the ENERGY lab

PROJECT FACTS

Advanced Research

Development of Model-Based Controls for GE's Gasifier and Syngas Cooler

Background

The U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) develops affordable and clean energy from coal and other fossil fuels to secure a sustainable energy economy. To further this mission, NETL funds research and development of advanced sensor and control technologies that can function under the extreme operating conditions often found in advanced power systems, particularly those that are gasification-based. Reliable and robust sensors and controls are essential to the development of high-efficiency, clean energy technologies, such as low-emission power systems that use coal or other fossil fuels.

In alignment with DOE Fossil Energy program goals, General Electric (GE) Global Research has developed advanced model-based sensing and controls technology for the gasification section in an integrated gasification combined cycle (IGCC) power plant, enabling enhanced robustness, availability, efficiency, and operational flexibility through increased automation.

Project Description

Focusing on the gasification section of an IGCC plant, project researchers developed advanced model predictive controls and sensing solutions to enhance the overall performance of the system. The gasification section, which is the core of an IGCC plant, has a particularly harsh environment. This directly limits available online sensors for monitoring and controls. Consequently, the operation of this section, using a combination of simple controls and operator judgment, is often conservative.

The research team used a systematic model-based approach to design an advanced integrated sensing and control system for improved steady state and transient operation of the gasification section of an IGCC plant. Specific key tasks included the following:

- Modeling, model reduction, and model validation—Implemented reduced-order dynamic model for real-time simulation and design of sensing and control systems.
- Sensing system design—Developed a comprehensive online sensing system combining available online sensors with model-based estimation for key unmeasured variables.
- Control system design—Developed a model predictive control to optimize the steady state and transient operation subject to hardware and operability constraints, for startup and nominal operation.

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PARTNERS

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PROJECT DURATION

Start Date
07/05/2007

End Date
12/31/2010

COST

Total Project Value
$3,016,848

DOE/Non-DOE Share
$2,413,478 / $603,370

Goals and Objectives

The goal of this project was to develop and evaluate an integrated advanced sensing and control solution to enhance operational flexibility and efficiency of the core gasification section in an IGCC power plant. The development and evaluation included flexible operation with feedstock changes for coal and coal/petcoke blends; throughput changes between part-load and base-load; and startup time-reduction of up to 30 percent dependent upon available actuator hardware, safety, and operability margins in the startup process.

Accomplishments

In the first year of the project, which began in 2007, GE Global Research (1) completed a set of control specifications allowing evaluation of the high-fidelity models and reduced-order models of the gasification block for turndown, startup, and fuel changes; and (2) identified the requirements for an ideal sensing/monitoring system for the gasifier and radiant syngas cooler.

