



Process optimization with sensor analysis of industrial batches
Folyamatoptimalizálás ipari sarzsok szenzorelemzésével

Barbara Honti, Dorottya Winter, Zoltán Finta, András Szabó

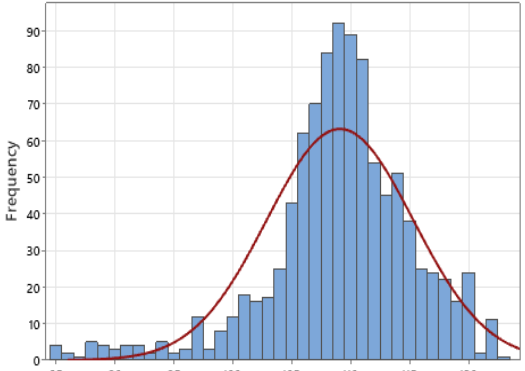
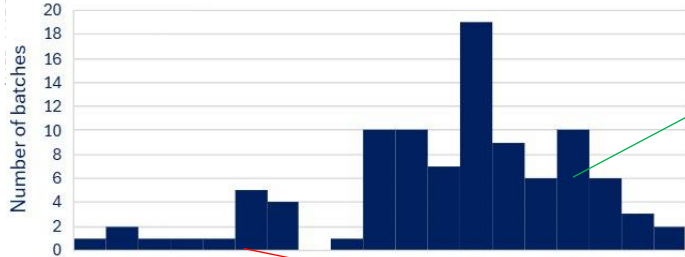
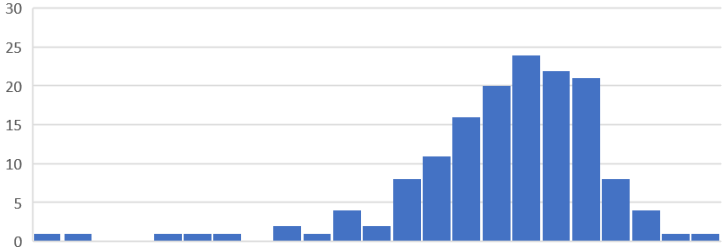
Adatvezérelt döntések a vegyiparban I. – Példák a jó gyakorlatra

27 Jan, 2026

open possibilities

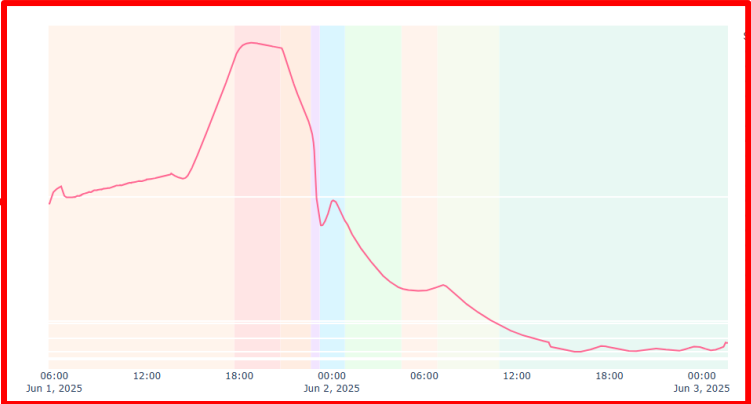
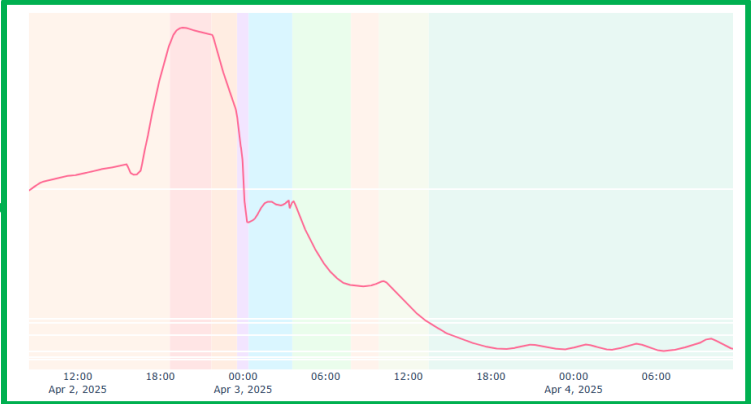
Same process. Same settings. Different outcome.

