Optimizing Batch Process Control

In Your Spare Time
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Overview

Identifying the Problem
Initial Troubleshooting
Cost Justification of New Instruments
Sizing, Selection, and Implementation
Developing a New Strategy
Final Results
Identifying the Problem

Use tools to find batch control issues
- Studies often proposed
  - Expensive
  - Time consuming
- Operator.tech complaints
  - First hand experience
  - Automatic buy-in

Example: Issue causing operator intervention; actually a major cost-savings opportunity
Identifying the Problem

Determine scope and goals for troubleshooting

- How much variability can the system handle?
- Which products need lower variability?
- Which phases do you care about?
- When can you call the project complete?

Example:

- Top and bottom column temperatures important
- Middle temperature(s) can move
- Temperatures only kept in bounds, not at set point
- Only a few products are problematic
Initial Troubleshooting

Understand the physical system
Initial Troubleshooting

How is the system currently controlled?

Example:

• Column temperature controlled by split range reflux flow valves cascaded to average bed temperature (feedback only)
• 5 minutes of dead time from reflux change to average temperature response
• Continuous cycle of overheating then overcooling
Setup software for data capture

- Difficult to find time to watch a process live
- Make sure everything needed is being captured
- Change batch logic to gather more information if needed
- See chart below for process control history guidelines
  - Over/under compressed historian data is useless for control work

<table>
<thead>
<tr>
<th>Loop</th>
<th>Compression</th>
<th>Filter Time</th>
<th>Update Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>0.1% [of range]</td>
<td>0.5 sec</td>
<td>1 sec</td>
</tr>
<tr>
<td>Gas Pressure</td>
<td>0.1% [of range]</td>
<td>0.5 sec</td>
<td>1 sec</td>
</tr>
<tr>
<td>Liquid Pressure</td>
<td>0.1% [of range]</td>
<td>0.05 sec</td>
<td>0.1 sec</td>
</tr>
<tr>
<td>Vessel Level</td>
<td>0.2% [of range]</td>
<td>5 sec</td>
<td>10 sec</td>
</tr>
<tr>
<td>Distillate Level</td>
<td>0.02% [of range]</td>
<td>1 sec</td>
<td>2 sec</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.02% [of range]</td>
<td>5 sec</td>
<td>10 sec</td>
</tr>
</tbody>
</table>
Finding hardware limitations

- Use historian and stats software
- Ask vendor for help explaining patterns if needed

**Example:** Flow control valve sticking and not reading at low range (left); vendor provided flow meter characteristics graph (below)

0-27% Output = 0-100% small valve
14-100% Output = 0-100% big valve
Cost Justification of New Instruments

Improve control to make batches safer and faster

Flow SP and Output

Flow below instrument capability
Cost Justification of New Instruments

Define as an “enabling” project

Example:

- Improve temperature control
- Reduce volatile organics
- Speed up heat-up phase
- Reduce cycle time
Use field measurements for instrument sizing

Worth time to walk down the system

Use spreadsheets or software to speed up dP calculations

Let vendors recommend instruments based on dP calculations and process information
Sizing, Selection, and Implementation

Control valves leak through
- Designed for throttling service leak
- Lower leakage leads to higher stiction
- Use automatic block valves tied to control valve output

Watch out for high turndown and start/stop operations
- Batching different products complicates instrument selection
- Let vendors know early if turndown is greater than 30:1 or if lines often go dry
- Plan for higher instrument costs
Developing a New Strategy

Select the best control point

• Look for large, symmetrical responses to variable change

Example: T2 reacts well to changing reflux, but not to disturbances
Decided to use T2 as control, with feed forward from T4
Developing a New Strategy

Add feed forward with the right timing

- Rules of thumb from mentor Greg McMillan

\[
\text{TD2} = \text{TD1} - \text{TD3} \\
\text{TC2} = \text{TC1} - \text{TC3}
\]

if \( \text{TD2} > 0 \)

- then feed forward dead time = TD2
- else feed forward dead time = 0

if \( \text{TC2} > 0 \)

- if \( \text{TD2} > 0 \) then feed forward lead time = 0
- else feed forward lead time = TD2
- feed forward lag time = TC2
- else feed forward lead time = TC2 & feed forward lag time = 0.2 \times \text{TC2} (\text{increase to filter out noise in T1})
Developing a New Strategy

Consider tuning software as a starting point

- Control systems interface directly with adaptive tuning software
- Provide automatic models as set points change to give starting points for time constants and lead/lag times

- Benefits and theory behind tuning application described in *Control Loop Foundation—Batch and Continuous Processes* by Terry Blevins and Mark Nixon

Example: Software set up to measure process dead time, gain, and time constants for slave and master loop automatically during batches
Final Results

Repaired control valve and properly sized flow meter resulted in a more stable and predictable flow control.

Control Valve Output
Final Results

Top of column temperature shown in blue below both before control changes and after for similar batches. Result is a faster cycle time with less operator intervention.
Summary

Identify and focus the problem
Troubleshoot with historian data
Justify with safety, cost, and other enabled projects
Spend time on calculations for selecting instrumentation
Develop new controls using expert rules of thumb and software
Cultivate support with final results
QUESTIONS?
I would like to add a special appreciation to the ISA Mentor Program, Greg McMillan, and support from Eastman Chemical Company.

http://automation.isa.org/isa-mentor-program/