Setting the Standard for Automation™

Optimizing Batch Process Control

In Your Spare Time

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Presenter

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Mentee of Greg McMillan (Coauthor)

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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

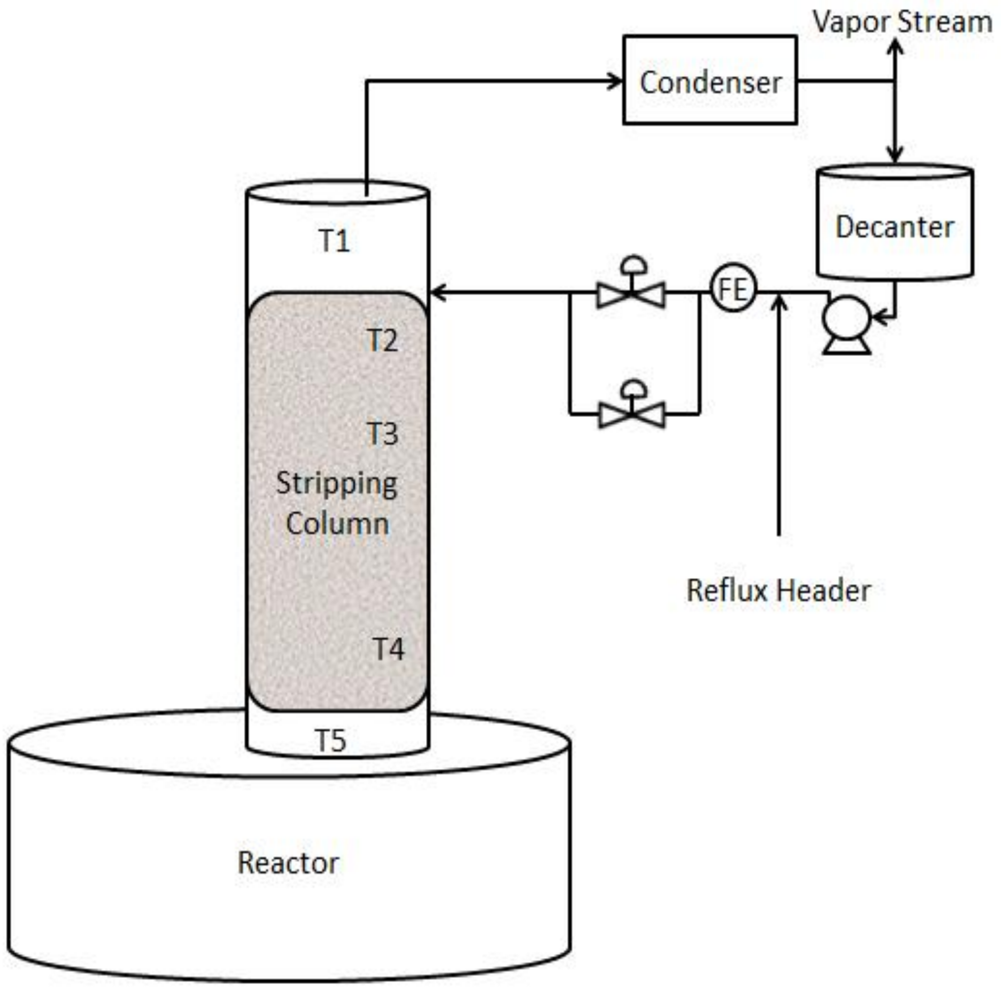
- How much variability can the system handle?
- Which products need lower variability?
- Which phases do you care about?
- When can you call the project complete?