Yield Distribution



Mean 109.1
StDev 6.221
N 985

Both runs within dossie limits

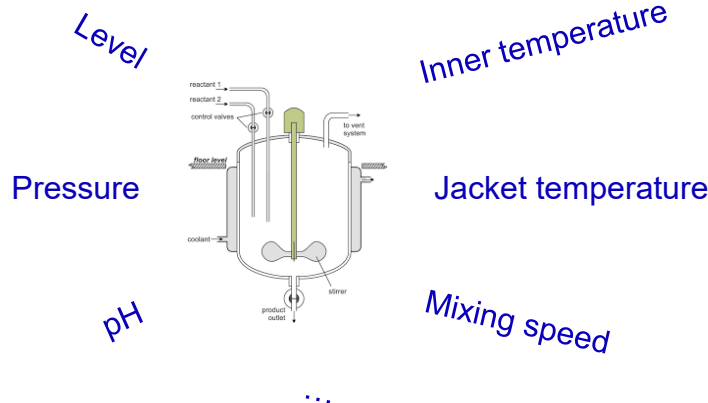
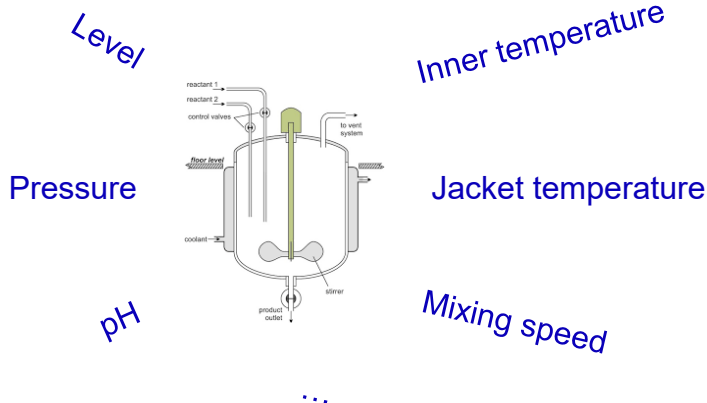


So where does the difference come from?

Why classical evaluation is often not enough?

Equipment 1

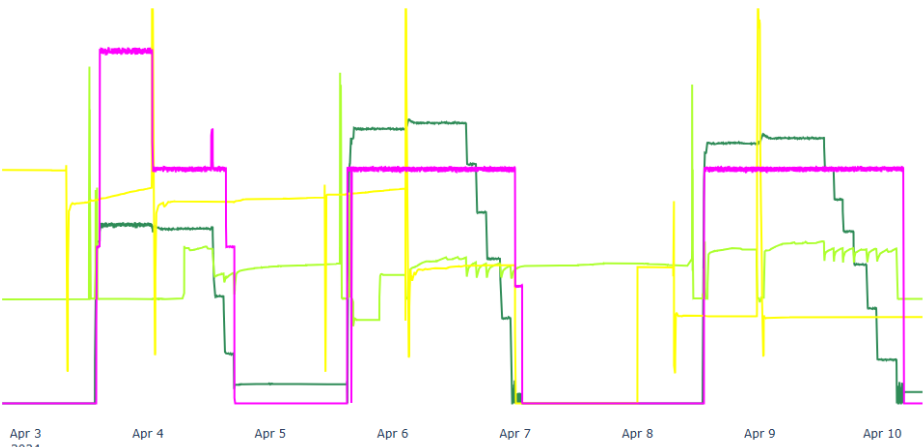
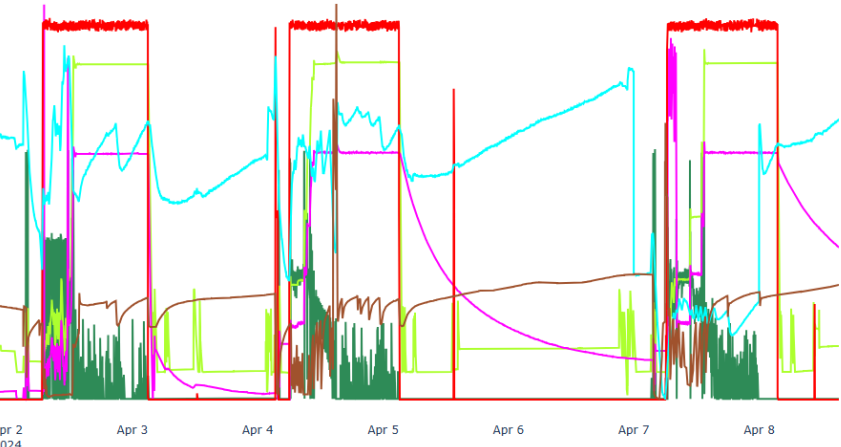
Equipment 2



