

Zero Emissions Syngas Combustor Test: Chemical Kinetics Experiments and Support

**Sean P. Cooper, Olivier Mathieu, Mattias Turner, and
Eric L. Petersen**

TEES Turbomachinery Laboratory
J. Mike Walker '66 Department of Mechanical Engineering
Artie McFerrin Department of Chemical Engineering
Texas A&M University



TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION



2021 UTSR Project Review Meeting
8 - 10 November, 2021



Background

Much Prior Work with UTSR and PSI on H₂- and sCO₂-Related Combustion Over Past 17 Years

- **UTSR Project (2004-2008)** – Chemical Kinetics of Gas Turbine Fuel Blends
- **UTSR Project (2010-2013)** – High-Hydrogen Fuels with Impurities
- **UTSR Project (2013-2017)** – Syngas Fuel Turbulent Flame Speeds and Kinetics

- **With PSI (2012-2015)** – Chemical Kinetics and Diagnostics Support for sCO₂ Combustor Design and Testing up to 300 bar

24+
Journal &
44+ Conf.
Papers



TAMU Team is Supporting Current PSI-Led sCO₂ Combustor Project

1. Chemical Kinetics Support

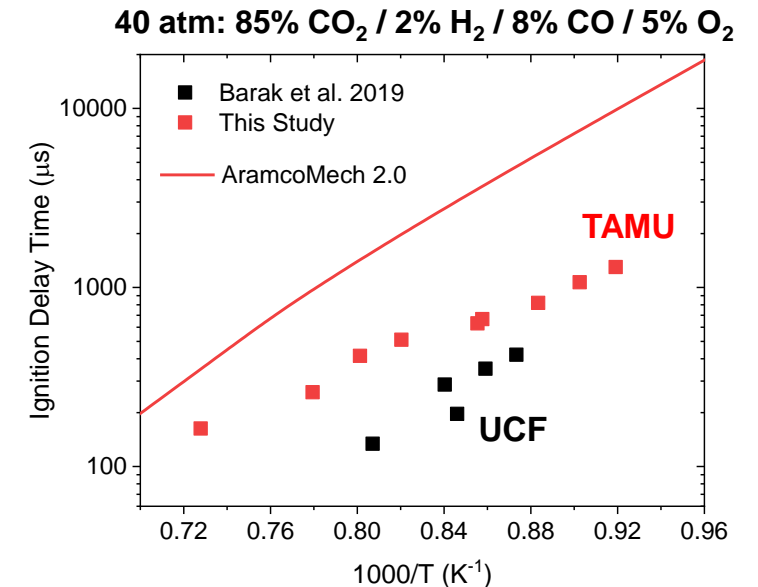
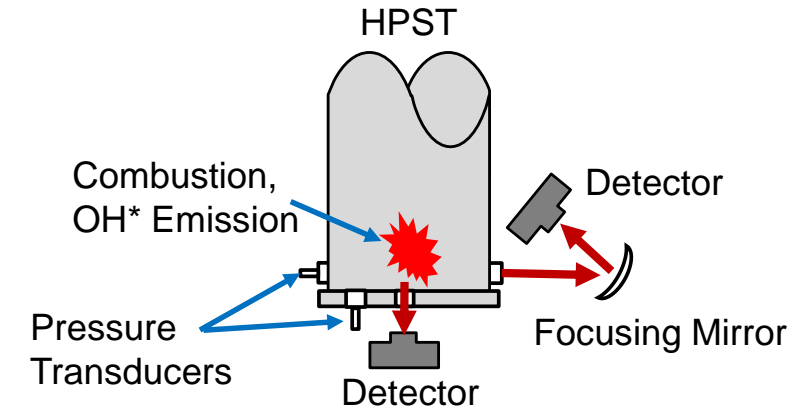
- Assessment of work to date
- Identify detailed mechanism for PSI efforts
- Kinetics support for PSI numerical modeling efforts

2. Shock-Tube Experiments

- Assess related Ignition Delay Time data from literature
- Matrix of H₂/CO + CO₂ tests to improve model predictions
- Detailed species time histories using laser absorption

