Week 5

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Write a summary of the topics about radiative heat transfer 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 resistance.

Emissivity: (ε)

Emissivity is defined as the ratio of the energy radiated from a material's surface to that radiated from a perfect emitter, known as a blackbody, at the same temperature and wavelength and under the same viewing conditions. It is a dimensionless number between 0 (for a perfect reflector) and 1 (for a perfect emitter, black body). The emissivity of a surface is not a constant; it is a function of temperature of the surface and wavelength and the direction of the emitted radiation, $\varepsilon = \varepsilon\,(T, \lambda, \theta)$ where θ is the angle between the direction and the normal of the surface.

Real surface:
$\varepsilon_\theta \neq \text{constant}$
$\varepsilon_\lambda \neq \text{constant}$

Diffuse surface:
$\varepsilon_\theta = \text{constant}$

Gray surface:
$\varepsilon_\lambda = \text{constant}$

Diffuse, gray surface:
$\varepsilon = \varepsilon_\lambda = \varepsilon_\theta = \text{constant}$

Reflectivity: (ρ)

It is total energy reflected by the body. Its value depends upon the nature of the surface of the body, its temperature and wavelength of incident radiations. It also depends on the wavelength of light, direction of the incident and reflected light, polarization of light, type of the material, chemical composition and structure of the material, and state of the material and its surface.

It is the ratio of reflected radiation (G012) to incident radiation (G). It is a dimensionless number between 0 and 1.

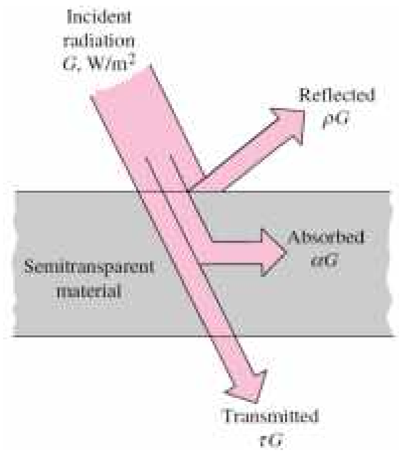
Absorptivity (α)

Absorptivity is defined as the fraction of irradiation absorbed by the surface. It depends on the wavelength and direction of the incident light, type of the material, chemical composition and structure of the material and state of the material and its surface.

Absorptivity: $$\alpha = \frac{\text{Absorbed radiation}}{\text{Incident radiation}} = \frac{G_{abs}}{G}, \qquad 0 \le \alpha \le 1$$

Reflectivity: $$\rho = \frac{\text{Reflected radiation}}{\text{Incident radiation}} = \frac{G_{ref}}{G}, \qquad 0 \le \rho \le 1$$

Transmissivity: $$\tau = \frac{\text{Transmitted radiation}}{\text{Incident radiation}} = \frac{G_{tr}}{G}, \qquad 0 \le \tau \le 1$$



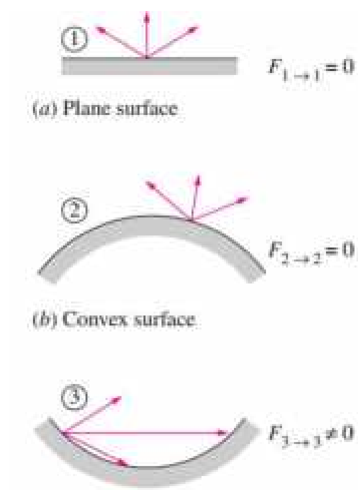
It is the ratio of absorbed radiation (G_{r}-.) to incident radiation (G). It is a dimensionless number between 0 and 1.

Transitivity: (τ)

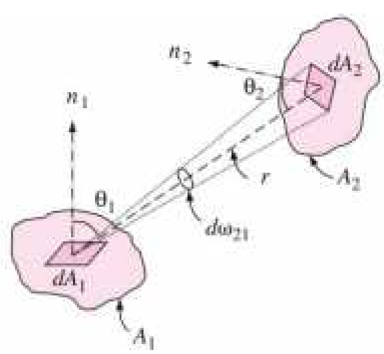
Transmissivity is defined as the fraction of irradiation transmitted through the surface.

