Autoignition delay measurements in syngas and natural gas at sCO2 conditions

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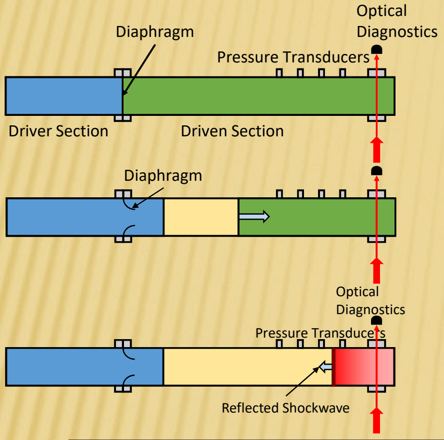
Introduction

- Supercritical CO_2 (SCO_2) power cycles offer thermal efficiency advantages over traditional supercritical steam.
- In ALLAM cycle, SCO_2 must operate from up to 300 atm (post-compression) to 70 atm (post-turbine).
- Direct-fired oxy-fuel SCO_2 operate in a closed cycle so almost all emissions are removed.

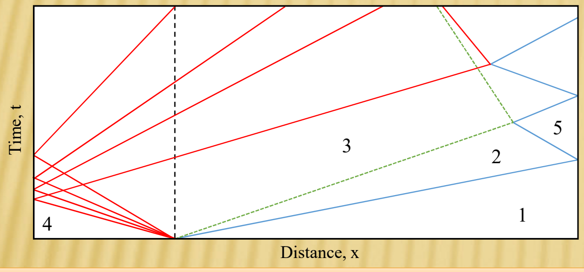
Shock Tube Operation



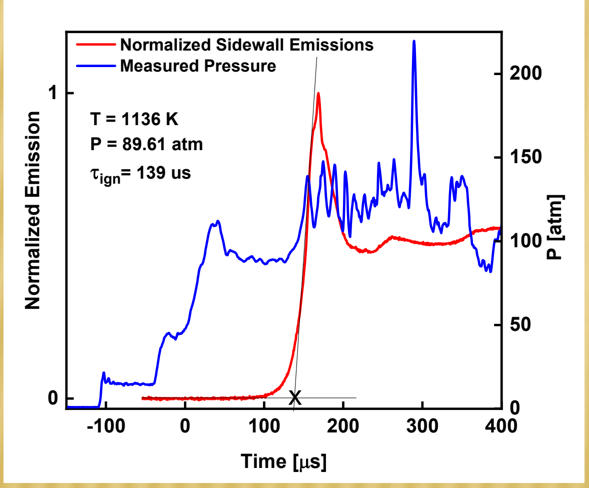
Shock tube starts with two isolated systems at different pressures.

Shockwave propagates down the driven section after diaphragm ruptures.

Shock wave reflects at the end wall causing a second pressure and temperature jump. Expansion waves quench the system



Ignition Delay Time



Ignition delay time of a oxy-syngas experiment.
Mixture: 12.5% H_2/11.5%CO/12.1%O_2/Bal CO_2

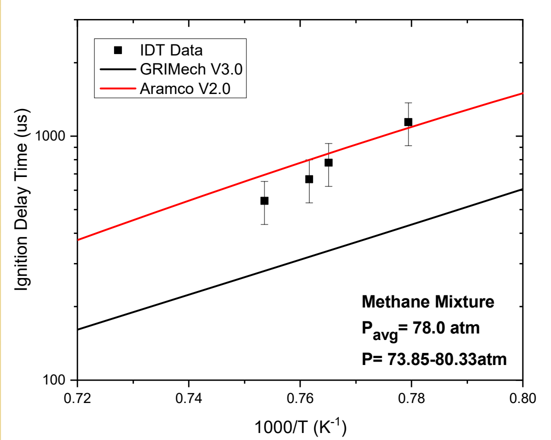
Side wall pressure and OH* time-histories are recorded for every experiment 2cm from the end-wall.

UCF's shock tube used has 14cm internal diameter with a double diaphragm configuration.

Oxy-Methane Combustion

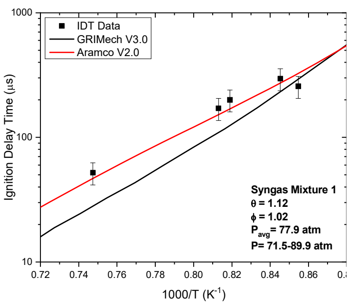
Oxy-Methane mixture to simulate natural gas combustion for these cycles. Nitrogen diluent was used to prevent detonations, however, fuel:oxidizer:CO_2 ratio was constant.

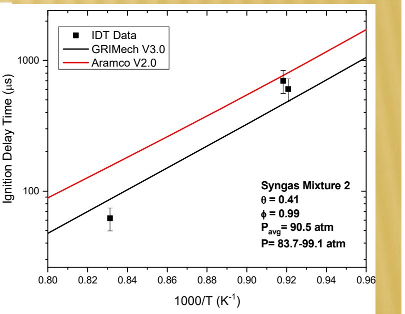
Φ	X_{CH4}	X_{O2}	X_{CO2}	X_{N2}	P_{avg} [atm]
1.00	0.045	0.090	0.365	0.500	78.00

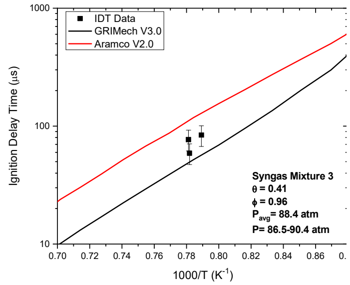


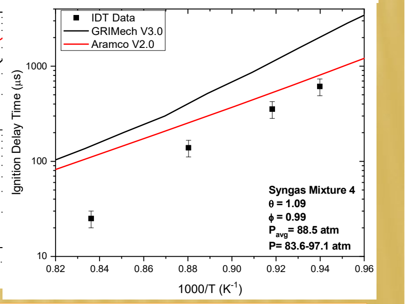
Oxy-Syngas Combustion

Mix	θ	φ	X_{H2}	X_{CO}	X_{O2}	X_{CO2}	P_{avg} [atm]
1	1.12	1.02	0.029	0.026	0.027	0.918	77.9
2	0.41	0.99	0.069	0.167	0.119	0.645	90.5
3	0.41	0.96	0.015	0.037	0.027	0.922	88.4
4	1.09	0.99	0.125	0.115	0.121	0.639	88.5









Conclusions

- AramcoMech V2.0 predictions align with experimental data for oxy-methane. It can capture some oxy-syngas behavior but fails to capture most. Captures trends with respect to T, P
- GRIMech V3.0 accurately predicts trends with respect to T, P but does not capture experimental data for oxy-methane or oxy-syngas mixtures.
- Continued experimental data is necessary up to pressures of 300 atm to develop chemical kinetic mechanisms that can accurately capture all behavior. Variations in T, P, Φ, and fuel loading are necessary to evaluate.

Acknowledgments

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