Distributed fiber sensing systems for 3D combustion temperature field monitoring in coal-fired boilers using optically generated acoustic waves

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OBJECTIVES
1. This poster presents a novel distributed optical fiber sensing system for the real-time monitoring of spatial and temporal distributions of high temperature profiles in the boiler of fossil fueled power plants.
2. According to the principle of pyrometer system, speed of the acoustic waves depends on the temperature of gaseous medium.
3. Photoacoustic material coated optical fiber sidewalls will generate acoustic waves. Fiber Bragg gratings (FBG) which can be multiplexed within one optical fiber will be used to detect acoustic waves. A 3D temperature distribution profile will be reconstructed using Gaussian Radial Basis Functions (GRBF) based on the sparse measurement data.
4. At this point, a simulation model for furnace temperature profile has been built, a sidewall ultrasound probe has been fabricated and tested, and a water temperature test has been performed.

RESULTS: GENERATION TEST

RESULTS: WATER TEMPERATURE

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Fig. 1 Distributed fiber sensor
Fig. 2 Survive high temperature

PRINCIPLE

- Speed of acoustic waves depend on the temperature of gaseous medium.
- The TOF (time-of-flight) of an acoustic signal over a propagation path can be calculated as:

\[ \text{TOF}(i) = \int_{C(x,y,z)} \frac{1}{d(x,y,z)} \, dz \]

- The heats ratio \( z \) the reciprocal of velocity \( j \) the number of paths;

Fig. 3 Reconstruct the 3D high temperature distribution within a boiler via a novel fiber optic distributed temperature sensing system using optically generated acoustic waves.

RELATED ACHIEVEMENTS

1. Support 1 Postdoc, 1 PhD student, 1 REU student.

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FUTURE WORK

1. Establish a boiler furnace temperature distribution model and guide the design of the sensing system;
2. Develop the sensors with one active sensing element on each fiber as well as a temperature distribution reconstruction algorithm for proof-of-concept;
3. Develop the distributed sensing system to integrate multiple active sensing elements on a single optical fiber.

Fig. 11 Overall objective and objectives for each phase.

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