14C - 2ND CLASS

EMISSIVE POWER

$$E_\lambda = \int_0^{2\pi}\int_0^{\pi/2} I_\lambda(\lambda,\theta,\phi)\cdot\cos(\theta)\,d\omega$$

$$d\omega = \sin(\theta)\,d\theta\,d\phi$$

$$\boxed{E_\lambda = \int_0^{2\pi}\int_0^{\pi/2} I_\lambda(\lambda,\theta,\phi)\cos(\theta)\sin(\theta)\,d\theta\,d\phi}$$

Spectral Emissive Power $\left[\frac{W}{m^2\,\mu m}\right]$

$$\boxed{E = \int_0^{\infty} E_\lambda\,d\lambda}$$

Emissive Power (intergrate over all wavelengths) $[W/m^2]$

"every direction is the same"

Diffuse Emitter

- The intensity is independent of direction

$$I_{\lambda,e}(\lambda,\theta,\phi) = I_{\lambda,e}(\lambda)$$

e for emitted radiation

$$E_\lambda = \int_0^{2\pi}\int_0^{\pi/2} I_{\lambda,e}\cos\theta\sin\theta\,d\theta\,d\phi$$

$I_{\lambda,e}$ is not a function of direction

$$= I_{\lambda,e}(\lambda)\int_0^{2\pi}\int_0^{\pi/2}\cos(\theta)\sin(\theta)\,d\theta\,d\phi$$

$$= 2\pi I_{\lambda,e}\underbrace{\int_0^{\pi/2}\underbrace{\sin\theta\cos\theta}_{\sin(2\theta)=2\sin\theta\cos\theta}\,d\theta}_{=1/2}$$

$$\boxed{\begin{aligned} E_\lambda &= \pi I_{\lambda,e}(\lambda) \\ E &= \pi I_e(\lambda) \end{aligned}}$$

for a diffuse emitter

Irradiation

$$G_\lambda = \int_0^{2\pi}\int_0^{\pi/2} \underbrace{I_{\lambda,i}}_{\text{incident radiation}}(\lambda,\theta,\phi)\cos(\theta)\sin(\theta)\,d\theta\,d\phi \qquad \left[\frac{W}{m^2\,\mu m}\right]$$

$$G = \int_0^\infty G_\lambda\,d\lambda \qquad \left[\frac{W}{m^2}\right]$$

Diffuse Irradiation

$$I_{\lambda,i}(\lambda,\theta,\phi) = I_{\lambda,i}(\lambda)$$

$$\boxed{\begin{aligned} G_\lambda &= \pi I_{\lambda,i}(\lambda) \\ G &= \pi I_i \end{aligned}}$$

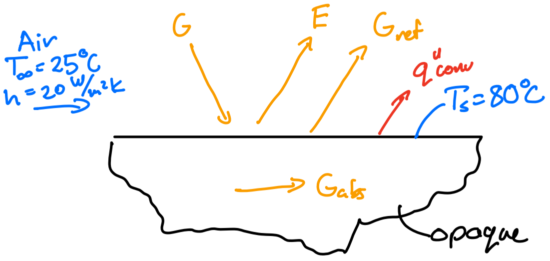
Diffuse Irradiation

Same approach for Radiosity

$$I_\lambda = \int_0^{2\pi}\int_0^{\pi/2} \underbrace{I_{\lambda,e+r}}_{\text{radiosity}}\cos(\theta)\sin(\theta)\,d\theta\,d\phi$$

⋮ (same as others)

Example



emissive power = 628 W/m² = E
irradiation = 380 W/m² = G
reflectivity = 0.3 = ρ

① Find the absorptivity

$$G = G_{ref} + G_{abs} = \rho G + \alpha G$$

$$\rho + \alpha = 1 \rightarrow \boxed{\alpha = 0.7}$$

② Find the emissivity

$\varepsilon = ?$ $\qquad \sigma = 5.67\times10^{-8}\ \frac{W}{m^2K}$

$$E = \varepsilon\sigma T_s^4 \ \boxed{= 0.71}$$

③ Is our surface a grey surface?

$\alpha \approx \varepsilon \Rightarrow$ Yes

④ Find rate of radiation leaving the surface. $J = ?$

$J = E + G_{ref}$

$= \varepsilon\sigma T_s^4 + \rho G = 1042 \frac{W}{m^2}$

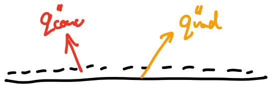
⑤ Find the net radiation leaving the surface

q''_{rad}

$q''_{rad} = G_{ref} + E - G$

$= \rho G + E - G = \underset{\overset{\uparrow}{*}}{-}338 \frac{W}{m^2}$

⑥ Find the net total heat transfer leaving surface.



$q''_{total} = q''_{rad} + q''_{conv}$

$= q''_{rad} + h(T_s - T_\infty) = +762 \frac{W}{m^2}$