ME 301

CONDUCTION AND RADIATION HEAT TRANSFER

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Review of previous class

- Introduction to Radiation Heat Transfer
- Thermal Radiation Properties and Spectra

At the end of the class you will come to know

- Radiation properties of Surfaces
  - Absorptivity, Reflectivity, Transmissivity, Emissivity
- Blackbody, Graybody, Specularbody , Diffusebody
- Kirchhoff's Law

Little more about Radiation basics …

- For gases and for semi-transparent solids and salt crystals at elevated temp, emission is a *volumetric phenomenon*. That is radiation emitted from a finite volume of matter is the integrated effects of local emission throughout the volume.

- In most solids and liquids radiation emitted from interior surface is strongly absorbed by the adjoining molecules. So radiation that is emitted from solid or liquid originates from molecules that are within a distance of 1μm from the exposed surface… so this is a *surface phenomenon.*

$$\text{Absorptivity} = \frac{\text{Absorbed Radiation}}{\text{Incident Radiation}} = \frac{G_{abs}}{G} \qquad 0 \le \alpha \le 1$$

$$\text{Reflectivity} = \frac{\text{Reflected Radiation}}{\text{Incident Radiation}} = \frac{G_{ref}}{G} \qquad 0 \le \rho \le 1$$

$$\text{Transmissivity} = \frac{\text{Transmitted Radiation}}{\text{Incident Radiation}} = \frac{G_{ref}}{G} \qquad 0 \le \tau \le 1$$

IRRADIATION, G: Radiation flux incident on a surface is called irradiation.

Proof: $\alpha + \rho + \tau = 1$

EMISSIVITY

- Emissivity of a surface represents the ratio of the radiation emitted by the surface at a given temp to the radiation emitted by a BLACKBODY at the same temp.

- Emissivity depends on
  - Body temp
  - Wavelength of the emitted energy
  - Angle of emission

BLACKBODY RADIATION

- Anybody above 0 K emits radiation in all directions over a wide range of wavelength.
- Amount of radiated energy emitted from a surface at a given wavelength contingent on
    - material of the body
    - surface condition
    - surface temperature
- Different body may emit different radiation per unit surface area so interest is on the max amount of radiation

DEFINITION OF BLACKBODY

- A blackbody can be defined as a perfect emitter and absorber of radiation.
- Any specified temp no body can emit more energy than blackbody
- Example- Carbon black, Carborundum, Platinum black, Gold black etc.
- Large isothermal cavity with a small opening. The small opening closely resemble a blackbody.
- Is it necessary for a body to be physically black for being considered as BLACKBODY?
  - NO

DEFINITION OF GRAYBODY

- If the radiative properties α, ρ, τ of a body are assumed to be uniform over the entire wavelength spectrum, such body is called gray body.
- This concept is used to simplify the analysis.

DEFINITION OF SPECULAR BODY

- If a body is mirror polished in such a way that it reflects the incident ray like mirror. The reflection is called specular reflection and the body is called specular body.
- In this case angle of incident is equal to angle of reflection.

DEFINITION OF DIFFUSEBODY

- When a body is has certain roughness that the incident radiation is reflected in all direction and it is assumed that for ideal case the reflected radiation is constant for all the angle of reflection and independent of the incident
- This concept is used to simplify the analysis.

EMISSIVE POWER

TOTAL EMISSIVE POWER, E

- E = emitted energy from a surface/time/surface area.

SPECTRAL EMISSIVE POWER, E_V

- E_v = emitted energy/time/surface area /frequency
- In can also be per unit wavelength E_λ.

KIRCHHOFF'S LAW

- At any temp the ratio of total emissive power, E to the total absorptivity ,α is a constant for all the substances which are in thermal equilibrium with their environment.

- Derivation of Kirchhoff's Law

STEPHEN BOLTZMANN LAW

- The emissive power of a blackbody is proportional to the fourth power of the absolute temperature of the body.

$$E = \sigma T^4$$

- **Proof that : BLACKBODY is a perfect emitter.**

THAT'S ALL ABOUT TODAY.....