Using Predictive Modeling to Increase Efficiency and Effectiveness

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PlantPAx Advanced Process Control Portfolio

Real-time Optimization

Model Predictive Control
  Nonlinear Multivariable Control
  Linear Multivariable Control

Inferential Sensors

Advanced Regulatory Control

Regulatory Control

Pavilion8 Dynamic MPC

PlantPAx Model Builder

PlantPAx Fuzzy Designer

Logix IMC, CC, MMC

Logix PID, PI DE, AOI

Increasing Effort & Increasing Value
Why Advanced Process Control?

- **Advanced Regulatory Control**
  - Focus is on **PROCESS** variables – levels, flows, temperatures, pressures, etc.
  - Improve poorly performing loops and/or automate manual loops
  - Compensate for dead-time and simple process interactions
  - Improve process stability, consistency, reliability

- **Advanced Supervisory Control**
  - Focus is on **PRODUCT** variables – production rate, product quality, product specifications (e.g. moisture, color, density, purity, etc.)
  - Sends setpoints to process control loops – good regulatory control is prerequisite to achieve full MPC benefits
    - Improve product quality
    - Increase throughput and/or yield
    - Reduce energy usage
Scalable Portfolio of Advanced Controls

Value-Add

- Optimize
- Control
- Predict
- Regulate

Span of Control

Single Loop → Multiple Loops → Process Unit → Multiple Units → Area → Plant-wide
**PID Temperature Control**

- Neither moisture laboratory samples nor moisture soft sensor are available
- Disturbances are not corrected or slowly corrected
  - Ambient humidity
  - Starch consistency
  - Inlet air flow temperature

![Starch Dryer Example Diagram](image)
**What is a Model?**

*Models Represent “Knowledge”*

A model explains or emulates the behavior of a process...

\[ y = a_3 u^3 + a_2 u^2 + a_1 u + a_0 \]

... using a computational/mathematical representation
Uses of Models

- **Analysis**
  - Analyze vast amounts of historical data to discover unknown correlations and relationships to gain better insight into the process

- **Prediction**
  - Build models that can accurately predict process changes based on changing process inputs and disturbances
  - Combine prediction models with real-time data to build Soft Sensors to identify product changes before they occur, allowing pro-active operator actions

- **Control**
  - Closed-loop multivariable model predictive control (MPC) provides faster responses to changing operating conditions and constraints to minimize product variability and improve yields

- **Optimization**
  - Steady-state models can identify the optimum operating parameters based on current conditions and constraints to meet desired economic objectives (maximize rate, minimize energy, …)
You Can’t Control What You Can’t Measure

- What if in-line sensors are unavailable, unreliable, too expensive

One hour to one day delay!
Solution: Soft Sensor

- **Software model that predicts process values based on real-time process data**

![Diagram showing process adjustments, real-time measurements, and soft sensor prediction.]

### Process Samples

![Diagram showing process samples and analysis.]

### Analysis

![Diagram showing real-time measurement and data analysis.]

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PlantPAx ModelBuilder

- PlantPAx ModelBuilder for off-line data analysis and modeling
- SoftSensor Designer converts models to AOI’s
Model Based APC Function Blocks

- Regulatory control functions based on Internal Model Control (IMC) algorithm
  - Handles first order plus dead-time (FOPDT) models
    - Gain, time constant, and delay parameters
    - Good for processes with dead-time or processes with simple coupling

- Different Function Blocks for Specific Problems
  - IMC (Internal Model Control)
    - Replace single PID loop to address dead-time
  - CC (Coordinated Control)
    - Additional control outputs (2 or 3) for coordinating multiple actuators for a single process variable
  - MMC (Modular Multivariable Control)
    - Coordinates 2 loops that interact with each other
**IMC Moisture Control**
- Moisture Soft Sensor is used for outlet moisture control

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**Diagram Description:**
- **IMC Moisture Ctrl**
  - Inlet Temp Ctrl
  - Valve Position
  - Hot Steam
    - 12 bar
    - 2 bar
  - Hot Water
    - Heat recovery
  - CTRL-valve(s)
  - Inlet air flow
  - Heat flow
  - Hot air & starch mixture
  - Heat exchangers
  - Starch density
  - PID
  - Feeder Speed
  - Motor
  - Starch feeder
  - Exhaust T Ctrl
  - SP
  - PV
  - CV
  - Tout
  - Time Delay
  - Moisture Lab Sensor
  - Sample
  - Dried starch out
  - Amb Air
  - Humidity
  - Sample

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IMC Control with Soft Sensor – SP Change

![Graph showing IMC Control with Soft Sensor - SP Change](image-url)
IMC Control with Soft Sensor
The key to effective control is good modeling
Spray Dryer Challenges

- Control powder moisture to target
- Maintain tower temperature and tower under-pressure below limits
- Minimize tower temperature when possible to reduce energy usage

Dual valve slurry flow control

Multiple interacting control loops

No inline moisture sensor
Manipulate air flow, slurry flow, and air temperature setpoints to control powder moisture to target and maintain tower temperature & pressure within constraints while compensating for slurry temperature and density variations.

- **Powder Moisture Prediction**
- **Startup Setpoints**
- **Slurry Flow**
- **Inlet air flow and temperature**
Spray Dryer Model Predictive Control
Spray Dryer MPC Performance Metrics
Benefits of Model Predictive Control

- Faster moisture measurement and tighter control allows average moisture target to be increased
  - Sell more water/less expensive ingredients
  - Reduce energy used for drying
  - Increase throughput through dryer
Pavilion MPC Applications

Typical Project Payback: 3 to 9 months!

**CPG**
- Typical Benefits
  - 5 to 8% production increase
  - 30 to 60% moisture variability reduction
  - 20 to 50% off-spec product reduction
  - 5 to 10% energy consumption reduction

**CMM**
- Typical Benefits
  - 2 to 5% production increase
  - 2 to 5% energy consumption reduction
  - 20 to 40% product variability reduction
  - 10 to 30% off-spec product reduction

**Polymer/Chemical**
- Typical Benefits
  - 4 to 8% prime product yield increase
  - 35 to 75% transition time reduction
  - 20-40% off-spec product reduction
  - 3 to 7% feedstock wastage reduction

**Bio-fuels**
- Typical Benefits
  - 4 to 12% ethanol production capacity increase
  - 2 to 5% ethanol yield increase
  - 3 to 6% energy use/gallon reduction
  - 1 to 2% DDGS yield increase
Benefits of PlantPAx Advanced Controls

Increased Production

Improved Product Quality

Reduced Manufacturing Costs

Reduced Environmental Risks

Smart, Safe & Sustainable Production
PlantPAx Advanced Controls & Optimization

- Scalable, integrated controls & optimization
- Value assessments and engagement methodology
- Industry expertise and best practices
- Sustained Value Services & Support
- Faster time to Value / Lower TCO