Boiler Optimization and MATS Work Practices Requirements

McIlvaine Hot Topics

September 27th, 2013

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ProcessLink®

Mercury and Air Toxics Standard (MATS)

- Requires all plants to reduce mercury and increase efficiency to mitigate unmeasurable air toxics
  - Requires an efficiency evaluation and tune-up every 3 years starting in 2015
- Complies with a universal consent decree
  - EPA, almost all generators, states and environmental groups are parties
- Generators are investing in mercury mitigation and efficiency
- Using a neural network relaxes timing of efficiency evaluation
  - Neural combustion optimization is only technology that enables plants to defer the evaluation to 2016 and to every four years thereafter
- Substantial business driver for NeuCo
  - NeuCo is seeing 2014 budgets established to include neural networks
  - Will drive universal adoption of combustion optimization in US coal generation

Units with Neural Network Optimization Get Favorable Regulatory Treatment

- Neural network optimization is explicitly addressed by MATS in three ways
  - Neural network optimization systems qualify for the requirement in the rule for "optimizing NOx and CO."
  - Units with optimizers can defer the initial EPA "best practices" requirement by a year.
  - Units with optimizers also qualify for less frequent subsequent evaluations from every 3 years to every 4 years.
- These provisions provide further evidence that the US EPA recognizes the value of optimization with respect to regulatory objectives relating to emissions and efficiency

Benefits of Neural Network Optimization for MATS Work Practices Requirements

- Clearly demonstrate "optimization of NOx and CO"
- Defer initial boiler tune-up by one full year
  - Learn how EPA enforces rule for those not employing neural optimization
  - Better plan for initial tune-up and associated repairs
  - Avoid or defer outage associated with tune-up
- Simplify emissions performance measurement protocol
  - Single before vs. after average as opposed to hourly measurements
  - Reduce sensitive data available to state and federal regulatory agencies
- Reduce subsequent tune-ups from every 3 to every 4 years
- Better meet emissions, efficiency, and availability objectives
- Provide upgrade path for integrated boiler optimization

Additional EPA Mandates and Enforcement Mechanisms

- Clean Air Act of 1970 and Clean Air Act Amendments of 1990
  - National Ambient Air Quality Standards, PM 2.5, Regional Haze
  - CO_2 for plants triggering New Source Review
  - And now CO_2 standards for existing power plants
- Enforcement Mechanisms
  - New Source Review
  - Internal administrative / judicial process
  - Prescriptive standards (BART/BACT)
  - Regional / market based approaches (CAIR, CSAPR)

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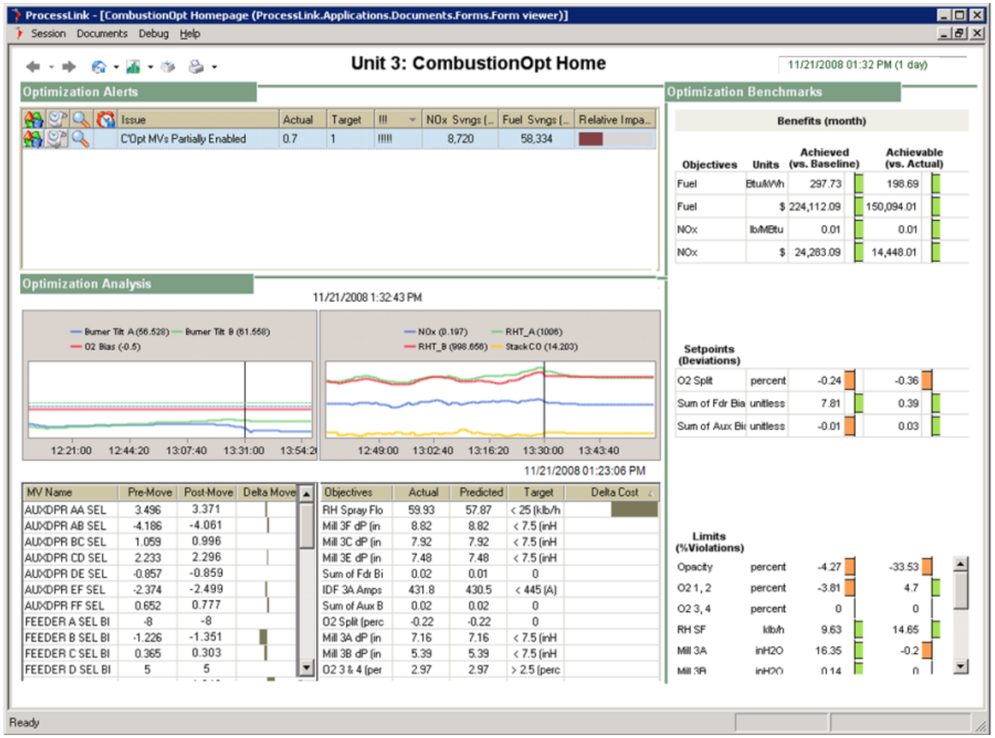
CombustionOpt®

- Provides real-time closed-loop optimization of fuel and air biases
- Using:
  - Model Predictive Control (MPC)
  - Neural Networks
  - Design of Experiments (direct search)
  - Expert Rules
- To Improve:
  - NOx
  - CO
  - Heat rate
  - Steam temps
  - Opacity
  - Reagent utilization
  - Constraint performance
    (Mill Dp's, Fan Amps, O2 split)



