Laminar Flame Speeds of Syngas and Hydrogen at Elevated Temperatures

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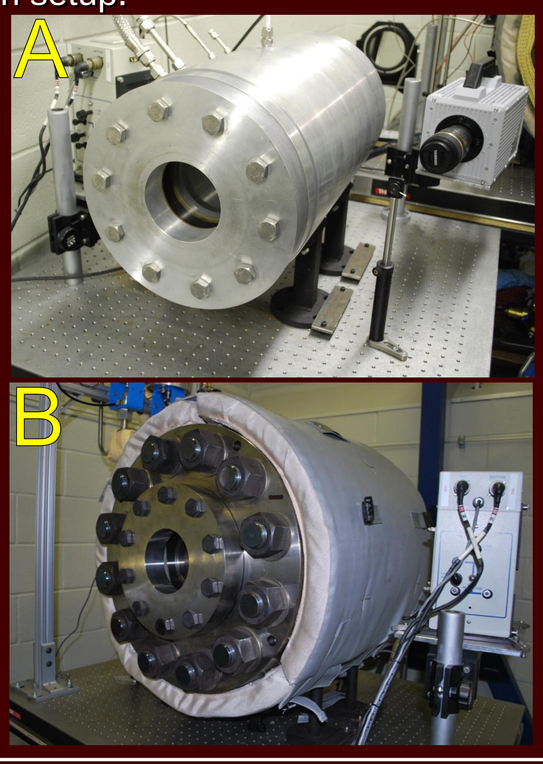
Background

Clean, reliable, and energy-efficient fuels are becoming more necessary and important for power systems, such as gas turbines. Many established gas turbines can operate with a wide range of fuels, which makes them an excellent source for clean energy production. Two current major fuel sources that are being developed are hydrogen and synthetic gas, or syngas. Hydrogen's CO_2-free emissions and wide flammability range make it a prime candidate for clean energy; however, hydrogen's fast chemical kinetics and high combustion temperature can prove to be problematic for applications. Syngas can be formed from many processes and feed stocks making it an excellent reliable energy source, but the composition of syngas can vary greatly depending on the type of feed stock and process. This variation drives the need to develop and improve chemical kinetic models through experiments with hydrogen and various compositions of syngas at different pressure and temperatures.

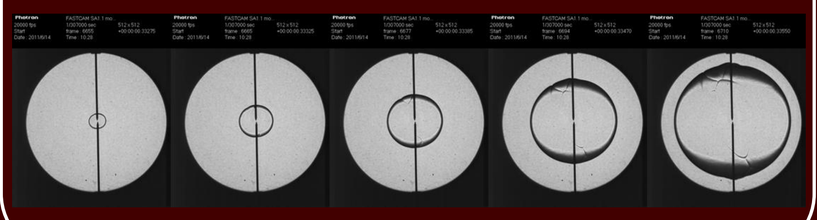
Experimental Setup

Experiments are performed in either an aerospace-grade aluminum cylindrical chamber, **A**, or a heated stainless steel cylindrical chamber, **B**. Both have optical access via 12.7-cm diameter fused quartz windows where the flame propagation is observed using a Z-type schlieren setup.