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

Initial Troubleshooting

Setup software for data capture

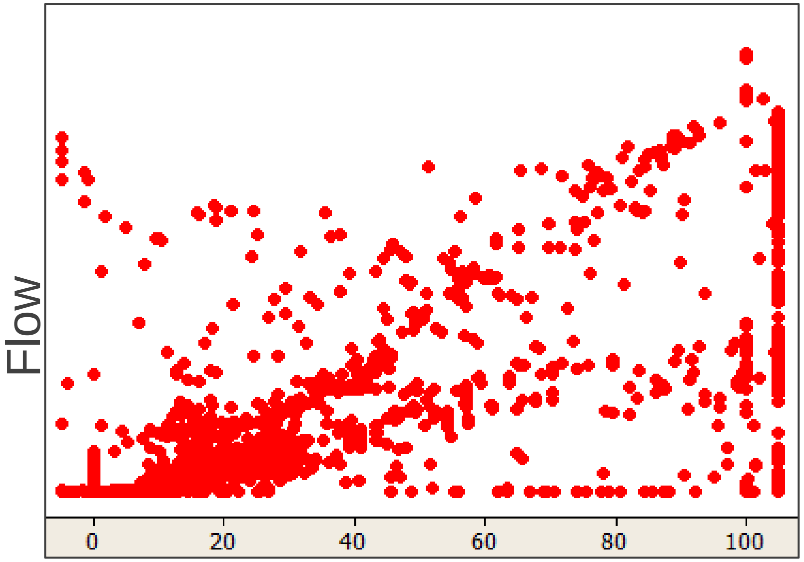
- Difficult to find time to watch a process live
- Make sure everything needed is being captured
- Change batch logic to gather more information if needed
- See chart below for process control history guidelines
  - Over/under compressed historian data is useless for control work

Loop	Compression	Filter Time	Update Time
Flow	0.1% [of range]	0.5 sec	1 sec
Gas Pressure	0.1% [of range]	0.5 sec	1 sec
Liquid Pressure	0.1% [of range]	0.05 sec	0.1 sec
Vessel Level	0.2% [of range]	5 sec	10 sec
Distillate Level	0.02% [of range]	1 sec	2 sec
Temperature	0.02% [of range]	5 sec	10 sec

