“The **biggest mistake** we’ve seen is the **assumption** lot of company leaders have that they have made such massive investments in IT that they must have **optimization all over the place**”

Senior VP – Major Oil and Gas Company

“I was naive and thought we had a very well run and **optimized** business. Some room for improvement maybe, but not huge - or that would mean I wasn't doing my job well.

Once we dug for data, we found out that the prize was much bigger than I thought.”
Return on Investment: MPC and Optimization

MPC Improves Process Stability and pushes the process to the most profitable operating point
Profit Optimization Suite

Consistent Technology – Multiple Platforms
- MPC and Dynamic Nonlinear Real Time Optimization
- Flexible Modeling environment
- Unmatched operational awareness
- Lowest lifecycle cost

Profit Loop  →  Experion Profit Controller (C300/ACE)  →  Profit Suite  →  Profit Optimizer  →  Profit Executive

Continuum of Control Solutions

<table>
<thead>
<tr>
<th>Single Variable Linear Control</th>
<th>Multiple-Variable Non–Linear Control and Optimization</th>
</tr>
</thead>
</table>

Sec → Profit CPM (Control Performance Monitor) → Hours/Days
Elements of MPC

• Objective and benefits
  - Calculating benefits (end goals)

• Understand the process
  - Documentation

• Instrumentation and handles
  - Sensor accuracy/availability
  - Process handles

• Modeling and design
  - Working with data
  - Modeling
  - Simulation and validation
  - Optimization objectives

• Operator visibility and training
  - Process versus MPC displays

• Optimize everything
Potential Benefit Cases
### Limit Information

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>StdDev</th>
<th>Median</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC102</td>
<td>Regenerator Temperature</td>
<td>777.51</td>
<td>766.13</td>
<td>784.62</td>
<td>2.2925</td>
<td>777.63</td>
<td>-0.1684</td>
<td>-0.04461</td>
</tr>
<tr>
<td>Z101</td>
<td>RCSV opening</td>
<td>84.457</td>
<td>76.529</td>
<td>93.873</td>
<td>2.6493</td>
<td>84.297</td>
<td>0.14625</td>
<td>-0.11569</td>
</tr>
<tr>
<td>A101</td>
<td>Excess O2</td>
<td>0.80341</td>
<td>0.15888</td>
<td>1.5092</td>
<td>0.2937</td>
<td>0.79418</td>
<td>0.26808</td>
<td>-0.1477</td>
</tr>
</tbody>
</table>

### Shift in Operating Point

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>After Control Std Dev (%)</th>
<th>LimitRule</th>
<th>Max/Min</th>
<th>Limit</th>
<th>% Violation Before Control</th>
<th>% Violation After Control</th>
<th>Average Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC102</td>
<td>Regenerator Temperature</td>
<td>50</td>
<td>SameLimit</td>
<td>Maximize</td>
<td>781.29</td>
<td>4.9731</td>
<td>4.9731</td>
<td>1.8885</td>
</tr>
<tr>
<td>Z101</td>
<td>RCSV opening</td>
<td>50</td>
<td>SameLimit</td>
<td>Maximize</td>
<td>89.152</td>
<td>3.4946</td>
<td>3.4946</td>
<td>2.3473</td>
</tr>
<tr>
<td>A101</td>
<td>Excess O2</td>
<td>50</td>
<td>SameLimit</td>
<td>Maximize</td>
<td>1.2874</td>
<td>6.7947</td>
<td>6.7947</td>
<td>0.29201</td>
</tr>
</tbody>
</table>

### Target Variables Notes

The regenerator temperature is running close to limit of 780 DegC. In the December month the standard deviation of temperature is low and it is running consistently closer to the limit.

To achieve feed maximization objective the Feed, reactor inlet temperature and Regen-1 air would be three main handles which will need manipulation to negotiate the regenerator temperature, Valve opening of RCSV and excess oxygen constraint.

RCSV opening should be kept below 90% to have controllability. Excess Oxygen average value is below 1%, but it's minimum limit is 1%. Advanced Control should help in maintaining that.
overcome by adjusting the variables in gas section itself without changing the feed to the unit.

