WEEK 5

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QUESTIONS

Task 1 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

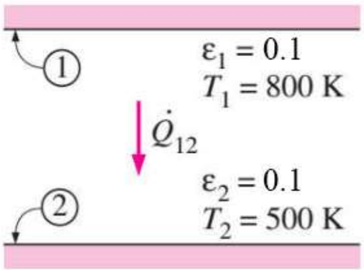
Task 2 Solve the last example you solved in the class (radiative heat exchange between two parallel plates) awhile considering the two emissivities to be 0.1, what can you conclude from the result?

ANSWERS

1. **RADIATIVE HEAT TRANSFER**

Emissivity: A relative index represented by "ϵ", showing the ratio of energy radiated by a particular material to energy radiated by a blackbody at the same temperature. The surface is more similar with blackbody if the emissivity is higher, while that of blackbody is 1 which is the maximum value.
Absorptivity: Represented by "α", the ratio of absorbed radiation of one material to the total incident radation from all directions. It shows the capacity of absorbing the radiative energy, when that of a blackbody is 1 which is the maximum value.
Reflectivity: Represented by "ρ", the ratio of reflected radiation of one material to the total incident radation from all directions. It shows the capacity of reflecting the radiative energy, when that of a blackbody is 0 which is the minumum value.
View factor: Represented by "F", it means the proportion of the radiative energy that is left from every 1m^2-zone of surface n.1 absorbed by every 1m^2-area of surface n.2 to the total radiation emitted by 1m^2-area of surface n.1
Heat transfer between two black surfaces:
Because of the complete absorption and emissivity of blackbodies ($J_i = E_{bi} = \sigma T^4$), meanwhile the view factors of each surface of blackbody are related to three factors, they are the angle between the radiative direction and surfaces, the area of two surfaces and the temperature of each surfaces. From that it comes the net rediative heat exchange between two black surfaces is $\dot{Q}_{i\to j} = A_i F_{i\to j}\sigma(T_i^4 - T_j^4)$
Heat transfer between two gray surfaces:
Because the gray surfaces don't neither absorb all incident radiation nor emit all inner heat, so the $J_i = \epsilon E_{bi} + \rho G = \epsilon\sigma T^4 + (1-\epsilon)G$, as the same process above we can know $\dot{Q}_{i\to j} = A_i F_{i\to j}(J_i - J_j)$
Radiative resistances:
From above we can have $G = \frac{J_i - \epsilon E_{bi}}{1-\epsilon}$, with $\dot{Q}_i = A_i(J_i - G_i)$ we can know $\dot{Q}_i = \frac{(E_{bi}-J_i)\,(A_i\epsilon_i)}{(1-\epsilon_i)}$, if we organize the fomule into $\dot{Q}_i = \frac{(E_{bi}-J_i)}{R}$, defining the $R = \frac{(1-\epsilon_i)}{A_i\epsilon_i}$ as the radiative resistance, since it indicates the variable factor in the radiative heat loss of a surface.
Then we know the view factor from surface i to surface j, we can define the resistance as $R = \frac{1}{A_i F_{i\to j}}$, representing the resistance of radiative heat transfer from the area near surface i to area near surface j.
So from one surface to another, the total resistance is $R_{total} = R_i + R_{i\to j} + R_j = \frac{(1-\epsilon_i)}{A_i\epsilon_i} + \frac{1}{A_i F_{i\to j}} + \frac{(1-\epsilon_j)}{A_j\epsilon_j}$

2. RADIATIVE HEAT EXCHANGE BETWEEN THE TWO PARALLEL PLATES



- As we know when the $\epsilon_1 = 0.2, \epsilon_2 = 0.7$,

$$R_{total} = \frac{1}{0.2} + \frac{1}{0.7} - 1 = 5.43$$

$$\dot{Q}_{12} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = A * 5.67 * 10^{-8} * \frac{800^4 - 500^4}{\frac{1}{0.2} + \frac{1}{0.7} - 1}$$
$$= 3625.37A\, W$$

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

$$R'_{total} = \frac{1}{0.1} + \frac{1}{0.1} - 1 = 19$$

$$\dot{Q}'_{12} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\epsilon'_1} + \frac{1}{\epsilon'_2} - 1} = A * 5.67 * 10^{-8} * \frac{800^4 - 500^4}{\frac{1}{0.1} + \frac{1}{0.1} - 1}$$
$$= 1035.82A\, W$$

When the emissivities decrease in the range from 0 to 1, which means the decrease is small, however the radiative resistance increases parently, that leads the heat exchange decreases more dramatically.