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BME 333

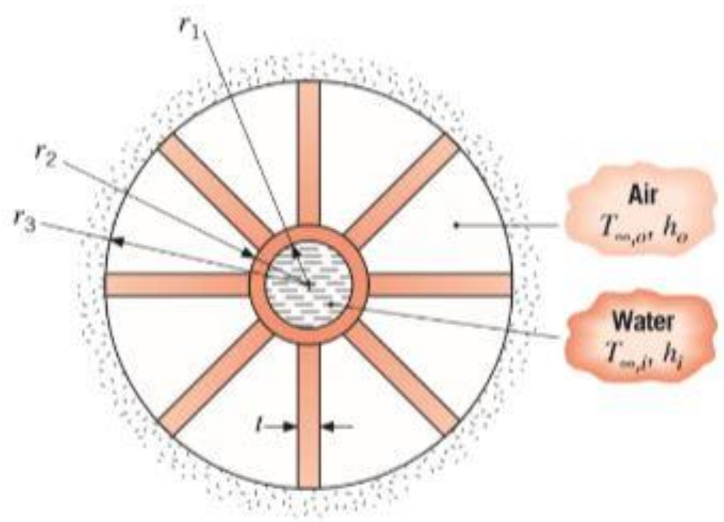
4/22/19

Project 1

Given: $k=20$ W/m*K, $r_1=0.013$ m, $r_2=0.016$ m, $r_3= 0.04$ m, 8 fins, $t=0.003$ m, $T_i=90$ C, $T_o=25$ C, $h_i=5000$ W/m^2*K, $h_o=200$ W/m^2*K, $N*t\leq 0.05$ m.

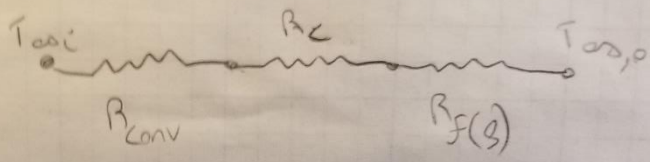
Find: Use Matlab to assess the effect of increasing the number of fins or increasing the thickness on the heat rate.

Sketch:



Assumptions: 1) Steady State, 2) One-dimensional heat transfer, 3) Negligible radiation 4)Heat rate is calculated per unit length

Solution for 8 fins and t =0.003 m:



$$R'_{conv} = \frac{1}{h_i(\pi r_1)} = \frac{1}{\left(5000\frac{W}{m^2\cdot K}\right)(\pi \cdot 0.013m)} = 0.0049\ \frac{K\cdot m}{W}$$

$$R'_c = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi K} = \frac{\ln(0.016/0.013)}{2\pi(20\ W/m\cdot K)} = 0.00165\ \frac{K\cdot m}{W}$$

$$R'_f = \frac{1}{\eta_o h_o A_t}$$

$$A'_t = NA'_f + A'_b \rightarrow A'_f = 2(r_3 - r_2) = 2(0.04 - 0.016) = \underline{0.048\ m}$$

$$A'_b = 2\pi r_2 - Nt = 2\pi(0.016m) - 8(0.003m) = \underline{0.0765\ m}$$

$$\eta_o = 1 - \frac{NA_f}{A_t}(-1 - \eta_f) \rightarrow \eta_f = \frac{\tanh mL_c}{mL_c} \rightarrow m = \sqrt{\frac{2h}{Kt}}$$

$$\eta_f = \frac{\tanh\left(\sqrt{\frac{2(200\ W/m^2\cdot K)}{\left(20\frac{W}{m\cdot K}\right)(0.003m)}}\cdot(0.024m)\right)}{\sqrt{\frac{2\cdot 200}{20\cdot 0.003}}(0.024m)} = 0.49$$

