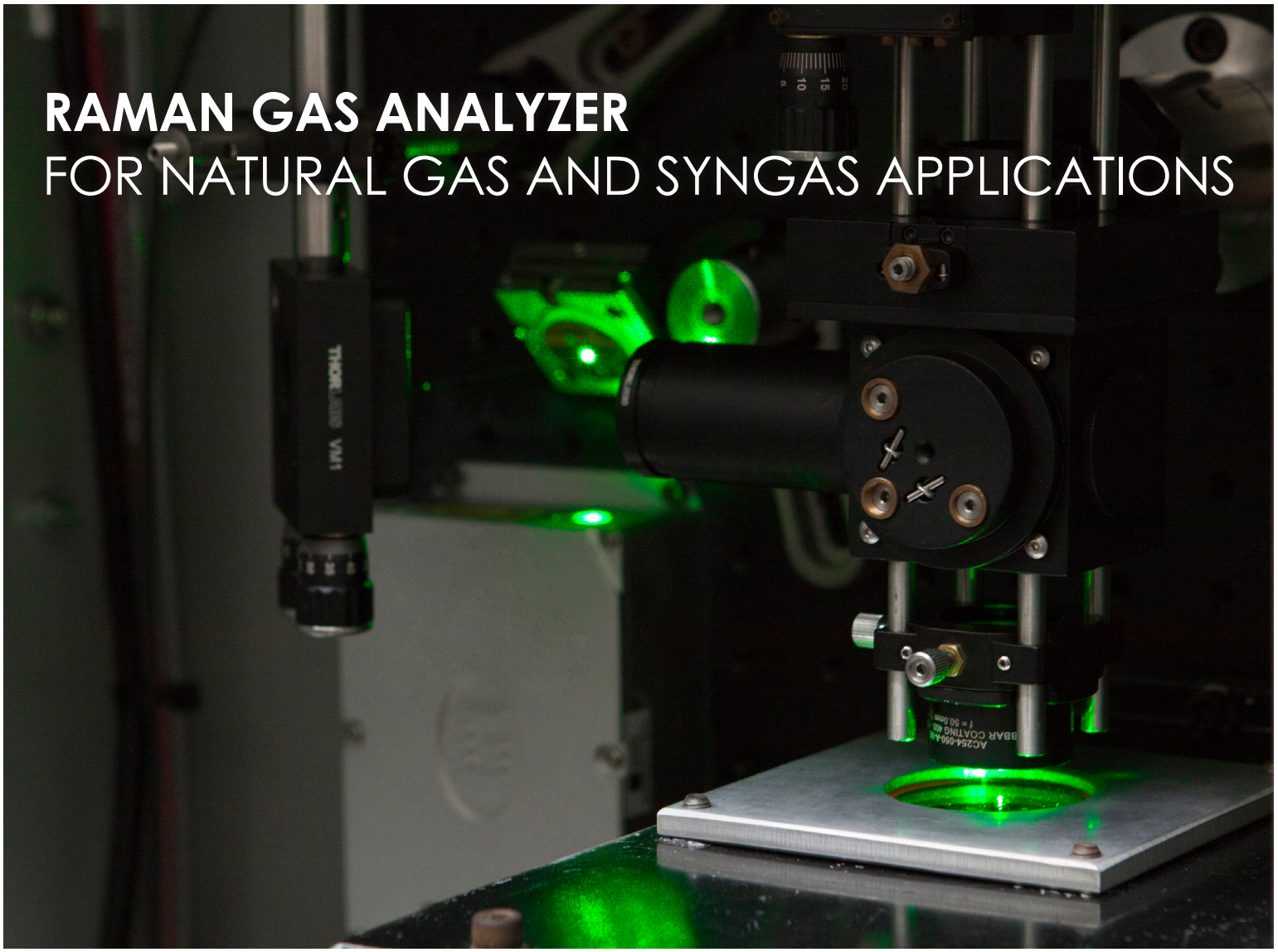
RAMAN GAS ANALYZER
FOR NATURAL GAS AND SYNGAS APPLICATIONS



NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

GOAL

NETL has developed a real-time gas composition monitoring instrument using Raman spectroscopy. It uses proprietary waveguides to enhance Raman signals and to permit very fast acquisition of gas-Raman spectra. This new instrument will improve the performance of power generation systems through better process control. The Raman Gas Analyzer system provides state-of-the-art enhancements, such as increased sensitivity and sample rate, which will help to meet the process control needs of advanced power systems. It can measure all gases in any mixture (excluding the noble gasses), and it can produce a measurement within 0.1% accuracy for every component in a mixture in 0.5 seconds. This is extremely fast compared to other multi-gas analysis techniques. It can therefore be used to control processes which involve gaseous inputs or outputs. It has been used extensively for real-time turbine system control based on fuel composition.

Industries that utilize natural gas, gasifier syngas, biogas, landfill gas, or any other type of fuel gas can benefit from knowing the composition of the fuel in real time. Natural gas, the most common of these fuels, can have significant variations in hydrocarbon composition due to the many sources feeding into the nation's pipeline network. Other fuel gases can also vary significantly in quality and composition. These gases differ in their Btu content, flame speed, Wobbe number, and dilution. The goal of this project is to: (1) continue incremental improvements to the Raman Gas Analyzer (RGA); (2) test and demonstrate its capability through field testing; and (3) support RGA technology transfer to industry.

Our team seeks an industrial instrument manufacturer to license and manufacture this system for sale. A complete field-tested design is available for Class 1 Div. 2 operation in flammable service locations, and field-test data is available from turbine, gasifier, and other industrial test campaigns. U.S. patents have been issued covering both the operation of the waveguide-enhancement system and the method of manufacturing the waveguides at the core of the system. They are available for licensing separately or as a complete package for a manufacturer.

BACKGROUND

Facilities based on natural gas-fired turbines represent an increasing share of both new and retrofitted energy generation capacity. These power generation facilities are an important target for studies seeking to positively affect both the efficiency and environmental impact of U.S. energy production. Available sources of fuel gases are diverse and include natural gas (both conventional and shale gas), liquified natural gas (LNG), syngas from coal/biomass gasification, coal bed methane, landfill gas, and biodigester gas. This diversity has contributed to the attractiveness of fuel gases but has also 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 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.

