the ENERGY lab

PROJECT FACTS

Advanced Research

Tunable Diode Laser Sensors to Monitor Temperature and Gas Composition for High Temperature Coal Gasification Systems

Description

Sensing and measuring temperature and gas compositions in and around a coal gasifier are important to controlling and operating the process. The conditions used to gasify coal and produce synthesis gas, a synthetic form of natural gas, are very harsh; therefore, it is challenging to have reliable measurements of temperature and gas composition in these environments. Two sensor requirements for the production and utilization of synthesis gas through gasification have been identified: (1) to control the temperature of the gasifier by adjusting feed rates of fuel and oxygen, and (2) to control the air dilution at the intake to the gas turbine. To help address these challenges and requirements, Stanford University has teamed with the University of Utah to develop a laser-based sensor capable of measuring water (H_2O), carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_4) concentrations in a high-temperature, high-pressure gasifier environment. CO and CO_2 concentrations have the potential for use as control variables for the gasifier and the subsequent utilization (e.g., in the gas turbine) of the syngas. The CH_4 concentration in the output syngas stream will serve as a surrogate monitor of gasifier temperature and could be used to adjust the oxidant-to-fuel ratio entering the gasifier.

Goals and Objectives

The goal of this project is to design, build, and test a tunable diode laser sensor capable of measuring gas composition to optimize gasifier output and gas turbine input. Objectives include investigating gas temperature and heating value control signals; measuring CO, CH_4, CO_2, and H_2O heating values; determining H_2 by gas balance (H_2S ignored); determining gas temperature by H_2O ratio measurements; and investigating four possible sensor locations.

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PERIOD OF PERFORMANCE

10/01/2009 to 09/30/2012

COST

Total Project Value
$1,097,321

DOE/Non-DOE Share
$877,856 / $219,465

Technological Approach

The design step includes simulation of the expected absorbance of the laser light leading to the selection of candidate optical transitions for investigation. In the first phase, a prototype design will be developed at Stanford and measurements in controlled environments will be performed to select specific optical transitions for H_2O and CO. Prototype sensor hardware and software will be developed and tested for use in field-measurement campaigns. The tunable diode laser will be tested at four locations inside a slagging, entrained-flow coal gasifier at the University of Utah. These test locations are (1) in the high-temperature, high-pressure reactor; (2) in the high-temperature, high-pressure gas at the exit of the reactor before the quench; (3) downstream of the quench when the gas has cooled and much of the solid material has been separated from the syngas; and (4) downstream of the particulate removal system (Figure 1).

Phase 2 will expand the capabilities of the tunable diode laser sensor to include measurement of CH_4, CO_2, CO, and H_2O concentrations which will enable determination of the heating value of the gasifier output. The work will again include design and laboratory testing at Stanford, followed by field testing at the University of Utah to verify the ability of the tunable diode laser to monitor gas composition in the harsh conditions of a large-scale gasifier.

Benefits

Advanced, near-zero emission power systems currently under development require sensing and control technologies that allow real-time, in situ monitoring of system operations involving highly automated process controls. The development of sensors and controls capable of withstanding high temperature and pressure conditions will permit integrated and optimized operation of complex power systems with higher efficiency and lower emissions. These sensors will permit gasification plants to produce power from various fuels cleanly and efficiently, supporting DOE goals to increase the availability of power from domestic fuels and decrease the negative environmental effects of power production.

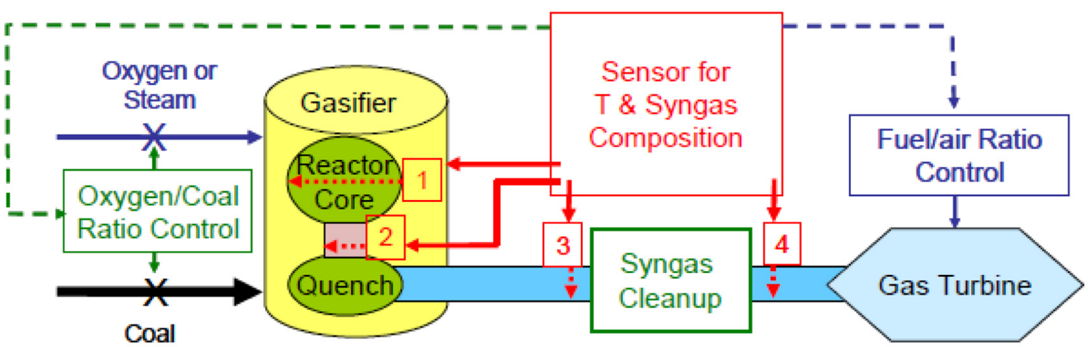

Figure 1. Illustration of the potential locations of gas sensors for control of a combined cycle power plant