Performance and Emissions Optimization Through Integration of a Miniaturized High-Temperature Multi-Process Monitoring System

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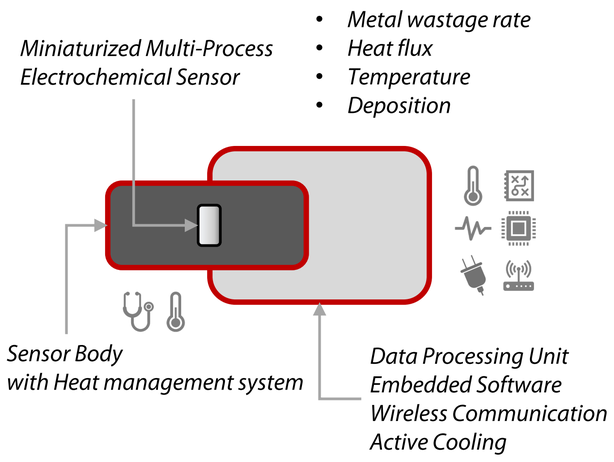
Objectives

Design, fabricate, test and demonstrate in a commercial scale lignite-fired boiler a miniaturized high temperature multi-process, high-spatial-resolution monitoring system (mMPMS) for boiler optimization

mMPMS

Real-time indication of tube surface conditions at key locations in the radiant section of a coal fired boiler based on electrochemical sensor that can provide metal loss rates, heat flux, metal surface temperature, and deposit thickness.



Project Organization

Prime Recipient

REACTION ENGINEERING INTERNATIONAL

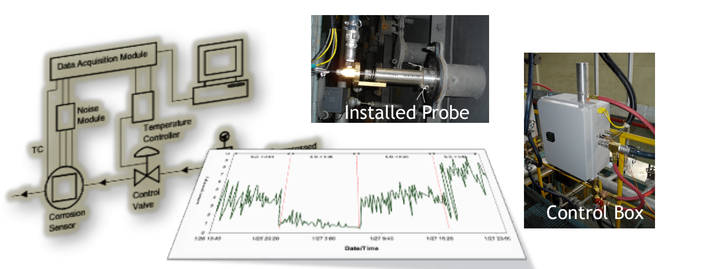
- *Project Management*
- *mMPMS Development*
- *Mechanism Derivation*
- *Computational Modeling*
- *Signal Conditioning and Data Communication Module Development*

Sub-Awardees

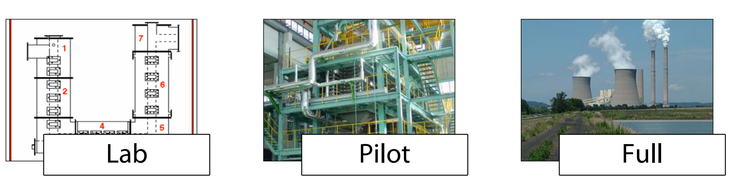
THE UNIVERSITY OF UTAH	*Pilot-scale Testing*
BASIN ELECTRIC POWER COOPERATIVE, A Touchstone Energy® Cooperative	*Full-scale Demonstration*
Bill Smith Engineering, LLC	*Technical Consultant*
	Boiler Tuning and Optimization

REI Team's Previous Work

- Electrochemical sensing system has been applied to low and high temperature zones of the boiler to assess corrosion behavior in the boiler and waste-to-energy system, improve thermal efficiency of the boiler, and compare tube materials under ultra-supercritical steam condition and oxy-firing combustion
- EN-based system provides high sensitivity, real-time, on-line monitoring technology
- REI has developed corrosion rate correlations through EPRI and KEPRI projects that can assess the impacts of planned changes in combustion environment on fire-side corrosion



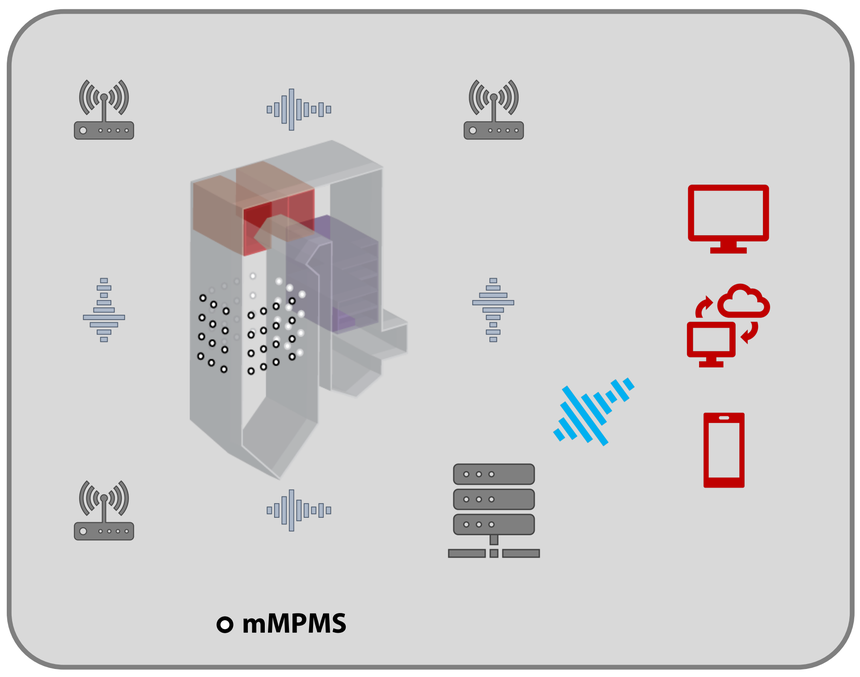
EN-based Corrosion Monitoring System and Application



