Optimization Services, Tools and Advanced Process Control
Outline

- Optimization Services and Tools
  - Loop Performance
  - Batch Optimization
  - Boiler Fuel Savings

- Sustaining Performance
  - ServicePort

- Advanced Process Control
  - Predict & Control
  - APC Applications
  - New Technology Developments
Optimization Service Methodology

Goal: Measure and Reduce Performance Gap, Extend system life, Operate at the mechanical system constraints
ABB Fingerprint finds gaps, develops customer ROI

Data Collection/Testing
- 12 to 24 hours at 5-second data
- Controller parameters
- Customer interview: process area and loop criticality definitions.

Performance Evaluation
- Standard Methodology
- Analysis Expertise
- Performance Visualization

Report
- Gap Analysis
- ROI Forecast
- Action Plan

Action

Interpret

Analyze

View

Get

Problem

People
- Process
- Tools

OPC Collection Tools

Benchmark

Findings

Plan

ABB Process Fingerprint Report

ABB Fingerprint Findings Plan

ROI

© ABB Group
October 29, 2013 | Slide 4
ABB Advanced Services: Fingerprints are packaged diagnostic services

- Common Industrial Services:
  - Boiler
  - Alarm
  - Loop Performance
  - Control System
  - Transition Analysis
  - Batch Analysis
  - Tuning
CCH-101-1  11:00 Tuesday, room 351C
Doug Reeder, Ted Matsko
Loop Performance Fingerprint for a DuPont Monomers Plant
LoopAnalyzer Tool: Control Loop Diagnoses

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>PROCESS</th>
<th>SIGNAL CONDITIONING</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1: Manual</td>
<td>P1: FCE Out of Range</td>
<td>S1: Quantized</td>
</tr>
<tr>
<td>C2: Oscillating Setpoint</td>
<td>P2: FCE Size</td>
<td>S2: Excessive Noise</td>
</tr>
<tr>
<td>C3: Error Deadband</td>
<td>P3: FCE Problem</td>
<td>S3: Spikes</td>
</tr>
<tr>
<td>C4: Offset</td>
<td>P4: FCE Leakage</td>
<td>S4: Step Out</td>
</tr>
<tr>
<td>C5: Over Control</td>
<td>P5: Intermittent Disturbance</td>
<td>S5: Data Compression</td>
</tr>
<tr>
<td>C6: Slow Control</td>
<td>P6: Persistent Disturbance</td>
<td>S6: Over Filtered</td>
</tr>
<tr>
<td>C7: FCE Travel</td>
<td>P7: Questionable</td>
<td>S7: Sampling Rate</td>
</tr>
<tr>
<td>C8: Slow Update Rate</td>
<td></td>
<td>S8: No Signal</td>
</tr>
<tr>
<td>C9: Questionable Control</td>
<td></td>
<td>S9: MV Out of Range</td>
</tr>
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</table>

FCE = Final Control Element
Loop Fingerprint

Oscillating Loops

- When a loop oscillates in automatic mode and there is not evidence of an external disturbance, over tuning is a possible cause.
- Power spectrum shows two frequencies of interest
- This loop is in the TFE Synthesis area
Loop Fingerprint
Final Control Element Problem

- This is a flow controller that is the inner loop of a cascade.
- Exhibits classic stiction
- Controller output ramps up and down in triangular pattern
- Process variable moves in square wave
The report highlights some loops, as shown in the previous slides and summarizes the results in tables. This table is for the TFE Synthesis section of the plant.

<table>
<thead>
<tr>
<th>F22 and Primary Columns</th>
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<tbody>
<tr>
<td>Loop Performance</td>
<td>Oscillating Error</td>
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<td>-----------------------------</td>
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<tr>
<td>1</td>
<td>0378FC</td>
</tr>
<tr>
<td>2</td>
<td>8098TC</td>
</tr>
<tr>
<td>3</td>
<td>8964PC</td>
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<td>4</td>
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<td>8146FC</td>
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<td>7</td>
<td>8177PC</td>
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<td>8</td>
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<td>9</td>
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<td>8156PC</td>
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<td>16</td>
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<td>17</td>
<td>8153TC</td>
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<td>25</td>
<td>8116FC1</td>
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<tr>
<td>26</td>
<td>8144LC</td>
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</table>
Disturbances in chemical plants act on many process variables.

