Sustain High Performance with Adaptive Process Control

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Challenges

Complete New Control projects
Improve efficiency of practitioners and solutions

Maintain Benefits
Solution maintenance
Large re-vamp pipeline

Develop APC Resources
Increase number of skilled practitioners
Build effective internal APC groups

Benefits
Develop APC Resources
Improve efficiency of practitioners and solutions
Complete New Control projects

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Empowering Users
Self-sufficiency Across the APC Lifecycle

- Simplify usability
- Develop an improved methodology
- Embed workflows and automated tools
- Maintain the infrastructure

Broader set of training delivery methods
## APC Projects

### Waterfall Methodology

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>Justification &amp; baselines</td>
</tr>
<tr>
<td>Pretest</td>
<td>Tags, instrumentation, test design</td>
</tr>
<tr>
<td>Test</td>
<td>Data collection, DCS interface, step testing</td>
</tr>
<tr>
<td>Modeling</td>
<td>Data slicing, transforms, identification</td>
</tr>
<tr>
<td>Configuration</td>
<td>Initial tuning, calculations</td>
</tr>
<tr>
<td>Simulation</td>
<td>Verify ranking, check robustness, adjust tuning</td>
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<tr>
<td>Commissioning</td>
<td>Open &amp; closed loop testing, gain adjustments</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Plant/model mismatch, PID tuning, SS &amp; Dynamics</td>
</tr>
<tr>
<td>Troubleshooting</td>
<td>Correct mismatch, correct loop problems</td>
</tr>
</tbody>
</table>
Focusing Automation on Key Tasks

Test  Model  Commission

Automated Testing  Calibrate Mode  Adaptive Modeling
Automated Slicing
Innovations

Adaptive Process Control

| Model Quality Analysis | Robust Control w/ Economic Relaxation | Closed-loop Capable Model ID | Automatic Data Slicing | Adaptive Modeling |

Automatic generation of candidate models. Assessment tools for rapid evaluation of fidelity.
Adaptive Process Control

Optimizing Control During Testing

Precision Re-vamps

Process vs. Projects
Situation: Controller Off During Testing

- First-generation maintenance tools delivered benefits, but didn’t solve the biggest cost issues
  - Shorter cycles, but more disruptive
  - Lost capacity
  - Reduced quality
  - Testing required constant management

- Controller turned off to collect open loop data
Revamping a controller often required up to 80% of the original effort (and cost!)
- Latent (and not-so-latent) costs of plant step testing
- Lack of precision in identifying problem areas of the models
- Co-linearity detection and repair were not integrated with the other modeling workflows
- Preparing data for Model Identification was manually intensive
- Generating candidate models required a lot of activity by the control engineer
Situation: Infrequent Maintenance Projects

- APC Maintenance methodology mirrored the initial project. That produced undesirable side effects
  - Maintenance is commonly deferred until unit turnarounds and in the interim, controller performance becomes untenable
  - Degrading performance oftentimes results in operators turning off the controller
Required Technology to Realize Benefits of Adaptive Process Control

- MQA: Model Quality Assurance to determine which models are bad – Which MVs to retest
- LP relaxation to drive process to a consensus constraint set agreed by Production
- Calibrate Mode: Use of Calibration Ratio to dial in sufficient robustness to prevent cycles
- Multistep Mode from Aspen SmartStep to move MVs in ratio to rapidly converge gain ratios and RGAs of the model
- Aspen Watch: Collect the test data
- PID Watch: Monitor PID loops for saturation and windup to enable auto-slicing
- Adaptive Modeling: New Closed Loop Capable version of Subspace ID
Calibrate Mode

- Calibrate mode moves CVs close to their LP targets via DMCplus, then run Multi-test within tolerance allowed by calibration ratio.

- Adaptive Modeling collect test data, excluding bad data through automated slicing and periodically identify the model by subspace ID.
Economic Relaxation

- Use Economic Relaxation to nominate an profitable LP solution within range $\Delta J < economic \ relaxation$ in DMCplus

- If we have significant model mismatch between model and process, should we change LP target every minute?