Initial Troubleshooting

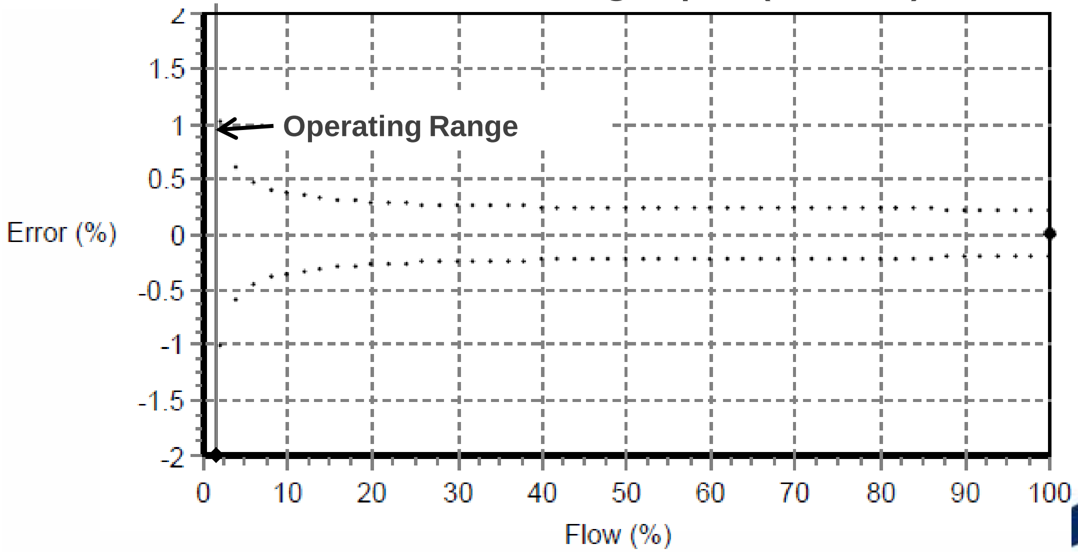
Finding hardware limitations

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



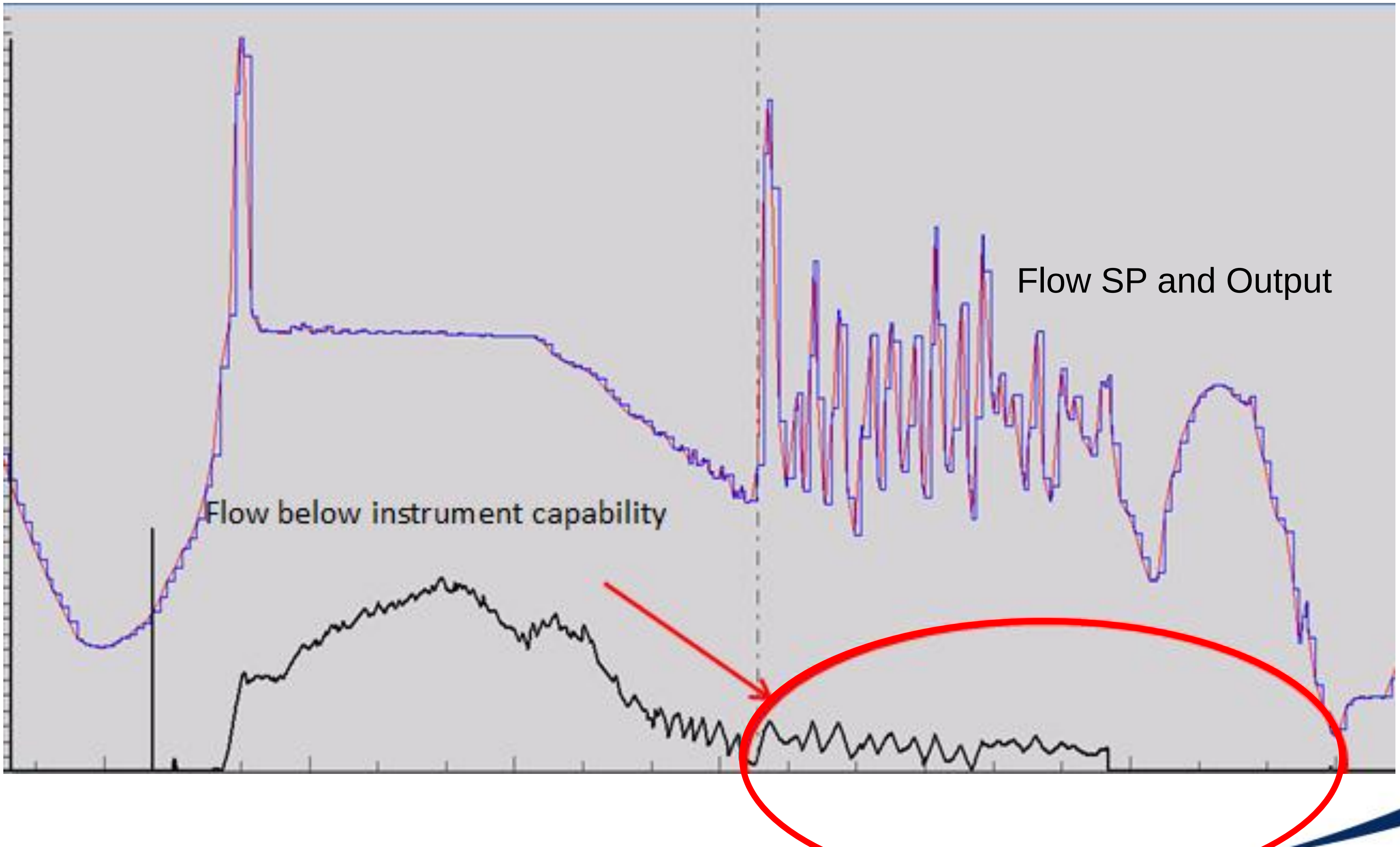
0-27% Output = 0-100% small valve
14-100% Output = 0-100% big valve