Disturbances can propagate counter flow because of recycle and thermal integration.
Loop Fingerprint
PCA Cluster Example

- Find signals with similar patterns, probably due to disturbances
- Not looking for oscillating signals
- Here all signals are in two columns that are adjacent

<table>
<thead>
<tr>
<th>PCACluster13</th>
<th>Tag name</th>
<th>Area</th>
<th>Tag description</th>
<th>Causality</th>
<th>Deadtime</th>
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<tr>
<td>8342FC</td>
<td>BARDE-DRC</td>
<td>DRC REBOILER STEAM FLOW CTRL</td>
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<td>2</td>
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<tr>
<td>8322FC</td>
<td>BARDE-DRC</td>
<td>DRC FEED FLOW CTRL</td>
<td>2</td>
<td>1</td>
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<tr>
<td>8252FC</td>
<td>BARDE-HCL</td>
<td>HCL COL DIST FL CTRL</td>
<td>3</td>
<td>3</td>
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<tr>
<td>8273FC</td>
<td>BARDE-HCL</td>
<td>HCL COL REBOIL STEAM FL CTRL</td>
<td>4</td>
<td>5</td>
<td></td>
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<tr>
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<td>BARDE-HCL</td>
<td>DIMER TO HCL COL FEED CTRL</td>
<td>5</td>
<td>4</td>
<td></td>
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<tr>
<td>8304FC</td>
<td>BARDE-HCL</td>
<td>HCL COL REFLUX CTRL</td>
<td>6</td>
<td>6</td>
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</tr>
</tbody>
</table>
Loop Optimization implements improvements

**Goal:** Improve current performance level

- Scope based on Diagnose phase
- Focused, scheduled activities
- Proven practices
- ABB-managed improvement program

**Solution categories:**
- Hardware
- Operations
- Tuning
- Application
- Process

Proactive and collaborative
Workbench: Implementation improvements

Tool Workbench

- Visualization and Setup
- Analysis
- Identification
- Collection
- Tuning and Simulation
- Standard Reporting
C549I
11:15 Wednesday, April 25, 2012 (room 371D)
Batch Process Optimization
BASF Polymerization Reactor
BASF Batch Reactor Optimization
Polyester – Key Equipment in “I” Reactor System

- 5,000 gallon reactor with Therminol-66 heating system
- Fractionator column
- Condenser and Decanter for water collection
BASF Batch Reactor Optimization
Temperature Control Loop Performance

- Looking at standard data, the oscillations are difficult to see because of the wide range of operation and different starting times.
- Define steps (events)
- View by event
Process Economics is tied to two things

- **Quality Control**
  - Decrease cost, i.e. lower energy
  - Increase yield at same quality
  - Reduce offspec losses
  - Value increases with quality

- **Production Rate**
  - Hold fixed costs constant
  - Increase production rate, revenue
  - For a batch process, production rate means cycle time

- For this polyester product, Step 4 dominates
BASF Batch Reactor Optimization
Process Economics - Quality Control and Production Rate

- Quality variance is very low for this product
  - Batch held until all specs met → increase time
  - Lab tests repeated, manual adjustments

- This plant is Production Rate limited on this product
  - Long cycle time
  - 5 day x 24 hr work week
  - 120 hrs working time
  - 60 hrs = 2; 40 hrs = 3 batches

- Opportunity
  - Reduce variance of step times
BASF Batch Reactor Optimization
Reducing Batch Cycle Times

- This plot confirms conclusion about vacuum and batch cycle time
- Real data is not always pretty (scatter)
  - Due to lab measurement, operator manual operations, unknown contaminants