Basic visual batch comparisons

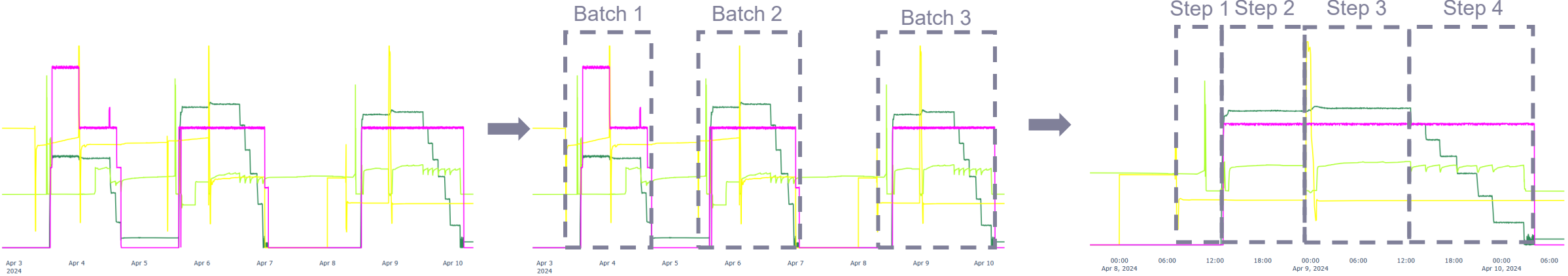
Analysis in Excel:

- averages
- min/max
- limits

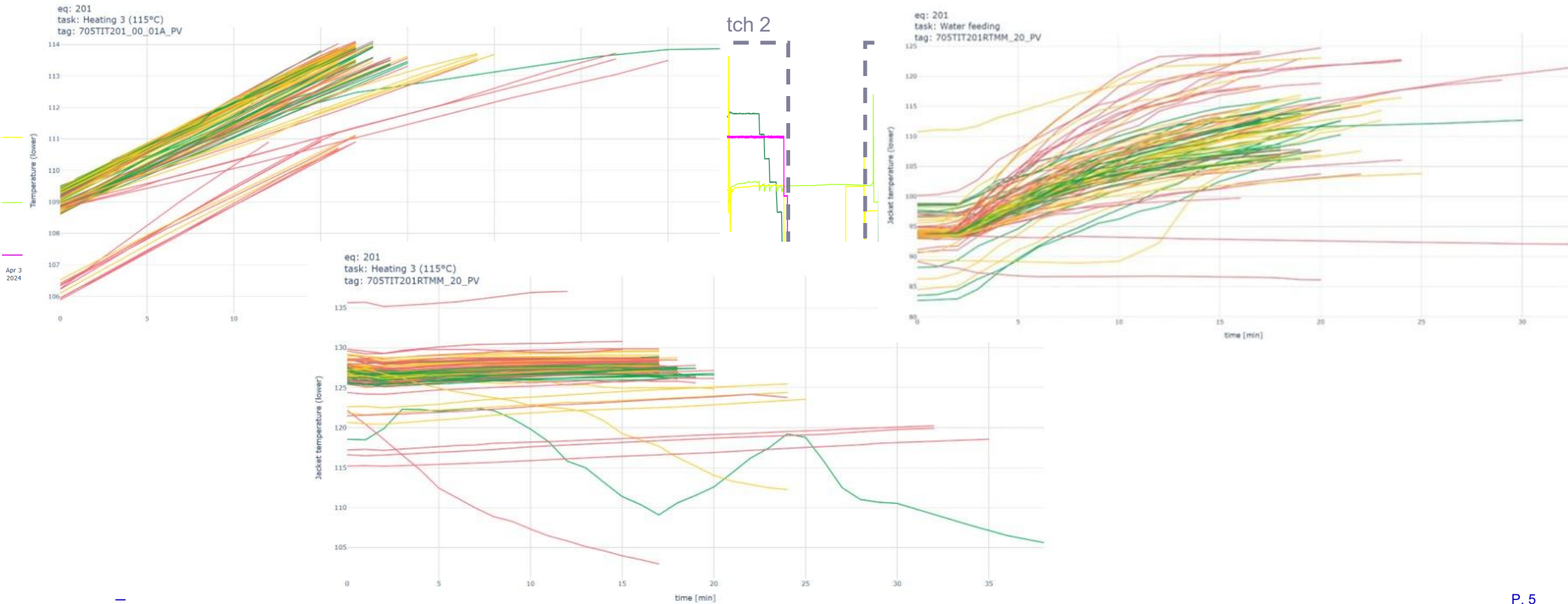


How to handle big data and complex relationships?

