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Task1:

In you own words (which means in your own words) 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

(1) Emissivity:

- The ratio of the radiant flux radiated by per unit area of the object's surface to the radiant flux radiated by the black body at the same temperature. It characterizes the proximity of the thermal radiation of the actual object to the thermal radiation of the black body, which is one of the important factors affecting surface temperature.
- The specific emissivity varies with the temperature, surface roughness, wavelength, and direction of emitted radiation, and the value is between 0 and 1.
- For objects with different surfaces, the emissivity at a specified wavelength(ε_λ)and in a specified direction(ε_θ) is different. For real surface, both of them are constant. For diffuse surface(its properties are independent of direction), ε_θ is constant, which equals to ε_λ of gray surface(its properties are independent of wavelength).

(2) Absorptivity&Reflectivity:

- When an object is exposed to radiation from other objects , the radiant flux radiated by the surface consists of three parts.
  Absorptivity: The ratio of the radiant flux absorbed by the surface to the total radiant flux radiated by the surface (the value is between 0 and 1).
  Reflectivity: The ratio of the radiant flux reflected by the surface to the total radiant flux radiated by the surface (the value is between 0 and 1).
  Transmissivity: The ratio of the radiant flux transmissivity by the surface to the total radiant flux radiated by the surface (the value is between 0 and 1).
  In general, A+R+T=1. For the opaque surfaces, A+R=1, which means that there is no radiation transmissivity.
- Kirchhoff's law: At the same temperature, the ratio of the emissivity to the absorptivity of the same wavelength for different objects is equal, and is equal to the emissivity of the black body to the same wavelength at that temperature. It is used to describe the relationship between the emissivity of an object and the absorptivity.

(3) View Factor:

- The view factor is a factor reflecting the relationship between geometry and position between different objects radiating from each other
- a reflection angle factor, it is part of the energy emitted from an opaque, diffusely reflective surface that is emitted directly to another surface (absorbed or reflected).

- It does not depend on the surface properties, and has no relationship with the temperature and emissivity of the two surfaces.

- The view factor of surface 1 to surface 2 is: the energy that surface 1 projects directly onto surface 2, as a percentage of the radiant energy of surface 1(F_{12}),the view factor of surface 2 to surface 1 can also be defined(F_{21}). According to the reciprocity law, $A_1 \times F_{12} = A_2 \times F_{21}$.
- The direction of emitted radiation from the first object to the other object varies with the shapes of surfaces. For the plane and convex surface, the value of the view factor is 0, while it is not 0 for the concave one. What's more, for an enclosure made of three surfaces, the total value is 1.

(4) Heat Exchange (between two Black Surfaces):

According to the view factor , the radiant energy emitted from the surface 1 and projected directly onto the surface 2 is $F_{12} \times E_b = F_{12} \times \sigma T_1^4 \ \left(\frac{W}{m^2}\right)$, while the radiant energy emitted directly from the surface 2 onto the surface 1 is$F_{21} \times E_b = F_{21} \times \sigma T_2^4 \ \left(\frac{W}{m^2}\right)$.

Since both surfaces are black, the radiation projected on them can be absorbed by each other, so the amount of direct radiation heat exchange between the two surfaces is $\dot{Q}\_1 \rightarrow 2 \ = \ A_1 \times F_{12} \times \sigma T_1^4 \ - \ A_2 \times F_{21} \times \sigma T_2^4 = \ A_1 \times F_{12} \times \sigma \left(T_1^4 - T_2^4\right)$.

(5) Heat Exchange (between the two Gray Surface):

- The radiation projected on the two gray surfaces can only be absorbed partially by each other, and also be partially reflected. So radiosity_i (which means everything leaving surface i)) = radiation emitted by surface i + radiation relfected by surface I = $\epsilon \times \sigma T^4 + \rho G$.
- A gray surface i emits radiation to another gray surface j, the amount of direct radiation heat exchange between the two surfaces = (radiation leaving the entire surface i to incident on surface j) – (radiation leaving the entire surface j to incident on surface i) = $\dot{Q}_i = A_i(J_i - G_i)$

(6) Radiative Resistances:

- The radiation resistance is caused by the radiation of the electromagnetic waves of the antenna; in contrast, the loss resistance usually causes the temperature of the antenna to rise. Radiant resistance and loss resistance add up to the resistance of the antenna.
- It is a value used to measure the loss resistance energy, which is converted into heat radiation.

Task 2:

Find the net heat exchange between the surface 1 and 2 where $\mathrm{A1} = 1.5\ \mathrm{m2}$, $\mathrm{F12} = 0.01$, $\mathrm{T1} = 298\ \mathrm{K}$, $\mathrm{T2} = 308\ \mathrm{K}$, $\boldsymbol{\epsilon_1}$=0.1, $\boldsymbol{\epsilon_2}$=0.1, $\boldsymbol{\sigma}$=5.67*10-8$\frac{\boldsymbol{W}}{\mathrm{m}^2\cdot\boldsymbol{K4}}$.

Solve the last example 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?

ANSWER:

$$\dot{Q}_{1\to2} = \frac{A_1\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\epsilon_1}+\frac{1}{\epsilon_2}-1} = \frac{1.5*\mathbf{5.67}*10^{-8}*\left(298^4-308^4\right)}{\frac{1}{0.1}+\frac{1}{0.1}-1} = -4.9823\mathrm{W}$$

$$F_{12} = \frac{1}{\frac{1}{\epsilon_1}+\frac{1}{\epsilon_2}-1} = \frac{1}{\frac{1}{0.1}+\frac{1}{0.1}-1} = 0.0526$$

The example in the class:

$$\dot{Q}_{1\to2} = A_1 \times F_{12} \times \sigma\left(T_1^4 - T_2^4\right) = 1.5*0.01*5.67*10^{-8}*(298^4 - 308^4)$$

$$= -\ 0.9466\ \mathrm{W}$$

$$\dot{Q}_{2\to1} = -\ \dot{Q}_{1\to2} = 0.9466\ \mathrm{W}$$

CONCLUSION:

The value of radiative heat transfer is proportional to the emissivity, when the value of emissivity increases, the value of radiative heat transfer will increase significantly.