Coal Flow Sensor

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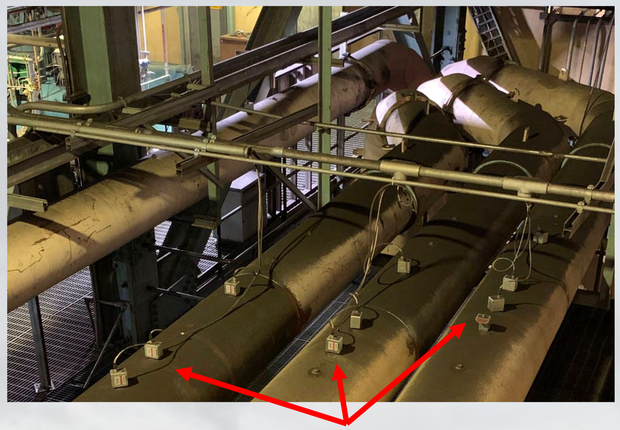
PACIFICORP

Introduction

The Pacificorp power plant in Huntington, UT currently uses probe sensors to measure the rate of powdered coal flow in each pipe leading to the boilers. However, the mined coal in Huntington is high in quartz content, making it extremely abrasive. As a result, the probe sensors pose the following issues:

- Invasive to pipe, abrade easily from coal flow
- Require replacement every ~6 months
- Costly to replace (~$1200/sensor)



Current probe sensors installed at plant

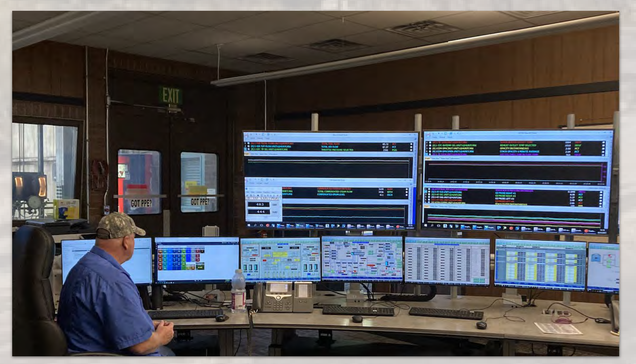
Objectives

1) Design a non-invasive sensor for Pacificorp power plant to measure air to coal ratio and coal velocity between pipes
2) Create a scaled test system to study and test sensor functionality

Why Measure Flow Rate?

Meeting these objectives will allow sensor data to be transmitted to a control system at the plant. This allows plant engineers to:

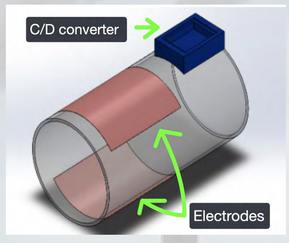
- Monitor relative air-coal ratio between pipes leading to the boilers
- Equalize flow distribution between pipes
- Ramp air velocity and mass flow rate of coal depending on demands of electrical grid → increase plant efficiency

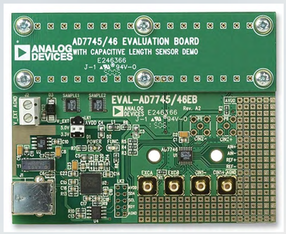


Process control center at Huntington coal power plant

Capacitance Sensor

- Capacitance is measured between electrodes placed inside of pipe
- Reading is processed with a capacitance-to-digital converter to produce a digital signal
- **More coal within pipe → higher permittivity → higher capacitance**



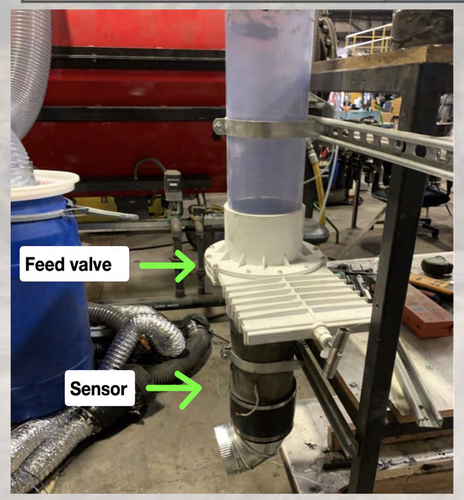


AD7746 C/D Converter

Forced Flow Testing Setup

- Material is released through system with a slider valve
- Material flows through section of pipe that houses sensor
- Vacuum pulls material through the dust collector

Testing Setup Metric	Unit	Target value	Measured value
Material delivery rate (max)	lb/s	40	30
Air velocity (max)	ft/s	15	50
Reset time	min	<3	1.5

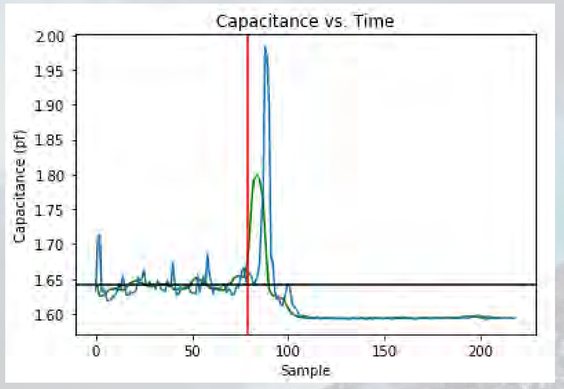


Feeder mechanism and sensor. Material flows through the sensor pipe into another section of pipe that feeds into the dust collector.

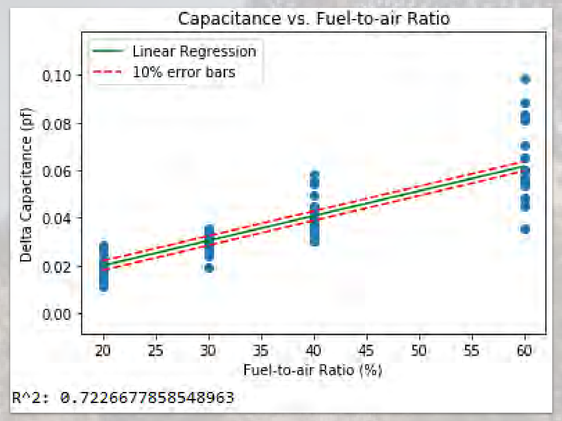
Dust collector shown above. Vacuum pulls material through piping that houses sensor. Material is collected in the blue drum

Data Analysis

- The data we collect from the AD7745 is processed by our python code which formats and averages the data at the current air-fuel ratio.
- This data is then used in a linear regression for modeling capacitance vs. amount of material (air-fuel ratio). As we test more this regression becomes more accurate.



A similar plot to above is produced for every test performed. This plot shows the raw data (blue), a running average with 8 data points (green), and the average generated from the running average (black horizontal line).



This linear regression indicates that there is a linear increase in the measured capacitance as the fuel-air ratio increases. Our total population size for this linear regression is comprised of 92 tests.

Conclusion

Our test setup was successful in reaching our target metrics. The data analysis shows a sufficient linear model for capacitance versus air-fuel ratio, but not within our desired values for consistency. This variation increases as the air-fuel ratio increases, indicating the testing setup may cause this variation. Future steps include adding another inline sensor to measure material velocity, creating a user interface, and installing a full scale measurement system at Pacificorp. Our results this year have shown capacitance sensing to be an improved method of measuring coal flow, but more work will need to be done in order to have a functional full scale system.

Background Photo Courtesy: https://www.cityweekly.net/utah/banking -on-coal/Content?oid=12775140