Advanced Laser-Based Sensors for Industrial Process Control

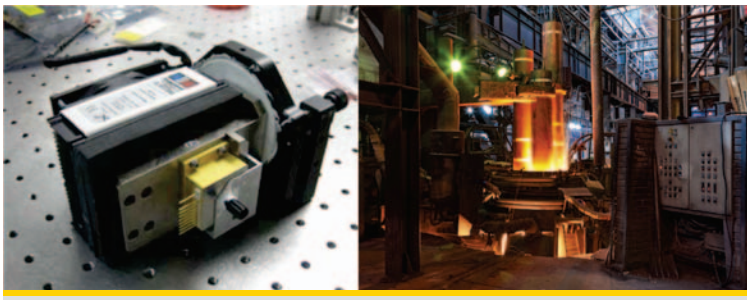
Increased Efficiency and Reduced Emissions Using Advanced Laser-Based Sensors for Process Control Monitoring in Electric Arc Furnaces

Introduction

Steel is a vital commodity widely used in a broad range of engineering, infrastructure, and construction applications. Currently, more than 120 electric arc furnace (EAF) steelmaking facilities (minimills) in the United States provide approximately 60 percent of domestic steel production. These minimills melt recycled scrap steel, consume a substantial amount of electricity, produce significant greenhouse gas emissions, and emit other pollutants.

One strategy to increase EAF efficiency is targeting process control improvements through advanced, real-time monitoring techniques. Even modest gains in this area can lead to a substantial reduction in energy usage and related emissions. However, real-time monitoring and control of industrial processes requires sensitive analyzers capable of unattended operation in harsh environments and remotely operated instrumentation that can generate and transmit data.

To capture the potential of real-time monitoring and overcome the challenges of harsh industrial environments, researchers will fabricate, deploy, and commercialize advanced laser-based gas sensors for industrial process control monitoring in electric arc furnaces. These sensors can achieve improvements in process control, leading to enhanced productivity, improved product quality, and reduced energy consumption and emissions. The first sensor will utilize both mid-infrared and near-infrared lasers to make rapid in-situ measurements of industrial gases and associated temperatures in the off-gas of an EAF. The second sensor will make extractive measurements of process gases. Researchers will manufacture three of each sensor type and deploy them at domestic EAF steelmaking facilities to evaluate their effectiveness for real-time control of the EAF process.



The Los Gatos Research mid-infrared laser module contains a quantum cascade laser mounted on a thermo-electric cooler (left). The Small Business Innovation Research (SBIR) Phase III analyzers will be deployed for long-term testing under industrial conditions at EAF facilities (right).

Photo on left courtesy of Los Gatos Research.
Photo on right from Istock/13896349.

Benefits for Our Industry and Our Nation

Significant energy savings and reduced carbon emissions will result from achieving real-time monitoring of industrial process controls using advanced laser-based sensors. An additional implementation benefit is a more agile and responsive industrial process control system that enables a reduction in the cost of operating EAFs.

Applications in Our Nation's Industry

The laser-based sensors will initially be designed and tested for application in the EAFs of steel minimills. However, advanced laser-based sensors capable of operating in harsh industrial conditions can be readily adapted for use in other industries such as aluminum, glass, petroleum refining, petrochemical, and synthetic gas manufacturing.

Project Description

The goal of the project is to develop, deploy, and commercialize advanced laser-based gas sensors for monitoring and process control of electric arc furnaces. To achieve this goal, researchers will leverage insight gained from two previous projects:

1. A Small Business Innovation Research (SBIR) Phase I project utilizing room-temperature, mid-infrared quantum cascade lasers and other laser technologies to record in-situ measurements of gas temperature and key combustion species.
2. An SBIR Phase II project that developed a heated, extractive gas analyzer for fast, sensitive measurements of multiple trace gases in process control applications.

In this SBIR Phase III effort, the Phase I project will serve as the basis for a gas sensor that will utilize both mid-infrared and near-infrared lasers to make rapid, in-situ measurements of carbon monoxide, carbon dioxide, oxygen, water, and gas temperature in the off-gas of an electric arc furnace. The Phase II project will serve as the basis for an analyzer that will make extractive measurements of multiple process gases and trace pollutants.

Barriers

- Developing advanced laser-based sensors capable of operating in harsh, high-temperature, and exceptionally dusty industrial environments with remote operation and little maintenance.

Pathways

Researchers will utilize both near-IR and mid-IR tunable diode laser absorption spectrometry (TDLAS) and Off-Axis Integrated Cavity Output Spectroscopy (Off-Axis ICOS) to make in-situ and extractive measurements. In TDLAS, a laser beam is passed through an absorbing sample allowing the simultaneous measurement of gas composition and temperature.

Off-Axis ICOS will be utilized for those species that do not have a sufficiently large absorption line-strength to permit in-situ detection. This ultra-sensitive process allows a beam to enter a gas cell by passing through an input mirror and to be collected as it passes through the output mirror.

Milestones

This project started in 2010.

- Year 1: Fabricate three industrial-grade, in-situ analyzers for CO, CO_2, H_2O, O_2, and gas temperature.
- Year 2: Fabricate and test three analyzers that sample off-gas to continuously measure concentrations of H_2, O_2, NO, NO_2, and CH_4 in real-time. Test in-situ analyzers.
- Year 3: Deploy units at EAF facilities to assess long-term performance and commercial viability.

Commercialization

Los Gatos Research (LGR) will fabricate and test both systems at three domestic EAF steelmaking facilities, including at those operated by The Timken Company, Nucor Corporation, and Rocky Mountain Steel. Following initial tests, systems will be deployed at more domestic EAF steelmaking facilities to assess long-term performance and commercial viability. Based on results, the systems will be optimized for large-scale manufacturing.

In addition, Analytical Specialties Incorporated, Dow Chemical Company, California Analytical Instruments, Lockheed Martin, Exxon-Mobil and other major companies have endorsed and are interested in applying and commercializing LGR's instruments for industrial process and combustion emissions monitoring.

Project Partners

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