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



Cost Justification of New Instruments

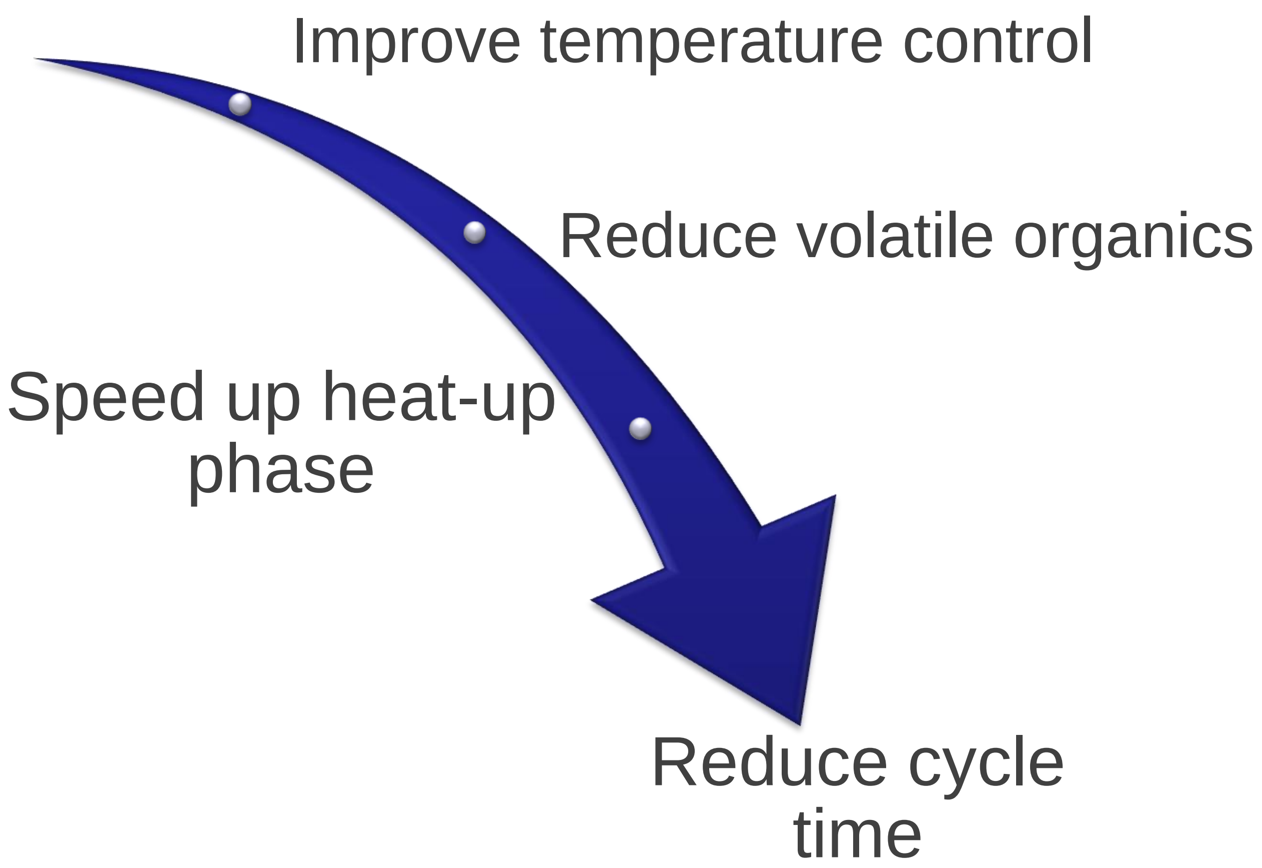
Improve control to make batches safer and faster



