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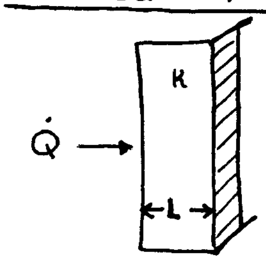
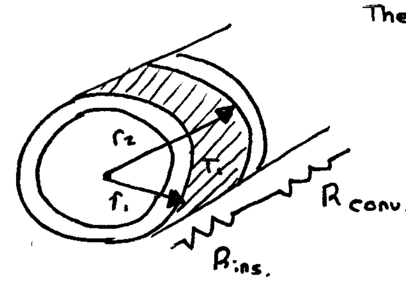
Thermal Sci.

Critical radius of insulation :



$R_{wall} = \frac{L}{KA}$

R_{wall} increases



$R_{ins} = R_{cyl} = \frac{\ln(r_2/r_1)}{2\pi L K}$

$R_{conv} = \frac{1}{\ln(2\pi r_2 L)}$

$\therefore \dot{Q} = \frac{T_1 - T_\alpha}{\left(\frac{\ln(r_1/r_2)}{2\pi L K}\right) + \left(\frac{1}{\ln(2\pi r_2 L)}\right)}$

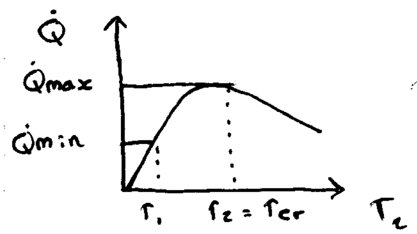
$\dot{Q} = \frac{T_1 - T_\alpha}{R_{TOTAL}}$

$= \frac{T_1 - T_\alpha}{R_{ins.} + R_{conv.}}$

→ For max heat transfer

$\frac{d\dot{Q}}{dr_2} = \emptyset$

→ $r_2 = \frac{k}{h}$ → $r_{cr} = \frac{k}{h}$



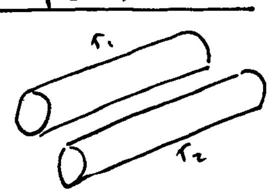
→ $r_2 < r_{cr}$ ($\dot{Q}$ increases)

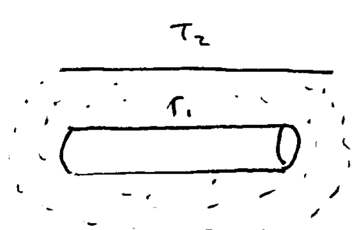
$r_2 > r_{cr}$ ($\dot{Q}$ decreases)

$r_{cr.} = \frac{k}{h}$ (0.05 W/m.K)

$r_{cr,max} = \frac{(0.05 \text{ W/m.K})}{(5 \text{ W/m}^2\text{.K})} = 0.01 \text{ m} = 1 \text{ cm}$

Conduction shape factor





$\dot{Q} = SK(T_1 - T_2) = \frac{T_1 - T_2}{r}$

S = in length unit

$SK = 1/R$

$S \propto 1/R$

Heat : Chapter 12 - Fundamentals of Thermal Radiation

Obj : (1) classify electromagnetic radiation and identify thermal radiation

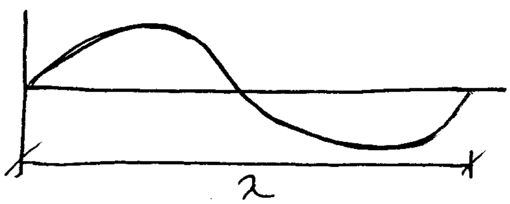
(2) Develop a clear understanding properties ; emissivity , absorption, reflectivity , transmissivity

Properties of radiation :

(1) All substances with body temperature above 0 K continuously emit energy

(2) Emitted radiation is proportional to the temperature of the body

(3) No intervening medium is required



Thermal radiation :

λ = 0.1 - 100 μm

(Infrared + visible + ultraviolet)

50% visible

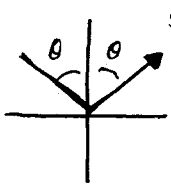
12% UV

$\simeq$ 38% infrared

Solar radiation : λ = 0.3 - 3 μm

Infrared : λ = 0.76 - 100 μm

Ultraviolet : λ = 0.01 - 0.4 μm



Blacker (with more absorption)

