Experimental Studies of Explosions of Methane-Air Mixtures in a Constant Volume Chamber

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Introduction

- Isochoric methane-air combustion
- Measure pressure within the combustion chamber vs. the position of the laminar flame front

- Experimental procedure already run for dust-air mixtures
  - Maximum pressure at significant time delay after flame reaches chamber wall
  - Explanation: turbulent structure of dust particles take longer to burn than laminar flame front of gas mixture
Objectives/Goals

1. Find the pressure in the chamber as a function of the flame front position
2. Determine if the maximum pressure occurs at:
   1. The moment when the flame front reaches the chamber wall
   2. Time delay after the flame reaches the wall
3. Improve numerical modeling of flame propagation
Experimental Procedure

- 1.25 m³ explosion chamber
- Vertical and horizontal probes
  - Each with 5 microthermocouples
  - Measure propagation velocity
- Ignition source: single electrical spark discharge (5 J)
- Piezo-electric Kistler transducer measured pressure
- System for preparing mixture at desired composition
- Viewing window
Stoichiometry of Methane Combustion

$CH_4 + 2(O_2 + 3.76N_2) \rightarrow CO_2 + 2H_2O + 7.52N_2$

Moles air: 9.52
Moles methane: 1

Molar Concentration, $y_{CH_4} = 9.51\%$
Results – Position of Laminar Flame Front

- Flame propagation velocity faster for stoichoimetric mixture
- Linear relationship with time
- Based on measurements of thermocouples
Results – Flame Pressure

- Explosion pressure greatest at stoichiometric mixture
- Explosion pressure > pressure when the flame front reaches chamber wall
- After laminar flame front reaches wall, energy still being produced in chamber
- In flame front during explosion, mixture not completely burned
Results – Time Delay of Maximum Pressure

- Maximum pressure occurs at delay after flame front reaches chamber wall
- Minimum delay time at stoichiometric mixture concentration ($\approx 150 \text{ ms}$)
Improvements to Experiment

- Chamber not perfectly spherical $\rightarrow$ partial time delay between flame front reaching wall and maximum pressure in chamber
- Microgravity conditions $\rightarrow$ better observation of flame propagation without influence of gravity
Conclusions

1. When flame front reaches chamber wall, pressure < maximum pressure
2. Shortest time delays occur near stoichiometry
3. Current computer code does not take real mechanisms of combustion in flame zone into account → improved computer models