation material of thermal conductivity $k = 0.05$ W/m·K between thin metal sheets. The oven air is at $T_{\infty,i} = 300°C$, and the corresponding convection coefficient is $h_i = 30$ W/m^2·K. The inner wall surface absorbs a radiant flux of $q''_{rad} = 100$ W/m^2 from hotter objects within the oven. The room air is at $T_{\infty,o} = 25°C$, and the overall coefficient for convection and radiation from the outer surface is $h_o = 10$ W/m^2·K.



(a) Draw the thermal circuit for the wall and label all temperatures, heat rates, and thermal resistances.

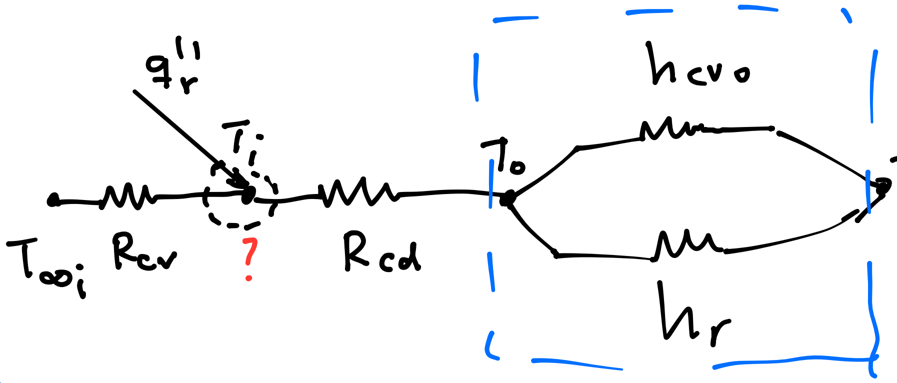


$$R_{cv} = \frac{1}{h_i A} \qquad R_{cd} = \frac{L}{k A} \qquad R_o = \frac{1}{h_o A}$$

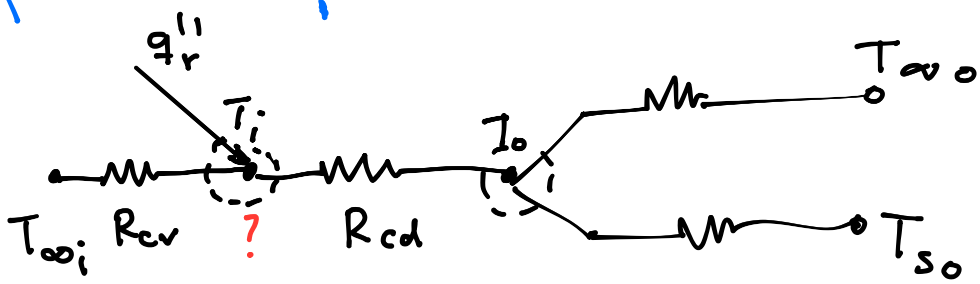
$$q''_r A + \frac{T_{\infty i} - T_i}{R_{cv}} = \frac{T_i - T_{\infty o}}{R_{cd} + R_o} = q_p$$

$$q_p = \frac{T_o - T_{\infty o}}{R_o} = \frac{T_i - T_o}{R_{cd}} \qquad T_o = 40°C$$

? → T_i, R_{cd}, q_p



$$\frac{1}{R_{eq}} = \frac{1}{\frac{1}{h_{cvo}A}} + \frac{1}{\frac{1}{h_r A}}$$



$$\frac{1}{R_{eq}} = h_{cvo} A + h_r A$$

$$R_{eq} = \frac{1}{A(h_{cv} + h_r)} = \frac{1}{A h_o}$$

1) $$q_r'' A + \frac{T_{\infty i} - \overset{?}{T_i}}{R_{cv}} = \frac{T_i - T_{\infty o}}{R_{cd} + R_o}$$

