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"Sensor for Individual Burner Control of Firing Rate, Fuel-Air Ratio, and Coal Fineness Correlation"

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ABSTRACT

To minimize program cost, additional testing is planned to be performed in concert with EPRI-funded testing at the Coal Flow Test Facility in late July. This will be followed by field testing to be performed by EPRI in August. The minimal effort put into the analysis during this reporting period revealed surprising variation in the trends of the dynamic signatures over time. It is unclear whether these temporal trends are related to noise or to the actual dynamics. Further data analysis and fine-tuning of the algorithm will be done upon arrival of the data to be collected in the near future.

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EXECUTIVE SUMMARY

The project's overall objective is to develop a commercially viable sensing system to infer the flow rate and fineness of pulverized coal flows using the dynamic signature from a pipe-mounted accelerometer. The preliminary calibration data for this effort are to be obtained using a Coal Flow Test Facility built and operated by our subcontractor, Airflow Sciences Corporation, in support of an EPRI program. Additional operational data are to be collected in field testing at coal-fired power plants to fine-tune the calibration.

Analysis performed on the laboratory data collected to date has produced encouraging results, considering the limitations of the available data. Careful examination of each data file disclosed that various types of noise are present in many data files, in many cases of such a type that it would be easy to identify by a straightforward analysis built into the instrument system. Through extensive analysis of the data sets that appeared to be noise-free, it was discovered that some data sets still suffer from some form of noise that is as yet unidentified. The cases not suffering this noise produce extremely good flow correlations, while the noisy cases are essentially uncorrelated to coal flow. This led us to decide that additional laboratory testing was needed to identify potential sources of noise and to obtain additional data to serve as the basis of the instrument calibration. This testing will be performed in concert with testing for an EPRI-funded program during the latter part of July, significantly reducing the cost to this program. In this reporting period, efforts to improve the algorithm were put on hold until the arrival of further data from the upcoming testing at the Coal Flow Test Facility.

During the upcoming report period, additional data will be collected and analyzed for the purposes of fine-tuning and validating the coal flow prediction algorithm.

EXPERIMENTAL

Additional laboratory testing will be performed in the Coal Flow Test Facility during the week of July 25, 2005. The testing will be performed in concert with testing by EPRI, providing a significant cost reduction for this program. Foster-Miller will send a project engineer to the Coal Flow Test Facility to observe the testing and assist with the data collection. A key point of focus for the Foster-Miller engineer will be to identify possible sources for the noise that has been evident in the laboratory data collected previously and, if possible, to find ways to eliminate or damp that noise.

Following the laboratory testing, Airflow Sciences will perform further testing in plants. This field testing is expected to be completed during August 2005.

RESULTS AND DISCUSSION

During the previous reporting period, a significant improvement in coal flow prediction was obtained based on differences between the median of the one-second signature quantities and the median of the corresponding five-second signature quantities. Based on neural net predictions, a maximum r^2 value of 0.97 was achieved using these differences, as compared with maximum r^2 values of only 0.78 and 0.79 based on the medians of the one-second signature quantities and the medians of the five-second signature quantities respectively. As noted in the previous report, it is unclear whether this improvement is due to noise reduction, with the difference of the medians effectively subtracting off the noise. A second possibility is that the extent to which the one-second signature quantities populate the state space as effectively as the five-second signature quantities depends on dynamics that vary with coal flow.

A closer examination of the signature quantities used as inputs for the optimal neural net revealed some unusual trends in the values over time. For some test runs, the values of the one-second and five-second signature quantities showed little variation with time. For other signature quantities, there was a distinct trend, with the value either increasing or decreasing over time. Figure 1 below contrasts the autocorrelation signature quantity for two different test runs with similar coal flow and air flow. The top half of the figure illustrates a case in which the autocorrelation clearly decreases over time while the bottom half of the figure illustrates a case with no such trend. This distinction could not be correlated with coal flow, air flow, pipe arrangement or test date. It remains unclear whether the trends that exist are related to the dynamics or noise.

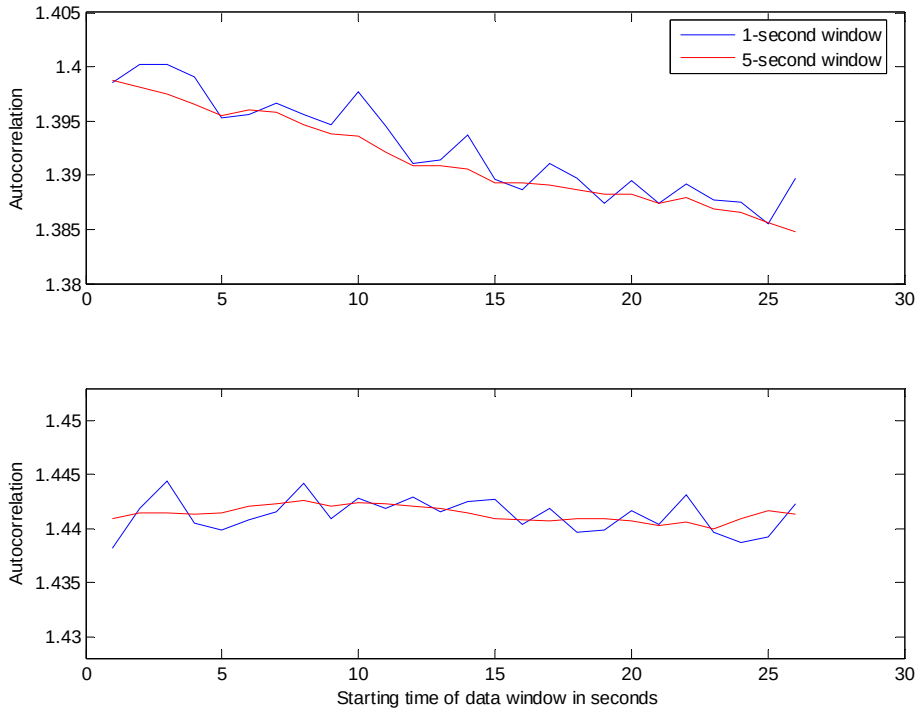

Figure 1. Trends of autocorrelation over time for two test runs with similar coal flow

With future laboratory testing scheduled for late July, it was decided that it would be best to wait for the availability of new test data before proceeding further with the analysis. Efforts will be made during the upcoming testing to pinpoint any noise sources and to reduce noise where possible.

CONCLUSIONS

Additional data will be collected first at the Coal Flow Facility and then in the field later this summer. This should allow us to determine the extent to which the improvement in the analysis is due to reduced noise sensitivity and the extent to which the current algorithm has pinpointed those aspects of the dynamics that vary with coal flow. Once this is accomplished, the signature quantities themselves can be fine-tuned to better capture the temporal variation of the dynamics so as to create a more incisive algorithm.