Advanced Solutions

Benefits from Advanced Process Control

Costin Ene – EMEA Solutions Consultant APC

Powered by MATRIKON

Honeywell
Agenda

• Introduction to Advanced Process Control
  – Why Advanced Control?
  – What is APC?
  – APC in Refining / Petrochemicals

• Honeywell’s APC Capabilities and Technology
  – Introduction to Profit Suite
  – Commercial & Business approach
Honeywell Today

- Automation and Control Solutions (ACS): 43%
- Aerospace: 31%
- Transportation Systems: 10%
- Specialty Materials: 16%

- A Fortune 100 company – $36B in Sales
- 122,000 employees in over 80 countries
- Over $1.5B spent annually on R&D

Diverse Businesses, Technologies and Products
Honeywell ACS Today

Automation and Control Solutions (ACS)

- $13B in sales

ACS Portfolio of Businesses:

- **Process Solutions (HPS)**
  - Building Solutions
  - Life Safety
  - Scanning and Mobility
  - Environmental & Combustion Controls
  - Security Group
  - Sensing and Control

Synergy in R&D, Products and Customers
Honeywell Advanced Solutions

Safety
- Protect People, Assets and Process
- Operate Within Process Constraints

Reliability
- Improve Availability
- Reduce Downtime
- Delivering On-Spec Quality and Sustained Benefits

Efficiency
- Improve Productivity
- Reduce Cost
- Increased Throughput & Reduced Energy Costs

Sustainability
- Extend Asset Lifecycle
- Optimize Performance
- Operate process & business in a sustainable & energy-efficient manner
Why should you consider APC?

Advanced Control and Optimization benefits are field proven and generate high rates of return on investment.

**Typical Benefits:**
- Increased Throughput
- Improved Yields
- Reduced energy usage
- Decreased Operating Costs
- Improved Quality Consistency
- Increased Operating Flexibility
- Improved Process Stability

<table>
<thead>
<tr>
<th>Industry</th>
<th>Typical Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil and Gas</td>
<td>1 to 2 months</td>
</tr>
<tr>
<td>Refining</td>
<td>3 to 6 months</td>
</tr>
<tr>
<td>Chemicals</td>
<td></td>
</tr>
<tr>
<td>Petrochem</td>
<td>4 to 6 months</td>
</tr>
<tr>
<td>MMM</td>
<td>4 to 6 months</td>
</tr>
<tr>
<td>Pulping/Paper</td>
<td>6 to 8 months</td>
</tr>
<tr>
<td>Industrial Power</td>
<td>10 to 12 months</td>
</tr>
</tbody>
</table>

