Combustion Class 2
Radiation, Thermo

Outline

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Progress

- Diffusion Flames
- Premixed Flames
- Homogeneous Combustion
- Heterogeneous Combustion
- Deflagration
- Detonation
- Stoichiometric
- Equivalence Ratio
- Extinction
- Flammability Limits
- Heat of Vaporization
- Heat of Combustion
- High Heating Value
- Chemical Equilibrium
- Dissociation
- Heats of formation & reaction
- Underventilated flames
- Overventilated flames
- Adiabatic Flame Temperature
- Soot
- Blackbody Radiation
- Thermal NOx
- Turbulence
- Ignition
- Flame Speed
- Flashback

Progress (cont.)

- How does a candle work?
- How does a fireplace work?
- Regimes of heterogeneous combustion
- Sources of NOx
- Single particle vs. cloud combustion
- As rec'd, dry, and daf bases for coal
- Turbulence effects
- Swirl
- Use of NASA-Lewis code
- Elementary step reaction sequences vs. global mechanisms

Modern Fireplace

- Fire contained in insert
- Quartz glass transmits radiation from fire
- Room air circulates around insert (fan?)
- Combustion air from outside vent

Transmittance Through Glass

Figure from Fire, by J. W. Lyons (1985)
**Radiation**

Planck’s Law

\[ \epsilon_{\lambda} = \frac{2 \pi C_1}{\lambda^5 \left( e^{C_2/\lambda T} - 1 \right)} \]

\[ \epsilon = \int \epsilon_{\lambda} d\lambda = \sigma T^4 \]

**Solar Radiation**

**Emissivities**

- Ratio of actual emission to blackbody emission
  - Emissivities range from 0 to 1
- May be wavelength dependent
  - Spectral emissivity (spectral means wavelength dependent)
- If emissivity is constant with wavelength, the source is termed a greybody rather than a blackbody

**IR Camera Demo**

**Infrared and Visible Images of a BurningLeaf**

CO₂ and H₂O emission visible in infrared region.

Soot emission not visible in infrared.

**Example 1.** Compute heat loss due to radiation from a surface of temperature \( T \) when the surrounding surfaces are at 300 K.

\[ Q = \sigma (T^4 - 300^4) \]
Example 2: At what wavelength is the peak emission from a blackbody radiating at a temperature of 1000 K?

\[
\lambda_{\text{max}} = \frac{C_3}{T}
\]

\[
\lambda_{\text{max}} = \frac{C_3}{T} = \frac{2897.8 \text{ } \mu\text{m} - K}{1000 \text{ } K} = 2.9 \text{ } \mu\text{m}
\]

Example 3. Plot the blackbody emission curve versus wavelength for several temperatures. Show where the visible light spectrum occurs.

\[
e_{bl} = \frac{2\pi C_1}{\lambda^5 \left( e^{\frac{C_1}{\lambda T}} - 1 \right)} \text{ } \text{W} \text{ } \text{m}^{-2} \text{ } \mu\text{m}^{-1}
\]