$E_b(T) = \sigma T^4$ (W/m^2) $\rightarrow$ Total emissive power = $A \sigma T^4$ (W)

Emissive power

$$E_b(T) = \sigma T^4$$

$E_{b\lambda}$ - spectral black body emission

$$E_{b\lambda}(\lambda, T) = \frac{C_1}{\lambda^5\left[\exp\left(C_2/\lambda T\right) - 1\right]}$$

$C_1 = 3.74177 \times 10^{8}\ w \cdot \mu m^4/m^2$

$C_2 = 1.43878 \times 10^{4}\ \mu m \cdot K$

Observations : (From Variation of emissive power graph)

1. The emitted radiation is a continuous function of wavelength
2. At any wavelength the amount of emitted radiation increases with increasing temperature
3. As temperature increases, the curves shift to the left to the shorter wavelength region.

Wein's displacement law :

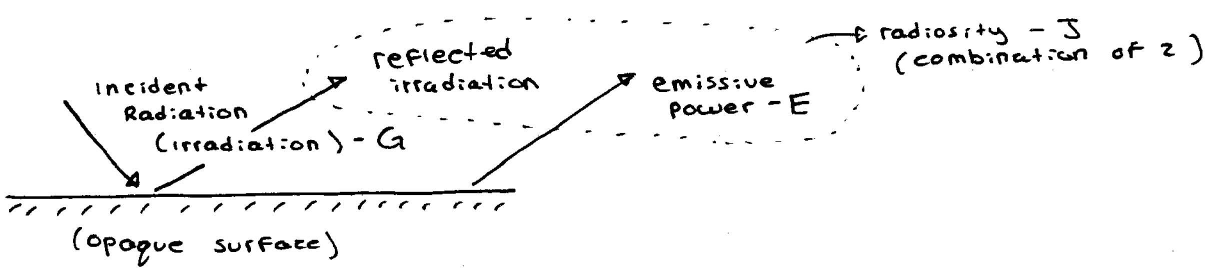
$(\lambda T)_{max\ power} = 2897.8\ \mu m \cdot K$

$\rightarrow$ λ of solar radiation for maximum power ?

$\therefore (\lambda)_{max\ power} = \dfrac{2897.8}{\underbrace{5780}_{given}} \simeq 0.5\ \mu m$

$@\,298\,K\ ;\ \lambda = \dfrac{2897.8\ \mu m \cdot K}{298 \cdot K} \Rightarrow \lambda = 9.72\ \mu m$

$E_b(T) = \int_0^{\alpha} E_{b\lambda}(\lambda, T)\, d\lambda = \sigma T^4\ \ w/m^2$



$\epsilon(T) = \dfrac{E(T)}{E_b(T)}\ ;\ \ 0 \le \epsilon \le 1$

For semitransparent material :

Absorptivity : $\alpha = \dfrac{\text{Absorbed radiation}}{\text{Incident radiation}} = \dfrac{G_{abs}}{G}$

Reflectivity : $\rho = \dfrac{\text{Reflected radiation}}{\text{Incident radiation}} = \dfrac{G_{ref}}{G}$

Transmissivity : $\tau = \dfrac{\text{Transmitted radiation}}{\text{Incident radiation}} = \dfrac{G_{tr}}{G}$

$G = G_{abs} + G_{ref} + G_{tr}$ (by first law of thermo.)

$G = \alpha G + \rho G + \tau G$

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

For a blackbody (perfect absorption)

then $\alpha = 1$ ($\rho = 0$, $\tau = 0$)

For gases (no reflection)

then $\alpha + \tau = 1$ ($\rho = 0$)

For opaque (no transmission)

then $\alpha + \rho = 1$ ($\tau = 0$)

$\epsilon \; \alpha \; T$ of the object

$\alpha \rightarrow$ does not depend on the objects temperature

$\rightarrow$ depends on the source temperature

$G_{abs} = \alpha G$ | $G = \sigma T^4$

$= \alpha \sigma T^4$ | $E_{emit} = \epsilon \sigma T^4$

$\rightarrow A_s \epsilon \sigma T^4 = A_s \alpha \sigma T^4$

$\therefore \epsilon^{(T)} = \alpha^{(T)} \Rightarrow \epsilon = \alpha$