Benefits of Advance Process Control Solutions

2015 ARIPPA Tech Convention
Harrisburg, PA

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## Outline

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The Current State

• Typical stats on Industrial boiler control systems
  – Typically, 10 – 35% of loops are in manual
  – 85% have incorrect tuning parameters
  – Operators “truck drive” the boiler

• The reasons are simple
  – Process related
  – Equipment related
  – Operator preference
What does an APC project look like? And why it matters?

- **Step 1 - Automating the control loops**
  - Review the major control loops
  - Identify loops in manual
  - Modify loops followed by tuning to ensure automatic control

- **Step 2 – Implementing Advanced Process Control (APC)**
  - Identify loops with non-linear processes, variable dead times, critical constraints
  - Implement fuzzy logic or model predictive control based APC’s
  - APC’s provide setpoints to base loops or directly write to final control elements

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Savings as a percentage of operating costs

Brisk M.L, Process Control: Potential Benefits and Wasted Opportunities
How does it help?

Seeking optimum O2 setpoint and air distribution for continuously changing fuel quality – minimum emissions with maximum efficiency
Examples of real cases from around the world

- Improvements in unit heat rate (thermal efficiency up by 1-2%)
- Reduction in emissions (CO 67% ↓, NO\textsubscript{x} 30% ↓)
- Reduction in reagent use such as limestone and ammonia (13% ↓)
- Increased steam output and generation
- Improved steam temperature and pressure control
- Operational uniformity across shifts
Automating base controls & enhancing where possible

- The base controls underpin the advanced controls
- Better tuned base controls ensure that the unit runs closer to the optimum
Real time fuel quality compensation

Fuel quality disturbance

Boiler O2

Boiler pressure

Stable pressure, no oscillation

Boiler fuel control

BTU Compensators should include the $O_2$ consumption
Fuel Quality Compensation input variables

- Steam Flow
- Steam Pressure
- Steam Temperature
- Feed Water Temp.
- Oil/Gas Flow
- Air Flow
- Flue Gas Flow
- Flue Gas O2
- Solid Fuel Flow

Fuel energy content

- Boiler balance
- Oxygen consumption

Steam pressure control

Fuel feed control

Max

Fuel flow

To air controls

Fuel power demand
Fuel Quality Compensation

- Coal increased manually in 15% steps. Fuel control is automatically responding to increased heat release by driving the biomass downward to maintain constant energy out.
Advance Process Control – The Technology

Model Predictive Control (MPC) → Steam networks

Fuzzy Control → Circulating fluidized bed boilers
Bubbling fluidized bed boilers

MPC + Fuzzy Control → Pulverized coal fired boilers
Grate fired boilers
APC Structure

**Outputs**
- fuel/air setpoints
- prim./sec. air setpoints
- lower/upper sec. air
- O\textsubscript{2} controller setpoint
- fuel distribution
- Limestone/ammonia feeder setpoint

**Calculated variables**
- fuel heating value
- oxygen consumption
- flue gas flow
- emissions mg/MJ

**Process Constraints**

**APC controller**
- Control
- Compensation
- Filtering

**Process Measurements**
Case 1 - Kuopio HP3

O₂ Distribution

Boiler design point

O₂ %
How does this make a difference?

- Fluegas O2 is very stable
- APC system drops $O_2 \sim 0.5\%$ below boiler OEM design point
- Efficiency increase +0.2%
- Less thermal $NO_x$ formation
- Less fluegas volume through the unit
Case 2 - Stora Enso (Kaukopää)

Fluegas O2 %

- Before Optimization
- After Optimization
Case 2 - Stora Enso (Kaukopää)

Back pressure 8 Mpa Setpoint

Before Optimization

After Optimization
Case 3 - Stora Enso (Veitsiluoto)

CO emissions before and after

Before Optimization

After Optimization

mg/Nm3
Case 3 - Stora Enso (Veitsiluoto)

Boiler steam load before and after

Before Optimization

After Optimization

kg/s

34.6  34.8  35  35.2  35.4  35.6
Case 4 GREC - Unit load profile

- Unit load is dispatched at 3%/min
- Time span is 24 hrs
- Combustion controls run in automatic
- Valmet advanced controls have no trouble keeping up with load demand
Bed Temperature Control

APC controlled
Average bed temp = 1530 F (830 C)
Std deviation = 5.5 F (3 C)
Excess Air Control

APC controlled average $O_2$ (2.4%)

Boiler design $O_2$ setpoint (2.8%)
CO Emissions Control

CO limit 0.12 lbs/mmbtu

APC controlled average CO = 0.37 lbs/mmbtu
NOx Emission Control

APC controlled average NOx = 0.049 lbs/mmbtu

NOx limit = 0.07 lbs/mmbtu

NOx emissions in lbs/mmbtu

Frequency
The take home message

- Process control with APC packages are going to be the new norm

- MPC & Fuzzy based controller technology are well established

- Projects typically pay for itself in less than a year but...

- Do your homework!

- No one size fits all solution

- And finally, optimization is a continuous process