Optimization Services, Tools and Advanced Process Control
Outline

- Assuring Optimal Performance
  - Fingerprint Offerings and Examples
  - Control Loop Performance
- Sustaining Performance
  - ServicePort
- Advanced Process Control
  - ABB Predict & Control MPC
  - APC Services
  - ABB MPC in 800xA
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

Report
- Gap Analysis
- ROI Forecast
- Action Plan

Performance Evaluation
- Standard Methodology
- Analysis Expertise
- Performance Visualization

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

Half life of Process Controllers

Given: a 100 PID loops all tuned at once.

Then: it is estimated that with in 6 months, 50 of these loops will have a degradation in performance.

PID Controllers are designed to:

- Regulate the process
- Reduce product instability
- Improve operations

However, ABB is finding that PID Automation:

- PID loops are not being maintained
- PID loops have degraded
- PID loops are standing in the way of production and performance.

Simple PID Utilization

- Manual Operation: 35%
- Output Out of range: 30%
- Increasing Variability: 15%
- Improving process: 25%

PID Controllers degradation over time.
## LoopAnalyzer Tool: Control Loop Diagnoses

### Control Process Signal Conditioning

<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>
</tbody>
</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.
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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<tbody>
<tr>
<td>8342FC</td>
<td>BARDE-DRC</td>
<td>DRC REBOILER STEAM FLOW CTRL</td>
<td>1</td>
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<td>8322FC</td>
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<td>DRC FEED FLOW CTRL</td>
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<td>1</td>
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<td>8262FC</td>
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<td>HCL COL DIST FL CTRL</td>
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<td>BARDE-HCL</td>
<td>HCL COL REFLUX CTRL</td>
<td>6</td>
<td>6</td>
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</table>
2. 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

1. Visualization and Setup
2. Analysis
3. Standard Reporting
4. Identification
5. Collection
6. Tuning and Simulation

Tool Workbench
ABB Automation & Power World: April 23-26, 2012

C549I
11:15 Wednesday, April 25, 2012 (room 371D)

Batch Process Optimization
BASF Polymerization Reactor
BASF Batch Reactor Optimization
Process Economics - Quality Control and Production Rate

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)
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
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.
Workbench Tools – Improve efficiency and quality of service results

Data Collection
- DL400
- AGP400

Loop Performance Fingerprint
- Loop Analyzer
- Signal Analyzer

Loop Tuning
- LoopTune

Batch and Grade Change Analysis
- Sequence Analyzer
- Loop Performance Monitoring
- ServicePort Loop Performance Channel

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ServicePort + Channels

- ServicePort Base Unit
- Process Channels
  - Control Loop
  - Quality Control System
  - Mine Hoist
- Equipment Channels
  - Harmony
  - 800xA
  - Cyber Security
- Remote Access Platform
ABB ServicePort: Access to experts, reduces costs
SCAN Performance Service Reports

- Statistical Evaluation of Historical KPI’s performed twice a year
- Ensures stability of KPI’s
- Reduces the risk of false positives
- Keep up to date with process
- Crucial to ensure continuous improvement
## Sustain: track KPIs to ensure improvement

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
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<tr>
<td><strong>Total</strong></td>
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<tr>
<td><strong>CD</strong></td>
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<tr>
<td><strong>RES</strong></td>
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<tr>
<td><strong>MDL</strong></td>
<td></td>
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</tr>
</tbody>
</table>

### Key Points:
- **Production increase!**
- **Variability decrease!**
- **Continuous Improvement**

#### KPI Tracking

- **Delivery Schedule**
- **Production increase!**
- **Variability decrease!**

### Graph Details:
- **X-axis:** Time (Jan 2002 to Oct 2009)
- **Y-axis:** Volatility
- **Lines:**
  - Total
  - RES
  - CD
  - MDL

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What’s APC?

- APC – Advanced Process Control
- ARC - Advanced Regulatory Control
- MPC – Model Predictive Control
- MIMO – Multiple Inputs, Multiple Outputs
- Constraints – Process or Physical Limits
- Linear Programming – Cost Minimization
- IMP – Inferential Modeling Platform
- Scheduling and Batch optimization
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
APC - Predict and Control

- Allows safe operation closer to constraints
- Smooths operation by predicting effects of control moves and compensating
- Works best when base level controls are optimized
APC Fingerprint

Features

- Uses Predict and Control Engineering Tools
- Quantifies critical process interactions
- Determines $ benefits from APC
- Suggests best structure
- Suggests required MV’s, CV’s, DV’s
- Determines additional measurement requirements and value
- Allows customer to get the best APC product for their plant
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.

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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
APC Recommissioning Services

- For APC controllers that are not in service or not performing as expected
- Reevaluate APC design
- Retest and rebuild MPC models
- Simulate and retune controller
- Monitor performance
- Recommissioning services available for various APC software
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
DMCplus 800xA Interface

CV Faceplate
MPC in 800xA 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 800xA**
  - Create application in Control Builder
  - Import model and tuning parameters in 800xA service using Plant Explorer
  - On-line tuning using 800xA 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 in 800xA

- Control Module for MPC
- Configured from CB or FD
- Control connections between CM and level 1 controllers
- Faceplates for interaction
- Mode logic
- Constraint definitions
- Options to connect signals
- Graphical connections
- Textual connections
PV and MV Faceplates
Overall Benefits of the ABB approach

- **Highest controller performance**
  - Choice of right technology for your process
  - Comprehensive performance service packages
  - ABB experience in over 500 APC implementations

- **Lower overall cost of ownership**
  - Modular and scalable software packages
  - User friendly modeling environment to lower implementation effort and model maintenance

- **Low project risk**
  - Process know how and experience
  - Strict project management procedures

**Results:** High ROI at low risk