INTRODUCTION
The autoignition temperature is an important characteristic of fuels for safety considerations. Of greatest concerns are hot surfaces within fuel tanks and flammable leakage zones in aircraft. The goal of this study is to observe some of the characteristics of the chemical processes occurring in an autoignition test of a gaseous hydrocarbon fuel and air mixture. Concentration measurements of the fuel provide insight into the time scale of the ignition event and possibly other time scales associated with the decomposition of fuel molecules. Dependence of ignition event threshold on temperature and pressure will be observed. While past experiments have taken the “appearance of any flame” as a criterion for ignition [1], this experiment measures the fuel concentration time history during the combustion event.

EXPERIMENTAL SETUP

The experimental configuration includes a glass vessel encased in an aluminum shell that is heated to the desired temperature, measured on the outer surface of the glass. The test cell is a cylindrical vessel, with an approximate volume of 300 cc, has windows mounted on the sides and an optical path length of 4 in.

The test fuel for these studies is hexane. Using hexane gives a more controllable experiment than kerosene, which is comprised of many different species of hydrocarbons. The targeted temperature range to observe autoignition processes in this case is between 200°C and 350°C. The autoignition temperature of hexane is listed at 225°C [1].

FUEL SENSING

The concentration of fuel present is obtained using laser absorption at 3.39 microns. Light of this wavelength, which corresponds to the C-H bond resonance, is emitted from a He-Ne laser. The ratio of the observed intensity to the intensity without any fuel present is related to the fuel concentration by Beer’s law, where the absorption cross-section is calibrated before heating the vessel.

\[ \frac{I}{I_0} = e^{-\alpha L} = e^{-\frac{a c_x L}{v_x}} \]

The calibration curve shows a linear relationship between the product of the partial pressure of the fuel and the absorption cross-section obtained from the laser absorption and the partial pressure of the fuel injected.

OXYGEN SENSING

A different optical technique is used to determine the concentration of oxygen. “2F detection” uses a tunable diode laser that scans across an electronic transition of the \( O_2 \) molecule. Combining Beer’s Law with the line shape function and the ability to sweep the wavelength of the laser, allows the detection of the second derivative of the intensity at the peak of the absorption feature. [4]

\[ \frac{d^2I}{dv^2} = \frac{2L_0 \alpha P}{kL^2 v_x^2} \]

The final result of the theoretical analysis is the relationship described below between the second derivative and the oxygen partial pressure.

\[ \frac{d^2I}{dv^2} = \frac{2L_0 \alpha P}{kL^2 v_x^2} \]

AUTOIGNITION

In past experiments samples of the fuel air mixtures have been taken at different times during the ignition process and utilized a gas chromatograph to determine the composition. With the present configuration, it is possible to measure the fuel concentrations without the delay of transporting the gas into the gas chromatograph.

Initial pressures examined range from 750 Torr to 200 Torr, comparable to those experienced on an aircraft flying below 30,000 feet. Hexane is used for its comparable autoignition temperature to kerosene, 225°C, and is one of the representative species of kerosene. [1]

At cooler temperatures a pressure-temperature diagram is divided into a slow reaction, cool flames, and ignition zone. However, no clear definition and lower boundary is given for a slow reaction zone [3]. The proposed setup and measurement techniques have the potential to reveal the reaction times at various temperatures and pressures in the slow reaction zone.

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With high temporal resolution it is possible to see a drop in the equivalent partial pressure of hexane just prior to the ignition. This is followed by a fast consumption of the hexane.

References