ACHIEVING UNIFORM COMBUSTION USING REAL TIME COAL FLOW AND GASEOUS EMISSIONS MEASUREMENT EQUIPMENT

Frederick P. Haumesser, P.E.
Richard E. Thompson, P.E.
Fossil Energy Research Corp

Douglas L. Eakle
Allegheny Energy Supply

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EVIDENCE OF NON-UNIFORM COMBUSTION

Symptoms Of Non-Uniform Combustion Often Include:

- **Uneven Excess Oxygen Readings (Side-To-Side)**
- **Inconsistent Flyash Loss On Ignition (LOI) Values And Localized High Carbon Monoxide (CO)**
- **Uneven Waterwall Deposition Patterns**
- **Side-To-Side O_2, CO And NO_x Data Change With Firing Pattern**
- **Uneven Flue Gas And Steam Temperatures**

WHY BALANCE THE STEAM GENERATOR'S COMBUSTION?

Non-Uniform Combustion Can Lead To:

- **Poor Equipment Performance**
- **Increased Flyash Loss On Ignition (LOI) And Increased Carbon Monoxide (CO) Resulting In Lower Boiler Efficiency**
- **Waterwall Corrosion And Fouling In The Convective Section**
- **Elevated NO_x Emissions Caused By Air Rich Burners**
- **Elevated CO Emissions Caused by Fuel Rich Burners**

STEP ONE:

Address Pipe-to-Pipe Fuel Flow Distributions

MEASURING AND OPTIMIZING COMBUSTION – COAL FLOW DISTRIBUTION TESTING

- **Extractive Sampling (RotorProbe™) Versus Real Time Coal Flow Measurements**
- **RotorProbe™ :**
  - **ISO Approved**
  - **Performed Well Under Most Test Conditions In FERCo's Evaluations And At The EPRI Coal Flow Test Loop**
  - **Sequential, "Snapshot" Testing**
- **MIC:**
  - **Real-Time Coal Flow Distributions**
  - **Data Logged Constantly For All Burner Lines Of A Pulverizer**
  - **Field Testing Confirmed Accuracy With RotorProbe™ Results**
  - **Data From The EPRI Test Loop Indicated Very Good Agreement**

MIC REAL TIME COAL FLOW DISTRIBUTION TESTING

- **Two (Vertical Piping) or Three (Horizontal Piping) Sensors Required Per Burner Line**
- **Attach To Burner Line Using Existing Sample Ports (Valves)**
- **Data Logged And Displayed Simultaneously For All Burner Lines**
- **Distribution Changes Due To Operating Conditions, Such As Feedrate, Or To Equipment Settings, Such As Adjustable Orifices, Can Be Seen Immediately**

TYPICAL MIC SENSOR SET-UP

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STEP TWO:

Address Flue Gas Distributions for O_2, CO and NO_x (Side-to-Side)

