Week 5_ Assignment _ Francesca Aiuti

6/11/19

Task 1: Write a summary of the topics about radiative heat transfer we went through, including definitions of emissivity, absorptivity, reflectivity, the view factor, the heat exchange between two black surfaces, heat exchange between the two gray surface and, finally, the definition of radiative resistance.

Task 2: Solve the last example solved in class (radiative heat exchange between two parallel plates), while considering the two emissivities to be 0.1; what can you conclude from the result?

Task 1:

- Radiative heat transfer: thermal radiation is an electromagnetic radiation generetade by the thermal motion of particles in matter, and it happens in an object that has a temperature higher than absolute zero (0 K or -273°C). It happens from a body that has a high temperature to a body with a lower temperature, but they do not need to have physical contact. Since "absolute zero" is an idealized physical condition, thermal radiation happens in all objects (solid, liquid, or gas), because everything is always emitting thermal radiation to the surroundings.

- Emissivity: the emissivity (ε) of the surface of a material is its effectiveness in emitting energy as thermal radiation. In terms of quantity, thermal radiation's ratio is defined by the radiation from a surface to the surface of an ideal black body at the same temperature, in which the value varies from 0 to 1 (the emissivity of the blackbody is 1 ($\varepsilon = 1$). the emissivity of a real surface is affected by the temperature of the surface and the wavelenght and direction of the emitted radiation.

- Absorptivity: the absorptance (α) of the surface of a material is its effectiveness in absorbing radiant energy. Ratio of absorbed radiation is used to calculate the value of absorptivity (0 to 1)

- Reflectivity: the reflectance (ρ) of the surface of a material is its effectiveness in reflecting radiant energy, independently measured of the material's thickness. The ratio of reflected radiation to the incident radiant power is used to calculate the value of absorptivity, with a value varying from 0 to 1.

- View factor: The view factor ($F_{A \to B}$) is the proportion of the radiation which leaves surface A until striking surface B. The intensity of emitted radiation depends on the view factor of the surface relative to the sky.

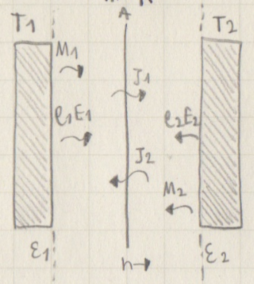
- Heat exchange between to black surfaces: A black surface emits a radiation of E_{b1} (per unit area and unit time). For example, if it has A_1 unit area, then it will emit $E_{b1} \cdot A_1$ radiation in unit time. The consequence is that the radiation will reach the 2nd black body and totally be absorbed by its black surface, but at the same time it will emit its radiation $E_{b2} \cdot A_2$ per second, going to the first body and totally absorbed by it, happening simultaneously to the first radiation. As a consequence, the net heat transfer between these surfaces will be the net heat per second gained by any of the two surfaces. Net heat transfer is the radiation leaving the entire surface 1 that strikes surface 2, subtracting the opposite radiation. The formula is: $A_1 E_{b1} F_{1-2} - A_2 E_{b2} F_{2-1}$.

- Heat exchange between two grey surfaces: A grey surface reflects or absorbs a given fraction of the thermal radiation that a blackbody surface would absorb. The greybody fraction is independent of radiation wavelenght. For a given grey body surface i, with the area A_i, emitting a radiation of E_{bi} per unit area and per unit time. The net heat transfer is the radiation leaving the entire surface i which subtracts the radiation incident on the entire surface i in formula: $A_i(J_i - G_i)$. The radiosity J_i can be calculated by the formula: $\varepsilon_i E_{bi} + (1-\varepsilon_i) G_i$.

- Radiative resistance: It is a value to measure the energy used up by loss resistance, converted into heat radiation. The energy lost by radiation resistance is converted into radio waves. The formula is:

$$R_1 = \frac{1-\varepsilon_1}{A_i \varepsilon_i}$$

Task 2: Find the net radiative heat exchange between the surface 1 and 2, where $A_1 - 1{,}5\ m^2$, $\varepsilon_1 = 0{,}1$, $T_1 = 298\ K$, $T_2 = 308\ K$, $\sigma = 5{,}67 \cdot 10^{-8}\ \frac{W}{m^2 K^4}$.



$$\dot{Q}_{net_{2-1}} = \frac{A\sigma(T_2^4 - T_1^4)}{\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1}$$

$$\dot{Q}_{net_{2-1}} = \frac{1{,}5\ m^2 \times \left(5{,}67 \times 10^{-8}\ \frac{W}{m^2K^4}\right) \times (308^4 - 298^4)\ K^4}{\frac{1}{0{,}1} + \frac{1}{0{,}1} - 1}$$

$$\approx 4{,}9823\ W$$

$$\Rightarrow F_{2-1} = \frac{1}{\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1} = \frac{1}{\frac{1}{0{,}1} + \frac{1}{0{,}1} - 1} \approx 0{,}0526$$

$$F_{1-2} = 0{,}01$$

$$\dot{Q}_{net_{1-2}} = A F_{1-2} \sigma (T_2^4 - T_1^4) = 1{,}5\ m^2 \times 0{,}01 \times \left(5{,}67 \times 10^{-8}\ \frac{W}{m^2K^4}\right) \times (298^4 - 308^4)\ K^4$$

$$\approx -0{,}9466\ W$$

$$\Rightarrow A_1 = A_2, \text{ then if } \frac{A_1\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = -\frac{A_2\sigma(T_2^4 - T_1^4)}{\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1} \Rightarrow \dot{Q}_{net_{2-1}} = \dot{Q}_{net_{1-2}}$$

$$\approx 0{,}9466\ W$$

By comparing the two values of net heat exchange under different situation we can see that the value of emissivity would greatly affect the radiative heat exchange between the two surfaces.