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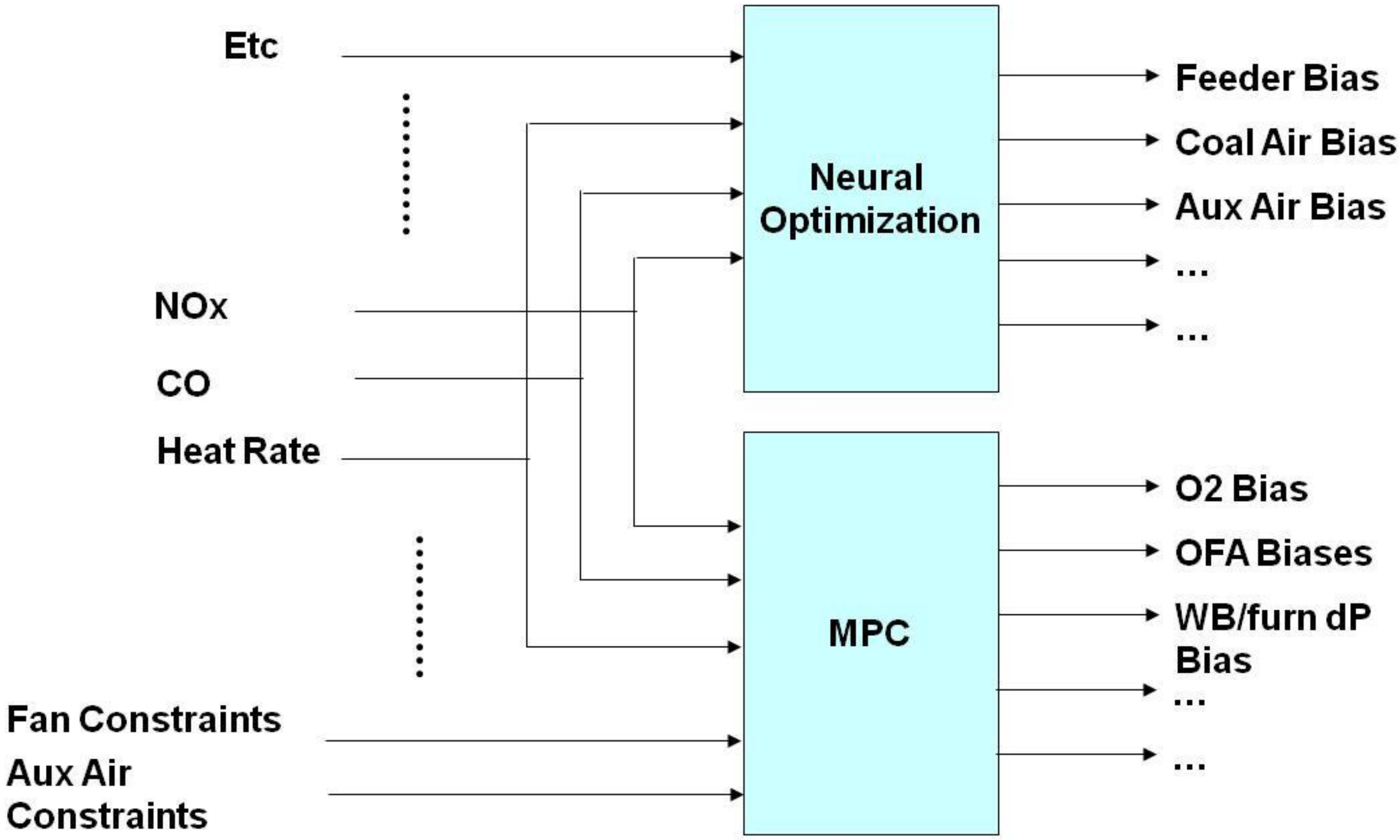
Combining Neural with MPC



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Typical CombustionOpt Benefits

- NOx reductions of 10-15%
- Boiler efficiency increase of 0.5-0.75%
- CO controlled to desired limit
- Better ramping and load-following performance
- Reduced opacity excursions
- Avoided tail-chasing behavior
- Better adherence to fan and mill amp limits
- Improved situational awareness and process insight

CombustionOpt at DTE Belle River

- B&W opposed wall-fired, balanced draft boiler built in 1984
- Normal full load of 645 gross MW, Max load with over-fire of 685 gross MW (turbine limited)
- Designed for and burns 100% PRB (Decker, Spring Creek, Wyoming)
- Pulverized coal from 8 B&W MPS-89 pulverizers, 7 operate during normal operation
- 5 burners per mill, 40 total
- Originally 4 burner levels per wall, burners replaced with LNB and redistributed into 3 levels
- Top level of burners replaced with OFA ports (1/3 and 2/3 control dampers in each port)
- 6 single-point extractive type O_2 probes at economizer exit

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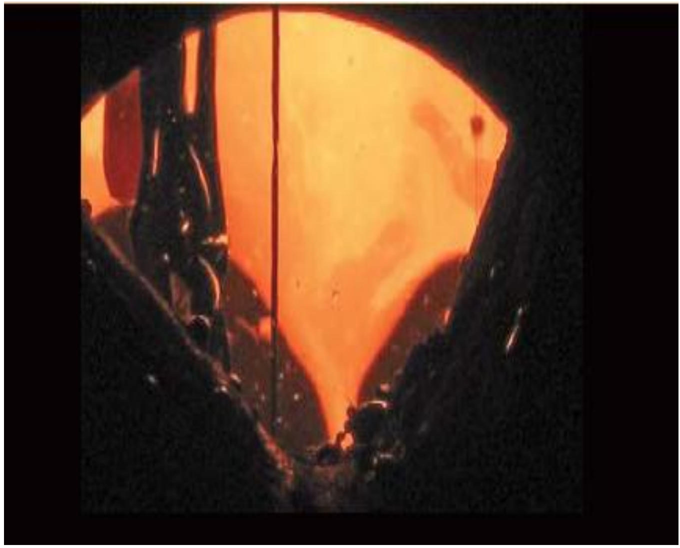
Unit 2 Performance Test Results