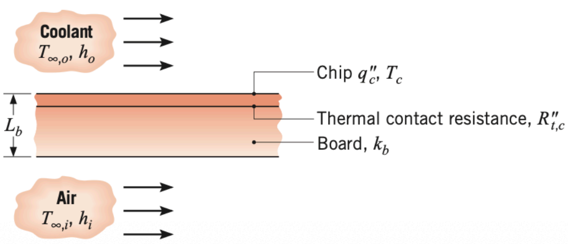
2) $$q_p = \frac{T_o - T_{\infty o}}{R_o}$$

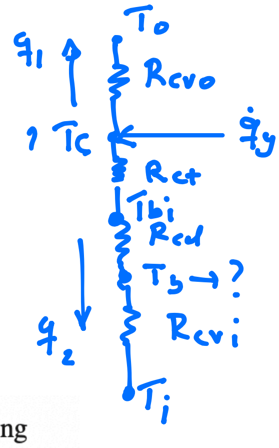
3) $$\frac{T_o - T_{\infty o}}{R_o} = \frac{T_i - T_o}{R_{cd}}$$

Rcontacto.

$$q = \frac{\Delta T}{R_{cont.}} \qquad R_{cont} = \frac{\Delta T}{q}$$

3.27 Approximately 10^6 discrete electrical components can be placed on a single integrated circuit (chip), with electrical heat dissipation as high as 30,000 W/m^2. The chip, which is very thin, is exposed to a dielectric liquid at its outer surface, with $h_o = 1000$ W/m$^2 \cdot$K and $T_{\infty,o} = 20°$C, and is joined to a circuit board at its inner surface. The thermal contact resistance between the chip and the board is 10^{-4} m$^2 \cdot$K/W, and the board thickness and thermal conductivity are $L_b = 5$ mm and $k_b = 1$ W/m$\cdot$K, respectively. The other surface of the board is exposed to ambient air for which $h_i = 40$ W/m$^2 \cdot$K and $T_{\infty,i} = 20°$C.





(a) Sketch the equivalent thermal circuit corresponding to steady-state conditions. In variable form, label appropriate resistances, temperatures, and heat fluxes.

(b) Under steady-state conditions for which the chip heat dissipation is $q''_c = 30{,}000$ W/m^2, what is the chip temperature?

? → $T_c, T_{bi}, T_b, q_1, q_2$

1) $q_g = q_1 + q_2$

2) $q_1 = \dfrac{T_c - T_o}{R_{cvo}}$

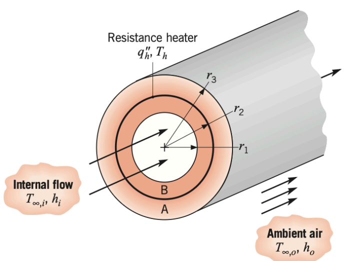
$$[A]\begin{bmatrix} T_c \\ T_{bi} \\ T_b \\ q_1 \\ q_2 \end{bmatrix} = [\quad]$$

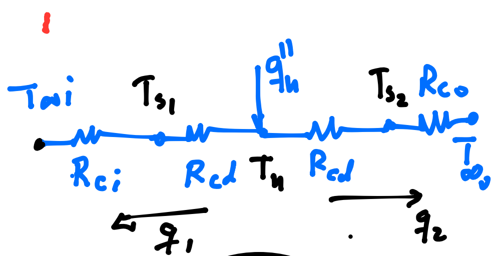
3) $q_2 = \dfrac{T_c - T_i}{R_{ct} + R_b + R_{cvi}}$

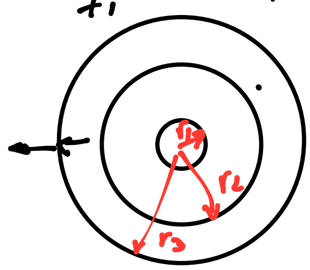
4) $q_2 = \dfrac{T_c - T_{bi}}{R_{ct}}$

5) $q_2 = \dfrac{T_{bi} - T_b}{R_{cdb}}$

3.57 A composite cylindrical wall is composed of two materials of thermal conductivity k_A and k_B, which are separated by a very thin, electric resistance heater for which interfacial contact resistances are negligible.







