Thermal Resistance of Heat sink

$$R_{\text{fin}} = \frac{T_b - T_f}{\dot{Q}_{\text{fin}}} = \left[1 + \frac{mL\,\phi}{Bi_c}\right]\left[\sqrt{hPkA}\,\phi\right]^{-1}$$

where:

$$\phi = \frac{mL\tanh mL + Bi_e}{mL + Bi_e\tanh mL}$$

and:

$$Bi_c = \frac{h_c L}{k}, \quad Bi_e = \frac{h_e L}{k}, \quad Bi = \frac{h t_e}{k} < 0.2$$

$$t_e = \frac{A}{P}, \quad mL = \sqrt{\frac{hP}{kA}}L$$

Inputs

- L – fin length
- A – cross sectional area of fins
- P – Fin perimeter
- k – Thermal conductivity of fin material
- h_c – Base contact resistance
- h – fin convection coeffiecient
- h_e – fin tip convection coefficient

Results

- R_fin – thermal resistance of Fins

IMPORTANT NOTE

R_fin was given for our heat sink was given as (0.57 W/K), these are the equation I used to determine the thermal resistance we would need to have in our heat sink. h and h_e are hard to calculate because they are dependent on the temperature distribution of the fin, which at the point I did these calculation was unknown, q was also not know at this point. The error in the EES model is most likely because I assumed R_fin = 0.57 W/K, this value is not a constant but varies with h.

EES model

(CODE)

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"CAPSTONE PROJECT"
"Thermoelectric Generators"

T_1 = converttemp(C,K,240) "Boiler Temperature"
T_amb =  converttemp(C,K,23)  "Ambient Temp."
"T_2 =  converttemp(C,K,165.7)"

R_tc_prime = 0.000005 [m^2-K/W]  "Contact Resistance"
W = 0.056 [m] "Width of TEG"
R_tc = R_tc_prime/W^2  "External resistance on TEGs"



{h_r = epsilon * sigma *(T_2+T_1)*(T_2^2+T_1^2)  }"Radiation heat transfer coefficient"           "(1)"
epsilon = 0.9  "emissivity"
sigma =  0.000000056703 [W/m^2-K^4]

"Conduction resistance trhough one module"
N = 900 "Number of p-n semiconducting modules in all 4 TEGS"
L_TEG = 0.0025 [m] "Use half the distance of TEG"
A_cs = 0.00000256 [m^2] "Cross-sectional Area of each pellet"
k_TEG = 1.2 [W/m-K] "Thermal Conductivity of Bismuth-Telluride"
R_t_cond_mod = L_TEG/(N*A_cs*k_TEG) "Coduction resistance of one module"

"Heat transfer rate into device"
q_1 = (1/(R_t_cond_mod))*(T_1-T_2) + I*S_eff*T_1 - I^2*R_eff                  "(2)"
S_eff = 0.1435 [V/K]  "Effiective Seeback Coefficient"
R_eff = 5.19 [ohms] "Internal resistance on TEG"

 "Heat transfer rate out of device"
q_2 = (1/(R_t_cond_mod))*(T_1-T_2) + I*S_eff*T_2 - I^2*R_eff                 "(3)"

"Heat transer through external resistances (plate and TEG)"
q_1 = (T_alpha1 - T_1)/R_tc                                           "(4)"

"Heat transfer thought Heat sink"
R_rad_conv = 0.57 "Thermal Resistance of Heat think"
q_2 = (T_2 - T_amb)/R_rad_conv                                        "(5)"



I^2*R_eff = I*S_eff *(T_1-T_2) - 2*I^2*R_eff                          "(6)"

P_n = q_1 - q_2

P_n = I * V
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Results

Unit Settings: SI C kPa kJ mass deg

A_{cs} = 0.00000256 [m^2]	ε = 0.9	I = 1.051 [amp]
k_{TEG} = 1.2 [W/m-K]	L_{TEG} = 0.0025 [m]	N = 900
P_n = 17.2 [W]	q_1 = 197.8 [W]	q_2 = 180.6 [W]
R_{eff} = 5.19 [Ωs]	$R_{rad,conv}$ = 0.57 [K/W]	R_{tc} = 0.001594 [K/W]
$\overline{R}_{tc'}$ = 0.000005 [m^2-K/W]	$R_{t,cond,mod}$ = 0.9042 [K/W]	σ = 5.670E-08 [W/m^2-K^4]
S_{eff} = 0.1435 [V/K]	T_1 = 513.2 [K] {240 [C]}	T_2 = 399.1 [K] {125.9 [C]}
T_{alpha1} = 513.5 [K]	T_{amb} = 296.2 [K] {23 [C]}	V = 16.37 [V]
W = 0.056 [m]		

No unit problems were detected.

Calculation time = 15 ms