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

ACCOMPLISHMENTS

The NETL Raman Gas Analyzer provides a continuous readout of the relative mole fraction of all major fuel gases, including hydrogen, oxygen, nitrogen, carbon monoxide, carbon dioxide, methane, ethane, propane, water vapor, and additional gases as needed. These species have unique Raman spectral fingerprints with linear response, which are used as the basis of a rapid-response sensor that can measure all species simultaneously in one instrument. The sensor utilizes state-of-the-art optical waveguides, solid-state lasers, and compact spectrometers to increase the speed and sensitivity beyond 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

The NETL Raman Gas Analyzer enables smarter and faster control of power systems using gaseous fuels, providing the capability for greater energy-conversion efficiency and cleaner operation along with increased fuel flexibility. The NETL Raman Gas Analyzer is designed for monitoring the natural gas species methane, ethane, and propane; the syngas species hydrogen, carbon monoxide, and carbon dioxide; and nitrogen and oxygen. These species and others can be monitored in the input fuel or fuel/air stream for feed-forward control of the combustion process.

For gas turbines, the NETL Raman Gas Analyzer provides a rapid measurement at the temperatures and high pressures present in the turbine system. The instrument is selective to all typical fuel gas compositional components, and sensitive to better than 1 percent variations in concentration, which can then be converted to a heating value and Wobbe number. The NETL Raman Gas Analyzer provides a combination of multi-species measurement and speed that is a generation ahead of presently employed gas chromatography or mass spectroscopy techniques.

For fuel-flexible power systems, in which the supply gas includes syngas or biogas and natural gas, large compositional changes occur during fuel switching. Real-time measurement of the fuel composition feeding a power system enables smarter, optimal combustion control during a switchover or while blending fuels.

The NETL Raman Gas Analyzer capabilities can be applied to today's power generation technology as well as the research, development, and operations of future high-efficiency, clean-power generation systems. The multi-species measurement and speed of the NETL Raman Gas Analyzer can benefit the development of chemical looping combustion, hybrid power systems, and modular gasification technologies.

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