Robust Heat-Flux Sensors for Coal-Fired Boiler Extreme Environments

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2020 UCR/HBCU-OMI Joint Kickoff Meeting

Project Objectives

- **Develop robust heat-flux measurement systems** capable of operating in the challenging high-temperature, corrosive environments of the boilers of coal-fired power plants.

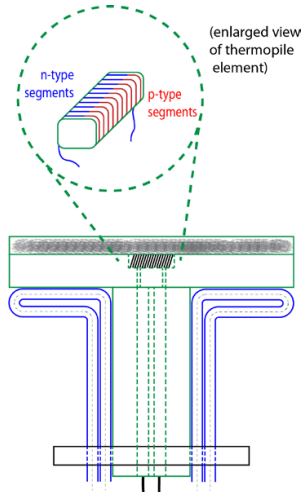
- Support the **training of graduate and undergraduate students** in STEM disciplines, preparing them to apply science and engineering principles to solve real-life problems.

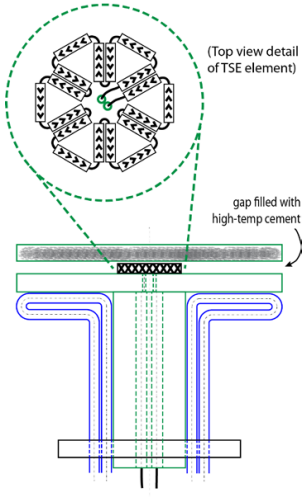
Objectives' Alignment to DOE/NETL Program

- Novel sensing and controls concepts for continuous, online monitoring for coal-based power generation processes undergoing flexible operation. (FOA-2193)
- Heat-Flux Sensing
  - Cost-effective, distributed network of sensors.
  - Data used to optimize operation and improve efficiency.
  - Data used to predict imminent failure and decrease downtime.
- Technology Barriers
  - Direct measurement: Compact heat-flux sensors are limited to ~650degC.
  - Indirect measurement: Complex system, lack of real-time data.

Technical Approach

- **Prototyping the wire-wound Schimdt-Boelter-style sensor head**
- **Prototyping the Transverse Seebeck Effect sensor head**





Technical Approach

- **Prototyping the wire-wound Schimdt-Boelter-style sensor head**
- **Prototyping the Transverse Seebeck Effect sensor head**

- **Modeling of the Thermo-Mechanical Properties of the sensor head**

- **System design**
- **Testing and Calibration**

Project Participants

- PI: Oded Rabin, Materials Science and Engineering
- Co-PI: Peter Sunderland, Fire Protection Engineering
- Graduate student (1)
  - To start in Spring 2021.
- Undergraduate students (3)
  - E. J., Senior in Fire Protection Engineering – Sensor head design
- Technical staff (PT)
  - Machining and rig construction

Project Timeline from SOPO

		Lead Person	FY 2021				FY 2022				FY 2023			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TASKS			1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36
1.0	Project Management and Planning	PD												
1.1	Project Management Plan	PD												
1.2	Technology Maturation Plan	PD												
2.0	Prototyping the Wire-Wound Schmidt-Boelter-Style Sensor Head	PD												
2.1	Materials Procurement	Staff												
2.2	Ceramic Machining	Staff												
2.3	Thermopile Wire Fabrication	PD				X								
2.4	Sensor Head Assembly	All												
3.0	Prototyping the Transverse Seebeck Effect Sensor Head	PD												
3.1	Materials Procurement	Staff												
3.2	Ceramic Machining	Staff												
3.3	Single Crystal Preparation	PD					X							
3.4	Sensor Head Assembly	All												
4.0	Modeling of the Thermo-Mechanical Properties of the Sensor Heads	co-PI				X								
5.0	System Design	PD						X						
6.0	Testing and Calibration	co-PI												
6.1	Design and Set-Up of Test Facilities	staff												
6.2	Low-Temperature Heat Flux Signal Testing	co-PI												
6.3	High-Temperature Resilience Testing	co-PI									X			
6.4	High-Temperature Heat Flux Signal Testing	co-PI												
6.5	Heat Flux-to-Electrical Signal Transfer-Function Analysis	PD												
6.6	High-Temperature Heat Flux Measurement: Testing against Commercial Sensor	co-PI												X
7.0	Presentations, Intellectual Property, and Partnerships	All	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Deliverables from SOPO

Task / Subtask Number	Deliverable Title	Due Date
1.1	Project Management Plan	Q1 2021
1.2	Technology Maturation Plan	Q1 2021, Q4 2023
6.2	Report: Low-Temperature Sensor Performance	Q1 2023
6.4	Report: High-Temperature Sensor Performance	Q4 2023
	Quarterly Report	Each quarter