- No, we use ‘Economic Relaxation’ to keep target constant until new target is outside blue triangle, then pick a new LP target

A is calculated LP solution based on model and B comes based on process. There is gap between A and B by model mismatch.

We don’t like to change A within range - delta J, because we cannot guarantee the optimal value, because of model uncertainty.

Dot : Process, line : Model
How do we decide CVs and MVs?

How do we decide CV & MV?
1. MV’s COST RANK
2. MV’s COST FACTOR
For example
① COST RANK : MV1 > MV2
② COST : Max(Min) of MV1
③ ‘B’ is optimum
Calibration Ratio

- If $\Delta J = J_{\text{optimal}} - J_{\text{current}} > \text{calibration ratio}$, closed loop with DMCplus control mode to track the CV target in calibration mode.

- If $\Delta J = J_{\text{optimal}} - J_{\text{current}} < \text{calibration ratio}$, open loop and multistep MV movement in calibration mode.
① We have economic relaxation and $\Delta J$ under limit conditions.
: No steady state target movement and multistep mode.

② We have economic relaxation higher than limit conditions and $\Delta J$ under limit conditions.
: New steady state target and multistep mode when we change target.

③ We have economic relaxation higher than limit conditions and $\Delta J$ under limit conditions.
: New steady state target and DMC+ mode, when we change target.
How does Calibration Ratio govern behavior in Calibration Mode?

- We can see how calibrate mode run per each $\Delta J$ condition.

![Graph showing the behavior of calibrate mode](image_url)
Effect of Calibration Ratio (CR) on MV step size

- **CR =1**: Big CV + MV movement, so we need shorter plant test time compared with small CR.

- **CR < 0.1**: Small CV + MV movement, lower S/N Ratio
  - If a big disturbance occurs and the MVs respond to counteract it (i.e., feedback correlation), we may fail to get a good model.
  - When we have large model/gain uncertainty, a small CR is the recommendable approach.

CR : Calibration Ratio
How is Calibrate Mode Different from SmartStep Multi-Test Mode?

- Higher Financial Return from Calibrate Mode:
  - Less disruptive and less supervision to operate – fewer alarms, less product give-away, low feed losses
  - Capture best practices in testing and model development – Anyone can get a qualified model.
  - Sustained performance tool – easily maintain model fidelity for high on-stream factor and performance.
Demo
Shaping the Timeline

- Test
- Model
- Commission

Months

Test
- Model
- Commission

Weeks

Adaptive Modeling

Calibrate Model

Maintenance Costs

New DMCplus Projects

Adaptive Process Control

Costs
Benefits

- Recent innovations in aspenONE APC deliver **game-changing improvements** to both controller sustainability and initial application development
- Enables optimizing control while doing small perturbation step testing
- Allows the engineer to set the degree of aggressiveness of the test
Want to see similar results?

Consider a training class from AspenTech

http://training.aspentech.com
Advance Process Control
Performance Monitoring (APC2600)

May 28, 2013 – Reading, UK
June 24, 2013 – Houston, TX
July 22, 2013 – Houston, TX
July 29, 2013 – Reading, UK
September 2, 2013 – Singapore

http://support.aspentech.com/supportpublictrain/CourseInfo.asp?course=APC2600

• Learn how to use Aspen Watch KPI to analyze and troubleshoot controller performance, and how to detect and repair model mismatch in Aspen DMCplus controllers.
  • Learn to sustain the benefits achieved by your control applications.
  • Learn how Aspen Adaptive Control can help improve performance of the controller through generating and deploying updated models.
Training Options: Webinars.. Continuous learning

- May 20, 2013: Sustain High Performance with Adaptive Process Control
- March 6 2013: First Look at aspenONE APC V8
- April 8, 2013: Managing APC Software with Virtual Machines

Recent webinars on many topics can be viewed on-demand on aspentech.com
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