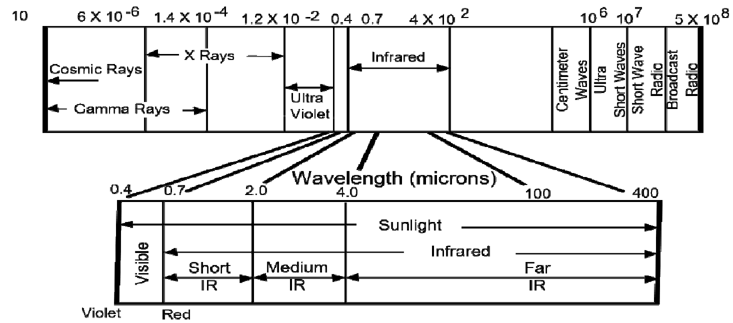
Wavelengh Calculation - By Wien's displacement law

Peak Wavelength = $\frac{5269\ °R}{Temp\ (°F) + 460}$



for Eaxample T = 1000°F

Peak Wavelength = $\frac{5269\ °R}{1000\ °F + 460}$

5269 °R

1460 °R

ANS = 3.60890411 micron

Radiant Heat Transfer Formula

1 Stefan-Boltzman Equation - To calculate the amount of power radiated by the heater.

$\frac{\text{Watts Radiated}}{\text{Area}}$ = Constant x (absolute temperature)^4

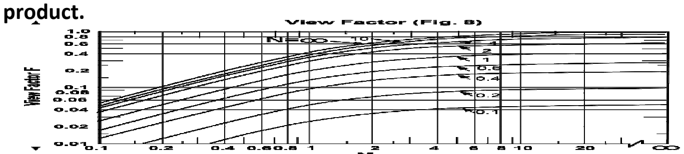
$\frac{\text{Watts}}{\text{ft}^2}$ = $\frac{(0.1714 \times 10^8\ BTU/Hrft^2\ °R)\ (°F + 460)^4}{3.412\ BTU}$

$\frac{\text{Net Watts Radiated}}{\text{Area}}$ = Constant [(Heater Absolute Temperature)^4 - (Product Absolute Temperature)^4]

$\frac{\text{Net Watts Radiated}}{\text{In}^2}$ = 3.4885 X 10 ^(-12) [(Th + 460 °R)^4 - (Tp + 460 °R)^4]

Th = Heater Temp. (°F)
Tp = Product Temp. (°F)

2 View Factor - It describes what percentage of the energy radiated by the heater actually hits the product.



M = $\frac{\text{Heater Width}}{\text{Distance to Product}}$

N = Heater Length

Distance to Product

Note : M and N are interchangable

For Example

Heater Width	4	Inch
Heater Length	12	Inch
Distance from Product	8	Inch
M	0.5	Inch
N	1.5	Inch

3 Emissivity - It determines how much of the incident radiant energy is actually absorbed by the product

Total Incident Energy = Absorbed + Reflected + Transmitted

Heater Emmisivity

Watts Radiated = Stefan-Boltzman Equation x Emissivity Heater

Watts Absorbed = Stefan-Boltzman Equation x Eh x Ep x View Factor

Eh = Emmisivity Of heater (0.85)
Ep = Emmisivity Of Product

$$E\ effective = \frac{1}{\frac{1}{Eh} + \frac{1}{Ep} - 1}$$

Problem Solving

Step I Collect Application Information

- Initial and final material temperature
- Heat-up time
- Specific heat of material
- Density or weight of material
- Material size
- Heat of vaporization/fusion of material, if applicable
- Conveyor speed, if applicable
- Emissivity of material or absorption spectrum
- Heater to material distance
- Proposed heater layout: size, spacing, heating one or both sides
- Are there secondary heat loads, such as air, conveyor, etc.?

Step II Determine the Required Wattage

Change in Temperature:

$$W/in2 = \frac{\text{Weight (lbs)/in2 x Specific Heat x Change in Temperature (°F)}}{\text{Time (hr) x watt hr}}$$

Change in Phase: - (Water to steam)

$$W/in2 = \frac{\text{Weight (lbs)/in2 x Latent Heat of Fusion}}{\text{Time (hr) x watt hr}}$$

Step III Compute the Absorbed Wattage for a Proposed Heater Array

$$\frac{\text{Watts =}}{\text{In^2}} \quad \frac{\text{S(Th^4-Tp^4) X E X F}}{\text{144 in^2/Ft^2 X 3.412 BTU/Watt Hr}}$$

W/in^2 = Watt per square inch absorbed by product
S = Stefan-Boltzman Constant (0.1714 x 10^8 BTU/Hrft^2 °R)
F = View Factor
Th = Heater Temperature in °R = °F + 460
Tp = Product Temperature in °R = °F + 460

Since the product temperature Tp is continously changing, the avg. product temperature is used :

$$\text{Avg Product Temp} = \frac{\text{T (initial) + T (Final)}}{2}$$

E = Effective Emissivity. When heater and product are parallel planes.

$$E = \frac{1}{\frac{1}{Eh} + \frac{1}{Ep} - 1}$$

Eh = Emmisivity Heater = 0.85
Ep = Emmisivity Of Product

Example 1 **GIVEN**

TO heat SS 304 Sheet to 300 °F from 60°F

InitialTemp	60 °F			
Final Temp	300 °F		Volume	
Product Size	24*24*0.031	Inch	17.856	Inch^3
SS 304 Emmisivity	0.8			
Heater to Product	2	Inch		
Sp Weight of Steel =	500	Lbs/Ft^3		