**Advanced Process Control provides lucrative returns in any economy**
What benefits does APC deliver?

<table>
<thead>
<tr>
<th>Industry</th>
<th>Benefit Area</th>
<th>Benefits ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrochemicals</td>
<td>Ethylene</td>
<td>2-4% Increase in Production</td>
</tr>
<tr>
<td></td>
<td>VCM</td>
<td>3-5% Increased Capacity / 1-4% Yield Improvement</td>
</tr>
<tr>
<td></td>
<td>Aromatics (50 KBPD)</td>
<td>3.4M - 5.3M US$</td>
</tr>
<tr>
<td>Petrochemicals</td>
<td>Ammonia</td>
<td>2-4% Increased Capacity / 2-5% Less Energy/Ton</td>
</tr>
<tr>
<td></td>
<td>Polyolefins</td>
<td>2-5% Increase in Production / Up to 30% faster grade transition</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>Upstream production</td>
<td>1-5% Increase in Production</td>
</tr>
<tr>
<td>Industrial Utilities</td>
<td>Cogeneration/Power Systems</td>
<td>2-5% Decrease in Operating Costs</td>
</tr>
<tr>
<td>Pulping</td>
<td>Bleaching</td>
<td>10-20% Reduction in Chemical Usage</td>
</tr>
<tr>
<td></td>
<td>TMP (Thermo Mechanical Pulping)</td>
<td>$1M-$2M</td>
</tr>
<tr>
<td>Refining</td>
<td>Crude Distillation (150 KBPD)</td>
<td>5-13</td>
</tr>
<tr>
<td></td>
<td>Coking (40 KBPD)</td>
<td>15-33</td>
</tr>
<tr>
<td></td>
<td>Hydrocracking (70 KBPD)</td>
<td>13-30</td>
</tr>
<tr>
<td></td>
<td>Catalytic Cracking (50 KBPD)</td>
<td>13-30</td>
</tr>
<tr>
<td></td>
<td>Reforming (50 KBPD)</td>
<td>10-26</td>
</tr>
<tr>
<td></td>
<td>Alkylation (30 KBPD)</td>
<td>10-26</td>
</tr>
<tr>
<td></td>
<td>Isomerization (30 KBPD)</td>
<td>3-17</td>
</tr>
<tr>
<td></td>
<td>Benefits ($0.01/bbl)</td>
<td>2.7M - 7.0M</td>
</tr>
<tr>
<td></td>
<td>Benefits (US$/yr)</td>
<td>2.2M - 4.8M</td>
</tr>
<tr>
<td></td>
<td>Benefits (US$/yr)</td>
<td>3.3M - 7.6M</td>
</tr>
<tr>
<td></td>
<td>Benefits (US$/yr)</td>
<td>2.4M - 5.4M</td>
</tr>
<tr>
<td></td>
<td>Benefits (US$/yr)</td>
<td>1.8M - 4.7M</td>
</tr>
<tr>
<td></td>
<td>Benefits (US$/yr)</td>
<td>1.1M - 2.8M</td>
</tr>
<tr>
<td></td>
<td>Benefits (US$/yr)</td>
<td>.3M - 1.8M</td>
</tr>
</tbody>
</table>
How Does APC deliver benefits?

More of the green, less of the blue....
How does APC improve performance?

- **Constrained Optimization**
  - APC pushes the process out of the comfort zone of individual operator towards the optimum performance while still honoring the plant operating constraints
    - High and low limits (set points) for CVs
    - Product composition specifications, metallurgical limits, valve output.
    - Honor Safety and Operational Constraints
  - All constraints are considered and accounted for in the overall control and optimization strategy
How Does APC deliver benefits?

Consistent Operation

Normal Operation

Increased Vigilance

Days per Year

< 60% Daily Production 100%

Plant Capacity Limit

$$
How does APC improve performance?

- **Manipulated Variable** e.g. Feed Rate
- **Winter Season** increases process capacity
- **Conservative operation**: Do nothing
- **Delay in responding to extra capacity**: Overcompensation for violation
- **Overcompensation for violation**: Costly operation beyond constraint
- **Best Operator** (chase the optimum)
- **Worst Operator** (do nothing)

**Advanced Control**

- **Optimum**: Summer Limits the Production Capacity
Intangible benefits are harder to quantify but can be quite significant depending on the project under evaluation.

**Typical intangible Benefits:**

- **Improved Process Safety**
  - Process Watchdog
  - Earlier Identification of Problems

- **Improved Operator Effectiveness**
  - Focuses on key operating parameters

- **Reduced Downstream Unit Variability**
  - Fewer Process Upsets

- **Better Process Information**
  - Increased Process Understanding
Agenda

- Introduction to Advanced Process Control
  - Why Advanced Control?
  - What is APC?
  - APC in Refining / Petrochemicals

- Honeywell’s APC Capabilities and Technology
  - Introduction to Profit Suite
  - Commercial & Business approach
So what is APC?

Advanced Process Control…
……is the replication of the

✓ most efficient and knowledgeable operator
✓ who understands the plant dynamics
✓ is able to predict the plant behavior
✓ control the process
✓ concurrently utilize every opportunity to optimize
✓ within hard and soft constraints
✓ every minute, twenty four hours, throughout the year!
Model Predictive Control Technology

- A well-established industrial control technology which dates back over 30 years.
- A wide variety of industrial technology offerings are available on the market.
- MPC technology has upwards of 5000+ vendor documented industrial applications.
- Refining and Petrochemical applications are typically dominant but MPC is being rapidly adopted in other markets.