Electrochemical Sensing Merits

- There is no temperature compensation requirement
- Corrosion rate measurements
- Measurements are instantaneous and quantitative
- Temperature and heat flux are measured simultaneously and deposition rate can be estimated

Boiler Condition Monitoring using mMPMS

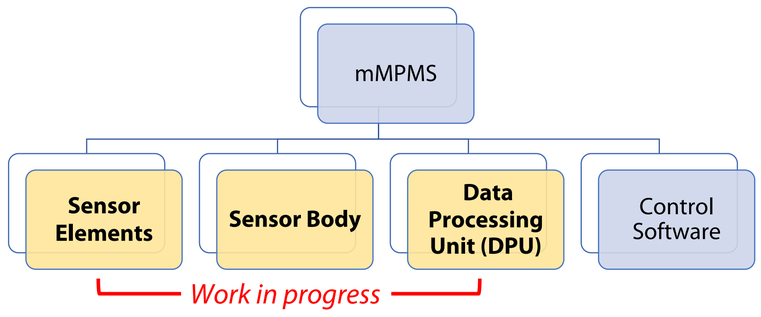


Project Schedule

Year 1 (Oct 2018 – Sep 2019)	• Design and construction of prototype sensor body • Design and fabrication of data processing unit • CFD analysis of full-scale lignite coal-fired boiler
Year 2 (Oct 2019 – Sep 2020)	• Construction of power and cooling unit • Development of data processing software for lignite fired unit • Test and validation of multi-process sensor in a lignite firing pilot-scale combustor • CFD analysis of demonstration site's full-scale lignite-fired boiler • Demonstration of multi-process sensor in a commercial scale lignite coal-fired boiler
Year 3 (Oct 2020 – Sep 2021)	• Control logic development and implementation for automated control

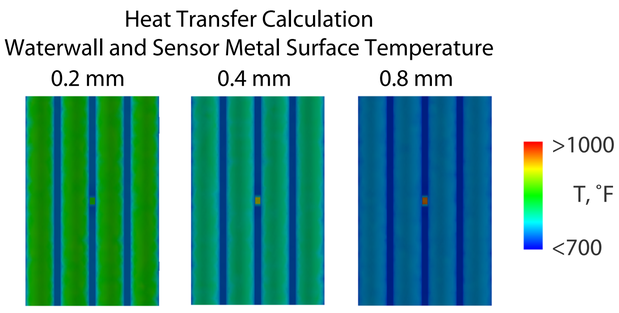
Project Status

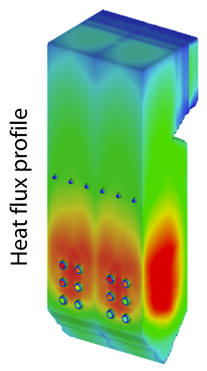
Prototype mMPMS has been developed and heat transfer calculation will assist to finalize the design prior to pilot- and full-scale testing

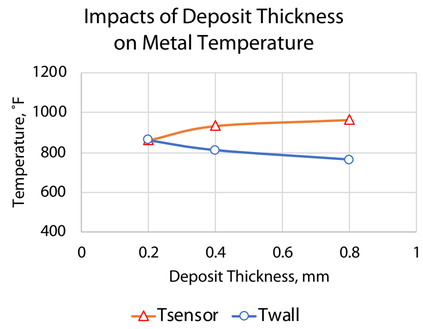


Sensor Body

Sensor body is designed to avoid any active cooling needs: heat transfer calculation provides guidance







Benefits & Future Work

A system of non-intrusive real-time sensors providing quantitative insight into several key indicators of boiler performance/maintenance will save individual plants tens of millions of dollars. Future efforts will include utilization of additional sensors throughout convective sections and backpass equipment as well as integration with advanced control approaches.

Approaches

- Re-design and Construct Prototype Sensor Body
- Re-design and Fabriction of Data Processing Unit
- Construction of Power and Cooling Unit
- Additional Development of Data Processing Software
- Validation of Multi-Process Sensor in Pilot-scale Unit
- Full-scale Demonstration of System

Demonstration Site

Leland Olds Station located near Stanton, North Dakota
Two lignite-fired units with total generating capacity 669 MW

Plant is interested in ash management and boiler tuning

Acknowledgements

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