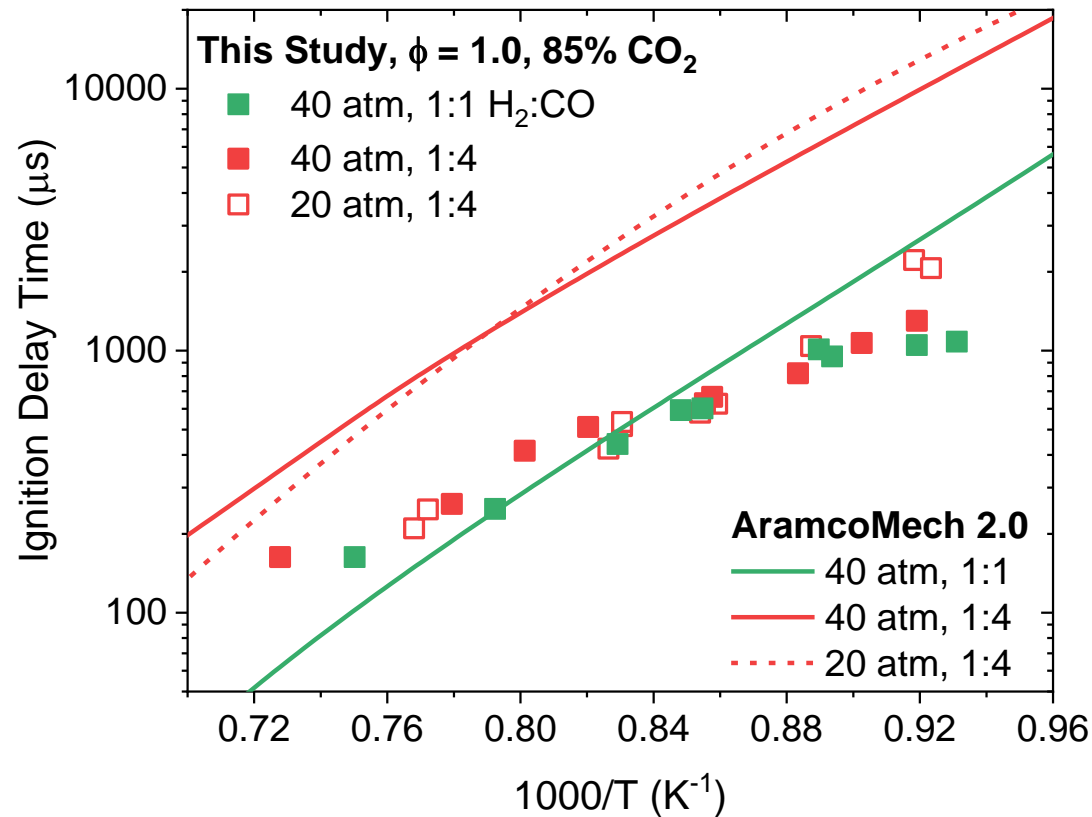
3. Flame Propagation Experiments

- Assess related Flame Speed data from literature
- Matrix of H₂/CO + CO₂ tests to improve model prediction



One Region of $H_2:CO + CO_2$ Space Points to Area for Improvement

Recent Shock-Tube Results



- New Data for 50/50 & 20/80 $H_2:CO$
- No real difference at 20-40 atm or with $H_2:CO$
- Model captures pressure effect but not $H_2:CO$ effect
- Possible update needed to rate used for reaction $CO+HO_2 = CO_2+OH$
- Also: practical combustor design simulations using detailed kinetics not very sensitive to reasonable changes in kinetics model

Follow-On Short Matrix for New Ignition Delay Times Underway

Additional Novel Experiments for IDT:

- Design of Experiments test matrix, 3 levels (L9)
- Vary H₂:CO (0.25, 1, 2)
- Vary phi (0.5, 1, 2)
- Vary pressure (10, 25, 50 atm)

Conduct ignition experiments according to chart
(pressure may change)

- First round **highlighted**: Underway
- Revise model using novel data as needed
- Matrix to be completed by **Dec. 2021**

Data Set	H ₂ :CO	ϕ	Pressure (atm)
1	0.25	0.5	10
2	0.25	1	25
3	0.25	2	50
4	1	0.5	50
5	1	1	10
6	1	2	25
7	2	0.5	25
8	2	1	50
9	2	2	10