3.2.1 Target Variable Statistics

The regenerator temperature is running close to limit of 780 °C. Deviation of temperature is less and it is running consistently closer

<table>
<thead>
<tr>
<th>Item</th>
<th>Dept</th>
<th>Pre-APC Avg</th>
<th>Post-APC Avg (min)</th>
<th>Post-APC Avg (max)</th>
<th>Conv. factor</th>
<th>LP Cost</th>
<th>Oil Value</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCO2</td>
<td>Regenerator Temperature</td>
<td>777.51</td>
<td>15E-20</td>
<td>778.755</td>
<td>1</td>
<td>0</td>
<td>778.755</td>
<td>0.16</td>
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<tr>
<td>Z101</td>
<td>RCV opening</td>
<td>84.457</td>
<td>15E-20</td>
<td>87.285</td>
<td>1</td>
<td>0</td>
<td>87.285</td>
<td>3.28</td>
</tr>
<tr>
<td>A101</td>
<td>Excess O2</td>
<td>0.00041</td>
<td>1,240,01</td>
<td>1E+20</td>
<td>1</td>
<td>0</td>
<td>1,240,01</td>
<td>5.46</td>
</tr>
</tbody>
</table>

Change in objective function can be calculated by:

\[
\Delta J = \sum_{i=1}^{n} \Delta Y_{i} \times LP_{i} + K_{i} + \sum_{j=1}^{m} \Delta W_{j} \times LP_{j} + K_{j}
\]
Where the rubber meets the road

Sensors, Valves, Actuators…
Sensor Health Diagnostics with CPM

- Sensor High and Low limits, Freeze duration, Acceptable violation of sensor limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Recommended Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiction High Limit</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>RPI Low Limit</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>RPI High Limit</td>
<td>2.5</td>
<td>10</td>
</tr>
<tr>
<td>Oscillation Index High Limit</td>
<td>0.2</td>
<td>1</td>
</tr>
</tbody>
</table>

Acceptable Violation of Sensor limits:

- Sensor Low Limit
- Sensor High Limit
- Freeze Duration Allowed

Note: Recommended values for Desired Settling Time and Sampling Time may vary with Loop Type.
MV – understanding issues with CPM

• Automatic Diagnosis for identifying key loop performance issues [Tune/ Fix/ Investigate]

• **Tune**
  - Run tuning software to improve

• **Fix**
  - Create a work-order

• **Investigate further**
  - Expert Guidance
    - Walks the user through steps to find the root cause
  - Common Oscillation
    - To identify common oscillation loops.
  - Poor performing loops
  - Saturated loops
  - Low utilization loops
MV – tuning with TaiJi PID

- Vendor neutral; universal OPC connectivity to DCS/PLC
- Preload DCS/PLC configurations
  - Easy to initiate
- Bulk configuration for all controllers across plant
- Automated plant testing, in either open or closed loop mode
  - Test within user specified ranges
  - Reduce operator intervene
- ‘One Button’ tuning – just specify desired response time
- Informative simulation graphics
- Closed loop robustness plot – tune with confidence
Profit SensorPro

Soft Sensor Development

• Extensive Data Pre-processing, Modeling, Data Validation, and Model Qualification Capabilities
• Linear and non-linear modeling capability
  - Ordinary, Weighted, and Partial Least Squares (OLS, WLS, PLS)
• Regressed and User-entered
  - Regress to custom equation forms
  - Visual “goodness of fit” statistical information
  - User-Entered Online Transformations
  - Allows convolution of expressions for online deployment
• Steady-state and dynamic
  - Dynamic Subspace Inferential
  - Automated dynamic compensation for asynchronous property data
  - Automated handling of bias updating
• Lab/Analyzer Update
  - Manual, Semi-automatic, or Automatic modes
  - Optional CUSUM based bias updating
• Automated deployment for all equation forms
• Improved Ease of Use and Data Visualization Features
• Tightly Integrated into Profit Suite Engineering Studio
Controller Design, Modeling…
Profit Controller

Model-Based Predictive Control

Inherently More Stable
- Minimum MV move – no overcorrections
- Optimal response trajectories
- Less sensitive to model error
- Built in robustness and stability with
  On-line Dynamic matrix conditioning
  protection

Easier to Tune
- “One-knob” tuning
- No need for move suppression
- Independent CV by CV tuning (MVs too)
- >90% of applications work with default
  tuning

