BROADBAND, HIGH-RESOLUTION ABSORPTION SPECTROSCOPY IN PISTON AND GAS TURBINE ENGINES, SHOCK TUBES, AND ROCKET PLUMES

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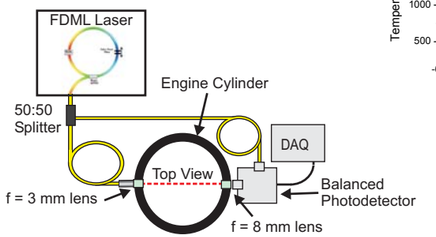
Piston Engine

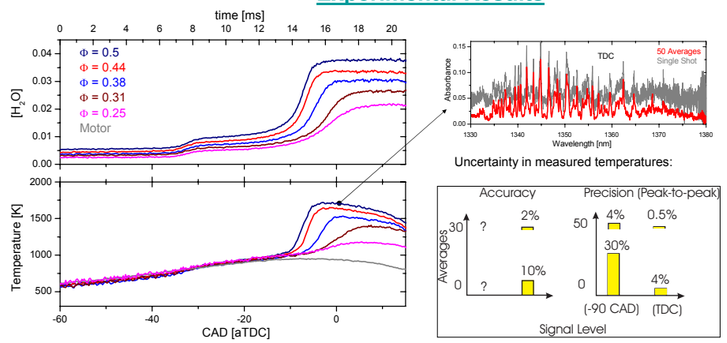
Goal

Develop a sensor for gas temperature and H_2O mole fraction in a Homogenous Charge Compression Ignition (HCCI) engine based on absorption spectroscopy.

Experimental Arrangement



Experimental Results



Uncertainty in measured temperatures:

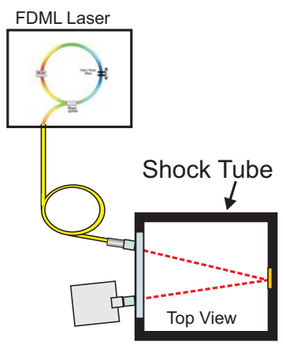
- Wavelength-agile absorption spectroscopy provides *line-of-sight-averaged* temperature and water mole fraction results.
- Differences between measured spectra and HITEMP/HITRAN emphasize need for measurements of reference spectra (our plan: combined in-cylinder OH and H_2O measurements)

Shock Tube

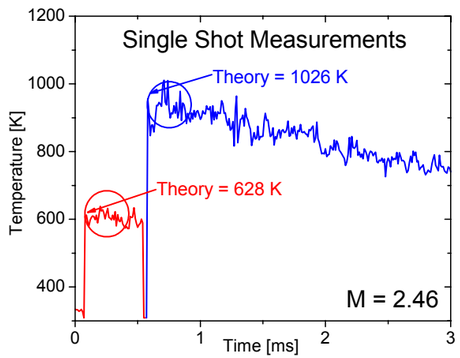
Goal

Validate accuracy of combustion water temperature sensor by measuring shock tube events where temperature is know from gas-dynamic equations

Experimental Arrangement



Experimental Results



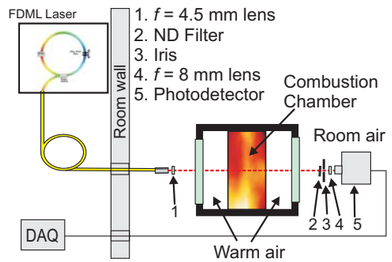
- 30 averaged spectra starting at shock result in ± 2.3% absolute accuracy
- Single spectra ±10% accuracy

Turbine Engine

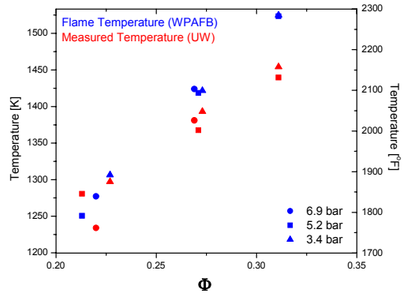
Goal

Apply previously developed combustion sensor to measure water mole fraction and temperature in a high altitude turbine burner rig.

Experimental Arrangement



Experimental Results



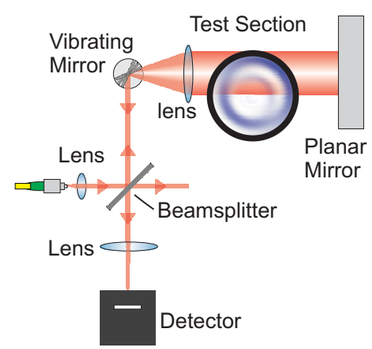
- Low bias could be due to
  - the warm air path contained non-negligible H2O,
  - measurements were taken 6 cm downstream from the hottest part of the chamber
  - thermal boundary layers were present near the windows
  - omissions or errors in the HITEMP database

Rocket Plume

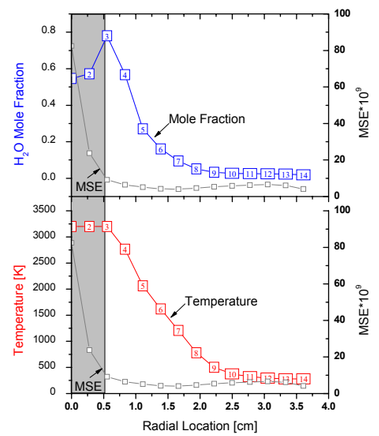
Goal

Use tomography to reconstruct the axis-symmetric temperature and water mole fraction radial profiles in a cross section of a rocket plume

Experimental Arrangement



Experimental Results



- Results from outside of plume agree well with ambient conditions verifying correction scheme for unwanted room water absorption
- Gray area indicates where fit to simulated spectra becomes unreliable and is indicated by the mean-square-error (MSE) of the fitting routine
- Imaging near the center of the plume is more difficult due to reduced signal-to-noise ratios caused by shorter optical path lengths and beam steering from refractive index gradients