Adapted from the following literature source:
Qin, Joe S. (University of Texas), Badgewell, Thomas A., (AspenTech),
“A Survey of Industrial Model Predictive Control Technology (2001 Draft)”
Advanced Process Control

The Hierarchical Layers of Advanced Process Control

- Steady State, Non-linear Process Models
- Multi-unit Coordination & Global Optimization
- Dynamic, Non-linear Process Models
- Multivariable Control & Unit Optimization
- Advanced Regulatory Control
- Base Level Regulatory Control
- Measurement and Control Devices
\[
\begin{align*}
\frac{dx}{dt} &= F(t, x, u), \quad x(0) = x_0, \\
J(u) &= \int L(t, x, \dot{x}, u) \rightarrow \text{extr.}
\end{align*}
\]
Imagine this is our process

• Imagine a shower…
  – Two taps, one mixer head

• What are the objectives?
  – Correct water flow
  – Correct water temperature
### What is Multi-Variable Control?

<table>
<thead>
<tr>
<th>Final Trials</th>
<th>MV1 - Hot</th>
<th>MV2 - Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV1 - Water_temp</td>
<td>Lap Order 1 Settle T = 0 TfSettle = 13.0 FIR Form = UK Trial 1</td>
<td></td>
</tr>
<tr>
<td>Final Error: Pending Error: Final Source: User</td>
<td>$G(s) = \frac{1}{3s + 1}$</td>
<td></td>
</tr>
<tr>
<td>CV2 - Water_flow</td>
<td>Lap Order 1 Settle T = 0 TfSettle = 4.10 FIR Form = UK Trial 1</td>
<td></td>
</tr>
<tr>
<td>Final Error: Pending Error: Final Source: User</td>
<td>$G(s) = \frac{1}{s + 1}$</td>
<td></td>
</tr>
</tbody>
</table>

$G(s) = \frac{1}{2s + 1}$
**Debutanizer Column**

**Interaction:**

Increase in reflux (MV1) causes:

↓ in top temperature

↓ in distillate

↓ in base temperature

↑ in base product

CV  Controlled variable
DV  Disturbance (FF) variable
MV  Manipulated variable
Debutanizer Column

Interaction:

Increase in steam (MV2) causes:

↑ in top temperature

↑ in distillate

↑ in bottom temperature

Both steam and reflux affect most column variables
These predictions are coming from the model.
Prediction Models

<table>
<thead>
<tr>
<th>MV / DV</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>01</th>
<th>02</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflux rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reboil rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stripper Steam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Flow rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient Temp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottoms Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottoms Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Models link all related input variables with control variables

Automatically generated in Profit Controller application
What are the features of APC?

- **Multi-Variable**
  - APC helps coordinate and decouple the effects of multiple process variable interactions.

- **Model-Predictive**
  - APC uses dynamic models to predict process behavior into the future. This information is then used to proactively control the process.

- **Constraint Aware**
  - APC monitors and maintains MVs and CVs within limits while it is controlling the process.

- **Optimized Control**
  - APC has integrated optimization capabilities to drive applications toward specified design objectives.
Model Predictive Control - Structure

- Controlled Variables (CV's)
- Disturbance Variables (DV's)
- Optimization Parameters (Prices, Costs, Directions, Targets)
- Control Targets (Setpoints/Ranges)
- Manipulated Variables (MV's)

MPC Technology

APC

DCS
Why do APC on Refinery Units?

- Complex interactive problems
- More constraints than variables to adjust
  - Qualities
  - Alarm limits
  - Process limits
- Difficult to optimise manually
  - Changing constraints.
  - Operators tend to be conservative
- Economics can be complicated
  - Changing operational requirements
Typical benefits from APC in refining

*in cents per barrel of crude input

(Source: Solomon Associates, Inc.)
Typical benefits from APC

Payback: 3 to 6 months
Honeywell has implemented APC on over 300 AD units worldwide.

