the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

Development of Novel Oxy-Syngas Zero-Emission Reheat Combustor—Precision Combustion

Background

Oxy-fuel combustion technology offers the benefits of zero-emission power generation coupled with economical carbon capture and storage. In order to boost cycle efficiency to levels equal to or greater than those of other fossil fuel power generating cycles, an oxy-fuel combustor needs to be integrated. A robust combustor capable of driving the working fluid temperature in oxy-fuel combustion plants needs an innovative injector/combustor design as well as advanced liner cooling techniques and material. Currently there is no existing reheat combustor design that can operate in the harsh steam/carbon dioxide (CO_2) environment expected in the cycle.

The unique design approach of Precision Combustion, Inc. (PCI) addresses a challenge unmet by existing injectors. PCI's novel oxy-fuel injector combustion provides fast and efficient steam/oxygen (O_2)/fuel mixing and complete carbon monoxide (CO) burnout using its distinctive mixing and flame zone design. This injector can effectively mix the fluid streams (steam-rich high-pressure turbine exhaust, O_2, and fuel) to deliver ultra-low unmixedness and establish a stable flame zone. The novel design enhances combustion, avoids excess O_2, reduces CO quenching, avoids high local primary zone temperatures, and reduces combustion acoustics. This technology enables a simple, robust, and cost-effective oxy-fuel combustor.

This project is managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). NETL is researching advanced turbine technology with the goal of producing reliable, affordable, and environmentally friendly electric power in response to the nation's increasing energy challenges. With the Hydrogen Turbine Program, NETL is leading the research, development, and demonstration of these technologies to achieve power production from high hydrogen content fuels derived from coal that is clean, efficient, and cost-effective, minimizes CO_2 emissions, and will help maintain the nation's leadership in the export of gas turbine equipment. This project was competitively selected under the Small Business Innovative Research (SBIR) Program.

Oxy-Fuel Atmospheric Operation with 100% O_2 with natural gas.

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PARTNERS

Clean Energy Systems

PROJECT DURATION

Start Date	End Date
06/30/2008	08/13/2012

COST

Total Project Value
$849,971

DOE/Non-DOE Share
$849,971/$0

AWARD NUMBER

ER85015

Project Description

A single injector module will be fabricated and tested to demonstrate stable combustion and low-emission performance. An optimized single injector will be fabricated for oxy-fuel application. The work plan is designed to address the key technical challenges of aerodynamics, mechanical robustness, emissions, and reliability with stable system performance.

Goals and Objectives

The goal of this project is to demonstrate the performance of the novel injector system for oxy-fuel application. An injector will be fabricated and tested to demonstrate stable combustion for various dilution levels and low emission performance. The objectives include the following:

- Design and develop an oxy-fuel injector for oxygen, diluent, and fuel streams.
- Fabricate injector hardware and test performance.
- Demonstrate equilibrium CO emissions and no emissions of nitrogen oxides (NO_x) within a short distance from the exit plane of the injector.
- Demonstrate injector capability to handle similar or lower pressure drop with low acoustics.

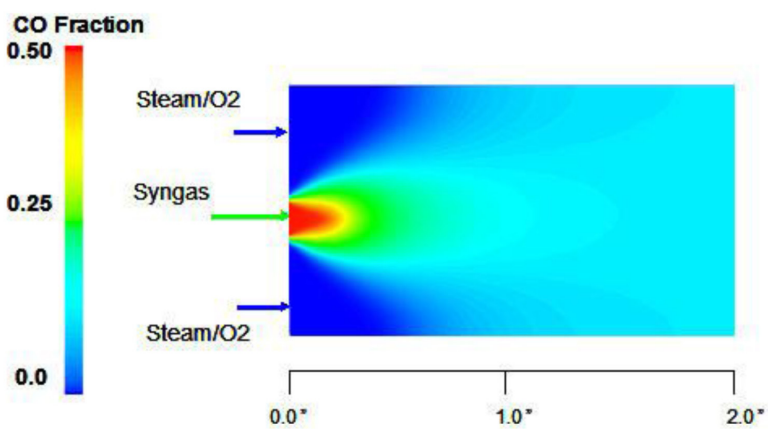
Accomplishments

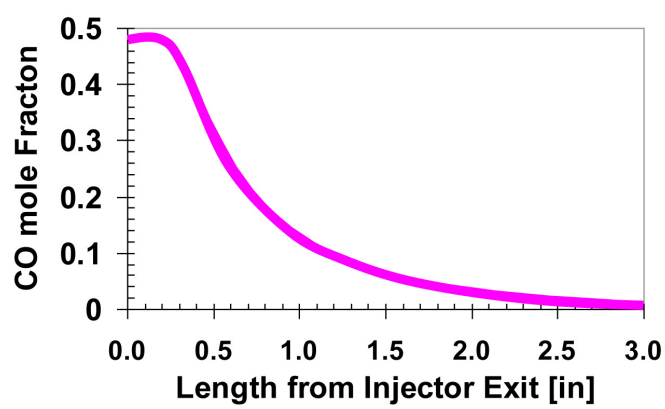
The fiscal year 2011 accomplishments of this project are as follows:

- Analytical studies provided successful demonstration of the oxy-fuel injector.
  - Non-combusting mixing studies indicated mixing occurred within a short distance—two inches from the exit of the injector—with low unmixedness (less than five percent).
  - Combustion studies showed stable flame characteristics with high diluents.
  - Near-equilibrium CO levels were reached within three inches from the injector exit.
  - No quenching of CO occurred and fast kinetics led to reduced emissions.
- Kinetic studies evaluating various steam/oxygen ratios for equilibrium CO levels with oxy-fuel mixtures were conducted using chemical kinetics software (Cantera).
- Atmospheric oxy-natural gas testing was performed to demonstrate system feasibility.

Benefits

This SBIR project supports DOE's Hydrogen Turbine Program that is striving to show that gas turbines that can operate on coal-based hydrogen fuels, increase combined cycle efficiency by three to five percentage points over baseline, and reduce emissions. The technology has the potential to be simple, robust, and cost-effective as a reheat combustor for the high-temperature working fluid of an intermediate-pressure steam/CO_2 turbine, thus enabling higher cycle efficiencies.



PCI Oxy-fuel Combustor System Allows Rapid Mixing (< 2 inches) of Fuel/Oxidant Allowing Highly Efficient and Short Combustors

Oxy-Fuel Reheat Combustor showing equilibrium CO emissions within 3 inches from exit of the injector