SOLUTION

1 Collect data assuming uniform heating on Product

	Width		Length	
Heater Size	28	Inch	28	Inch
Delta T =	240	°F		
Weight/In^2	0.008969907	for Steel		
Specific Heat	0.12	BTU/lb°F		
Time	1	Mins		
	0.016666667	Hours		
Emissivity of Product (Ep)	0.8			

2 Wattage Required

$$\text{Watt} = \frac{\text{Weight X Sp. Heat X Delta T}}{\text{Time X 3.412 BTU/Watt hr}}$$

$$\frac{\text{Watt}}{\text{In\^{}2}} = \frac{0.00897 \times 0.12 \times 240}{0.0167 \times 3.412} \qquad \frac{\text{lbs/In\^{}2 X BTU/lb°F X °F}}{\text{Hrs. X BTU/watt. Hr}}$$

$$\frac{\text{Watt}}{\text{In\^{}2}} = 4.542790152$$

3 Radiant Heat Transfer *Equation*

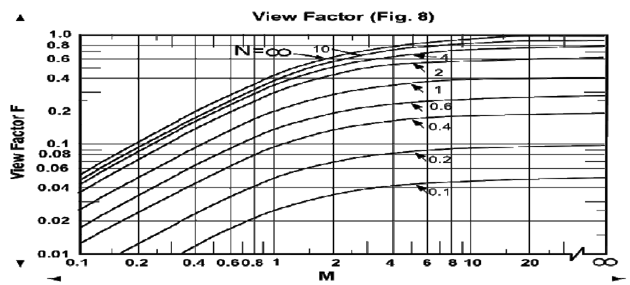
$$\frac{\text{Watts}}{\text{In\^{}2}} = \frac{\text{S(Th\^{}4-Tp\^{}4) X E X F}}{\text{144 in\^{}2/Ft\^{}2 X 3.412 BTU/Watt Hr}}$$

A. Compute the view Factor F

M = 14

N = 14

(From Figure 8) F = 0.85



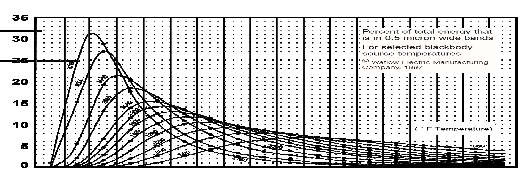
B. Compute the effective emissivity (E).

Emissivity of heater (Eh)= 0.85

$$E = \frac{1}{\frac{1}{Eh} + \frac{1}{Ep} - 1}$$

$$E = \frac{1}{\frac{1}{0.85} + \frac{1}{0.8} - 1}$$

E = 0.70



C. Determine the average product temperature (Tp)

Tp= FT+IT / 2

180 °F

640 °R

D. Plug into the radiant heat transfer Equation

4.54 Watts = / In^2 = S(Th^4-Tp^4) X E X F / 144 in^2/Ft^2 X 3.412 BTU/Watt Hr

7.62 Watts = / In^2 = (0.1714 x 10^8 BTU/Hrft^2 °R)(Th^4-Tp^4) / 144 in^2/Ft^2 X 3.412 BTU/Watt Hr

From beside Graph at 7.62 we get Th = 800 °F

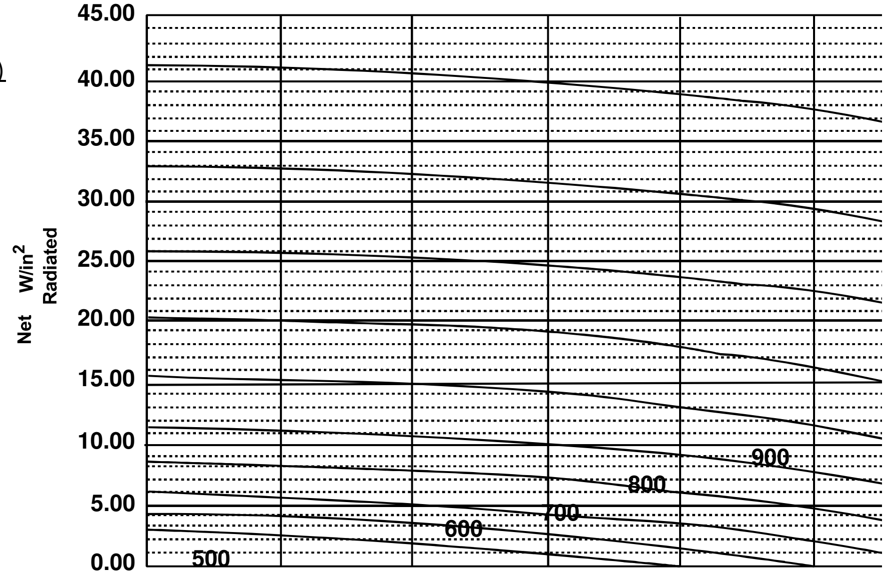
1260 °R

OR We can continous with Calculation as below

Th^4 = 2.35315E+12

Th = 1238.55 °R

778.55 °F



Conclusion

We Required Heater Density	7.62	Watt/In^2
Heater Temp.	778.5	°F
Type of Waveform	3.5 - 4	Medium Wave
Total IR Panel Load	4389.12	Watt