				Manual Tuning		Neuco Tuning	
	Baseline Heat Rate Test 07/27/10	Manual Tuning Heat Rate Test 07/28/10	Neuco Tuning Heat Rate Test 07/30/10	Manual Tuning Change (Absolute)	Manual Tuning Change (Relative, %)	Neuco Tuning Change (Absolute)	Neuco Tuning Change (Relative, %)
Gross Load, MW	647.954	647.948	645.058	-0.006	0.00%	-2.896	-0.45%
Net Load, MW	606.641	608.604	607.743	1.964	0.32%	1.102	0.18%
Auxiliary Power, MW	41.313	39.343	37.315	**-1.970**	**-4.77%**	**-3.998**	**-9.68%**
Raw Net Unit Heat Rate (Heatloss), BTU/kWhr	10517	10402	10331	-115	-1.10%	-186.0	-1.77%
Corrected Net Unit Heat Rate (Heatloss), BTU/kWhr	10393	10286	10224	**-108**	**-1.0%**	**-169.184**	**-1.63%**
Net Unit Heat Rate (Input/Output), BTU/kWhr	10493	10362	Not Avail.	-131	-1.25%	Not Avail.	Not Avail.
Corrected Net Unit Heat Rate (Input/Output), BTU/kWhr	10458	10358	Not Avail.	-100	-0.96%	Not Avail.	Not Avail.
NOx, lb/MBTU	0.2513	0.2025	0.2010	**-0.0488**	**-19.43%**	**-0.050**	**-20.02%**
CO, PPM	88	78	157	-10	-11.18%	68.200	77.18%
CO2 Intensity, Tons CO2/MWhr	1.069	1.047	1.043	**-0.02**	**-2.06%**	**-0.03**	**-2.43%**
Total Boiler Air Flow, klb/hr	6313	5926	5483	-387	-6.13%	-830	-13.14%
Average Excess O2, %	4.39%	3.23%	2.45%	-1.15%	-26.31%	-0.019	-44.18%
Excess Air, %	30.50%	20.75%	15.12%	**9.75%**	**-31.97%**	**-15.38%**	**-50.43%**

Comprehensive Boiler Optimization

- Interrelated boiler variables must be continually managed
  - Combustion quality, fuel & air mixing, gas & steam temps, fouling, tube erosion, & emissions
  - Fluctuating constraints & changing objectives add complexity
- Independently optimizing combustion & sootblowing delivers value, but leaves benefits on the table



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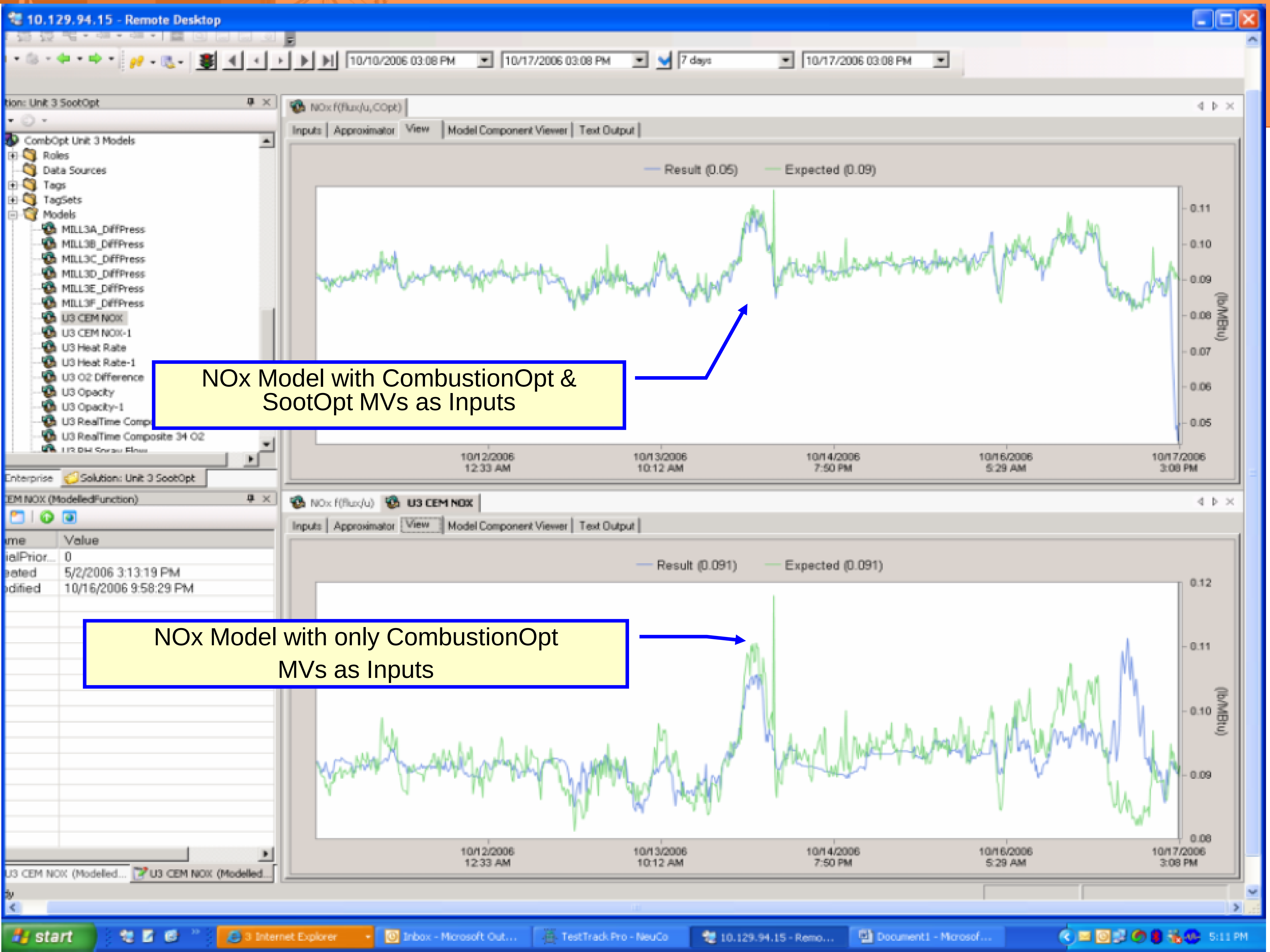
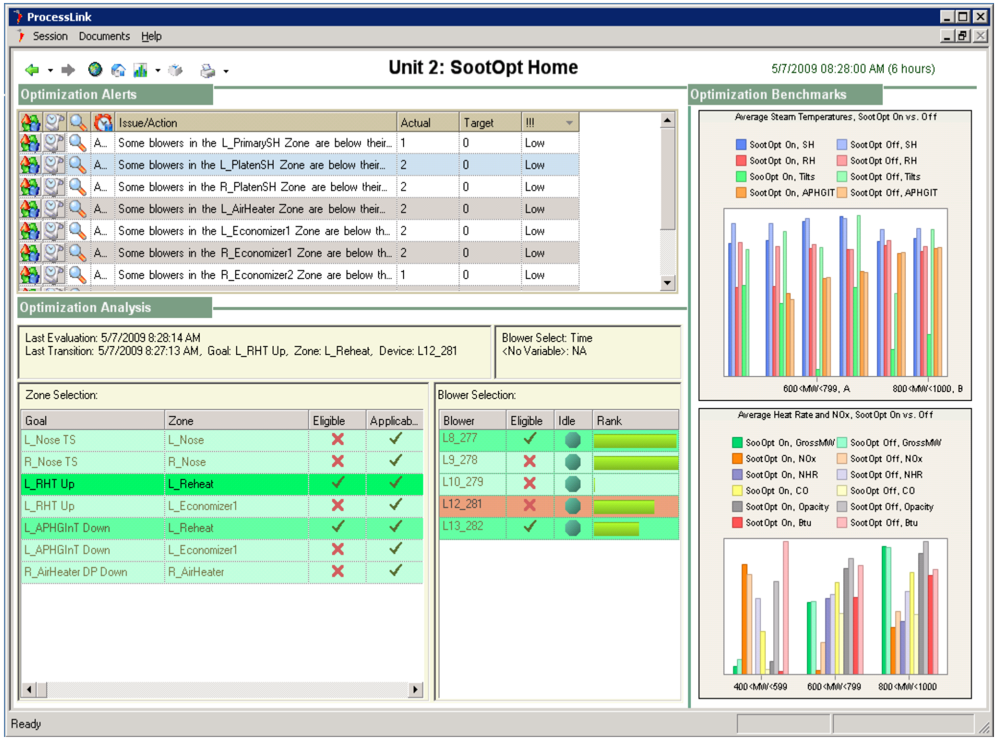

