COLLEGE OF ENGINEERING

Mechanical, Industrial, and Manufacturing Engineering

Motivation

Pressure gain combustion and magnetohydrodynamic (MHD) systems have the potential to provide a step increase in the efficiency of combined-cycle power plants. This can occur by enabling topping cycles in power plants. MHD systems require no moving components, hence they can be used at much higher temperatures and would be less susceptible to pressure fluctuations from detonation waves. The tremendous benefit of MHD systems for power generation has been recognized in the community. For example, a 60% thermal efficiency has been estimated for a combined-cycle coal-fired power plant using a MHD topping cycle [1].

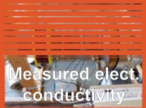
Objectives

The overall goal of this project is to develop and evaluate a pulse detonation combustion system for direct power extraction. The long term vision is that a detonation based device can be coupled with a MHD system and be used as a topping cycle for a power plant. The specific objectives of this effort include:

1) Design, build, and operate a pulse detonation engine that operates on gaseous or solid fuels with oxygen as the oxidizer.
2) Evaluate the operational envelope and performance of the pulse detonation engine.
3) Develop and validate a numerical design tool to calculate the performance of pulse detonation-MHD systems.

Approach

Experimental



Pulse detonation engines operate using CH_4/O_2, CH_4/coal/O_2, or $C3H8/N_2O$. Boundary conditions provided for simulations. Detonation speeds and electrical conductivity (pending) measured.

Modelling of Detonations and MHD

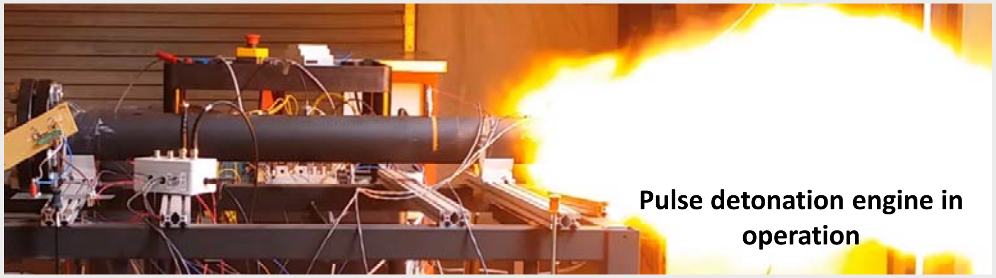
Coupled detonation and MHD solver being developed, in parallel a CESE solver is in progress

Oregon State University

PULSE DETONATION ENGINE FOR POWER EXTRACTION FROM OXY-COMBUSTION OF COAL-BASED FUELS

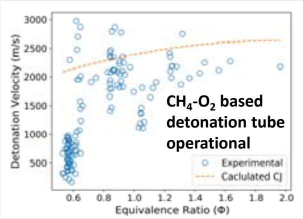
Investigators: David L. Blunck, Kyle Niemeyer, Sourabh Apte
Oregon State University

NETL Grant: FE0025822

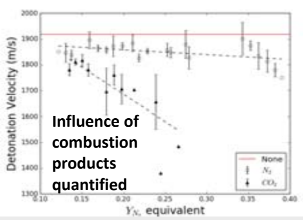


Progress and Results

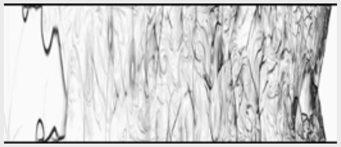
Experimental



Detonations achieved with coal injection with CH_4 and O_2. Visible images of tube exhaust provide evidence that coal is not completely combusted in the tube. The arrangement is in place to measure electrical conductivity in addition to detonation velocities.

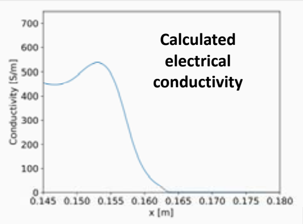


Computational: MHD/detonation solver

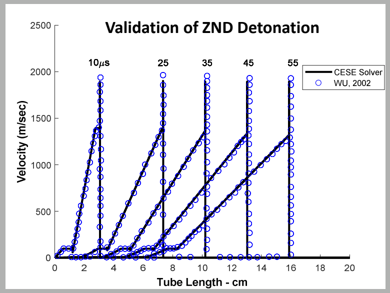


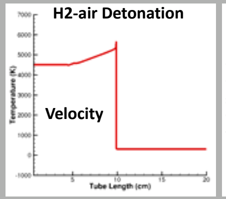
H_2-O_2 detonation, calculated cell size of 3.2 mm

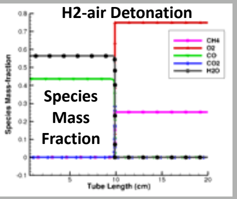
The detonation and MHD solver have been developed. Efforts are being made to perform coupled simulations.



Computational: CESE Solver







Key Outcomes

1) A pulse detonation tube has been successfully built to enable critical detonation characteristics to be measured and allow for model validation
2) Coal injector operational, successful detonation achieved.
3) Coupled MHD-detonation solver developed.
4) CESE solver development underway. This solver will allow solid phase particles to be tracked.

Future Work

1) Measure electrical conductivity and detonation speeds for O_2/fuel mixtures
2) Improve method for achieving detonations when coal is present
3) Perform and validate coupled detonation and MHD calculations

References

[1] Petrick M, Shumyatsky BY. Open-cycle magnetohydrodynamic electrical power generation. Argonne, IL, USA: Argonne National Laboratory; 1978.

PROPULSION LABORATORY

CIRE Lab

NRG