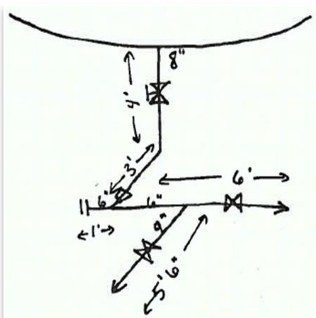
Cost Justification of New Instruments

Define as an "enabling" project

Example:



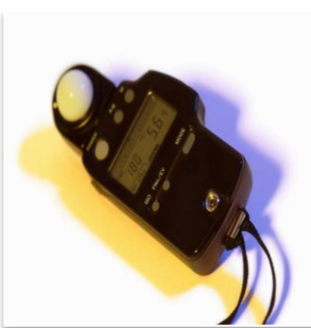
Use field measurements for instrument sizing



Worth time to walk down the system

Use spreadsheets or software to speed up dP calculations

	Pump Disch. to Junction A		
Fitting	Number	Equiv. Ft. each	Equiv. Ft. Total
Horz. Pipe			8
Vert. Pipe			18
Ft Pipe			26
Ells-short	8	5.25	42
Ells-long	2	3	6
Tee-branch			0
Tee-run	1		0



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

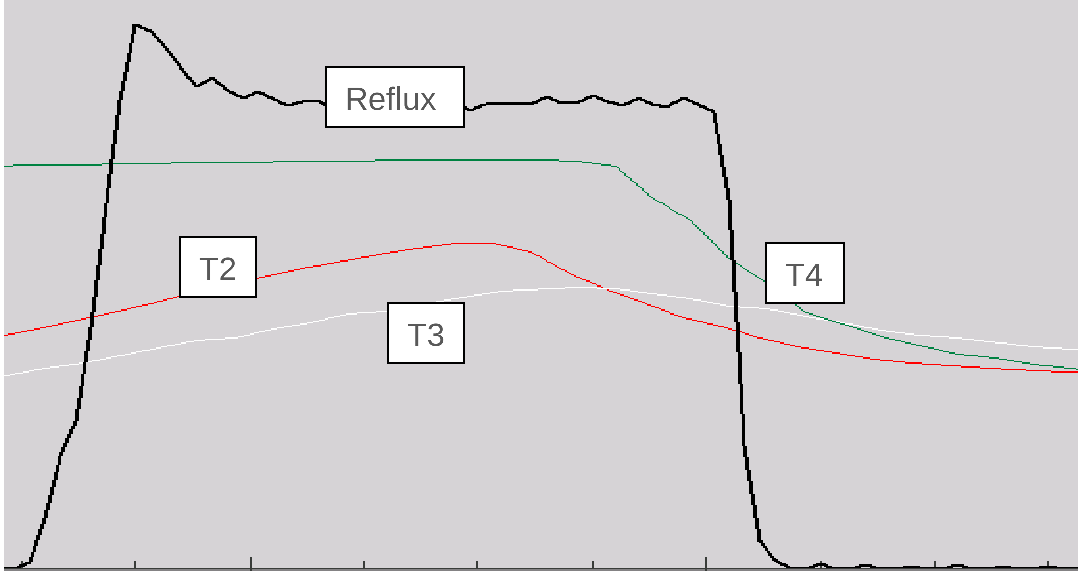
Watch out for high turndown and start/stop operations

- 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



- Consider channeling, dead time, range, and drift
- Try to keep things simple

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

TD2 =
- TD1 (time delay between change in bottom temp and change in control temp) - TD3 (time delay between change in reflux and change in control temperature)

TC2 =
- TC1 (time constant between change in bottom temp and change in control temp) - TC3 (time constant between change in reflux and change in control temperature)