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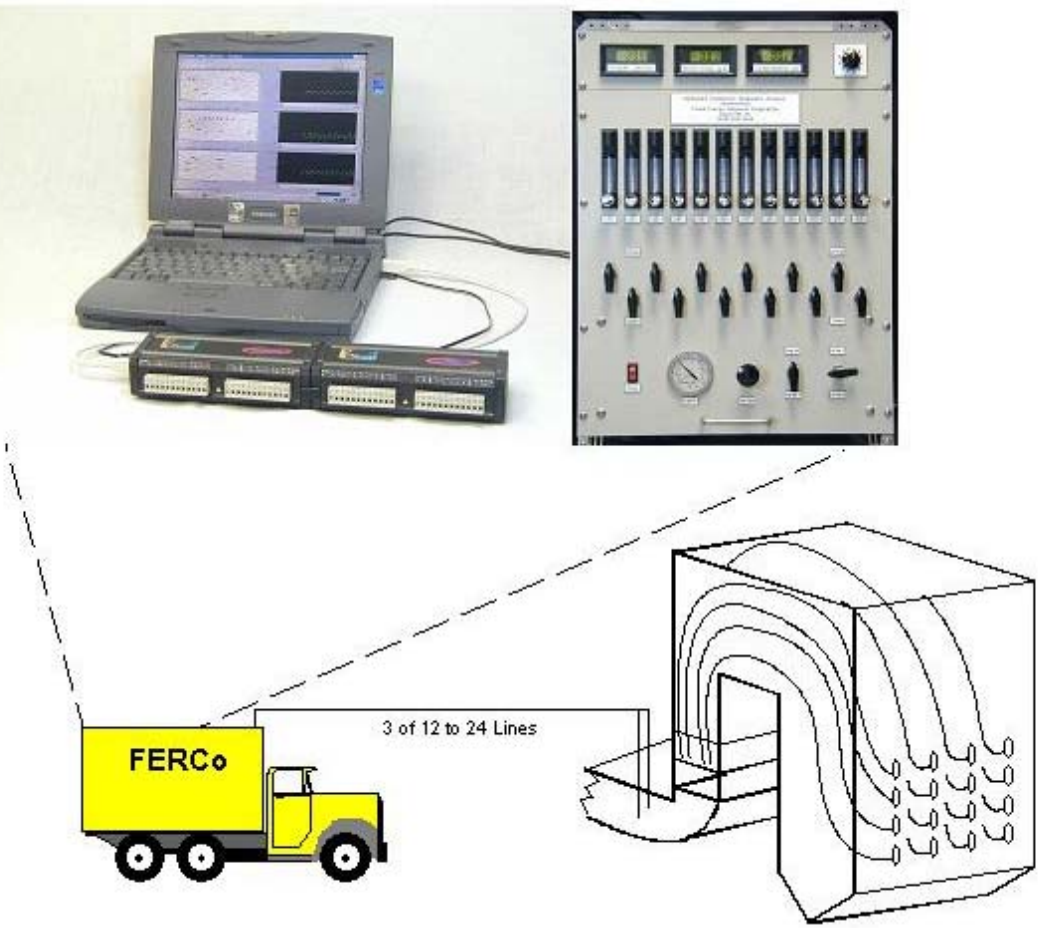
MEASURING AND OPTIMIZING COMBUSTION – GASEOUS EMISSIONS DISTRIBUTION TESTING

- **Traditional (Point-To-Point) or Real Time Using the FERCo Multipoint Combustion Diagnostic Analyzer (MCDA)**
- **Traditional Sampling:**
  - **Perform Flue Gas Analysis Sequentially, Requiring Approximately 3-5 Minutes Per Point (24 Points = 72-90 Minutes)**
  - **Boiler May Change, Thus Initial Data May Not Be Representative**

MEASURING AND OPTIMIZING COMBUSTION – GASEOUS EMISSIONS DISTRIBUTION TESTING (Cont'd)

- **MCDA:**
  - **Perform Flue Gas Sampling Of Points In Parallel; 12 Points Can Be Sampled Simultaneously; 24 Points = 10-13 Minutes**
  - **Data Logged Automatically Every 10-20 Seconds And Can Be Replayed For Additional Analyses**
  - **Data Can Be Monitored In Real Time To See The Cause And Effect Relationships Of Operating Parameter And Equipment Changes, Such As Mill Loadings Or Air Register Settings**
  - **MCDA Data Compared With Traditional CEM Instruments For Increased Confidence**

TYPICAL MULTIPOINT NO, O_2, CO ANALYZER (MCDA) INSTALLATION



CASE HISTORY:

Combustion Diagnostics Using Real Time Instrumentation

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UNIT DESCRIPTION

- **Allegheny Energy Supply's Harrison Unit 2**
- **640 MWg**
- **Foster-Wheeler Supercritical Boiler**
- **Opposed Wall Fired**
- **Six D9 Ball Tube Mills With Four Burner Lines Per Mill**
- **Firing Pattern: Three Elevations With Four Burners Across For Both Walls**

