

ASSIGNMENT WEEK 5

A. 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?

When the $\epsilon_1 = \epsilon_2 = 0.1$,

$$\therefore R_{total} = \frac{1}{0.1} + \frac{1}{0.1} - 1 = 19 \frac{^\circ\text{C}}{\text{W}}$$

$$Q_{12} = \frac{A_1 \sigma (T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = \frac{1.5 \times 5.67 \times 10^{-8} \times (298^4 - 308^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} = -4.9823 \text{ W}$$

And from the equation solved in the class,

$$\begin{aligned} Q_{12} &= A_1 F_{12} \sigma (T_1^4 - T_2^4) \\ &= 1.5 \times 0.01 \times 5.67 \times 10^{-8} (298^4 - 304^4) = -0.9466 \text{ W} \end{aligned}$$

Therefore, we can conclude that emissivity directly affects the net heat exchange irrespective of the same temperature difference for both the situations.

B. 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:

Radiative heat transfer refers to the transfer of heat between objects in the form of electromagnetic waves. All objects above absolute zero temperature emit thermal radiation. Thermal radiation is observed in the wavelength range from 100 μm to 0.1 μm (Infrared, Visible light and higher wavelength Ultraviolet rays). Radiative heat transfer depends on the temperature of the surface; the intensity of radiation emitted depends on the wavelength and direction of the waves. A black body is an ideal body which is a perfect absorber and emitter of thermal radiation.

The thermal energy emitted by a black body is

$$\therefore E_B = \sigma T^4$$

Emissivity: Emissivity of a material surface is used to measure the amount of thermal radiation the surface is emitting. The ratio of the radiation emitted by a surface at a time divided by the radiation emitted by a black body at same temperature is used to calculate emissivity of that surface. The value of emissivity is between 0(lowest) and 1(highest). The more the value is, the closer it is to the blackbody.

$$\therefore \epsilon = \frac{E}{E_B}, 0 \leq \epsilon \leq 1$$

Absorptivity: The radiation coming from a surface to another surface, fraction of it is absorbed by the second surface. The ability of the second surface to absorb part of radiation is called absorptivity. It is calculated by the amount of absorbed radiation divided by the overall incident radiation of the surface. The calculated ratio is called absorptivity(α) of the surface.

$$\therefore \alpha = \frac{G_{abs}}{G}, 0 \leq \alpha \leq 1$$

The view factor: A fraction of radiation going from surface 1 towards surface 2 gets obstructed by surface 2. This fraction number is called the view factor. The view factor works differently for plane, convex and concave surfaces. In case of concave surface, it hits another part of the same surface when in plane and convex surfaces, it hits other surfaces. In this way, heat passes through radiation.

Acc to law of reciprocity

$$A_1 \times F_{1-2} = A_2 \times F_{2-1}$$

Reflectivity: The incident radiation coming from a surface to another surface, fraction of it is reflected by the second surface. The ability of the second surface to reflect part of radiation is called reflectivity. It is calculated by the amount of reflected radiation divided by the overall incident radiation of the surface. The calculated ratio is called reflectivity(ρ) of the surface.

$$\therefore \rho = \frac{G_{ref}}{G}, 0 \leq \rho \leq 1$$

Heat exchange between two black surfaces: If we consider radiative heat exchange between two black surface B1 and B2, the heat exchange will be the subtraction between radiation leaving from B1 hitting B2 and radiation leaving B2 hitting B1. Black bodies absorb the radiation so both the radiations will be absorbed by both surfaces.

Heat exchange between two grey surfaces: Unlike black bodies, when a grey surface receives radiation, it absorbs and reflects a portion of the incident radiation. The emissivity of a grey surface depends on the direction and the wavelength is constant in this case. So, if we consider a grey surface g1, the net heat transfer rate is the subtraction between the incident radiation and the radiation leaving the surface through absorption and reflection.

Radiative resistance: During the radiation process, energy loss happens while creating electromagnetic waves and converted to heat radiation. This phenomenon is called radiative resistance, to measure the incident.

SUBMITTED BY – JAGRIT VIJ

STUDENT ID - 10654065