10.129.94.15 - Remote Desktop
10/10/2006 03:08 PM
10/17/2006 03:08 PM
7 days
10/17/2006 03:08 PM
NOx f(flux/u,COpt)
Inputs
Approximator
View
Model Component Viewer
Text Output
Result (0.05)
Expected (0.09)
(lb/MBtu)
NOx Model with CombustionOpt & SootOpt MVs as Inputs
CombOpt Unit 3 Models
Roles
Data Sources
Tags
TagSets
Models
MILL3A_DiffPress
MILL3B_DiffPress
MILL3C_DiffPress
MILL3D_DiffPress
MILL3E_DiffPress
MILL3F_DiffPress
U3 CEM NOX
U3 CEM NOX-1
U3 Heat Rate
U3 Heat Rate-1
U3 O2 Difference
U3 Opacity
U3 Opacity-1
U3 RealTime Composite 34 O2
Solution: Unit 3 SootOpt
NOx f(flux/u)
U3 CEM NOX
Result (0.091)
Expected (0.091)
Value
5/2/2006 3:13:19 PM
10/16/2006 9:58:29 PM
NOx Model with only CombustionOpt MVs as Inputs
10/12/2006 12:33 AM
10/13/2006 10:12 AM
10/14/2006 7:50 PM
10/16/2006 5:29 AM
10/17/2006 3:08 PM
start
5:11 PM

SootOpt ®

- Provides real-time closed-loop optimization of soot cleaning equipment
- Using:
  - Expert Rules
  - Neural Networks
- To Improve:
  - Sootblowing consistency
  - Unnecessary sootblowing
  - Steam temps
  - Sprays
  - Leverage on heat rate