NON-UNIFORM COMBUSTION SYMPTOMS ON HARRISON UNIT 2

- **High CO And LOI On One Side Only**
- **Increased LOI Forced Operators To Increase Excess Air**
- **Higher Excess Air And High LOI Caused Decreased Electrostatic Precipitator (ESP) Performance**
- **The Increased Ash In The Flue Gas Leaving The ESP Was Eroding An Induced Draft Fan**

DIAGNOSTIC METHODOLOGY

- **Perform Fuel Distribution Testing**
- **Evaluate PC Samples For Fineness**
- **Measure Concentrations of O_2, CO and NO_x At Economizer Exit**
- **Establish Cause And Effect Relationships By Varying O_2 Level, Firing Pattern, Mill Loading And Burner Register Settings**
- **Program Completed Within Seven Test Days**

HARRISON 2E MILL COAL FLOW DISTRIBUTION DATA

- **F-W BALL TUBE MILLS WITH 4 – 15¼" BURNER LINES**

ROTORPROBE™ RECOVERED MASSES:		Pipe 1	Pipe 2	Pipe 3	Pipe 4
(Four Minute Collection Period)	Run 1	235gm	230gm	93gm	117gm
	Run 2	186gm	217gm	125gm	221gm
	Run 3	277gm	208gm	71gm	176gm
CALCULATED % DEVIATION PIPE TO PIPE		20.0%	24.2%	-39.4%	-4.8%

- **MIC % DEVIATIONS PIPE TO PIPE** 20.8% 42.5% -42.0 -21.3%
  (MIC Data Recorded Over 4 ½ Hours)

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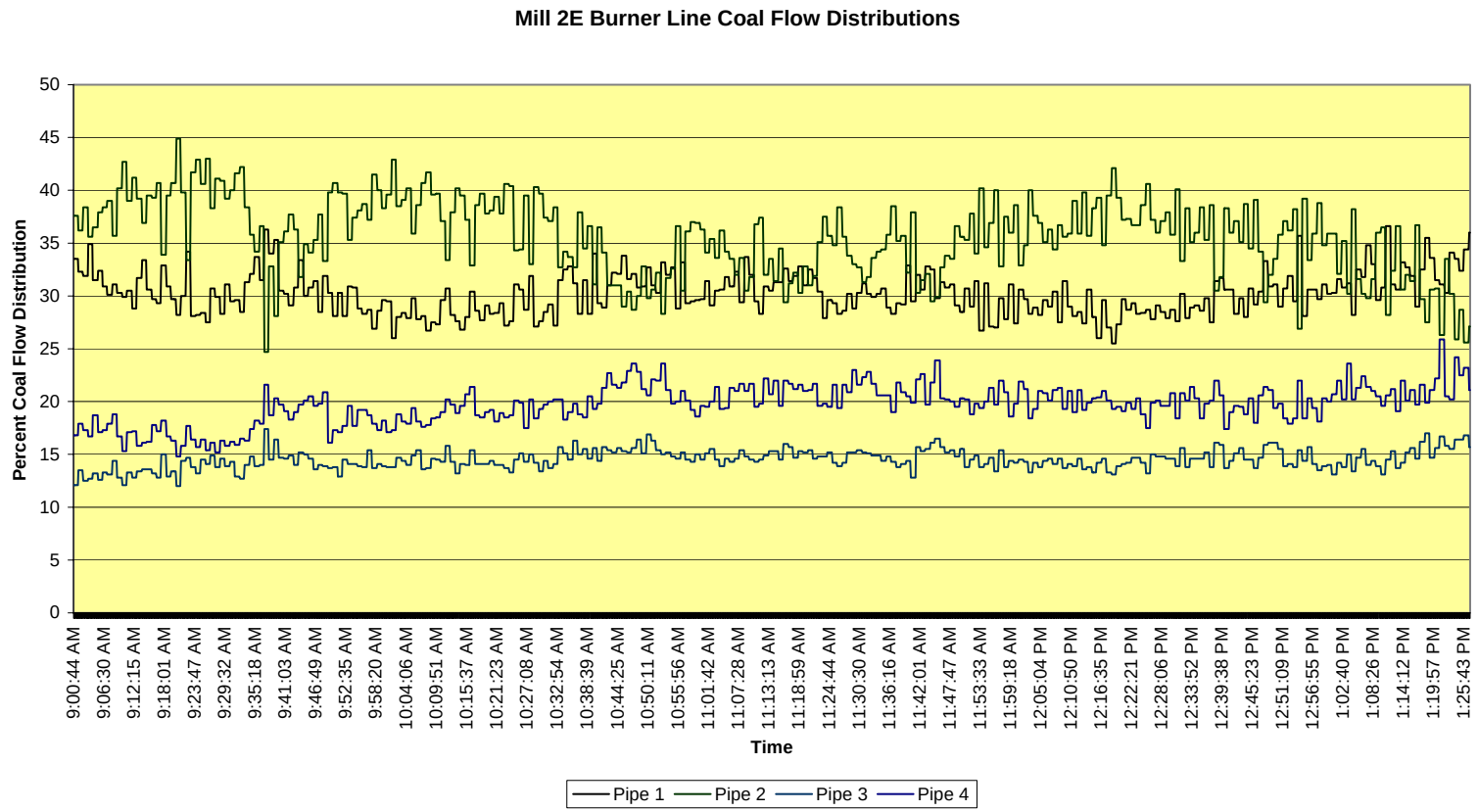
MIC PLOT OF COAL FLOW DISTRIBUTIONS OVER TIME FOR 2E PULVERIZER



