Lasers and Combustion

Experimental Measurement of Temperature and Species in a Pre-mixed Laminar Flame

Ethan Cambell, Keegan Kirkwood, Emma Woods, Madeline Queener
The purpose of this experiment is to measure the carbon monoxide concentration and temperature simultaneously in a \( \text{C}_2\text{H}_4/\text{air} \) premixed laminar flame using a laser based absorption technique. In our experiment, we used an ethylene flame in a shroud of nitrogen.
Combustion

- Incomplete combustion produces water, carbon monoxide, and carbon
  - hydrocarbon + oxygen $\rightarrow$ carbon monoxide + carbon + water
- Carbon monoxide is a by-product of the combustion
Effects of Carbon Monoxide

• Bonds to hemoglobin in the human body
  • Prevents hemoglobin from distributing oxygen to the body
• Makes it more difficult for the atmosphere to rid itself of other pollutant gases
• Causes formation of smog
Basics of a Laser

- Tunable infrared diode laser
  - Consists of diode and focusing crystal
  - Frequency tuned by a function generator to match the molecule being detected
Procedure

- Matched the laser to the frequency of the carbon monoxide
- Laser shot through the flame twice in order to obtain a more accurate reading
- Oscilloscope used to read data from laser
- Data was matched against database consisting of the work of other scientists
Lab Setup

Materials

• Tunable diode laser
• Function generator
• Infrared camera
• Oscilloscope
• Photo diode (camera)
Results
Results Continued
Results Continued

• Analyzed the distance between the two dips to determine the concentration of CO and the temperature of the flame
  • Concentration of CO: 0.002632 ppm
  • Temperature of flame: 1768 K
  • To find the results, we ran the data through Matlab

  \begin{verbatim}
  Iteration: 199, Best: 0.045934, F: 0.600000, CR: 0.900000, NP: 40
  best(1) = 0.069150
  best(2) = 0.002632
  best(3) = 1.161935
  best(4) = 4283.732334
  best(5) = 1768.823554
  best(6) = -0.000000
  best(7) = -0.000000
  \end{verbatim}
Policy

- Air Quality Standards for Carbon Monoxide
  - Primary:
    - 35 ppm within a 1 hour period

- Standards have been in place since 1971
  - Standards were reviewed multiple times and were retained without revisions
Future Applications

• Creating a commercial device that can measure CO emissions during the ignition of a boiler and during normal operating levels
  • Can help companies to reduce the amount of CO that are emitted
  • Easily monitor and adjust carbon monoxide levels
Questions?
Sources

- http://www.bbc.co.uk/education/guides/z6xbkqt/revision
- http://www.epa.gov/ttn/naaqs/standards/co/s_co_history.html