Conclusion:
Investigate cost to improve vacuum
Achieved cycle time improvements

Step4 Elapsed Time (Vacuum)
CSE-102-1: Boiler Fingerprint
Success Story: How Arkema Saved $300,000 per year on Energy

Dwight Stoffel, Bob Horton
ABB Optimization Services

ABB Automation & Power World
Boiler Fingerprint : Value

- Energy Savings
- More Responsive to Process Steam Demands
- Extended Operating Range
- More Reliable
- Improved Safety
- Reduced Carbon Footprint
FD Fan Control – Combustion Air

Raw Data

Sample Number, Ts = 5, Total Samples = 10801

Positioner and Dampers = Suspect
Boiler Hardware Issues

- Positioner drives not operating smoothly.
- Cylinder/Piston assemblies should be rebuilt or replaced.
- Motors are oversized.
Hysteresis – Air and Fuel

Hysteresis in Fuel and Air Controls
14-May-08 PM Data Set


Updated Air Curves

**Gas Fuel for Air Curve**

- **Steam Flow (KLB/Hr):** 10, 15, 20, 25, 30, 35, 40, 45, 50
- **Demand for Air Flow:** 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

**Oil Fuel for Oil Curve**

- **Steam Flow:** 10, 15, 20, 25, 30, 35, 40, 45, 50
- **Demand for Air Flow:** 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

**Steam to Trim O2 Curve**

- **Steam Flow:** 10, 20, 30, 40, 50
- **O2 Setpoint:** 2, 3, 4, 5, 6, 7, 8, 9, 10

- **Air (Original)**
- **Air (new)**
- **O2 Trim (Original)**
- **O2 Trim (New)**
Boiler #2: Customer results
Financial Impact – Boiler #2

Boiler #2 rated at 40 klb steam/hr

Savings range of 2% to 3% achieved without major capital

Approximate value = $75K to $100K for Boiler No. 2 alone

Savings for all four boilers = $300,000
Loop Optimization helps sustain customer results

Goal: Maintain improved performance level

- Adjust maintenance operating procedures
- Adjust standard operating procedures
- Remote process monitoring

- Specifics are a function of the Implement phase
- Periodic monitoring of key process indices utilizing local or remote expertise

Proactive and collaborative
ABB ServicePort™
Secure, remote delivery for Scan and Track

- Secure portal residing at customer site through which plant personnel and ABB experts can access:
  - Configuration tools
  - Diagnostic applications
  - Improvement activities
  - Performance-sustaining troubleshooting
  - Scanning software that deploys agreed actions.

- ABB can connect to any system through ServicePort and implement fixes to diagnosed problems.
ServicePort + Channels

- ServicePort Base Unit
- Process Channels
  - Control Loop
  - Quality Control System
  - Mine Hoist
- Equipment Channels
  - Harmony
  - 800xA
  - Cyber Security
- Remote Access Platform
Outline

- Optimization Services and Tools
  - Loop Performance
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  - Boiler Fuel Savings

- Sustaining Performance
  - ServicePort

- Advanced Process Control
  - Predict & Control
  - APC Applications
  - New Technology Developments
ABB’s Predict and Control APC Solution

Features

- True Multivariable Control
- State Space, Model Predictive Control (MPC) Structure
- Subspace and Prediction Error model identification methods
- Constraints (MVs and CVs): prioritize up to 30 classes
- OPC connectivity to process data
- Inferential Modeling Platform (IMP) to infer variables or properties that are difficult to measure
Predict and Control: Engineering Tool

- Data import, analysis and trending
- Allows process model development
- Shows interaction effects among variables
- MPC simulation to simulate control and benefits

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Optimize IT Predict & Control Performance

- 3 simulation runs of the HOF problem

- 3rd example, P&C with Kalman Filter estimate for disturbances.
- Using additional PVs
- Further reduction in PV deviation.