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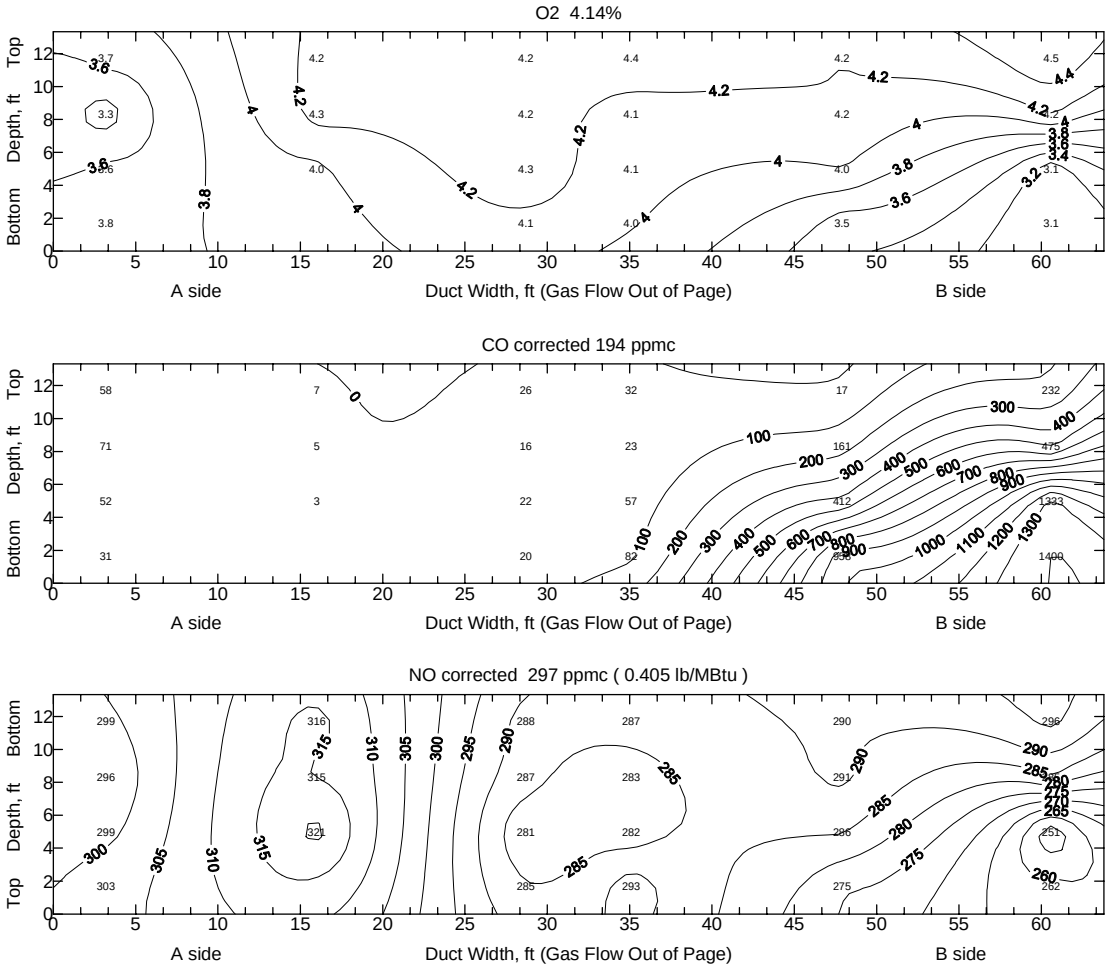
THE EFFECT OF 2E MILL ON COMBUSTION UNIFORMITY WITH ALL MILLS IN-SERVICE



