week5_TPletneva

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Task 1: summary about radiative heat transfer, including:

- ***the definitions of emissivity, absorptivity & reflectivity;***
- ***the view factor;***
- ***the heat exchange between two black surfaces;***
- ***the heat exchange between the two gray surfaces;***
- ***the definition of radiative resistances.***

Emissivity, absorptivity & reflectivity.

Emissivity - ϵ is the relation in between the emissive power of a black body and the emissive power of a surface at a given temperature. $0 \leq \epsilon \leq 1$
ϵ_blackbody=1

ϵ = Emissive power of the real surface / Emissive power of the black body at a given temperature

-> ϵ = E_real / E_bb (T)
-> ϵ = E_real / σT^4
-> E_real = ϵ * σT^4

The emissivity is usually given in tables.

Emissivity of a real surface depends on the *temperature* (T) , *wavelength* (λ) and the *direction* (θ) of the emitted radiation:
$\epsilon_\vartheta \neq constant$
$\epsilon_\lambda \neq constant$

For a *diffuse surface* the emissivity will be independent of direction (angle):
$\epsilon_\vartheta = constant$

For a *gray surface* it will be independent of wavelength (λ):
$\epsilon_\lambda = constant$

For a *diffused, gray surface*:
$\epsilon = \epsilon_\lambda = \epsilon_\vartheta = constant$

Absorptivity - α is the ability of the surface to absorb incident radiation (Irradiation - G), it is expressed in the following way:
α = G_abs/G; $0 \leq \alpha \leq 1$ (where 1 is α of a blackbody)

Reflectivity - ρ is the ability of the surface to reflect incident radiation:
ρ = G_refl/G; $0 \leq \rho \leq 1$

Transmissivity - t is the ability of the surface to transmit incident radiation:
t = G_transm/G; $0 \leq t \leq 1$

->

$G\_\alpha + G\_\rho + G\_t = G$

$\alpha + \rho + t = 1$ - for surfaces with transparency

$\alpha + \rho = 1$ - for non-transparent surfaces

The view factor.

The view factor - F_{12} is the part of radiation emitted by the surface 1 and received by the surface 2:

$F_{12} = \dot{Q}_{\text{emitted by the surface 1 and received by the surface 2}} / \dot{Q}_{\text{emitted by the surface 1}}$

The view factor does not depend on the properties of the surface.

Reciprocity law

$A_1F_{12} = A_2F_{21}$

The heat exchange between two black surfaces.

If we have two black surfaces both of them will emit and absorb all radiation.
Let's suppose black body 1 has surface area = A_1 and the second one, A_2.
Both of them will have emission power of E_{b1} & E_{b2}. And, therefore, view factors of $F_{1\text{-}2}$ & $F_{2\text{-}1}$. From here: $E_{b1}*A_1*F_{1\text{-}2} - E_{b2}*A_2*F_{2\text{-}1} = \dot{Q}_{1\text{-}2}$

The heat exchange between two gray surfaces.

Because gray bodies not only absorb, but also reflect radiation, the heat exchange between the two of them will have a loss of energy after a while. Taking on account the fact, that not all the reflected radiation will be absorbed by the surfaces (The view factor).

Radiative resistances.

It is the ability of a surface to resist against radiation heat exchange. This property depends on geometry and overall thermal resistance of the material.

Task 2: solving the example from the class (radiative heat exchange between two parallel plates), considering the two emissivities = 0.1; conclusions from the result.

Find the net heat exchange between the surface 1 and 2 where:

$A_1 = 1.5\ m^2$
$F_{12} = 0.01$
$T_1 = 800\ K$
$T_2 = 500\ K$

$\epsilon_1 = 0.1$
$\epsilon_2 = 0.1$

$\sigma = 5.67 * 10^{-8} \frac{W}{m^2\ K^4}$

Introducing the equation for calculating heat transfer between two parallel plates:

$$\dot{Q}_{net2-1} = \frac{A\sigma({T_1}^4 - T_2^4)}{\frac{1}{\epsilon_2} + \frac{1}{\epsilon_1} - 1}$$

$$\rightarrow \dot{Q}_{net2-1} = \frac{1.5 * (5.67 * 10^{-8}) * (800^4 - 500^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} \approx 1035.82\ W$$

The exercise above shows that the greatest impact on the net heat exchange between the two surfaces will be produced by the emissivity value (in comparison with the results obtained in class with emissivity_1=0.2, and emissivity_2=0.7).