Measurements and Characterization of Gasoline HCCI Combustion

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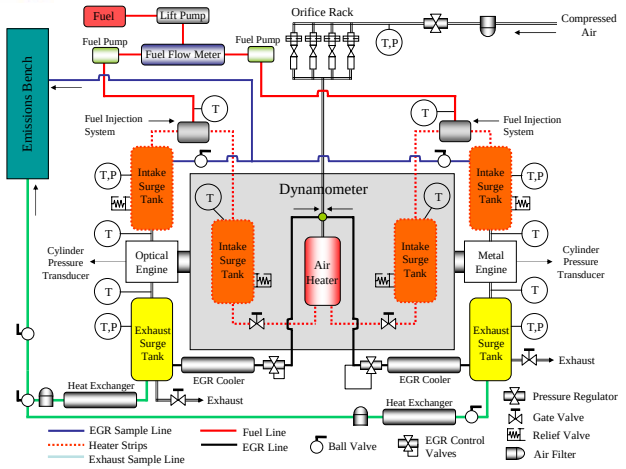
Lab Objective

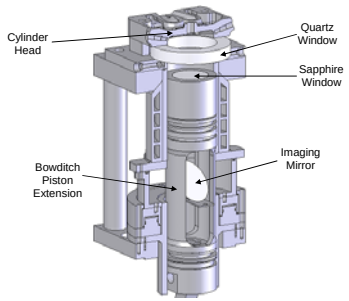
- To quantify the effects fuel/air, thermal, and residual gas unmixedness have on gasoline HCCI combustion

Experimental Facilities

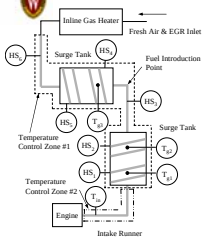


- Metal Engine
- Optical Engine

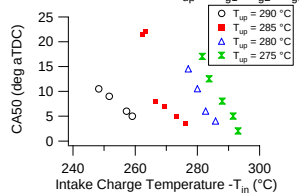
Metal Engine Picture



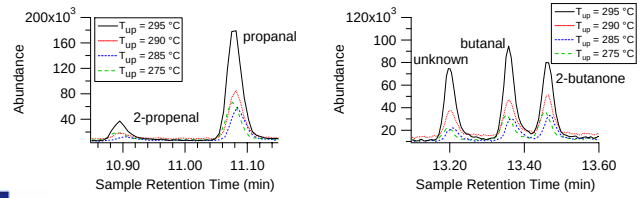
Effects of Intake Charge Preheating



- Fuels with non branched-chain molecules (PRF 87, gasoline) exhibited a sensitivity to the thermal conditions upstream of the intake runner ($T_{up} = T_{g1} = T_{g2} = T_{g3}$)

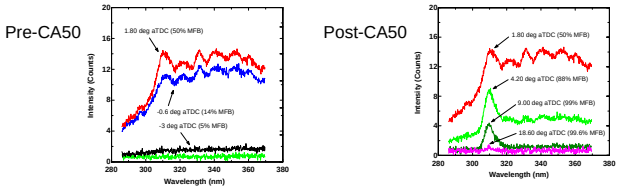


- Gas composition analysis found oxygenated species in the intake charge for tests performed with PRF 87, but not for tests performed with iso-octane
- The amount of the oxygenated species increased with increasing T_{up}

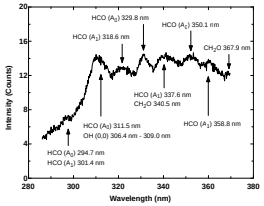


Spectroscopic Investigation

- Time- and wavelength-resolved chemiluminescence measurements were made to investigate if changes in HCCI operation resulted in changes in the chemical kinetic processes
- Measurements made through a fiber mounted in spark plug hole via a custom made adapter
- General trend in chemiluminescence:



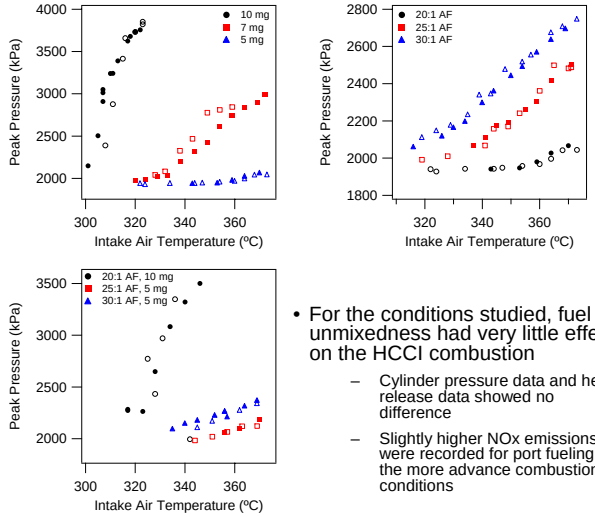
- Molecules responsible for peaks:



- Changing the engine parameters affected the ignition timing without altering the reaction pathways of the fuel after the combustion had started
- The chemiluminescence spectra of HCCI combustion appear as several distinct peaks corresponding to emission from CHO, CH2O, CH, and OH superimposed on top of a CO-O continuum
- A strong correlation exists between the chemiluminescence light intensity and the rate of heat release

Isolating Fuel Unmixedness Effects

- In-cylinder fuel unmixedness was created by injecting the prevaporized fuel in the intake port immediately before the valves closed
- Care was taken to ensure the fuel was at the same temperature as the intake air
- Experiments were performed detailing the engine performance with this fueling method and were compared to the engine performance when fuel distribution was fully homogeneous
- Sample Peak Pressure Results
  - Closed symbols = Premixed, Open symbols = Port Injected



- For the conditions studied, fuel unmixedness had very little effect on the HCCI combustion
  - Cylinder pressure data and heat release data showed no difference
  - Slightly higher NOx emissions were recorded for port fueling at the more advance combustion conditions

Future Work

- Conduct experiments in the optical engine detailed the level of unmixedness produced in the intake charge with fueling prevaporized in the port
- Thermal unmixedness
  - Split the port in the cylinder head and supply homogeneous fuel/air to each port independently
  - Heat the intake fuel/air mixture to each port differently, thereby creating thermal gradients
  - Verify thermal unmixedness optically
- EGR unmixedness
  - Install two intake surge tanks, one to supply each intake port
  - Supply different levels of EGR to each surge tank which will result in EGR gradients in the intake charge
  - Verify EGR unmixedness optically