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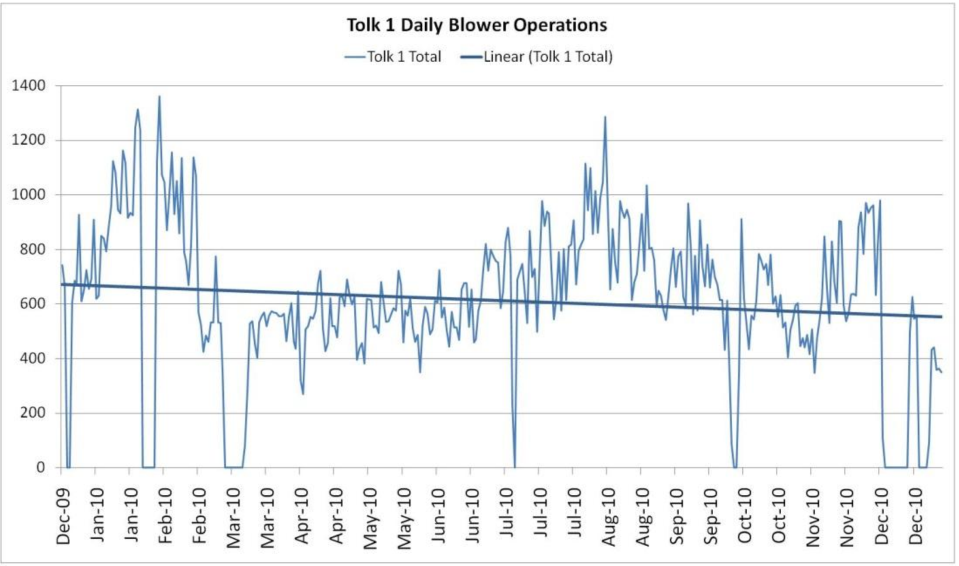
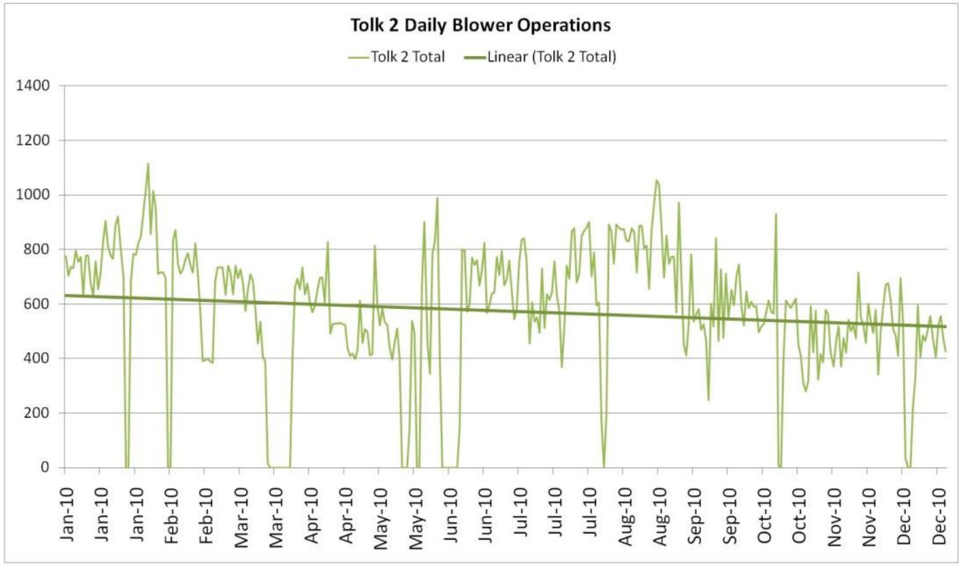
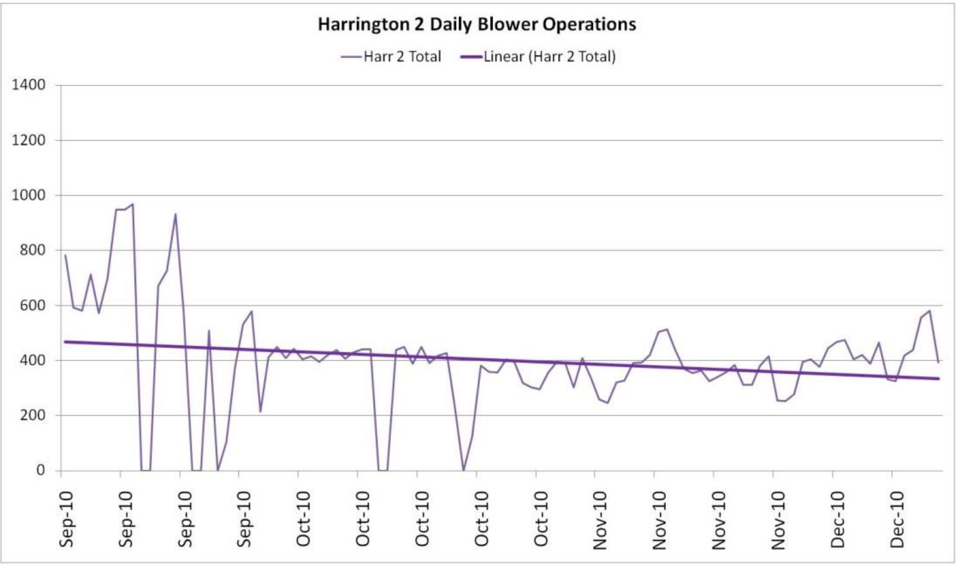
Typical SootOpt Benefits

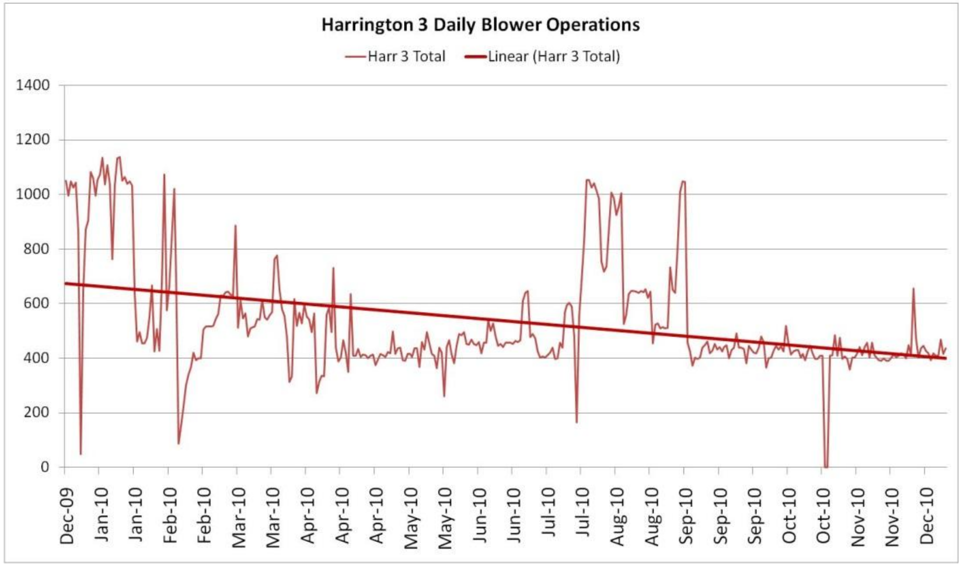
- Reduced and more tightly controlled APH inlet temps
- Improved SH and RH steam temperature control
- Reduced attemperation sprays
- Heat rate reduction of 0.75-1.00%
- Incremental NOx reduction of 2.5-5%
- Avoided opacity excursions
- Reduced blowing of 10-35%
- Avoided thermal stress from blowing clean surfaces
- Fewer tube-leak failures
- Improved situation awareness and process insight

