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U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Turbines

12/2006

Oxy-Fuel Combustion

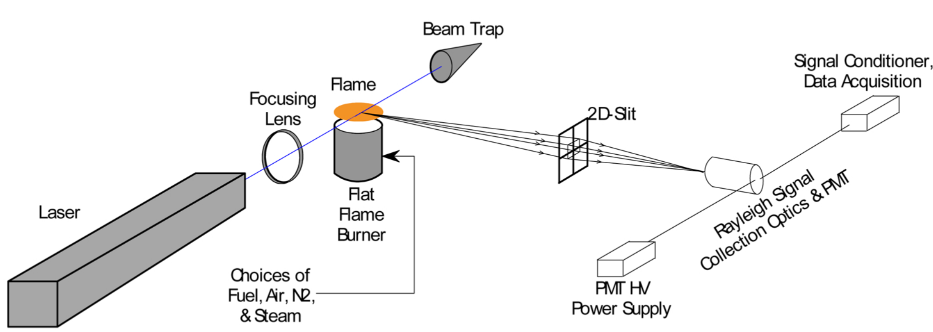
Objective

This project aims to measure fundamental combustion data such as laminar flame speeds required for development of oxy-fuel combustion systems for turbine applications.

Background

The U.S. Department of Energy Clean Coal Technology Roadmap (today thru 2020) calls for coal plants with 60 percent efficiency (HHV) and near-zero emission capabilities with the goal of zero CO_2 emissions. In addition, the requirement for ultra-low NO_X emissions (i.e. 2 ppm at 15 percent O_2) will remain. With these goals in mind, new power cycles have been proposed that use oxygen, rather than air, with the controlled addition of a diluent (steam, nitrogen or carbon dioxide recycling) to limit combustion temperature and hence reduce thermal NO_X.

For broad application of carbon sequestration, oxy-fuel turbines should be compatible with power generation fuels (H_2, syngas, natural gas, and liquefied natural gas). Some of the most promising proposed cycles for power generation with CO_2 sequestration employ high levels of steam or water to serve as diluent for the combustion with oxygen. Oxy-fuel combustion with high steam dilution represents a significant departure from conventional combustor development experience; as a result, fundamental combustion data for these environments are required to aid in the design and optimization of these systems. While limited fundamental combustion data relevant to oxy-fuel combustion—such as laminar flame speeds--has been published, nothing is available that is directly applicable to gas turbine applications. In this project, we propose to experimentally measure flame speeds for oxy-fuel-diluent combustion relevant to gas turbine power systems. These data are needed for combustor design, as inputs to combustion models tuned for oxy-fuel combustion, and to assess the adequacy of chemical kinetic mechanisms relevant to high steam combustion environments.



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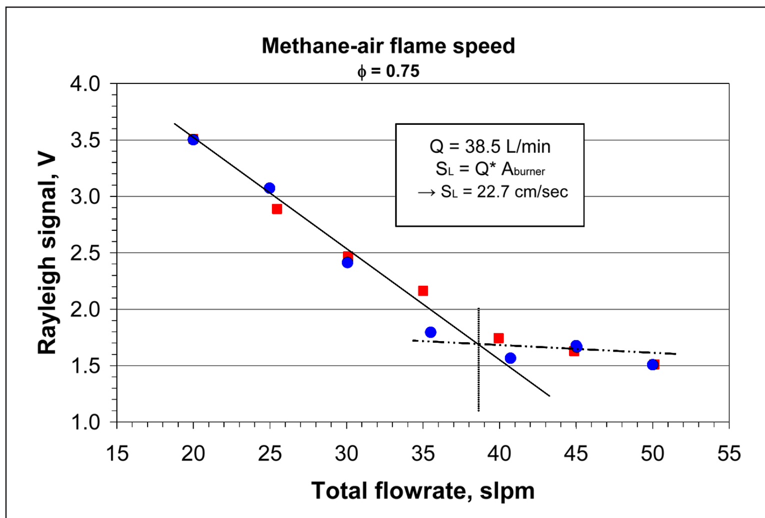
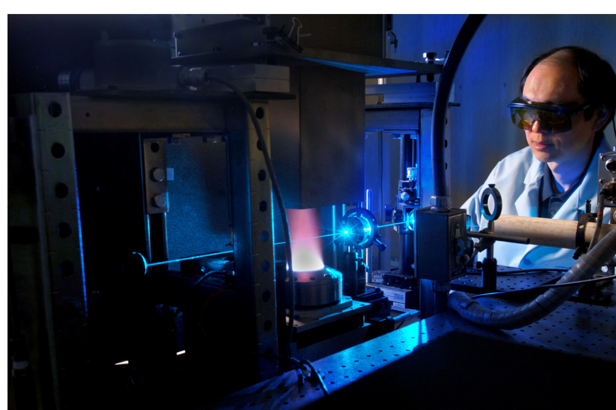
Project Description

For coal-based Integrated Gasification Combined Cycle systems, the primary fuels will be syngas (CO/H_2) or hydrogen (from syngas shifted to remove carbon). Consequently, the initial focus of this project is H_2 or CO/H_2 fuel mixtures, combusted with oxygen. The flame temperature is controlled by dilution with steam. (Later testing may utilize CO_2 or CO_2/He for the diluent gas.) To achieve the high steam loadings required for the target flame temperatures, a specialized apparatus and method for determination of flame speed are required. The apparatus is based upon a laboratory flat-flame burner with a small steam boiler providing the bulk of the flow to the burner. The apparatus has been carefully designed to address the problems of maintaining the steam temperature, handling the condensation, and safely mixing the fuel, steam, and oxygen in a well-controlled and precise manner. Assembly of this apparatus is in progress.



The laser-based Rayleigh scattering technique was selected to determine flame speed. Studies are under way to verify this technique using a flat-flame burner in our laboratory applied to the methane-air system. Flame speed measurements for the methane-air flame are abundant in the literature, so this provides a means to characterize the expected experimental uncertainties for this measurement technique.

Following assembly and shakedown of the apparatus, flame speed measurements for oxy-fuel conditions (H_2/O_2/steam) will commence.



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