Task 1 In you own words (which means in your own words) write a summary of the topics about radiative heat transfer we went through including the definitions of emissivity, absorptivity and reflectivity, the view factor, the heat exchange between two black surfaces,the heat exchange between the two gray surface and finally the definition of radiative resistances

emissivity

The emissivity of the surface of an object depends on the temperature of surface temperature, as well as the wavelength and the direction of the emitted radiation. This shows that the emissivity is only related to the object that emits radiation, not related to external factors.

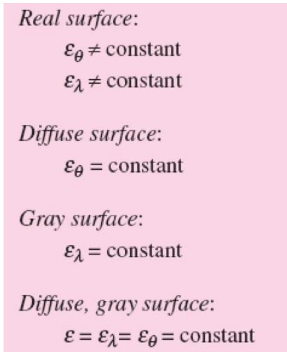
For a prescribed temperature and wavelength, no surface can emit more energy than a blackbody.

$\varepsilon = 1$

The surface of a real object has a lower emission capacity than the black body at the same temperature.

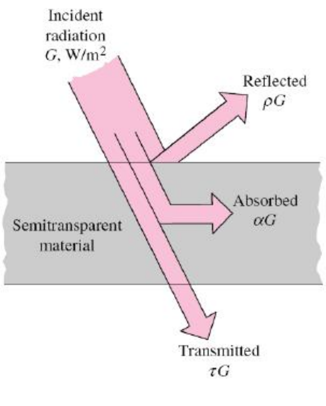
Emissivity: the ratio of the radiative force of an actual object to the radiating power of a black body at the same temperature $\varepsilon = \frac{E}{E_b}$

Spectral emissivity $\varepsilon_\lambda = \frac{E_\lambda}{E_{b\lambda}}$; directional emissivity $\varepsilon_\theta = \frac{E_\theta}{E_{B\theta}}$



Absorptivity、Raflectivity、Transmissivity

When thermal radiation is projected onto the surface of the object, absorption, reflection and transmission occur as well as visible light.



$G_{abs} + G_{ref} + G_{tr} = G$

Absorptivity α is Ratio of absorbed radiation to incident radiation $\frac{G_{abs}}{G}$; $0 \le \alpha \le 1$

Raflectivity ρ is ratio of reflected radiation to incident radiation $\frac{G_{ref}}{G}$; $0 \le \rho \le 1$

Transmissivity τ is ratio of transmitted radiation to incident radiation $\frac{G_{tr}}{G}$. $0 \le \tau \le 1$

$\alpha + \rho + \tau$ =1; $\alpha + \rho = 1$ for opaque surface

View Factor

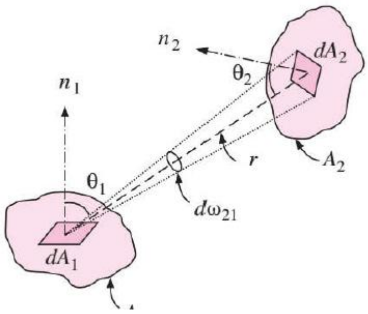
Factors affecting radiative heat transfer: surface temperature, geometrical characteristics of the surface, relative position between surfaces, and radiation properties of the surface.

Definition of the view factor: the view factor is defined as the fraction of the radiation leaving surface i that is intercepted by surface j

From the definition of the view factor as the fraction of the radiation that leaves A_1 and is intercepted by A_2

$$F_{12} = F_{A_1 \to A_2} = \frac{\dot{Q}_{A_1 \to A_2}}{\dot{Q}_{A_1}} = \frac{1}{A_1}\int_{A_2}\int_{A_1} \frac{\cos\theta_1 \cos\theta_2}{\pi r^2}\, dA_1\, dA_2$$

$$F_{21} = F_{A_2 \to A_1} = \frac{\dot{Q}_{A_2 \to A_1}}{\dot{Q}_{A_2}} = \frac{1}{A_2}\int_{A_2}\int_{A_1} \frac{\cos\theta_1 \cos\theta_2}{\pi r^2}\, dA_1 dA_2$$



For diffuse emitters and reflectors

$$A_1 F_{12} = A_2 F_{21}$$

Flat surface: : $F_{1\to 2} = 0$; Concave surface: $F_{2\to 2} = 0$; Convex surface: $F_{3\to 3} \neq 0$; An enclosure:

$$\sum_{j=1}^{N} F_{i \to j} = 1$$

the heat exchange between two black surfaces

The net heat transfer is the radiation leaving the entire surface 1 that strikes surface 2 subtracts the radiation leaving the entire surface 2 that strikes surface 1, applying the reciprocity relation:

$$A_1 F_{1\to 2} = A_2 F_{2\to 1}$$
$$\dot{Q}_{1\to 2} = A_1 F_{1\to 2} \sigma (T_1^4 - T_2^4)$$

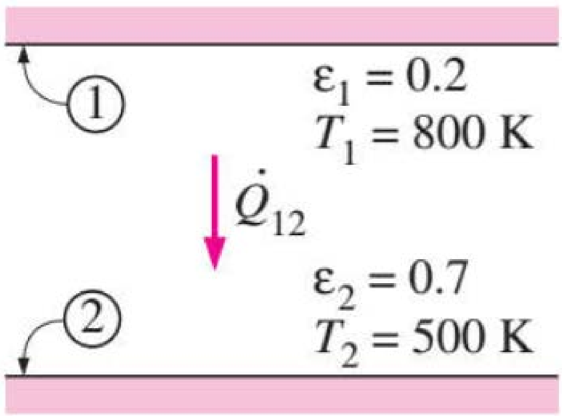
the heat exchange between the two gray surface

We know grey body surface i, with the area A_i, emitting a radiation of E_{bi} per unit area per unit time. The net heat transfer is the radiation leaving the entire surface i subtracts the radiation incident on the entire surface i, so $J_i = \varepsilon_i E_{bi} + (1-\varepsilon_i) G_i$

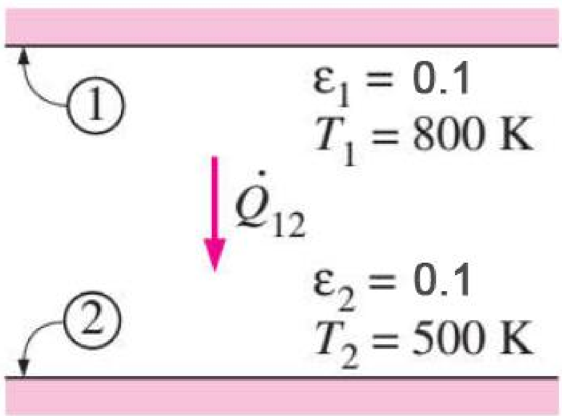
the definition of radiative resistances

Radiative resistance is a value to measure the energy depleted by loss resistance which is converted to heat radiation $R_i = \dfrac{1-\varepsilon_i}{A_i \varepsilon_i}$

Task 2 Solve the last example you solved in the class (radiative heat exchange between two parallel plates) awhile considering the two emissivities to be 0.1, what can you conclude from the result?



$$\dot{Q}_{12} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{1.5 \times 5.67 \times 10^{-8} \times (800^4 - 500^4)}{\frac{1}{0.2} + \frac{1}{0.7} - 1} = 3625.37W$$



$$\dot{Q}_{12} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{1.5 \times 5.67 \times 10^{-8} \times (800^4 - 500^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} = 1035.81W$$

Conclusion: By comparing the two values of net heat transfer, we can see the value of emissivity is proportional to the net radiation heat transfer .The lower the emissivity , the lower the net radiation heat transfer