Sensors and Automation

Fiber Optic Sensor for Industrial Process Measurement and Control

Temperature and chemical sensors used to monitor high-temperature gas combustion in process control applications typically rely on such intrusive techniques as extractive sampling. As a result, measurements are reported too slowly to be useful for real-time process control or monitoring applications. Conventional sensors also tend to be fragile and require frequent calibration and maintenance, which further limits their effectiveness.

This project, led by MetroLaser, Inc., seeks to remedy these issues through the development of an advanced diode laser-based fiber optic sensor for direct, rapid, and quantitative measurement of gaseous species and temperature in industrial processes. Because researchers intend to apply this technology to industrial combustion applications, the project addresses technical barriers related to combustion. These barriers include determining an acceptable degree of particulate loadings, ensuring that the technology is sensitive enough to successfully measure CO and CO_2, and optimizing calibration so sensors can handle more turbulent, heterogeneous flows.

Project goals for the development of the sensors have centered on creating a product that is accurate, has a large dynamic range, is affordable and rugged, and has a high temporal resolution. Researchers have met these goals by combining low-cost telecom components with MetroLaser's proprietary software and spectroscopic measurement strategy. Recently, researchers demonstrated the non-intrusive temperature profiling abilities of the new sensor technology. Using fiber-coupled tunable diode lasers in a highly turbulent combusting plume, the device was deployed on a spray combustor nozzle used for precision chemical vapor deposition. It successfully demonstrated that the required measurements can be accomplished despite vibration, flame luminosity, temperature extremes, and particle interferences.

Applications and Benefits

- Unlike conventional sensors, which cannot withstand high-temperature environments and frequently drift out of calibration, the new system can perform measurements regardless of vibration, flame luminosity, temperature, pressure extremes, and particle interferences.
- Benefits also include reduced material and energy consumption and lowered maintenance costs.

Project Participants

- MetroLaser, Inc. (Lead organization)
- Bergmans Mechatronics
- University of CA, Irvine
- General Electric - Energy and Environment Research Corporation (GE EERC)
- U.S. Department of Energy, Small Business Innovative Research Program

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Project Plans and Progress

Project History: This project was awarded under the SBIR solicitation. SBIR projects are conducted in multiple phases: Phase I awards were made in the spring of 2001, while Phase II awards were made in the spring of 2002.

Past Accomplishments

So far, researchers have successfully:

- Simulated spectra and relevant absorption features.
- Verified the accuracy of the HITRAN database.
- Demonstrated a two-laser temperature and H_2O sensor on an industrial combustion chemical vapor deposition torch.
- Demonstrated a single-laser temperature sensor on industrial burner.
- Simultaneously accessed two spatial locations.
- Identified and probed transitions insensitive to ambient H_2O.
- Demonstrated adequate sensitivity to combustion temperatures.
- Demonstrated high spatial and temporal resolutions .
- Demonstrated excellent correlation with chemiluminescence, well-suited for active control applications.
- Designed and built a portable prototype system for follow-on demonstration tests.

Future Plans

Continuing efforts will also focus on:

- *Applying the technology to coal-fired power plants.* The occurrence of slag build-up and associated heat-transfer losses could be reduced by maintaining furnace exit gas temperatures below the ash softening temperatures. By allowing precise measurement and control of furnace temperature on startup, boiler tube failures due to thermal stresses can be minimized, thereby reducing unscheduled plant shutdowns for boiler tube repairs. Also, a multi-beam system could measure the temperature of individual burners in a pulverized-coal furnace. This technique could allow hot, NOx-producing burners to be identified and repaired.

- *The need for simultaneous non-intrusive temperature and water vapor measurements in the hydrogen reforming industry for fuel cell applications.* A temperature control system could be used to ensure that the system is operating at its optimum temperature and to detect if the catalyst is overheating due to improper gas flow control or mixing of reactants.

Sensors and Automation

The Sensors and Automation Activity (S&A), part of the Industrial Technologies Program, develops and deploys integrated measurement systems for operator-independent control of manufacturing processes with broad applicability across multiple industry sectors.

The industry sectors served by S&A are those that have established partnerships with the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy to collaborate in joint technology development for the competitiveness and vitality of the industry.

Work done under S&A will lead in providing the advanced measurement and control technology solutions to meet the needs of all industry sectors supported by the IOF strategy.

To learn more about S&A activities, visit the program web site at:

www.oit.doe.gov/sens_cont/

A Strong Energy Portfolio for a Strong America

Energy Efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

This fact sheet was prepared in June 2004.

The CPS number for this project is 1604.