$$A_t = 8(0.048) + 0.0765 = 0.4605\ m$$

$$\eta_o = 1 - \frac{8(0.048)}{.4605}(1 - 0.49) = 0.57$$

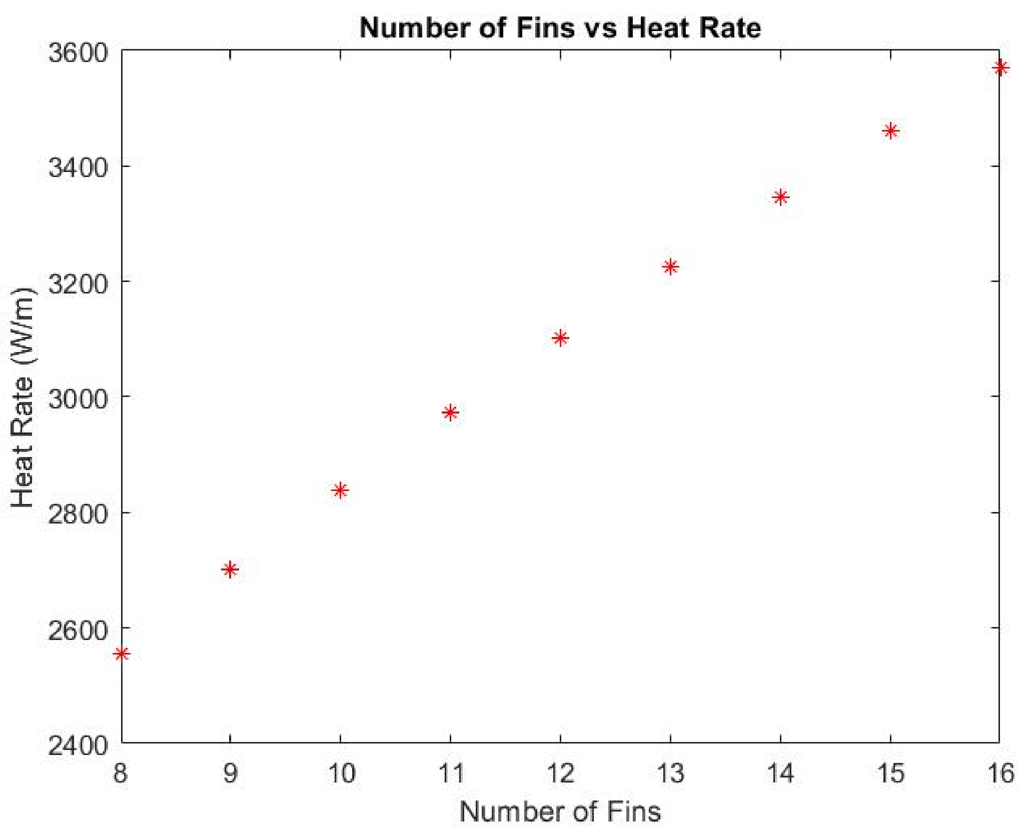
$$R'_f = \frac{1}{(0.57)(200)(.4605)} = 0.019\ m\cdot K/W$$

$$R_{tot} = 0.0049 + 0.00165 + 0.019 = 0.0256\ m\cdot K/W$$

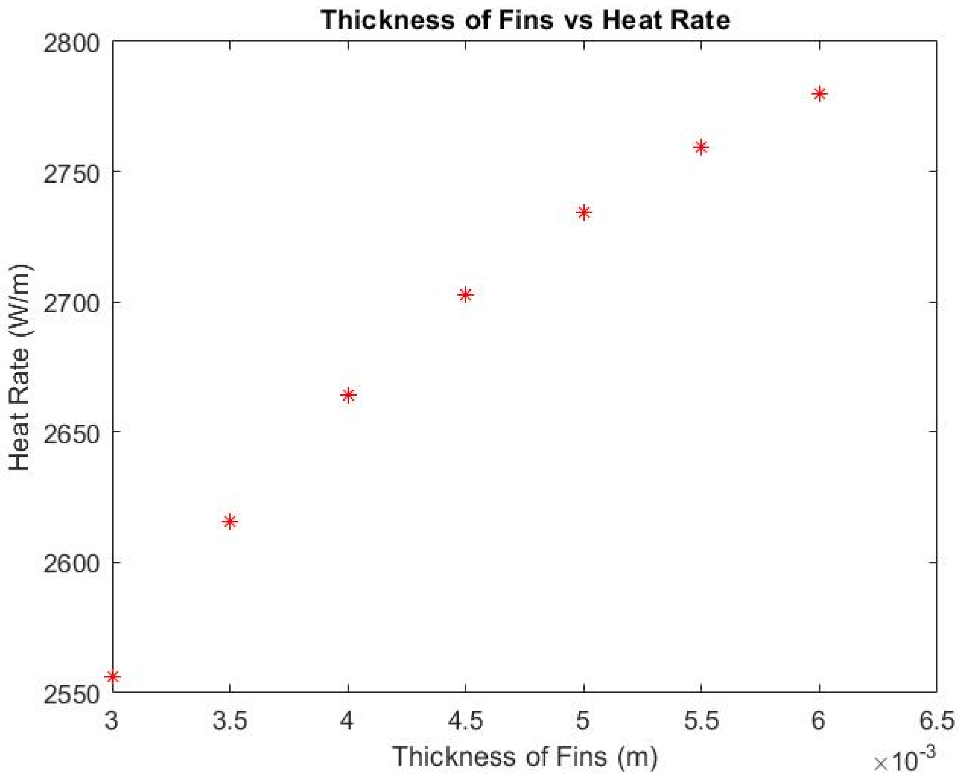
$$q' = \frac{T_i - T_o}{R_{tot}} = \frac{90-25}{0.0256} = 2539.2\ W/m$$

Explanation of Code:

The first part of my code inserts all the given information from the problem as well as calculating the length and surface area of one fin since those calculations are independent of how many fins and the thickness of a fin. I then created a while loop set for $N*t \leq 0.05$ m and then in that loop I calculated the necessary resistance factors and from those, calculated the heat rate. That point is plotted and then the number of fins is increased and the loop repeats. The graph is shown below.



The second while loop does the same exact thing as the first while loop except it increases the thickness and plots those points. The graph is shown below.



As the fins increase, the heat rate increases linearly and as the thickness increases, the heat rate increases logistically.