PROJECT facts

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Advanced Research

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Intelligent Monitoring System With High Temperature Distributed Fiberoptic Sensor For Power Plant Combustion Processes

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Description

The objective of the proposed work is to develop an intelligent distributed fiber optic-based sensor system for real-time monitoring of temperature in a boiler furnace in power plants. Of particular interest is the estimation of spatial and temporal distributions of high temperatures within a boiler furnace, which will be essential in assessing and controlling the mechanisms that form and remove pollutants at the source, such as NO_X.

The basic approach in developing the proposed sensor system is three-fold: (1) development of high temperature distributed fiber optical sensor capable of measuring temperatures greater than 2000 °C with spatial resolution of less than 1 cm; (2) development of distributed parameter system (DPS) models to map the three-dimensional (3D) temperature distribution for the furnace; and (3) development of an intelligent monitoring system for real-time monitoring of the 3D boiler temperature distribution.

A Novel High Temperature Distributed Fiberoptic Sensor Development

Task 1 is focused on the development of an innovative high temperature distributed fiber optic sensor by fabricating gratings into single crystal sapphire fibers. This unique high temperature distributed fiberoptic sensor can precisely monitor the temperature distribution inside a boiler. Since there are no sapphire fibers with in-fiber gratings, it is difficult to develop traditional grating based distributed fiber sensors. To solve this problem, a novel sapphire fiber with periodically etched cladding is being developed. The key innovations are: (1) how to fabricate wavelength sensitive mode-converter in sapphire fiber; and (2) how to find the location information from the mode coupling between the fundamental modes and the selected excitation modes. Since this mode coupling is wavelength sensitive, the distributed fiber sensing is achieved by scanning wavelengths of the light source (i.e., wavelength division multiplexing).

PROJECT COST

Grant

$200,000

PROJECT DURATION

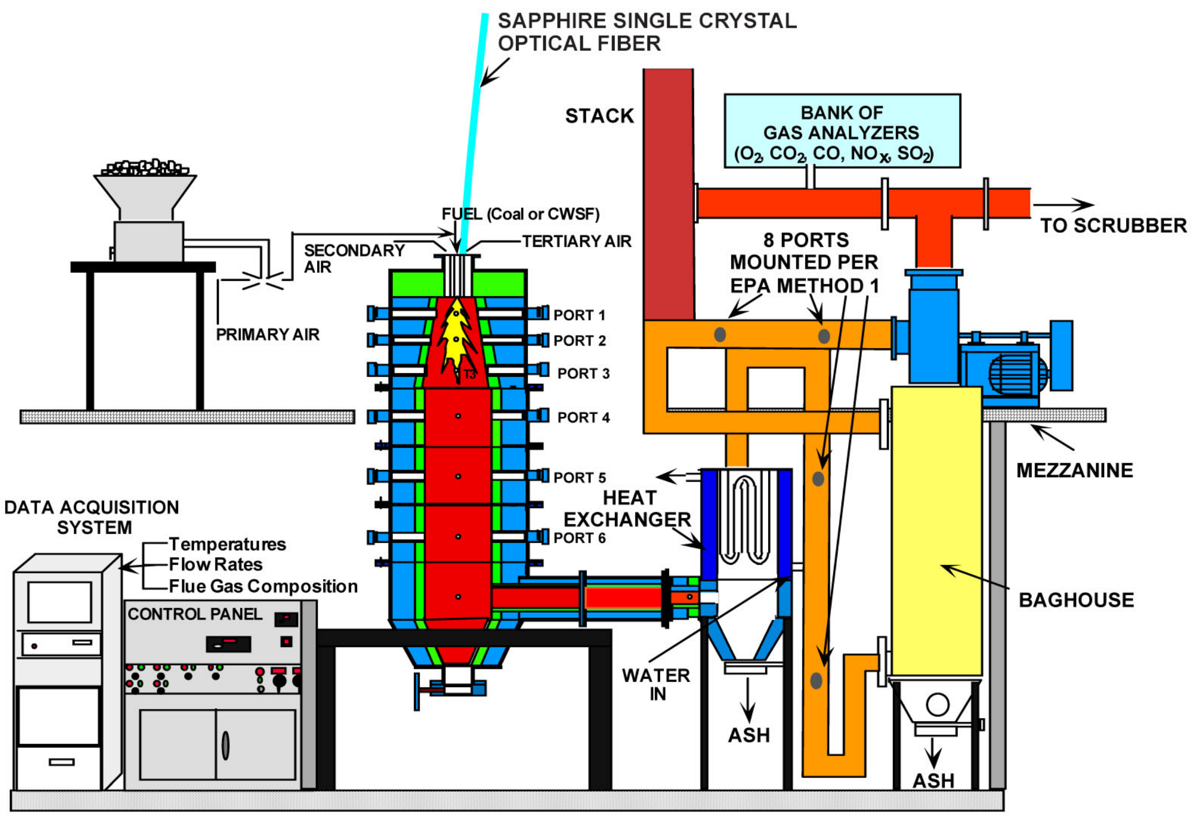
09/27/2002 – 09/26/2004

WEBSITES

www.netl.doe.gov/coal

Improving the performance of coal fired boiler systems and enabling the operation of advanced fossil fuel technology can be achieved through better control of the process. Process control relies on sensor data to operate effectively. Since this novel concept incorporates the ability to conduct distributed sensing of temperature, the temperature of the vessel can easily be mapped. Task 2 integrates the distributed fiberoptic sensors and analytical models of boiler dynamics to create a new three-dimensional (3D) flame temperature distribution mapping model. This model will build upon combustion simulation code, such as FLUENT and will use data collected from two experimental boilers available at Penn State, 2 MBtu and 20 MBtu boilers, which have numerous access points for instrumentation and control.

The proposed boiler furnace-monitoring model addresses the estimation of spatial temperature distribution continuously for any operating condition. The three-dimensional (3D) distributed parameter systems (DPS) model, however, is highly nonlinear and time varying with significant uncertainties in model parameters. Therefore, an efficient state estimation methodology will be developed for this class of DPS models. State estimation technique has matured for lumped parameter systems; however, its application has been limited due to the complexity of the model. Consequently, real-time computation is not feasible for on-line distributed parameter estimation. As an alternative to the model-based estimation techniques, an intelligent monitoring scheme will be developed for 3D temperature estimation by using intelligent methods such as artificial neural networks. The combustion simulation code will generate temperature data for the boiler 3D-DPS model and will be used to train the neural networks. The trained neural networks will be used to map the 3D temperature distribution on-line using the 1D distributed measurement data from the fiber optical sensors. The generalization property of the intelligent system techniques will result in the mapping of the sensor data into the three-dimensional temperature distribution.



Schematic of a boiler with an embedded fiber optic sensor