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

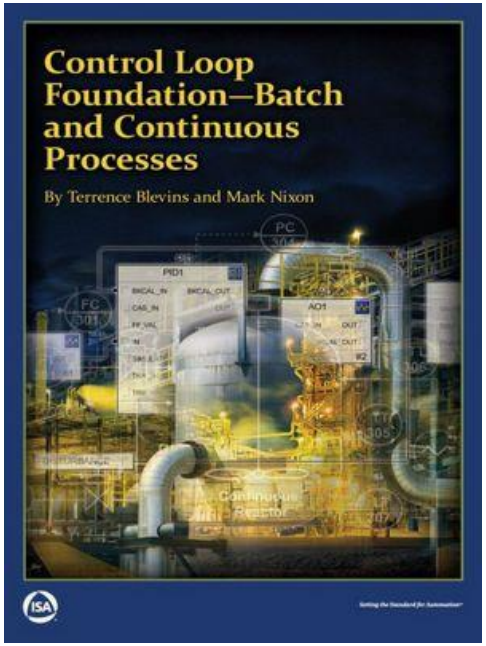
if TC2 > 0
- if TD2 > 0 then feed forward lead time = 0
  - else feed forward lead time = TD2
- feed forward lag time = TC2
- else feed forward lead time = TC2 & feed forward lag time = 0.2 x TC2 (increase to filter out noise in T1)

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

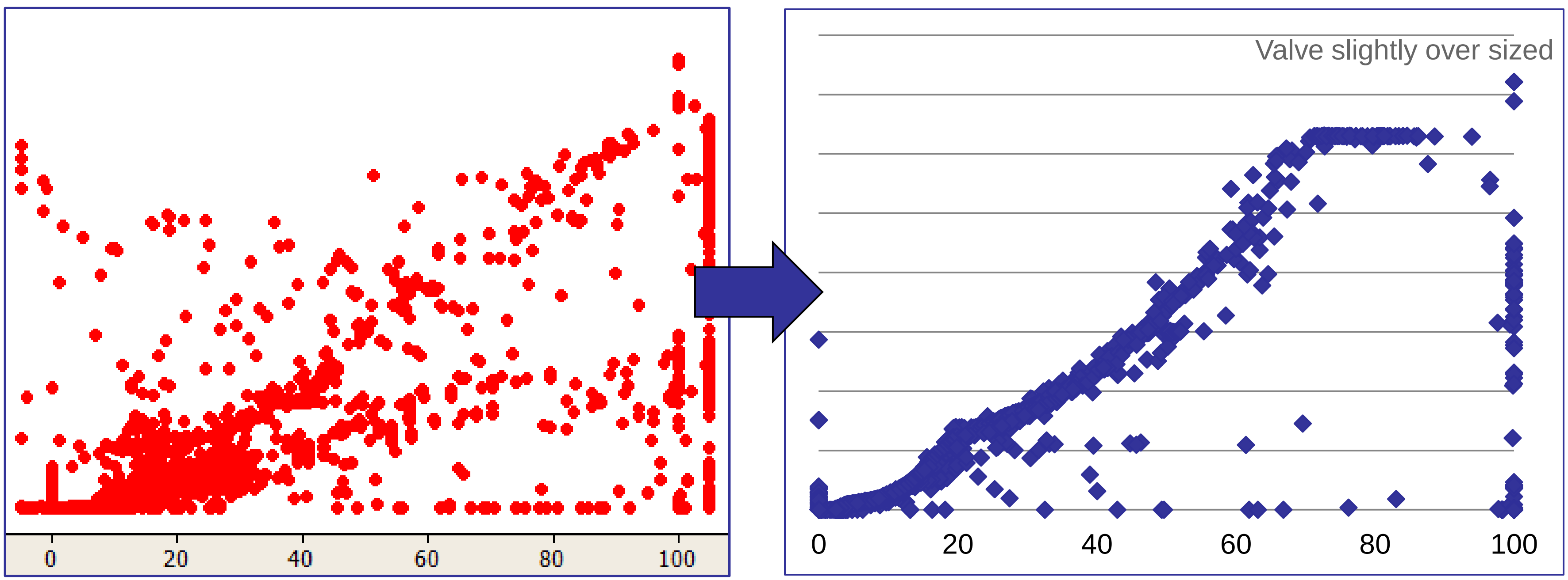


Example: Software set up to measure process dead time, gain, and time constants for slave and master loop automatically during batches