Easier to Commission and keep running
- Fully supports closed-loop identification
- Warm mode enables validation
Control Platforms

Experion Server
ACE
Console Station
EAS (URT)
Flex Station
C300

5 PCs (10x5x5)

5000 Submodels (200x250x600)

10 PCs (30x15x9)
Honeywell Modeling Solutions: Profit Online Modeler

• Automates key tasks:
  - Data collection & Plant Testing (perturbation)
  - Model identification
  - Visualization of test progress
  - End of test indication

• Applicable to all Development Scenarios
  - Open-loop testing
  - Closed-loop with constraint management
  - Combined open/closed-loop scenarios

• Superior Workflow Integration
  - Leverages existing Engineering and Operator i/f
  - ID algorithm common to runtime and offline environments (Profit Suite Engineering Studio)
  - No external model identification necessary
  - Immediate visualizations on model quality; easy to interpret

• Results
  - 40% to 60% reduction in plant test time
  - 60% to 99% reduction in post-test model ID
  - Improved controller performance
Minimize Plant Tests with History ID and Online Modeling

- Automatic segment selection after removal of bad segments
- Checks for controllers in Manual
- Can handle large data as ID does not use all data (~ 6 months)
- Integrated with profit controller PSES infrastructure
  - Calculations
  - Transformations
  - Merge models
  - Build controller (xm, xs, xp)
  - Simulation
- Identify individual CVs in history ID nodes and assemble complete model in Merge model
- Use SEED models and go direct to online closed loop modeling
Honeywell Optimization Solutions

• Profit Optimizer - Dynamic optimization
  - no steady-state detection is needed
  - 3-5 minute execution frequency
  - Full formulation objective function w/ QP solver

• Cooperative optimization approach
  - Shares common models with Profit Controller application(s)
  - Calculates optimization speed for each controller depending on underlying process dynamics & settling time
  - Patented bridge model technology: full dynamic relationships across the optimization scope.

• Gain scheduling (via Profit Controller/Optimizer Gain Mappers)
  - Direct move in the most profitable direction
  - Global optimum when possible

• Hessian Updating for non-linear optimization
  - Ability to (re-)use existing process models for nonlinear optimization
  - Drives to Global optimum
Adding *Process Intelligence* with UOP

**What is it?**
- Pre-packaged MPC applications for key UOP units
  - Best practice from HPS, Expert review and input from UOP, UOP toolkits as appropriate
- MPC for UOP packages are currently available for:
  - CCR Platforming, Oleflex

**What is the Value Proposition?**
- Best in class knowhow from both UOP and HPS
- The inferential calculations enable better estimation of key variables that are either:
  - Difficult to measure (e.g., tube wall temperature in furnaces)
  - Difficult to measure online (e.g., octane or aromatics content)
- Allowing the customer to push their units to their constraints increasing throughput or yield
- Empirical model gains of the MPC for UOP models can be kept up to date using the rigorous non-linear optimization models from UOP CPS/Optimization Advisor
Profit Executive in R500
Race Strategy

Overall Optimization...
Key Challenge: How to get the solution layers to stay consistent and reach the global optimum jointly?

Business Planning
- Plantwide economics
- Production Planning

Schedule & Optimization

Optimal feasible

Control & Optimization
- Local economics

Planning (Months)

Scheduling (Day/Weeks)

Integration Scheme? How?

Manage intermediate and final:
- Inventory (volumes)
- Properties (quality)
- Timeline (just in time)

Real Time Dynamic Optimization - DQP (hr)

App -1
App -2
App -3
App -n
Implementation of the plan today
Closing the Gap with Profit Executive

Returned values can include the actual versus predicted yields and proxy limits.