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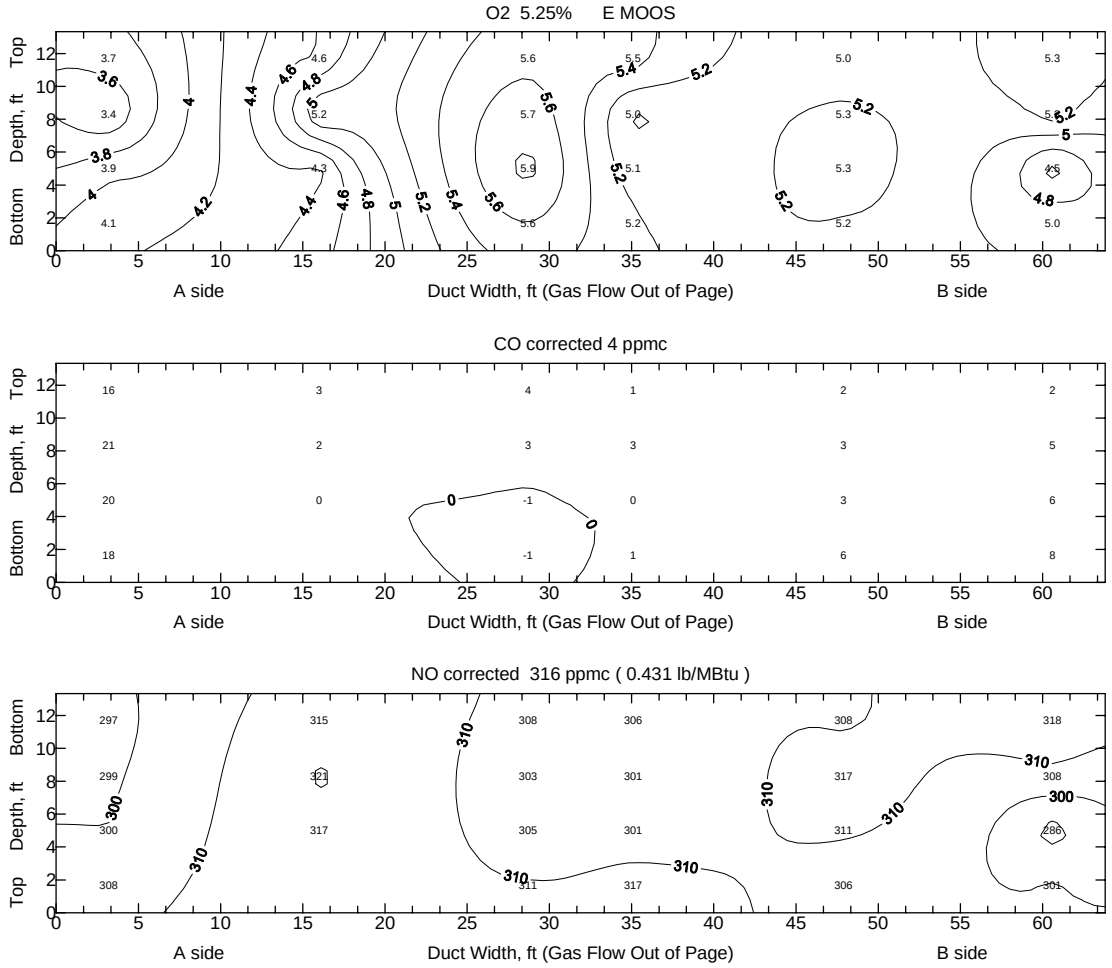
THE EFFECT OF 2E MILL ON COMBUSTION UNIFORMITY WITH 2E MILL OUT OF SERVICE



