TASK 1

In your own words, write a summary of the topic about radiative heat transfer we went through including the definition of emissivity, absorptivity and reflectivity, the view factor, the heat exchange between two black surfaces, the heat exchange between two gray surfaces, and finally the definition of radiative resistance

ANSWER

Emissivity

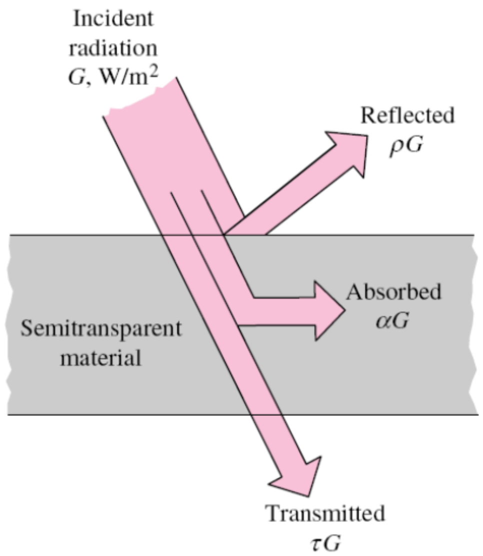
Is the indicator used to calculate the emissive energy of a surface at temperature T, wavelength λ in relation with a black body at that same temperature and wavelength (because the emissive energy of a black body at T and λ is already given by experiment).

In examples, we often consider the surface as the gray body (emissive energy related to the emissive energy of the black body is the same regardless of wavelength) → Total energy in all wavelength can be calculated by:

$$E_{graybody} = \varepsilon \times E_{blackbody} = \varepsilon \times \sigma \times T^4 (W)$$

Absorptivity, Reflectivity and Transmissivity

Are the 3 indicators used to determine the performance of a surface when an incident radiation reach that surface. As a result, these 3 indictors determine the performance of 2 surfaces when they exchange heat radiation



$$E_{incoming} = E_{Reflected} + E_{Absorpted} + E_{Transmitted}$$
$$1 = \frac{E_{Reflected}}{E_{incoming}} + \frac{E_{Absorpted}}{E_{incoming}} + \frac{E_{Transmitted}}{E_{incoming}}$$
$$1 = \rho + \alpha + \tau$$

For opaque material, $\tau = 0$,
$$1 = \rho + \alpha$$

It is also proven that for a surface, $\alpha = \varepsilon$
(Kirchhoff's law)
(absorptivity at an T degree equal to the emissivity). In the case of an opaque object, emissivity is enough to calculate $\rho \& \alpha$

View factor

View factor is a geometric indicator to show the relationship between 2 planes 1 (emitter) and 2 (receiver) in 3D space, to show the amount (percentage / ratio) of radiation that 2 may receive from the total emission of 1.

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

In general, it is time consuming to calculate all planes related to the source(s) of energy in a given environment, and we can use computer program.

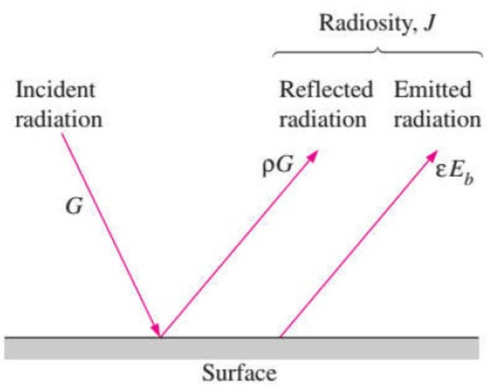
The Heat Exchange Between Two Black Surfaces

Net energy heat exchange = (Energy from surface 1 to 2) – (Energy from surface 2 to 1)

For 2 black bodies:

$\dot{\boldsymbol{Q}}_{\boldsymbol{12}} = F_{1\to 2} \times A_1 \times \sigma(T_1^4 - T_2^4)$

The Heat Exchange Between Two Gray Surfaces and Radiative Resistance



From know equations, it can be proven that:

$$\dot{\boldsymbol{Q}}_{\boldsymbol{12}_i} = \frac{A_i \times \varepsilon_i}{(1-\varepsilon_i)} \times E_{bi} - J_i$$

We can rewrite:

$$\dot{\boldsymbol{Q}}_{\boldsymbol{12}_i} = \frac{E_{bi} - J_i}{R_i}$$

with

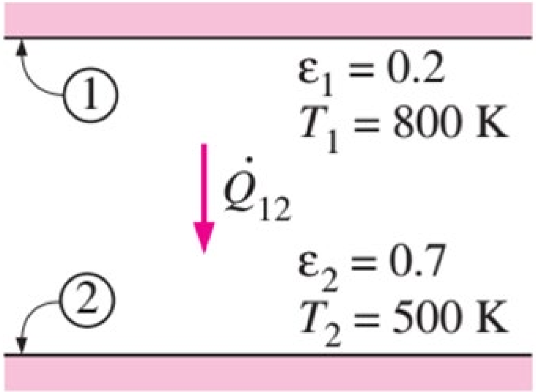
$$R_i = \frac{1-\varepsilon_i}{A \times \varepsilon_i}$$

R_i indicate the resistance of the surface, defined by the surface's area and radiative characteristic ε_i (as mentioned above)

In an example, we can calculate E_{bi} (depends on measurable temperature T) and measure J_i. When we know the ε_i of the surface, we can calculate Q.

TASK 2

Solve the example of radiative heat exchange between the two parallel plates emissivities to be 01.



What can you conclude from the result?

ANSWER

$$\dot{\boldsymbol{Q}}_{\mathbf{12}} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

$\boldsymbol{With\ \varepsilon_1 = 0.2\ and\ \varepsilon_2 = 0.7},$

$$\dot{\boldsymbol{Q}}_{\mathbf{12}} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{\left[1(m^2) \times 5.67 \times 10^{-8}\left(\frac{W}{m^2.K^4}\right) \times \left(800^4(K^4) - 500^4(K^4)\right)\right]}{\left[\frac{1}{0.2} + \frac{1}{0.7} - 1\right]} = \frac{19680.57}{5.428}$$

$\dot{\boldsymbol{Q}}_{\mathbf{12}} = 3625.39\text{W}$

$\boldsymbol{With\ \varepsilon_1 = 0.1\ and\ \varepsilon_2 = 0.1},$

$$\dot{\boldsymbol{Q}}_{\mathbf{12}} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{\left[1(m^2) \times 5.67 \times 10^{-8}\left(\frac{W}{m^2.K^4}\right) \times \left(800^4(K^4) - 500^4(K^4)\right)\right]}{\left[\frac{1}{0.1} + \frac{1}{0.1} - 1\right]} = \frac{19680.57}{19}$$

$\dot{\boldsymbol{Q}}_{\mathbf{12}} = 1035.82\text{W}$

Conclusion:

When emissivity (which means the absorptivity: $\alpha = \varepsilon$) of the 2 surface is smaller, the net radiative heat trancalsfer between 2 parallel planes reduces.