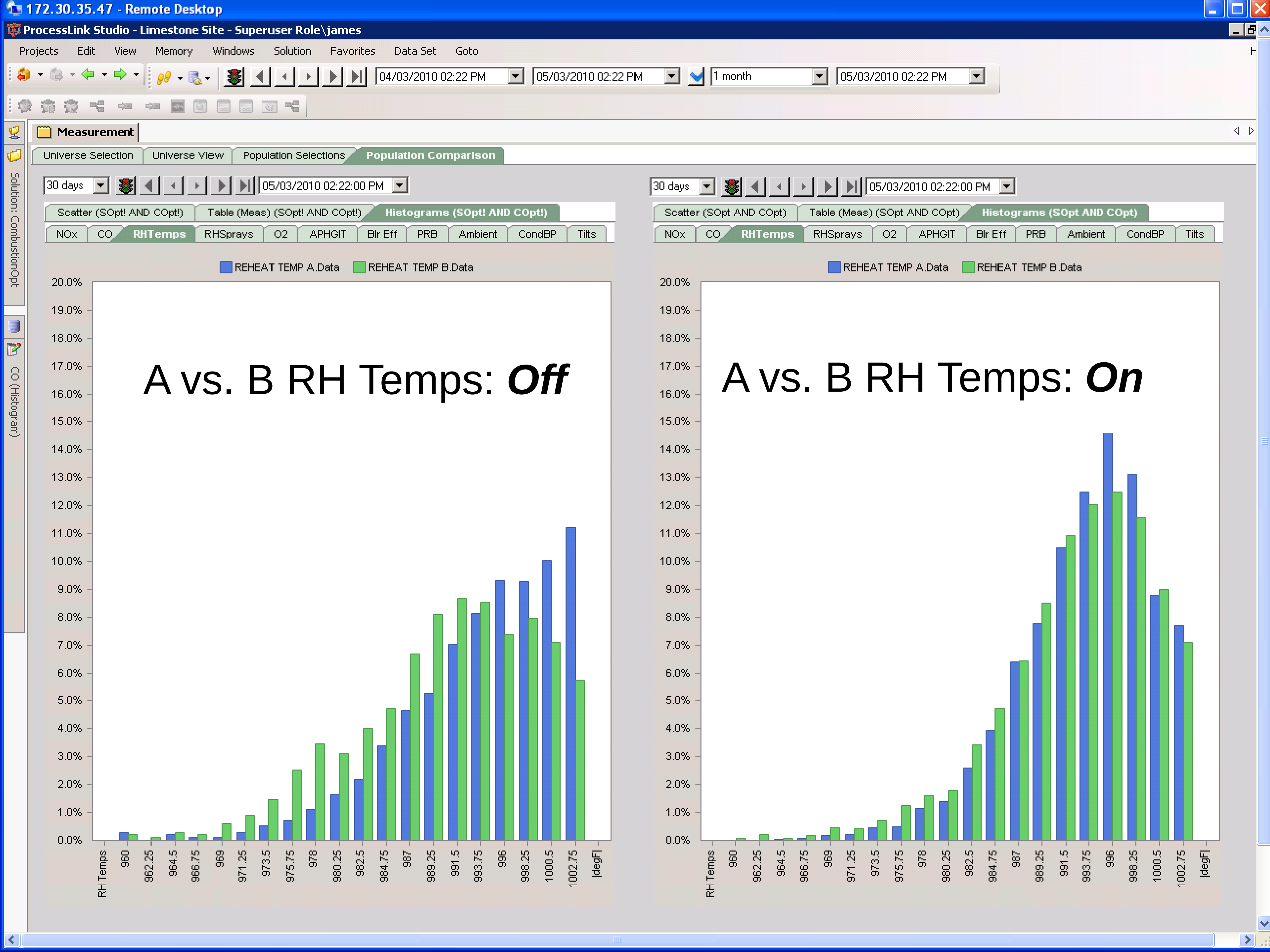
Blower Count Trends











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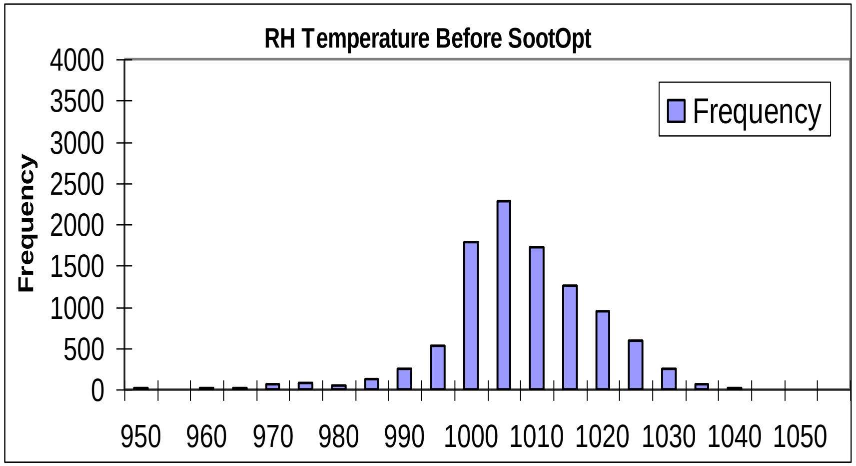
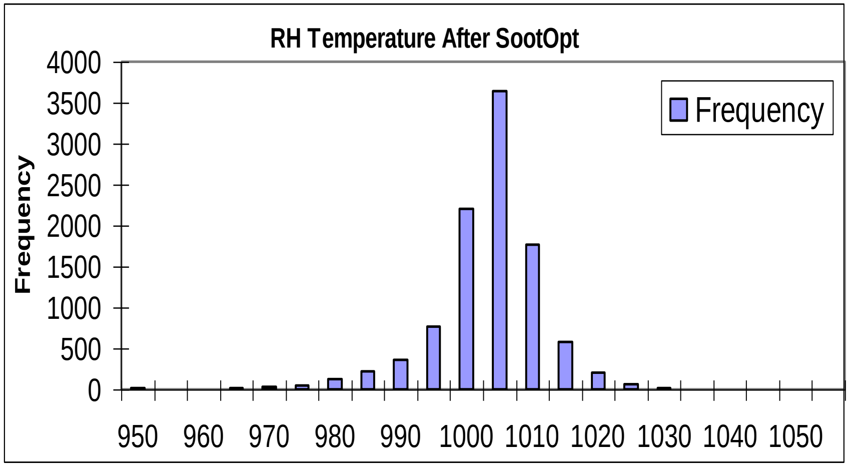
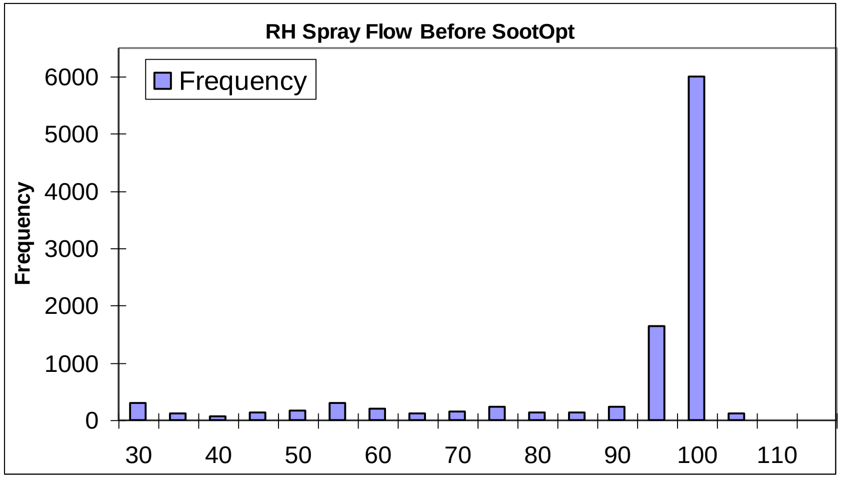
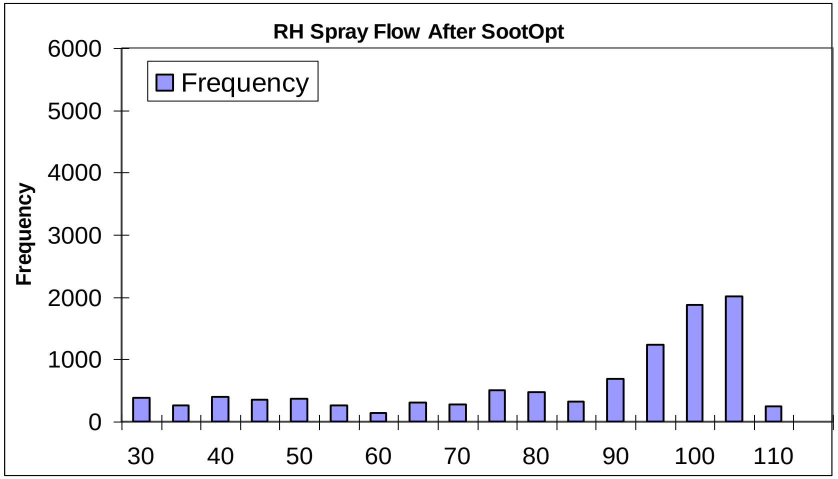
ProcessLink Studio - Limestone Site - Superuser Role\james
Projects
Edit
View
Memory
Windows
Solution
Favorites
Data Set
Goto
04/03/2010 02:22 PM
05/03/2010 02:22 PM
1 month
05/03/2010 02:22 PM
Measurement
Solution: CombustionOpt
CO (Histogram)
Universe Selection
Universe View
Population Selections
Population Comparison
30 days
05/03/2010 02:22:00 PM
Scatter (SOpt! AND COpt!)
Table (Meas) (SOpt! AND COpt!)
Histograms (SOpt! AND COpt!)
NOx
CO
RHTemps
RHSprays
O2
APHGIT
Blr Eff
PRB
Ambient
CondBP
Tilts
REHEAT TEMP A.Data
REHEAT TEMP B.Data
A vs. B RH Temps: ***Off***
Scatter (SOpt AND COpt)
Table (Meas) (SOpt AND COpt)
Histograms (SOpt AND COpt)
A vs. B RH Temps: ***On***
20.0%
19.0%
18.0%
17.0%
16.0%
15.0%
14.0%
13.0%
12.0%
11.0%
10.0%
9.0%
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
RH Temps
960
962.25
964.5
966.75
969
971.25
973.5
975.75
978
980.25
982.5
984.75
987
989.25
991.5
993.75
996
998.25
1000.5
1002.75
[degF]

