Maximizing Operating Effectiveness with Integrated Combustion and Soot Blowing Optimization

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Agenda

- Dynegy Overview
- Motivations for Optimization
- CCPI Project Overview
- Soot Cleaning Optimization
- Looking Ahead
About Dynegy

U.S. PORTFOLIO
11,259 net MW

Midwest-Peakers
2,970 MW Gas

Midwest
3,316 MW Coal/Oil
442 MW Gas

Northeast
1,507 MW Gas/Oil
370 MW Coal
1,137 MW Gas
49 MW Hydro

Southeast
815 MW Gas

Texas
610 MW Gas

West
43 MW Gas

NEPOOL

WECC

SPP

ERCOT

FROG

MAIN

SERC
Dynegy’s Baldwin Energy Complex

3 - 600 MW Units
1970-1975

Units 1 & 2 Cyclone Fired
14 Cyclones/Unit

Unit 3 T-Fired
6 Mills

PRB Coal
Conversions
1999 & 2000
Motivations for Optimization

◆ Full Load PRB operation requires tight control
  - Loss of spare fuel delivery capacity
  - Small process changes have significant effects
  - Seasonal impacts to heat rate

◆ Expectations
  - Ability to control key parameters on consistent basis
  - Ability to compensate for changes in coal quality
  - Improved understanding of available data and its use for improved operations
  - Ability to optimize controls to meet plant objectives.
NeuCo’s CCPI Project @ Baldwin

- **About the Clean Coal Power Initiative (CCPI)**
  - $1.3 B initiative to demonstrate clean coal technologies in the field
  - Sponsored by DOE’s National Energy Technology Laboratory
  - NeuCo’s project at Baldwin selected as Round 1 winner in 2004

- **Five integrated optimization modules, parallel development**
  - SCR
  - Combustion
  - **Soot blowing**
  - Performance
  - Maintenance

- **Products developed iteratively with multiple releases**
Why Optimize Soot Cleaning?

- Cleaning actions (or lack thereof) affect many plant parameters:
  - Slagging/fouling impacts heat transferability
  - Capacity: Steam and gas temperatures, spray flows, differential pressures, fan limits
  - Performance: Boiler efficiency, heat rate
  - Emissions: NOx, Opacity, LOI, CO
  - Availability/Reliability: Waterwall/tube longevity, EFOR, equipment wear-and-tear

- Operational complexities:
  - Fuel and equipment variations
  - SCR/SNCR systems
  - LOI control objectives

- Bottom line economic impact - $$$$
SootOpt, because of its neural model, can operate in this narrower range.
What SootOpt Does

- Optimizes boiler cleaning based on unit-specific objectives:
  - Improves emissions control (NOx, opacity, CO)
  - Improves Heat Rate including Reheat & Superheat steam temperature control
  - Balances tradeoffs between furnace/backpass absorption
  - Reduces O&M costs by avoiding unnecessary boiler cleaning actions and reducing tube wear and thermal stressing
  - Compensates for off-design fuels and operations
  - Leverages existing soot cleaning instrumentation, models, equipment and control systems
How SootOpt Works

Hybrid Expert Adaptive System

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<th>SH &lt; 990</th>
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Soot Blowing Control PLC

Hybrid Expert Adaptive System

Boiler State
CF-SHDiv
CF-SHFin
CF-SHPrim
CF-RH

Flux 1-16
Freq IR-1
Freq IR-2

NOx

DYNEGY
SootOpt at Baldwin Unit 3

- 630 MW, Base-Loaded, T-Fired
- SOFA, Low NOx Burners
- High variability in PRB coal
- Heat Flux Sensors and Water Cannons
- Diamond SentrySeries 1500 control system with locally intelligent controls
- PrecisionClean and standard IK’s in convection pass
- Also thermocouples and FEGT
- Prevailing sootblowing guidelines:
  - ISB preset flux targets in the furnace, operators intervene
  - Operator initiated in the convection pass
SootOpt - Diamond SentrySeries 1500 Interface

(ACE) Adaptive Cleaning Expert
- ACE Module generates Cleanliness Setpoints

(SCE) Soot Cleaning Expert
- SCE provides Clean/Dirty, CF, Bypass*

(FCM) Furnace Cleanliness Module
- FCM provides Clean/Dirty, Hflx, Bkstop

Convection
- (AIM) Automatic Interface Module

Furnace
- AIM provides Seq #

Region and Zone Permissives
- Note: Pausing an active sequence or zone does not prevent others from being serviced

Adaptive Sootblower Prioritization (Conv Region Only)
- (SIM) Sootblower Interface Module

SB PLC

WC PLC

Clean/Dirty Threshold (SCE)
- Sequence Triggered

Bypass* Limit Sequence stopped or removed from queue

Region and Zone Permissives

SootOpt F1

SootOpt F2
### SootOpt Sensitivities: Net HR

- **Net HR**

SootOpt Causality Profile: RH Attemperation Sprays
Unit 3: SootOpt Analysis

- Net Unit Heat Rate
- SootOpt Master En: Yes
- Conv Perm All: Yes
- Conv Auto: Yes
- Conv Pause: No
- Furn Auto: Yes
- Cannon 12 Pause: No
- Cannon 34 Pause: No

Sequence Operations
IK Operations
Convection Details
Furnace Details

Operations (24hr)
- Min Required Operations (24hr)
- Manual Operations (24hr)
- Auto Operations (24hr)
- Avg Operations (7 day)
Unit 3: SootOpt Analysis

Modelled Function: Heat Rate [MW/h]

Inputs: Flux/Slag
SootOpt at Baldwin: Results Thus Far

- Operating and Producing Results on Unit 3
  - Initially operated only on Water Cannons for furnace cleaning
  - Now operating on furnace and all convection pass regions
  - Now being integrated with CombustionOpt

- Being installed on Unit 2 now
  - Unique opportunity to quantify contributions of individual ISB control and instrumentation components
Heat Rate vs Wet Bulb over Time
Heat Rate vs Cond Press over Time
NOx Model with CombustionOpt & SootOpt MVs as Inputs

NOx Model with only CombustionOpt MVs as Inputs

Integration Improves Model Accuracy
Integration Increases Benefits

SootOpt MVs added to CombustionOpt NOx Model
**SootOpt – Summary**

- SootOpt improves control of heat-transfer process
- Relates impacts to global objectives. Searches for global optimum across multiple sometimes competing objectives
- SootOpt performance can be changed by changing relative priority of objectives, e.g., Steam Temperature Max vs. Heat Rate, or all can be given equal priority
- Lets user assess where priority should be given based on bottom line impact.
- The highly inter-related processes of combustion and boiler cleaning confirms the need for integration to achieve maximum benefits
Looking Ahead

- Complete Integration of CombustionOpt and SootOpt and at Unit 3
- Complete installation of SootOpt on Unit 2
- Integrate CombustionOpt, SCR-Opt, SootOpt, PerformanceOpt and MaintenanceOpt at Unit 2
- Further refine CombustionOpt, PerformanceOpt & MaintenanceOpt at Unit 1
- Further refine Unit and Plant Advisors
- Subsequent refinement and releases based on feedback from Baldwin and other NeuCo Showcase sites