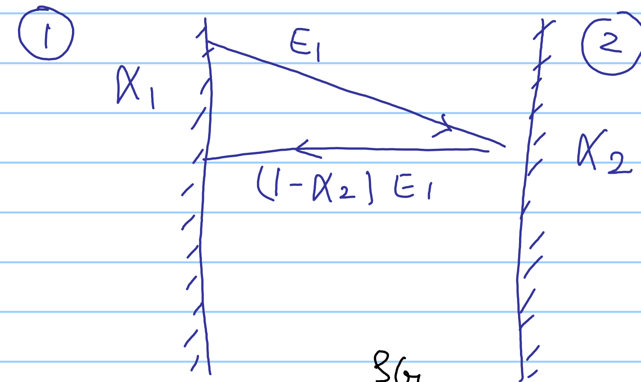
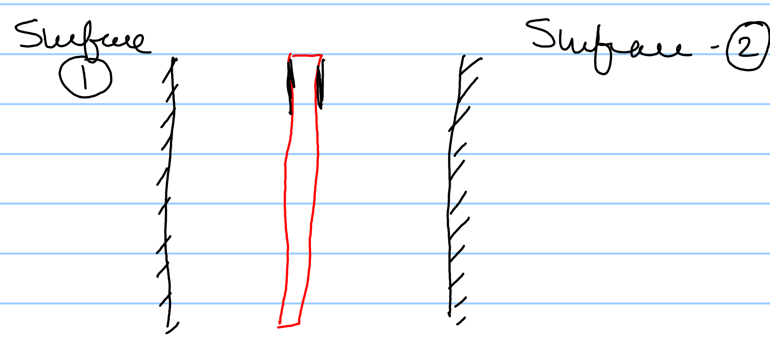
Radiation shield



$A_1 = A_2 = A$

$F_{1-2} = F_{2-1} = 1$

$$\phi_{1-2} = \frac{\sigma A (T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)}$$

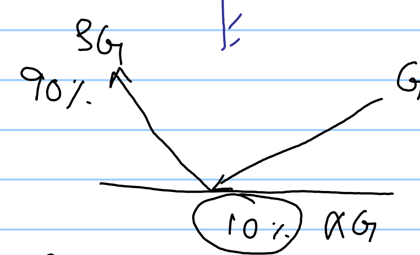


thin Plastic sheet

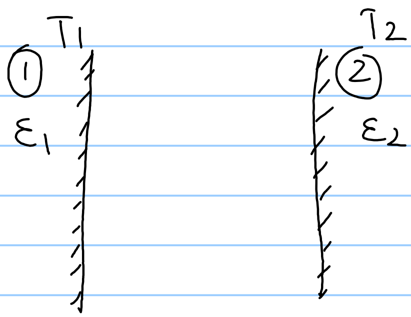
$\rho > 0.9$

$\varepsilon < 0.1$

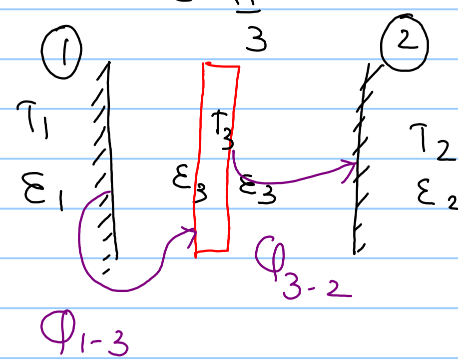
gold, silver < 0.02

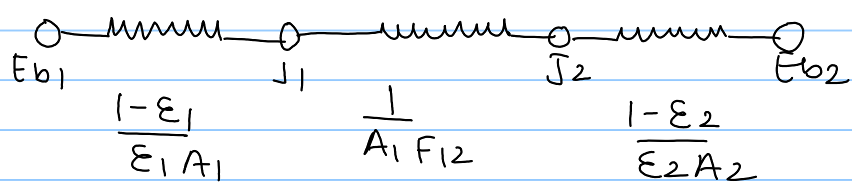


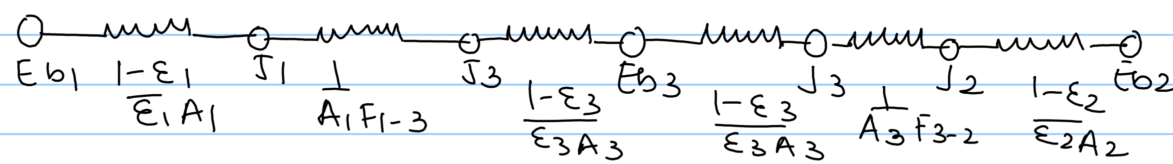
Case - I



Case - II







$$\phi_{1-2} = \frac{\sigma A (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

$$\phi = \phi_{1-3} = \frac{A \sigma (T_1^4 - T_3^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1} \quad \text{— (1)}$$

$$\frac{\phi}{A} \cdot \frac{1}{\sigma}\left[\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1\right] = T_1^4 - \cancel{T_3^4}$$

$$\phi = \phi_{3-2} = \frac{A \sigma (T_3^4 - T_2^4)}{\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_2} - 1} \quad \text{— (2)}$$

$$\frac{\phi}{A} \frac{1}{\sigma}\left[\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_2} - 1\right] = \cancel{T_3^4} - T_2^4$$

