the ENERGY lab

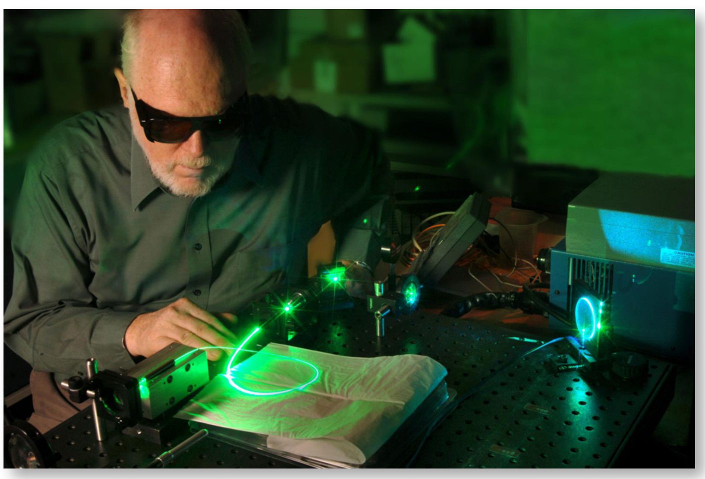
R&D FACTS

Sensors and Control

Raman Gas Analyzer for Natural Gas and Syngas Applications

Goal

The goal of this project is to develop and test a Raman laser spectroscopy system for responsive gas composition monitoring, and to transfer the technology to industry for commercial implementation. The instrument provides state-of-the-art improvement of reduced size and increased sensitivity and sample rate to facilitate the process control needs of advanced power systems. Industries that utilize natural gas, gasifier syngas, biogas, landfill gas, or any type of fuel gas can benefit from knowing the composition of the fuel in real time. Natural gas, the most common fuel, can have significant variations in hydrocarbon composition because of the many sources feeding into the nation's pipeline network. The other gases also have significant variation in quality, and also use natural gas as a backup. All of these gases differ in their Btu content, flame speed, Wobbe number, dilution gases, and composition.



Background

Facilities based on natural gas fired turbines represent an increasing share of both new and retrofitted energy generation capacity and therefore are an important target for studies seeking to positively affect both the efficiency and environmental impact of U.S. energy production. The diversity of available sources for fuel gases, including natural gas (both conventional and shale gas) and liquified natural gas (LNG), as well as syngas from coal/biomass gasification, coal bed methane, landfill gas, and

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biodigester gas, has contributed to their attractiveness but also has created significant challenges for achieving efficient control of the combustion process. Modern lean burning, low emission gas turbines and reciprocating engines require fine tuned control of the combustion process to achieve their optimal operation. Upsets to the operating point, which may be caused by fluctuations in the fuel gas, can result in reduced efficiency, high pollutant emissions, or even turbine damage. Real-time fuel gas composition sensing enables the turbine control system to adjust, and maintain optimal combustion conditions.

Accomplishments

The NETL Raman Gas Analyzer gives a continuous readout of the relative mole per cent of all major fuel gases including H_2, O_2, N_2, CO, CO_2, CH_4, C_2H_6, C_3H_8, water, and additional gases as needed. These species have unique Raman spectral fingerprints with linear response which can be used to base a rapid response sensor which can respond to all of these species simultaneously in one instrument. The sensor utilizes state-of-the-art optical waveguides, solid state lasers, and compact spectrometers to reduce the size and increase the sensitivity above commercially available Raman spectroscopic systems. The NETL Raman Gas Analyzer provides measurements of all the major species in the fuel gas in one second or less.

Benefits

For fuel flexible operations, in which the supply gas includes syngas or biogas, as well as natural gas, large compositional changes are expected during fuel switching. Real time measurement of the fuel composition feeding the gas turbine or reciprocating engine enables smarter, optimal combustion control with both fuels as well as during a switchover or blending.

In any turbine application, the measurement must be rapid, reliable, and capable of operation at the temperatures and high pressures provided to the power system. The sensor should be selective to all gas compositional components, sensitive to at least 1% variations in concentration, and capable of integration and cost-effective manufacture. Presently employed gas chromatography or mass spectroscopy techniques are either time consuming or require bulky, expensive equipment.

The target application is the monitoring of the natural gas species methane, ethane, and propane, and the syngas species hydrogen, carbon monoxide, and carbon dioxide, as well as nitrogen and oxygen. These species and others can be monitored in the input fuel/air stream for feed forward control of the combustion process.

The NETL Raman Gas Analyzer was initially developed in collaboration with the University of Pittsburgh. Current efforts are focused on system improvement, field testing, and technology transfer activities.

NETL