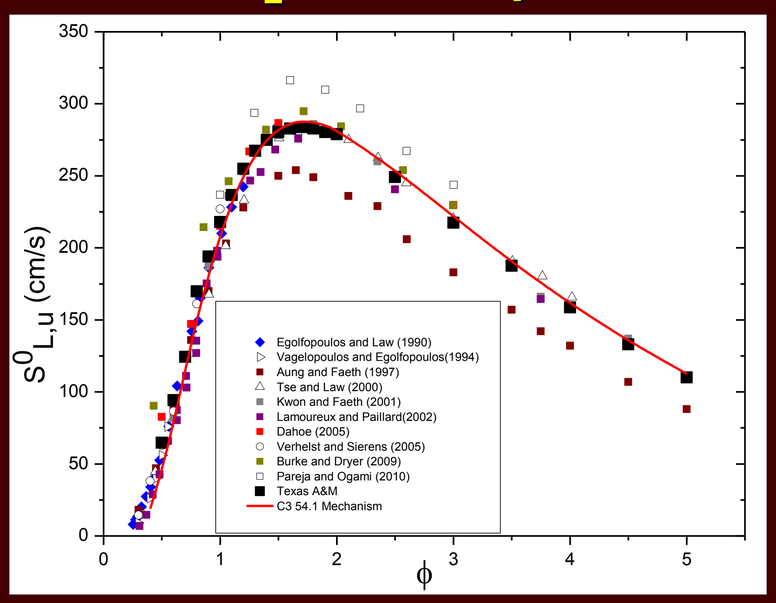


Photron FastCam SA1.1 Image Display

1-atm H_2-Air ϕ=1.9 at T_i=298 K

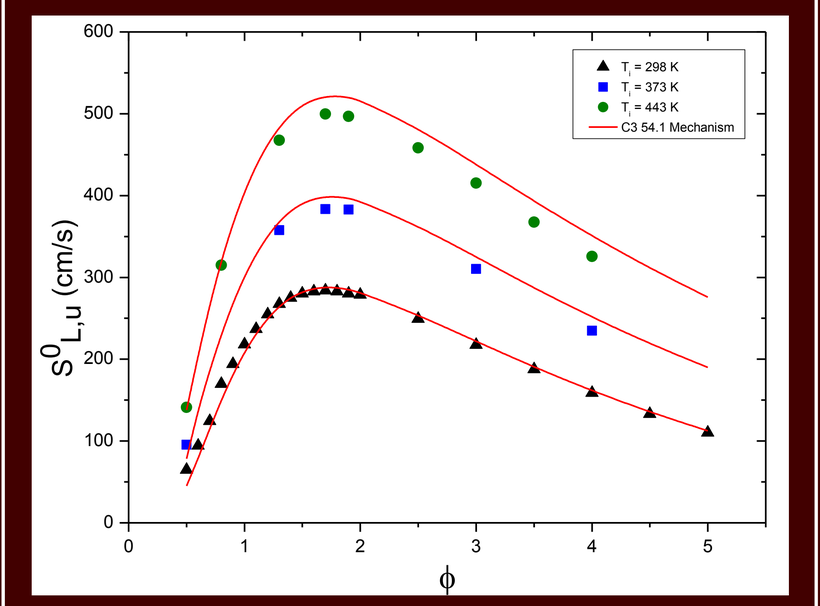


1-atm H_2-Air Comparison



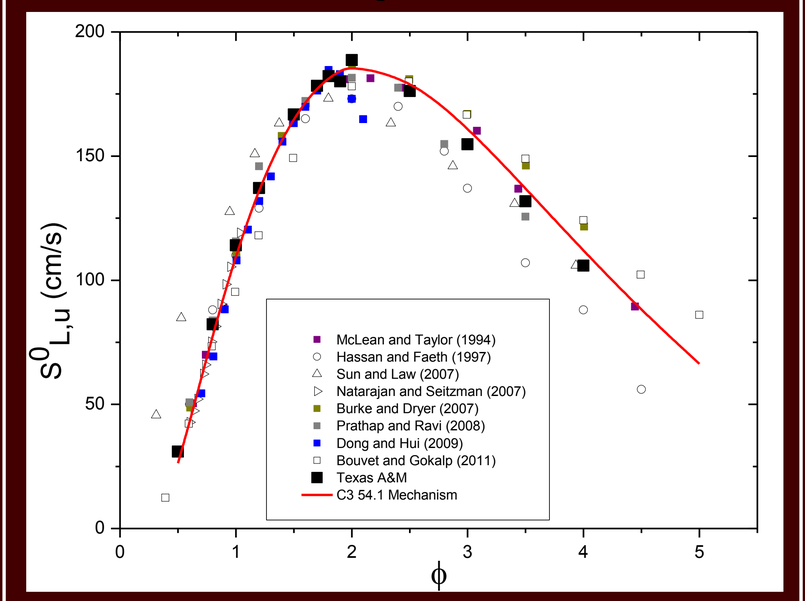
- Model accurately predicts the flame speed of H_2-Air at an initial temperature of 298 K.
- Good agreement seen between the data herein and other published data on the fuel-lean side, but large discrepancies can be seen on the fuel-rich side.

1-atm H_2-Air at Elevated Temperatures



- Model agrees well with experimental data, but slightly over predicts the flame speed on the fuel-rich side as temperature is increased.

1-atm 50:50 H_2:CO Comparison



- Good agreement can be seen between published data and the model with increasing discrepancies on the fuel-rich side.

Summary

- Overall, the chemical kinetics model from NUI Galway accurately predicts the flame speed of hydrogen and syngas mixtures at room temperature and elevated temperatures.
- There is good agreement between published experimental data on the fuel lean side for both hydrogen and syngas, but there are large discrepancies as the equivalence ratio increases above 1.0.

Ongoing Work

- A design of experiments method is being used to study the effects of temperature, pressure and water concentration on the laminar flame speeds of various compositions of syngas.
- The L9 matrix is for 3 temperatures, 3 pressures, 3 water concentrations and 3 syngas compositions.

Experiment	Temperature (K)	Pressure (atm)	% H2O (by mol)	H2:CO
1	323	1	7.5	5:95
2	323	5	0	50:50
*3	323	1	15	100:0
4	373	1	0	100:0
5	373	5	15	5:95
6	373	10	7.5	50:50
7	423	1	15	50:50
8	423	5	7.5	100:0
9	423	10	0	5:95

* Pressure was changed from 10 to 1 atm due to the high water concentration

2011 University Turbine Systems Research Workshop, Columbus, Ohio
October 25-27, 2011