WEEK 6 SUBMISSION

QUESTION 1:

Considering the same example you solved in the previous assignment (radiative heat transfer between two parallel plates), how many shields with epsilon = 0.1 should you add in order to have the new heat transfer rate to be 1% of the case without shields?

ANSWER 1:

First we look at the example of last week assignment:

The radiative heat transfer between surface 1 and 2. The area is 1.5 ㎡, ε_1 = 0.2, ε_2 = 0.7, T_1 = 37℃, T_2 = 17℃. The answer is:

$Q_{12,\ \text{no shields}} = A\sigma(T_1^4 - T_1^4)/1/\varepsilon_1+1/\varepsilon_2-1 = 1.5*5.67*10^{-8}\ (310^4-290^4)\ /1/0.1+1/0.1-1 = 9.6789W$

If we would like to have the new heat transfer which is the 1% of this case, then

$1\% * Q_{12,\ \text{no shields}} = 0.096789W$

According to the equation

$Q_{1\text{-}2,\ N\ \text{shields}} = A\sigma(T_1^4 - T_1^4)/(N+1)(1/\varepsilon_1+1/\varepsilon_2-1) = 1/N+1 * Q_{1\text{-}2,\ \text{no shields}} = 0.096789W$

Then

$Q_{1\text{-}2,\ N\ \text{shields}} = 1/N+1 * 9.96789 = 1/100 * 9.96789 = 0.096789W$

N=100-1=99

Therefore, we need 99 shields with epsilon = 0.1 to have the new heat transfer rate to be 1% of the case without shields.

QUESTION 1:

You should create a pdf file with screenshots of all of the steps we went through (clearly from your own file) and explain briefly the reason behind the use of each step (in your own words!)

ANSWER 1:

When we calculate the heat transfer between two planar faces without shields, the equation is:

$.Q_{1\text{-}2,\ \text{no shields}} = A\sigma(T_1^4 - T_1^4)/1/\varepsilon_1+1/\varepsilon_2-1$

When there is one shield between the two faces:

$.Q_{1\text{-}2,\ \text{one shields}} = A\sigma(T_1^4 - T_1^4)/(1/\varepsilon_1+1/\varepsilon_2-1)+(1/\varepsilon_{3.1}+1/\varepsilon_{3.2}-1) = 1/2.Q_{1\text{-}2,\ \text{no shields}}$

When there are two shields between the two faces:

$.Q_{1\text{-}2,\ \text{two shields}} = A\sigma(T_1^4 - T_1^4)/(1/\varepsilon_1+1/\varepsilon_2-1)+(1/\varepsilon_{3.1}+1/\varepsilon_{3.2}-1)+(1/\varepsilon_{4.1}+1/\varepsilon_{4.2}-1)=1/3.Q_{1\text{-}2,\ \text{no shields}}$

When there are three shields between the two faces:

.$Q_{1\text{-}2,\ \text{three shields}} = A\sigma(T_1^4 - T_1^4)/(1/\varepsilon_1+1/\varepsilon_2-1)+(1/\varepsilon_{3.1}+1/\varepsilon_{3.2}-1)+(1/\varepsilon_{4.1}+1/\varepsilon_{4.2}-1)+ +(1/\varepsilon_{5.1}+1/\varepsilon_{5.2}-1) =1/4.Q_{1\text{-}2,\ \text{no shields}}$

From the example above we could see every time we add a shield between the two surfaces, the heat transfer will be 1/N+1 of the case that without the shields. Therefore:

$Q_{1\text{-}2,\ N\ \text{shields}} = A\sigma(T_1^4 - T_1^4)/(N+1)(1/\varepsilon_1+1/\varepsilon_2-1)$