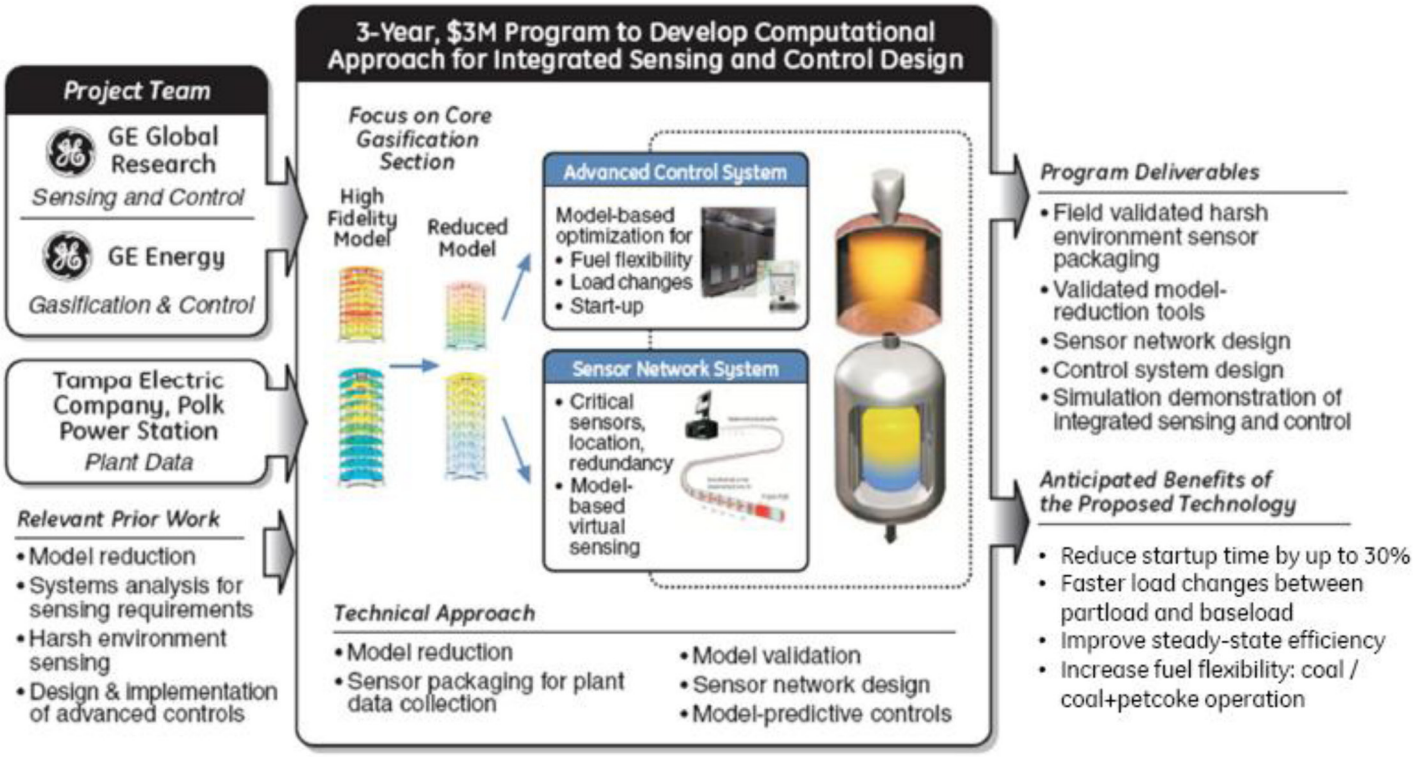
In 2008, researchers completed the implementation of a dynamic model for nominal operation as well as startup for the gasification section. In addition, the advanced control architecture, combining model-based estimation and model predictive controls, was defined for subsequent design and evaluation.

In 2009, laboratory development and testing of fiber optic temperature sensors was completed and the sensors were installed at Tampa Electric's Polk Power Station to collect temperature and strain distribution data in the radiant synthesis gas cooler. The collected temperature data and available plant measurements were used to validate the model. Researchers also developed the advanced model-based sensing/estimation solution and evaluated its performance for estimating key performance variables in the presence of sensor and modeling errors. In parallel, a model predictive controller with ideal sensing was developed and evaluated for performance improvements during startup and normal operation under various operation modes. These studies showed potential for 25 percent faster startup, 20–25 percent faster ramps during load changes, and improved steady-state efficiency for both coal and coal/petcoke blends.

In 2010, GE Global Research completed the design of an advanced sensing and control system by updating the underlying models for estimation and control, and integrating the separate estimation and controls implementations in the overall closed-loop solution. The performance of the integrated sensing and control system was evaluated through extensive simulations in the presence of modeling and sensor errors. The performance improvement results were similar to those obtained in 2009.

Benefits

Automated operation through advanced sensing and control will enable increased robustness, efficiency, and operational flexibility in terms of faster fuel changes, throughput changes, and startup with a significant reduction in cold startup time. The automated operation of the gasification section provides the basis for extension to plant-level automation, coordinating the robust, optimized, and flexible operation of the gasification section with other key plant sections.



Program overview and scope for advanced integrated sensor and controls design for improved operation of gasification section in IGCC plant.