Typical benefits are:
- Maximize feed rate within specified limits
- Maximize yield of most valuable products

Typical $ benefits 1-3 MUSD

ROI less than 6 months expected

Project delivery time around 6 months
• Introduction to Advanced Process Control
  – Why Advanced Control?
  – What is APC?
  – APC in Refining / Petrochemicals

• Honeywell’s APC Capabilities and Technology
  – Introduction to Profit Suite
  – Commercial & Business approach
Profit Suite solutions improve process performance and overall business results through:

- Flexible and scalable control & optimization technology infrastructure spanning from linear and nonlinear control through to multi-plant optimization
- Domain and control/optimization expertise across the globe
- Access to 100+ years of process technology expertise via UOP
- Proven track record of sustained solution benefits
Profit Suite for Control and Optimization

- Profit Suite solutions improve process performance and overall business results through:
  - Flexible and scalable control & optimization technology infrastructure spanning from linear and nonlinear control through to multi-plant optimization
  - Domain and control/optimization expertise across the globe
  - Access to 100+ years of process technology expertise via UOP
  - Proven track record of sustained solution benefits

Comprehensive Solutions for all Processing Industries
Profit Controller – Model-Based Control

Range Control Algorithm – Next generation technology
- Funnel based
- Minimum MV move
- Optimal response trajectories
- Built in robustness and stability
- Ease of tuning, no move suppression

Built-in Local Optimization
- Linear and/or quadratic objective function
- Optimization speed tuning parameter
- MV/CV economic values
- Accepts ideal target values from outside applications
- Constrained optimization

“One-knob” tuning
- Dynamic state estimation capability
- On-the-fly gain updating

Better Control, Faster Deployment, Easier Maintenance
Profit Suite On-line Optimization

- A comprehensive, unified, and layered optimization solution
- A methodology to determine appropriate level of optimization:
  - Profit Controller – **Multivariable control & unit optimization**
  - Profit Optimizer – **Multi-unit/global coordination & optimization**
  - Profit Bridge – **Non-linear model based gain updating based on UniSim™ models or other 3rd party models**
- Not a ‘one size fits all’ approach
- Enables evolution of optimization technology application
Profit®Suite Operator Visualization

- Engages operator in proactive monitoring and control
  - Provide operator tools for problem analysis
  - Maximum flexibility in layout and personalization
- Easy configuration
- Two environments to suit wide variety of user needs
  - “Standard” .net-based windows interface
  - HMIweb shape-based interface
- **Optional access from Level 4 Desktop**

*Only Honeywell products focus on the Operator!*
Profit® Suite Operator Visualization

Only Honeywell products focus on the Operator!
Experion Process display – example w face plate
Profit Suite Roadmap

Profit Suite R320
Model-based Nonlinear Control
Embedded Historian
Enhanced Operator Visualization
Improved Engineering Efficiency
L4 Visualization
2008

Profit Suite R410
PSES Extensions
Knowledge management
Industrial Adaptive Workflow
USD Integration Improvements
UOP Inside
Operator Effectiveness
2012

AES R110
Fluidized Bed Support
Multi-Fuel Support
Utility Optimization
2011

June 2010
Profit Suite R400
Control Engine Enhancements
Empirical Nonlinear Control
Virtualization Support
Profit Design Studio Modernization
Web Service Visualization
Full (Legacy) LCN NW Support
Profit XL Bridge (new!)
Training Integration with UniSim
UOP Inside

2014

Profit Suite R420
PSES Extensions for Power, NLC
UOP Inside
Business Optimization
Integration
Embedded Algorithms
Energy Management
Recycle Support
Batch APC
MES Foundation

Unified technology platform,
Engineering & Ops tools, User Interface
to drive and sustain
benefits across the enterprise