© ABB Service
Inferential Modeling Platform Model Builder

- Data Import
- Data Analysis & Preprocessing
- Modeling functions are provided by proven, field-tested, latest generation routines
- Model development is executed through Wizards, to reduce effort for inexperienced users
- The Model Explorer facility allows off-line use of models for engineering purposes
IMP Online Features

- Quick and effective real-time implementation on different DCS through OPC
- Configurable filtering of inputs and outlier removal strategies
- Direct connection to Laboratory Information Management Systems
- Built-in functions for periodic recalibration (Bias calculation)
Predict & Control Performance
Ammonia Stripping Operation APC

- Minimizes operating cost (steam, caustic, & acid)
- Regulates pH and NH3
- Enforces environmental limits on waste stream
- 9% reduction in unit operating cost

ROI: 6 months
Predict & Control Performance
Butadiene Purification Process APC

- Reduction of steam consumption
- Reduction of solvent use
- Lower product quality variability
- Key process variables closer to setpoint targets
- Less work load for operators at all levels

ROI: 11 months
Alumina Refinery Powerhouse Optimization
Alumina Refinery Powerhouse Optimization

Results

- 80% reduction in header pressure standard deviations
- Reduction in cascaded boiler trips, reducing outage time and production losses
- Savings in energy costs alone provided ROI within 6 months
APC Example: Zellstoff Celgar
Supervisory Control Architecture

- Multi-Layered Solution

LOAD FORECASTING AND PRODUCTION PLANNING

SHORT-TERM OPTIMIZATION AND INVENTORY CONTROL

ADVANCED PROCESS CONTROL (APC)

COORDINATED HEADER CONTROL

POWER PLANT PERFORMANCE ASSESSMENT

OPTIMIZATION LAYER

ADVANCED CONTROL AND MONITORING LAYER

BASE CONTROL LAYER

ABB INFI-90 DCS

SENSORS AND ACTUATORS

© ABB Service
DMCplus 800xA Interface

- ABB Interface tags defined in 800xA to link DMCplus tags to control loop and analog tags
- 800xA library created and can be reused for different DMCplus applications
DMCplus 800xA Interface

MV Faceplate

<table>
<thead>
<tr>
<th>Tab 1</th>
<th>Tab 2</th>
<th>Tab 3</th>
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<tbody>
<tr>
<td><strong>Subcontroller</strong></td>
<td><strong>SubDmcControl</strong></td>
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<td>Active Constraint Ind</td>
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<td>Upper Engineering Limit</td>
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<tr>
<td>Lower Validity Limit</td>
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<td>0.00</td>
</tr>
</tbody>
</table>

Enable Auto Mode Switching | On | On |
Current PID Mode | Cas | Cas |
MV Mode1 | CAS | CAS |
MV Mode2 | AUTO | AUTO |
MAN | MAN | MAN |

SP Mode Entered When DMC is OFF | Previous | Remote |
| No Change | Local |

Critical Switch | NOT CRITICAL | NOT CRITICAL |
External MV Target? | No | No |
New ABB MPC Project Workflow

- **Controller design off line**
  - Perform plant testing
  - Use Model Builder to create model
  - Use closed loop simulation module to calculate initial set of tuning parameters
  - Export model and parameters

- **Controller implementation in DCS**
  - Create application in Control Builder
  - Import model and tuning parameters to service using Plant Explorer
  - On-line tuning using console faceplates
Model and Control Design Tool

- Environment for handling data import and data set manipulation
- Subspace identification and graphical methods for modelling
- Initial controller design
- Controller export for subsequent import in runtime environment
Controller Configuration

- Control Module for MPC
- Configured from Control Builder or Function Designer
- Control connections between to level 1 controllers
- Faceplates for interaction
- Mode logic
- Constraint definitions
- Options to connect signals
- Graphical connections
- Textual connections
PV and MV Faceplates
Summary

- Optimization Services
  - Fingerprint diagnostic services
  - Implementation services
  - Sustaining services with ServicePort
- Workbench Tools
- ServicePort Channels
- Advanced Process Control
Power and productivity for a better world™