Liquid pumped through the tube is at a temperature $T_{\infty,i}$ and provides a convection coefficient h_i at the inner surface of the composite. The outer surface is exposed to ambient air, which is at $T_{\infty,o}$ and provides a convection coefficient of h_o. Under steady-state conditions, a uniform heat flux of q_h'' is dissipated by the heater.

(a) Sketch the equivalent thermal circuit of the system and express all resistances in terms of relevant variables.

(b) Obtain an expression that may be used to determine the heater temperature, T_h.

(c) Obtain an expression for the ratio of heat flows to the outer and inner fluids, q_o'/q_i'. How might the variables of the problem be adjusted to minimize this ratio?

$$R_{ci} = \frac{1}{h_i(2\pi r_1)}$$

$$R_{co} = \frac{1}{h_o(2\pi r_3)}$$

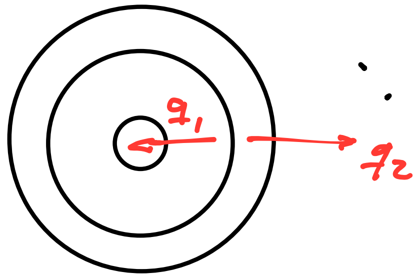
$$R_{cdB} = \frac{\ln\left(\frac{r_3}{r_2}\right)}{2\pi K_B}$$

$$R_{cdA} = \ln\left(\frac{r_2}{r_1}\right)/2\pi K_A$$

$$q_1 = \frac{T_h - T_{\infty i}}{R_{ci} + R_{cdB}}$$

$$q_2 = \frac{T_h - T_{\infty o}}{R_{cdA} + R_{co}}$$

$q_h''(2\pi r_2) = q_1 + q_2$



$$q_x - q_{x+dx} - dq_{conv} = 0$$

$$dq = q_{x+dx} - q_x$$

$$-\frac{dq}{dx} - \frac{dq_{conv}}{dx} = 0$$

$$-\frac{d}{dx}\left(-kA(x)\frac{dT}{dx}\right) - \frac{d}{dx}\left(h\overbrace{P\,dx}^{dA_s}(T-T_f)\right) = 0$$

$$\frac{d}{dx}\left(kA(x)\frac{dT}{dx}\right) - h\frac{dA_s}{dx}(T-T_f) = 0$$

$$kA(x)\frac{d^2T}{dx^2} + k\frac{dA(x)}{dx}\frac{dT}{dx} - h\frac{dA_s}{dx}(T-T_f) = 0$$

$A_s = Px$

$$kA_t\frac{d^2T}{dx^2} - hP(T-T_f) = 0$$

$$\frac{d^2T}{dx^2} - \overbrace{\frac{hP}{kA_t}}^{m^2}(T-T_f) = 0$$

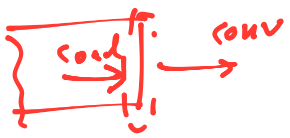
$$\frac{d^2T}{dx^2} - m^2(T-T_f) = 0 \qquad \theta = T-T_f$$

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0$$

$$\theta = C_1 e^{-mx} + C_2 e^{mx}$$

1) $x = 0 \quad \theta(0) = \theta_b = T_b - T_f$

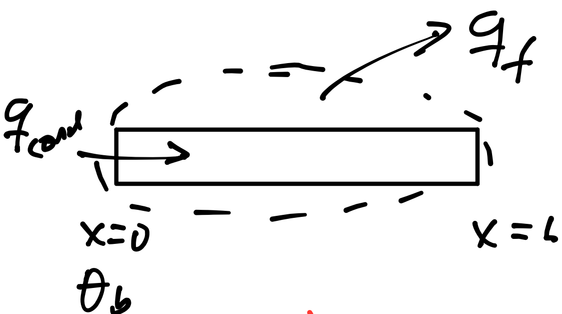
2) $\underline{\underline{x = L}}$



$$-kA_t \frac{d\theta}{dx}\bigg|_{\underline{\underline{x=L}}} = hA_t\left(\underline{\underline{\theta_{x=L}}}\right)$$