It is the ratio of transmitted radiation (G40) to incident radiation (G). It is a dimensionless number between 0 and 1.

View Factor

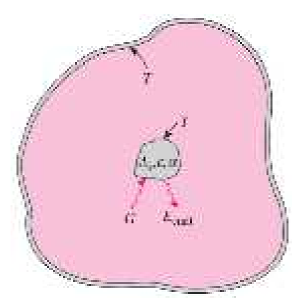


View factor is defined as the fraction of the radiation leaving



surface that is intercepted by surface A. It ranges between 0 and 1 but there are few methods to calculate the view factor: In radiative heat transfer, It is the proportion of the **radiation** which leaves surface that strikes surface. In a complex 'scene' there can be any number of different objects, which can be divided in turn into even more surfaces and surface segments.

Kirchhoff's law:



The total hemispherical emissivity of a surface at temperature T is equal to its
total hemispherical absorptivity for radiation coming from a blackbody at the same temperature.

$$\varepsilon(T) = \alpha(T)$$

Reciprocity Law:

$$A_1F_{12} = A_2F_{21}$$

Heat exchange between two non black bodies:

The analysis of radiant heat exchange between two non-black parallel surfaces shall be based on the following assumptions:

(i) The surfaces are arranged at small distance from each other and are of equal area so that practically all radiation emitted by one surface falls on the other. The configuration factor of either surface is therefore unity.

(ii) The surfaces are diffuse and uniform in temperature, and that the reflective and emissive properties are constant over all the surface.

(iii) The surfaces are separated by a non-absorbing medium such as air.

Assume all the surfaces are diffusive and uniform in temperature that reflective and emissive properties are constant over all the surfaces.

G = irradiation = total radiation incident upon a surface per unit time and per unit area

J = radiosity = total radiation which leaves a surface per unit time and per unit area

The net energy leaving the surface is the difference between radiosity and the irradiation.

Radiation heat transfer in two enclosures:

That is the net rate of radiation heat transfer from surface 1 to surface 2 must equal the net rate of radiation heat transfer from surface 1 and the net rate of radiation heat transfer to surface 2.

The radiation network of this two-surface enclosure consists of two surface resistances and one space resistance. In an electrical network, the electric current flowing through these resistances connected in series would be determined by dividing the potential difference between points *A* and *B* by the total resistance between the same two points. The net rate of radiation transfer is determined in the same manner and is expressed as:

This important result is applicable to any two gray, diffuse, and opaque surfaces that form an enclosure. The view factor *F* depends on the geometry and must be determined first.

Task 2:

Find the net radiative heat exchange between the surface 1 and 2:

$$Q. = \frac{\alpha(T_1^4 - T_2^4)}{\frac{1}{\varepsilon} + \frac{1}{\varepsilon} - 1}$$

$$Q. = \frac{5.67x10^{-8}x(800^4 - 500^4)}{\frac{1}{0.2} + \frac{1}{0.7} - 1} = \frac{19860{,}57}{5.43} = 3624{,}4\ W/m^2$$

Solve the same problem where $\varepsilon 1$ = 0. , $\varepsilon 2$ = 0. , $T1$ = 800 K, $T2$ = 500 K, σ = 5.67 * 10^-8

Comparing the two value found we can

$$Q. = \frac{\alpha(T_1^4 - T_2^4)}{\frac{1}{\varepsilon} + \frac{1}{\varepsilon} - 1}$$

$$Q. = \frac{5.67x10^{-8}x(800^4 - 500^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} = \frac{19860{,}57}{19} = 1035.8\ W/m^2$$

conclude that the Q. increases when the values of emissivity also increase.