Final Results

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

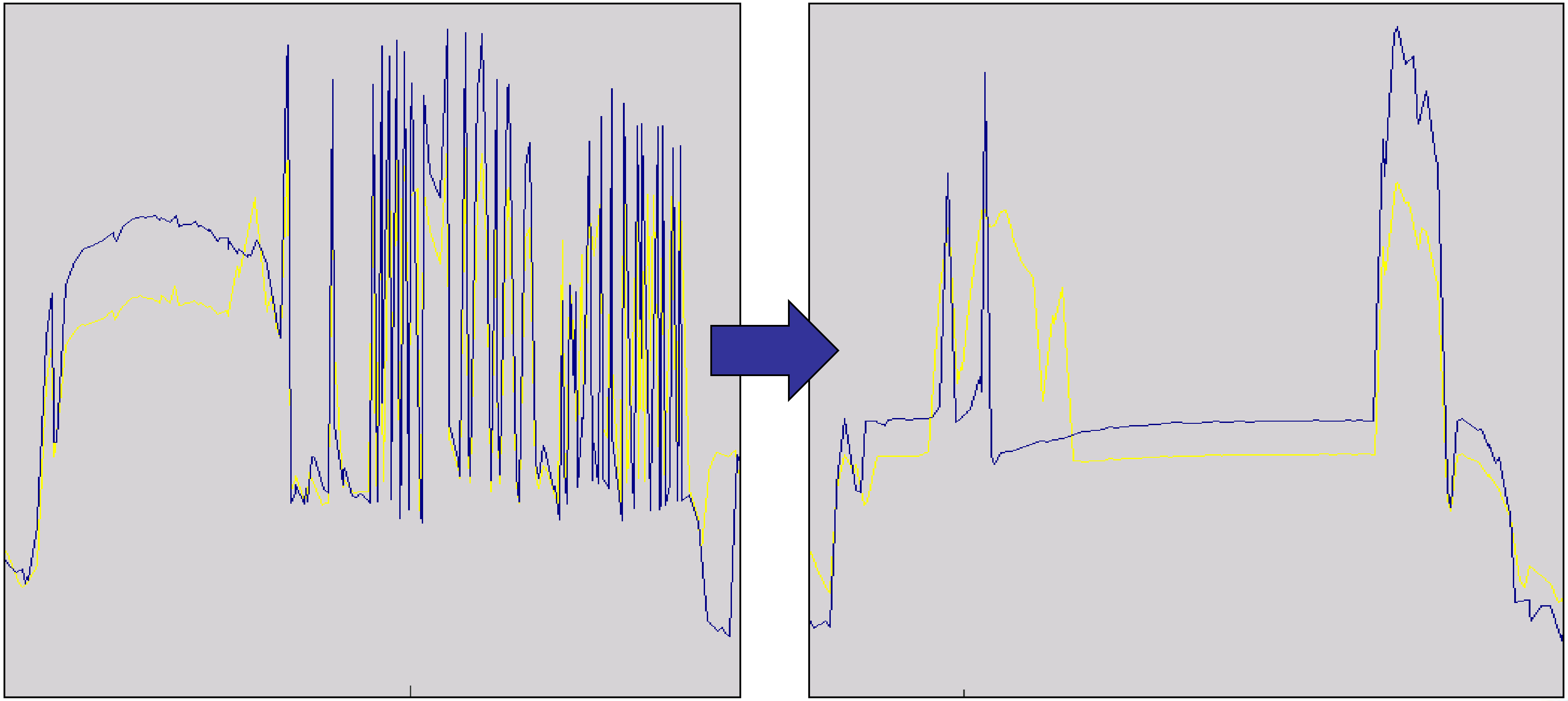
Flow



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/