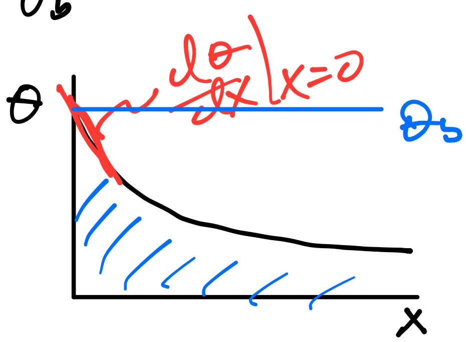
1) $\theta_b = C_1 + C_2$

2) $-kA_t\left(-C_1 m e^{-mL} + C_2 m e^{mL}\right) = hA_t\left(C_1 e^{-mL} + C_2 e^{mL}\right)$



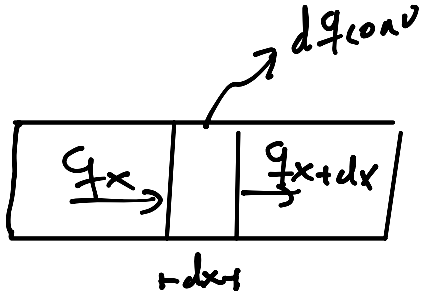
$$q_{\substack{cond\\base}} = q_f.$$

$$-kA_t \frac{d\theta}{dx}\bigg|_{x=0} = q_f$$



$$\theta = \theta_b \times \left(\frac{\cosh m(L-x) + (h/mk)\sinh m(L-x)}{\cosh mL + (h/mk)\sinh mL}\right)$$

$$\frac{d\theta}{dx} = \theta_b\left(\frac{m\sinh m(L-x) + (h/k)\cosh m(L-x)}{\cosh mL + (h/mk)\sinh mL}\right)$$



$$q_f = \int_L dq_{conv} = \int hPdx\,\theta$$

$$q_f = hP\int_0^L \theta\, dx$$

$$\epsilon = \frac{q_f}{q_{base}} = \frac{q_f}{hA_b\theta_b} \qquad \cancel{\epsilon = 1} \qquad \epsilon \geq 2$$

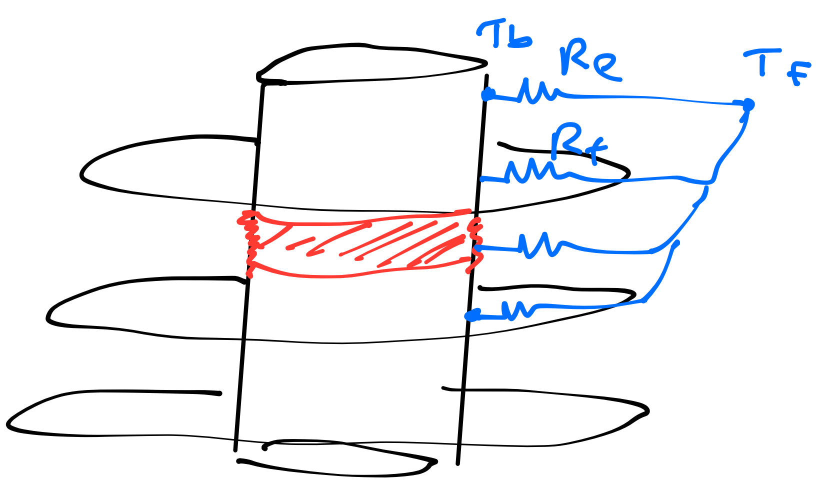
$$\eta = \frac{q_f}{hA_f\theta_b} \leq 1 = \frac{q_f}{q_{max}}$$

$$q_f = \eta\, hA_f\theta_b$$

Ej: Aleta anular $r_1 = 1\,cm$ $r_2 = 3\,cm$ $\delta = 2\,mm$

cobre $h = 10\ W/m^2K$ $T_\infty = 25\,^\circ C$ $T_b = 180\,^\circ C$

10 aletas separadas 5 mm $q_{TOT} = ??$



$$q_f = \eta h A_f \theta_b$$

$$q_f = \frac{\theta_b}{\left(\frac{1}{\eta h A_f}\right)}$$

$$R_f = \frac{1}{\eta h A_f}$$