Radiation shield does not Remove OR deliver heat

$$\phi_{1-3} = \phi_{3-2}$$

$$\frac{\phi}{A} \cdot \frac{1}{\sigma}\left[\left[\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1\right] + \left[\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_2} - 1\right]\right] = T_1^4 - T_2^4$$

$$\frac{\phi}{A} \frac{1}{\sigma}\left[\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} + \frac{2}{\varepsilon_3} - 2\right] = T_1^4 - T_2^4$$

$$\varphi = \frac{A\sigma(T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1\right) + \left(\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_3} - 1\right)} \quad \text{—— (3)}$$

$$\varphi = \frac{A\sigma(T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)} \quad \text{— (4)}$$

$$\frac{\varphi_{net} \text{ with shield}}{\varphi_{net} \text{ without shield}} = \frac{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1\right) + \left(\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_3} - 1\right)}$$

Special case $\varepsilon_1 = \varepsilon_2 = \varepsilon_3 = \varepsilon$

$$= \frac{(1+1-1)}{(1+1-1)+(1+1-1)} = \frac{1}{2}$$

$n \rightarrow$

$$\frac{1}{n+1}$$

Note Title 10/16/2020

Consider two large parallel plates, one at temperature at 727 0C with emissivity 0.8 and other at 227 0 with emissivity 0.4. An aluminium radiation shield with an emissivity of 0.05 on both sides is placed between two plates. Calculate reduction in heat transfer rate between two plates as a result of shield.

Given Data

$T_1 = 727 + 273 = 1000\,K$

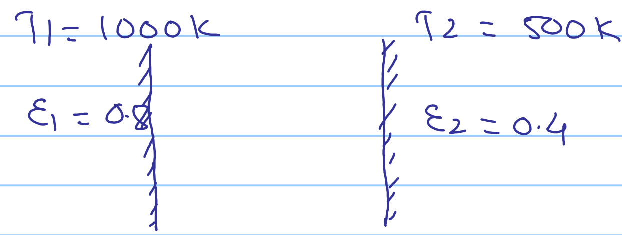
$T_2 = 227 + 273 = 500\,K$

$\varepsilon_1 = 0.8$

$\varepsilon_2 = 0.4$

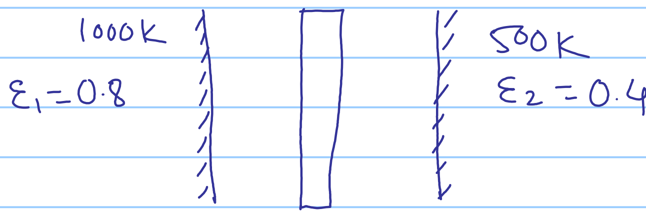
$\varepsilon_3 = 0.05$

Case - I



$$\frac{Q_{1-2}}{A} = \frac{\sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{5.67 \times 10^{-8} (1000^4 - 500^4)}{\frac{1}{0.8} + \frac{1}{0.4} - 1} = 19.33\ kW/m^2$$

Case - II



$$\varphi_{1-3} = \varphi_{3-2}$$

$$\frac{\sigma A (T_1^4 - T_3^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1} = \frac{\sigma A (T_3^4 - T_2^4)}{\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_2} - 1}$$

$$\frac{5.67 \times 10^{-8} (1000^4 - T_3^4)}{\frac{1}{0.8} + \frac{1}{0.05} - 1} = \frac{5.67 \times 10^{-8} (T_3^4 - 500^4)}{\frac{1}{0.05} + \frac{1}{0.4} - 1}$$

$$T_3 = 834.36 \text{ K}$$

$$\frac{\varphi_{1-3}}{A} = \frac{\sigma (T_1^4 - T_3^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1}$$

$$= \frac{5.67 \times 10^{-8} (1000^4 - 834.36^4)}{\frac{1}{0.8} + \frac{1}{0.05} - 1} = 1.43 \text{ kW/m}^2$$

$$\varphi_{1-2} = 19.33 \ kW/m^2$$

$$\varphi_{1-3} = 1.433 \ kW/m^2$$

$$\% \text{ Reduction} = \frac{\varphi_{1-2} - \varphi_{1-3}}{\varphi_{1-2}} = \frac{19.33 - 1.433}{19.33} \times 100\%$$

$$= 92.53\%$$