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COMBUSTION IMPROVEMENTS

The Results Of Removing 2E Mill Were:

- **CO Was Reduced From 194 ppm_c To 4 ppm_c**
- **O_2 Increased From 4.14% To 5.25% (Dry Basis)**
- **NO_x Increased From 0.405 To 0.413 lb/MBtu**
- **Flyash LOI Reduced From 6.0% to 3.2%**
- **Improvements Realized With No Changes In Fuel Flow, Total Airflow, Steam Flow Or Any Burner Settings**

COMBUSTION IMPROVEMENTS

The Results Of Removing 2E Mill Were:

- **Additional Tuning Reduced NO_x Emissions From 0.413 lb/MBtu To 0.372 lb/MBtu With Minimal Impact On CO (4ppmc to 90ppmc) At A Reduced Excess Oxygen Level (5.3% to 3.7%)**
- **ESP Performance Restored To Expected levels**
- **2E Mill Fineness Was Found To Be 98.15% Passing 50 Mesh And 74.47% Passing 200 Mesh**

CONCLUSIONS

THE KEY POINTS OF THIS CASE HISTORY ARE:

1. **The Unsteadiness Of The Combustion Could Easily Be Misinterpreted By Conventional, "Snapshot-Style" Extractive Coal Flow Sampling.**
2. **Real Time Coal Flow And Emissions Sampling Allows A Much Quicker And More Accurate Analysis Of Combustion Variability.**
3. **Real Time Pulverizer Fuel Distribution Data Can Be Monitored Over Time And Compared To The Unit's DCS Data For Impact-Based Analysis Of Combustion, Emissions And Efficiency.**
4. **Real Time Gaseous Emissions Monitoring Allows The Effects Of System Changes To Be Readily Evaluated In Terms Of The Unit's Combustion, Emissions And Efficiency.**

CONCLUSIONS (Continued)

5. **The Performance Of Only One Pulverizer Can Have A Very Pronounced Impact On Combustion Uniformity And Equipment Performance.**
6. **The Combustion Impacts Were Reducing Unit Availability And Key Equipment Life.**
7. **These Combustion Impacts Were Quickly And Accurately Identified Using The FERCo Proprietary Real Time Combustion Diagnostic Technologies.**
8. **These Same Diagnostic Technologies Were Used To Make Corrections To Key Operating Parameters, Which Were Proven To Improve The Unit's Combustion And Reduce The Associated Impacts On Key Equipment Performance.**

ACKNOWLEDGEMENTS

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