RH Temps & Sprays – SootOpt Before vs. After









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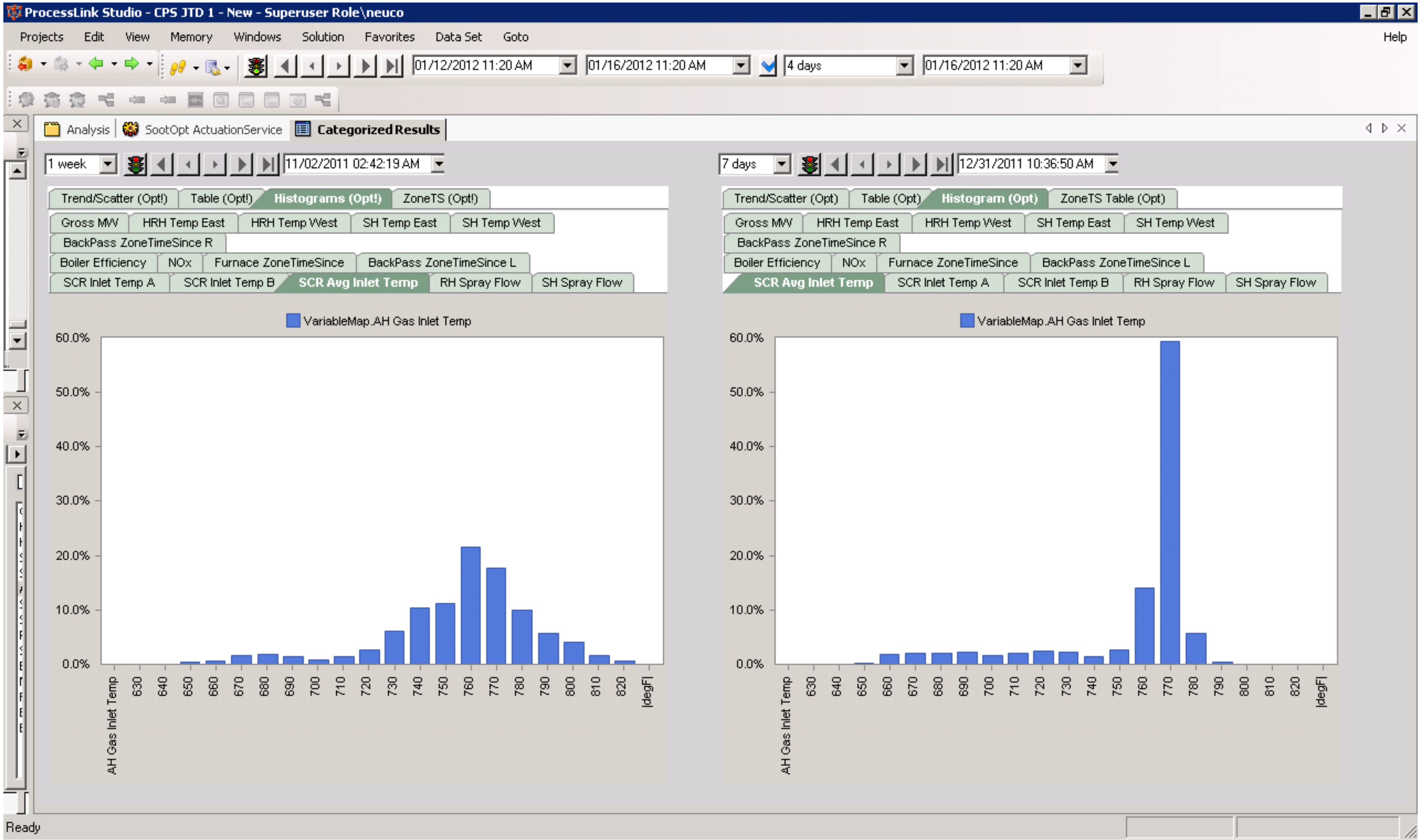
Typical Gas Inlet Temps SootOpt Off vs. On



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BoilerOpt Availability Mechanisms

- Reduced Boiler Tube Leak Outages
  - Less unnecessary cleaning (SootOpt)
  - Avoided thermal stress (SootOpt & CombustionOpt)
- Avoided Slagging/Fouling De-Rates & Outages
  - Pro-active cleaning for vulnerable surfaces (SootOpt)
  - Improved stoichiometry control (CombustionOpt)
  - Tighter control of gas path temperatures (SootOpt & CombustionOpt)
  - Reduced ammonium bi-sulfate air heater pluggage (SootOpt & CombustionOpt)
- Improved Situational Awareness
  - Overtaxed mills and fans (CombustionOpt)
  - Malfunctioning sootblowers (SootOpt)
  - Insufficient media (SootOpt)

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BoilerOpt Efficiency Mechanisms

- Boiler Efficiency
  - Reduced O2 (CombustionOpt)
  - More balanced fuel and air distribution (CombustionOpt)
  - Improved heat transfer (SootOpt)
  - Better gas temperature control (SootOpt)
    - APH gas inlet temps
    - Economizer inlet and exit temps
    - Furnace exit gas temperature (FEGT)
- Additional Heat Rate Components
  - Better superheat steam temperature control (SootOpt)
  - Better reheat steam temperature control (SootOpt)
  - Reduced attemperation sprays (SootOpt)

BoilerOpt Emissions Mechanisms

- NOx
  - More balanced fuel-air distribution (CombustionOpt)
  - Reduced overall O2 (CombustionOpt)
  - More balanced temperature profile (SootOpt)
- CO
  - Explicitly controlling to desired limit (CombustionOpt)
  - Fewer pockets of oxygen-deficient combustion (CombustionOpt)
- Opacity
  - Proactive cleaning to avoid ash accumulation (SootOpt)
  - Not cleaning specified zones when opacity trending high (SootOpt)
  - More balanced fuel-air distribution (CombustionOpt)
  - Preemptively increasing O_2 to manage excursions (CombustionOpt)
- CO_2
  - Improved boiler efficiency (CombustionOpt)
  - Tighter steam and gas temperature control (SootOpt)
  - Reduced unnecessary attemperation sprays (CombustionOpt and SootOpt)

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Questions?

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