Profit Executive

Manage intermediate and final:
- Inventory (volumes)
- Properties (quality)
- Timeline (just in time)

Manage:
- Unit operation
- Limits
- Constraints
Giveaway Estimation

➢ A more profitable product mix could have been produced in the study year

Over-Qualification: $65M/year ~$3/Barrel of Product

➢ The actual product mix was produced and sold in the study year

The purpose for estimating the quality giveaway is to show:
➢ how less optimally the components were produced at a potentially higher cost.
➢ the potential room for reducing the component quality while still meeting the same demand.
Visibility, awareness

Operator displays, alarms…
Faster Setup with Profit Web Viewer

- HTML5 based visualization using Internet Explorer or Chrome web browser
Engaging and Informing the Operator

Tips Messaging
- Displays notifications and advice for CV/MV

Horizontal Bar Charts
- Shows the relationship

Ideal Limits
- Shows the relationship between current and ideal operating limits
Pit Strategy

Maintenance/Predictive Optimization…
MPC Performance Assessment Lifecycle

Tools to help not only detect the problem but also fix it, resulting in clear financial benefit

Move from performance assessment to performance improvement
Profit Performance Monitor

Overview

• Key design intent is to enable the operations, process engineering and APC teams to understand what is limiting APC from driving the unit to its best potential
  - Prioritizing limiting issues by financial impact
  - Identifying how the critical variables are kept within their high and low bounds

• Goal is to engage all the stakeholders of APC / Unit performance
Key Variables

Actual Trend | Potential Trend
---|---
Causes of Lost Opportunities
Frequency and magnitude of Constraint Violations
Performance data segmented by shift

Current Focus Week
Key Variables
Lost opportunity cost (Weekly)

Actions / comments. Mixture of auto-generated from analytics and manually entered
Manage Change with Auto Documentation & PSES Backbuild

- Often running platforms are adjusted/modified
- The variable combinations or logic block calculations which have been designed with PSES are adjusted by the user in URT.
- The changes can be done in the equation or connection or the value of coefficients.
- These calculation changes can now be read back into PSES to update the original calculations and be fully documented with Auto-Documentation in PSES.
Profit Suite Roadmap

What is Honeywell doing differently? Why?
Proactive Monitoring and Honeywell Connected Plant
Profit Control and Optimization Roadmap

Control Performance Monitor R600
- Next generation Diagnostic workflow
  - Tune/Fix/Investigate (Expert Guidance)
  - Completely updated user centered reporting views
- Intuition platform
  - Improved security/user management

CPM R601
- Performance improvements
- Enhanced cross correlation
- Improved displays/trending
- Revised Custom Templates
- Migration support to PID

CPM R602
- Multiple MPC templates
- Cross Domain support
- Management reporting
- Migration Support to MPC

CPM R610
- Enterprise CPM
- Next generation MPC monitoring
- Integration with Intuition alerting (Pulse)

Profit Optimization Suite R440
- Optimization engine enhancements
- UOP Oleflex and Hydroprocessing toolkits
- MV Transforms
- Profit Web Viewer
- Models from Historical Data

Profit Optimization Suite R441
- Enhancements for optimization
  - Phase 2 APC Agnostic Multi-Unit Dynamic optimization
  - Proxy Limits
  - Extend Profit Web Viewer
  - Profit Applications
  - Variable combinations naming & chaining

Profit Optimization Suite R442
- Process Monitoring and data analytics
- Extend thin client
- Profit Applications
- Profit Optimizer large scope enhancements
- Proxy limits added for CVs

Profit R500
- Enhanced Optimization
- Planning integration
- Master/slave controllers
- Guaranteed feasibility
- Engineering AppStore
- Process Monitoring/modeling with what-if and support capabilities
- Runtime license update
- Extend thin client
  - Profit Applications
  - L4

Profit R510
- Extend Planning integration
- Enhanced Optimization
- Full blend integration
- Nonlinear constraints
- Extend process Monitoring/modeling with what-if and support capabilities
- UOP toolkit enhancements
How can Honeywell technology help?

• Technology inherently addresses the Deploy / Sustain challenges customers are facing – it lends itself to minimizing lifecycle costs.

• Technology specifically built to reduce implementation effort and lifecycle burden of profit-generating control applications.

• Enables a lifecycle support program instead of providing a box of tools that the user must figure out how to configure/use.

• Every development of an extended technology or new tool has a goal to minimize the lifecycle cost.
Honeywell is building a smarter, safer, and more sustainable world

THAT’S THE POWER OF CONNECTED
THAT’S THE POWER OF HONEYWELL

Connected Aircraft  •  Connected Automobile  •  Connected Home  •  Connected Building
Connected Plant  •  Connected Supply Chain  •  Connected Worker