Week 5

Radiative Heat Transfer

Emissivity

It indicates the object's ability to emit energy. Emitted energy indicates the temperature of the object. Emissivity of each object varies according to the surface roughness, temperature wavelength and radiation direction.

$$0 \leq \mathcal{E} \leq 1 \text{ (blackbody)}$$

The emissivity of a surface at a specified wavelength is called spectral emissivity ε_λ. The emissivity in a specified direction is called directional emissivity ε_θ where θ is the angle between the direction of radiation and the normal of the surface.

Types of Objects

Real Surface:
Diffuse Surface: Doesn't depend on the direction.
Gray Surface: Doesn't depend on the wavelength.

Absorptivity

The ability of the object to absorb the emitted radiation. It depends on the material of the object, temperature and the circumstances.

$$\alpha = \frac{Absorbed\ radiation}{Incident\ radiation}\ , \qquad 0 \leq \alpha \leq 1$$

Reflectivity

The ability of the object to reflect the emitted radiation. It depends on the material of the object, temperature and the circumstances.

$$\rho = \frac{Absorbed\ radiation}{Incident\ radiation}\ , \qquad 0 \leq \rho \leq 1$$

Transmissivity

The ability of the object to transmit the emitted radiation. It depends on the material of the object, temperature and the circumstances.

$$\tau = \frac{Absorbed\ radiation}{Incident\ radiation}\ , \qquad 0 \leq \tau \leq 1$$

The View Factor

The degree to which heat carried by radiation can be passed between two surfaces. The view factor is the fraction of radiation leaving one surface which is intercepted by a second surface.

Heat Exchange between Two Black Surfaces

Heat exchange between two black surfaces occur when one surface emits radiation and the other one totally absorbs the radiation.

$$A_1 \text{ X } E_{b1} \text{ X } F_{1\text{-}2} - A_2 \text{ X } E_{b2} \text{ X } F_{2\text{-}1}$$

Heat Exchange between Two Gray Surfaces

Heat exchange between two black surfaces occur when one surface emits radiation and the other one absorbs part of the radiation.

$$A_i \text{ X } J_i \text{ X } F_{i\text{-}j} - A_j \text{ X } Jj \text{ X } F_{j\text{-}i}$$

Radiative Resistance

The loss in heat radiation is transferred into radio waves.

Task 2

$$Q_{12} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

$$= A \frac{5.67 \times 10^{-8} \times (800^4 - 500^4)}{\frac{1}{0.2} + \frac{1}{0.7} - 1} = A * \frac{19680.57}{5.423}$$

$$= 3625.35 \text{ W}$$

if the emissitivity is 0.1:

$$\dot{Q}_{12} = \frac{5.67 \times 10^{-8} (800^4 - 500^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} = 1035.8 \text{ W}$$

∴ if the two surfaces have low emmissivity, the heat transfer between the surfaces decreases.