Honeywell leads the way in solution innovation
Profit Suite Services & Support

- Development/Product Management
  - >30 developers world-wide
- Project Services
  - >200 representatives globally
- Advanced Application Aftermarket and Support Services
  - >60 dedicated Application Support personnel

- *Depth of education, experience and knowledge in technology and domain expertise spread across all functions*

Worldwide Service and Support Capabilities

"Local expertise, globally networked”

(3rd Party implementation where appropriate)

More than 3,500 years Domain Experience
Sustaining Long-term APC Value

Problems Customers Face

- Inability to sustain full value of benefits over time
- Insufficient time to properly support applications
- Insufficient expertise available to resolve problems
- Operators don’t understand what the applications are doing
  - So applications turned off or overly constrained (MVs)
- Not enough resources to both support
  - And implement new applications
- Inability to recognize opportunities to widen constraint boundaries
  - To increase economic returns
APC Support and Maintenance

• Market trends indicate
  – APC resources are few and are focused on new projects globally
  – APC annual benefit loss of 10% to 25%
  – APC loss of investment over 18 month period
  – APC sustenance should be a priority
• Major causes of benefit loss
  – Model degradation leads to performance problems
  – Operators/unit operations lose confidence
  – Instrumentation, loop or valve problems
  – Equipment problems
  – Key variables left out
  – Process modifications invalidate design
APC Support and Maintenance

- An after market services offering with the objective to help clients manage performance of APC in order to avoid loss on investment
- Leverages technology and Customer + Honeywell resources to provide desired outcome
Why Honeywell?

• Technology
  – Continuum of control solutions provides flexibility without sacrificing robustness of control objectives
  – Experion integration and excellent usability on non-HW DCS
  – Superior maintenance tools
    • Profit Stepper, Profit Expert facilitates maintenance, sustains/enhances value
  – Layered Optimization drives long-term value
    • Profit Optimizer
    • Alternative – suboptimal unit-based performance

• Capability
  – 3,500 man-years experience distributed globally
  – BG-Max provides continuous access to latest technology and global expertise

• Cost Effectiveness
  – Perpetual licensing drives long-term value
  – Experion Integration reduces total cost of ownership

Technology and Service capabilities drive lowest cost deployment and long-term benefits sustenance
Honeywell is the Market Leader in APC and RTO*

150+ Higher Level Optimization Applications
3200+ Multivariable Controller Applications
1000+ Major Unit Implementations (MPC-Based Optimization)
550+ Industrial Sites
300+ Customers Worldwide

Estimated $5 Billion in Benefits since 1996

Honeywell APC Experience

**Refining Processes**
- Alkylation (40+)
- Catalytic Cracking (225+)
- Coking (50+)
- Crude Distillation (275+)
- Hydrocracking (60+)
- Hydrotreating (45+)
- Isomerization (15+)
- Lubes (25+)
- Reforming (100+)

**Petrochemical**
- Aromatics
- Butadiene
- Ethylene
- VCM
- PTA

**Foodstuffs**
- Milk Spray driers

**Pulp & Paper**
- MD Control
- Bleaching
- Lime Kiln
- ClO2 Generation
- O2 Delignification
- Kamyr Digester (R&D)
- Thermo-Mechanical Pulping (TMP)

**Polymers**
- Nylon
- Polyethylene
- Polypropylene
- Polystyrene

**Industrial Utilities**
- Co-Generation
- Power/Steam

**Oil & Gas**
- NGL Plants
- Off-Shore Production
- LNG Production

**Chemicals**
- Acetic Anhydride
- Methanol
- Ammonia
- Phthalic Anhydride

**Mining & Minerals**
- Grinding Mill Control
- Digestion
- Precipitation
- Evaporation

**Foodstuffs**
- Milk Spray driers

**Car Manufacture**
- Air Supply House
• Assess the opportunity of APC deployment
• Perform a benefits study on-site
• Agree on the most suitable APC solution
• …