Homework 5

Sunday, November 3, 2019 10:08 PM

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 resistances.

RADIATIVE HEAT TRANSFER:

When any object gains heat through convection and conduction, it's temperature increases to a significant rate and it's molecules and atoms releases energy which we call thermal radiation. So, radiative heat transfer is when an object or surface transfers the heat through radiation to another object or surface. This generally happens when a body contains more heat than the other body. Unlike convection and conduction, radiative heat transfer does not need a medium or to be in contact. Radiative heat transfers in form of wavelength. Almost all objects (solid, liquid or gas) do radiative heat transfer from all surfaces.

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 particular 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.
The emissivity of a real surface depends on these aspects- wavelength and direction of radiation and temperature
The emissivity of diffused surface depends on the wavelength and the direction is a constant here.
The emissivity of a grey surface depends on the direction and the wavelength is constant in this case.

ABSORPTIVITY:

The incident 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.

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.

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. It does not depend on the quality of surface.
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. It this way, heat passes through radiation.

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 radia tions will be absorbed by both surfaces. In this case, the net heat transfer is the amount of heat gain by one of the two surfaces.
So if we consider A_{B1} *and* A_{B2} as areas of B1 and B2, and F_{1-2} *and* F_{2-1} as view factors, then the heat exchange-

$$\dot{Q} = E_{B1}A_{B1}F_{1-2} - E_{B1}A_{B2}F_{2-1} = (\sigma T^4)A_{B1}F_{1-2} - (\sigma T^4)A_{B2}F_{2-1}$$

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. The absorption and reflection by surface 1 altogether is called Radiosity (J_1).
So, if we consider surface area A_1 and incident radiation G_1
Then, the net heat transfer $\dot{Q} = A_1\ (J_1 - G_1)$

RADIATIVE RESISTANCE:

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

Find the net heat exchange between the surface 1 and 2 where A1 = 1.5 m^2*, F_12 = 0.01 , T__1 = 298 K, T_2 = 308 K,* $\in_1 = 0.1$, $\in_2 = 0.1$, $\sigma = 5.67 * 10^{-8}\ \frac{W}{m^2K^4}$

Here,

$$\dot{Q}_{1-2} = \frac{A_1\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\epsilon_1}+\frac{1}{\epsilon_2}-1} = \frac{1.5 * 5.67 * 10^{-8} * \left(298^4 - 308^4\right)}{\frac{1}{0.1}+\frac{1}{0.1}-1} = -4.9823\ W$$

And, from the equation solved in the class,

$$\dot{Q}_{1-2} = A_1F_{12}\sigma\left(T_1^4 - T_2^4\right) = 1.5 * 0.01 * 5.67 * 10^{-8} * \left(298^4 - 308^4\right) = -0.9466\ W$$

From the two results, we can conclude that, the value of emissivity greatly affects the net heat exchange between two surfaces. Even though the temperatures are same in both situation, the lower value of emissivity results into a lower radiative heat exchange rate.