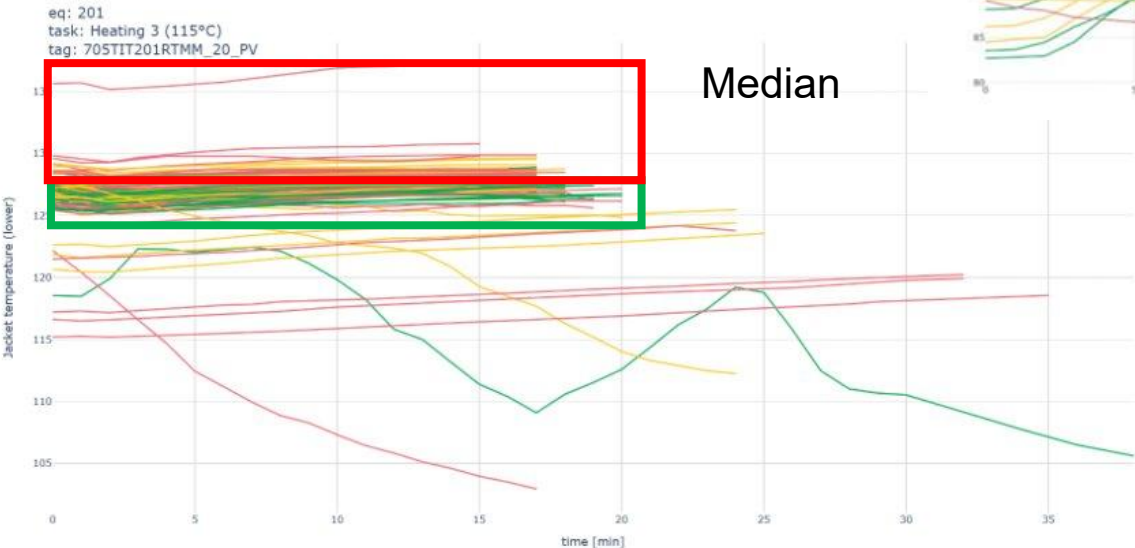
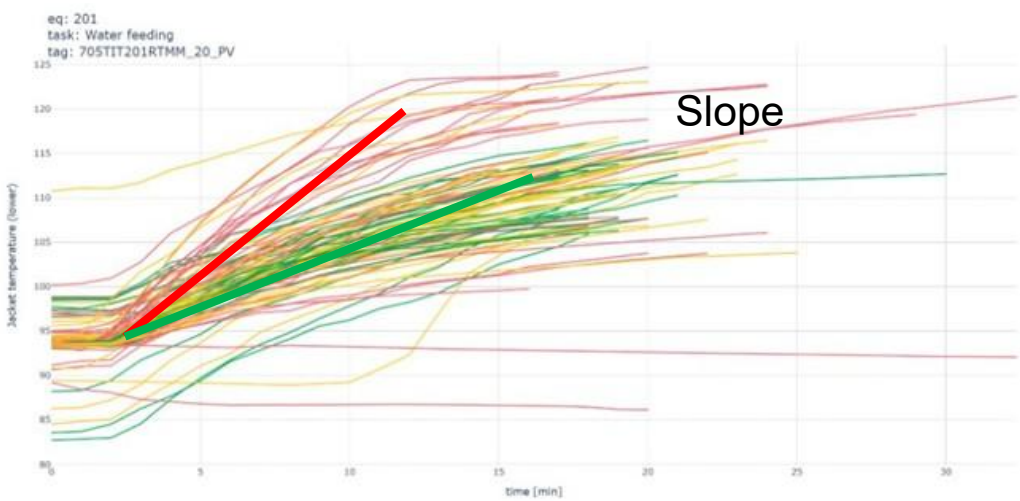
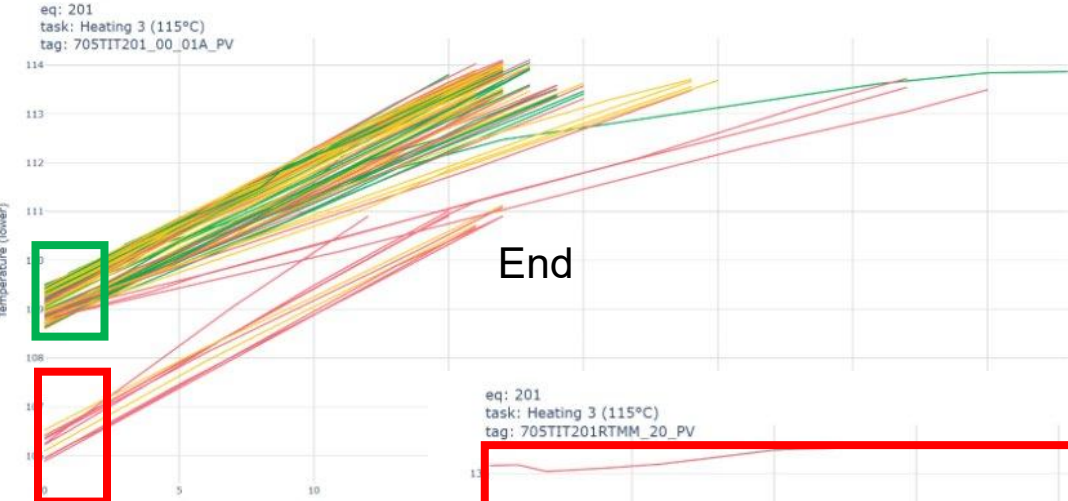
SPA workflow: from raw data to process insight



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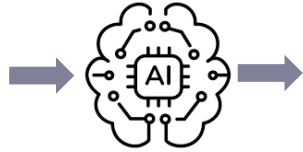


SPA workflow: from raw data to process insight



Feature list

- HCl adding duration
- HCl adding inner temp start
- Heating 1 jacket temp slope
- Heating 1 mixing speed
- Material transfer duration
- etc.

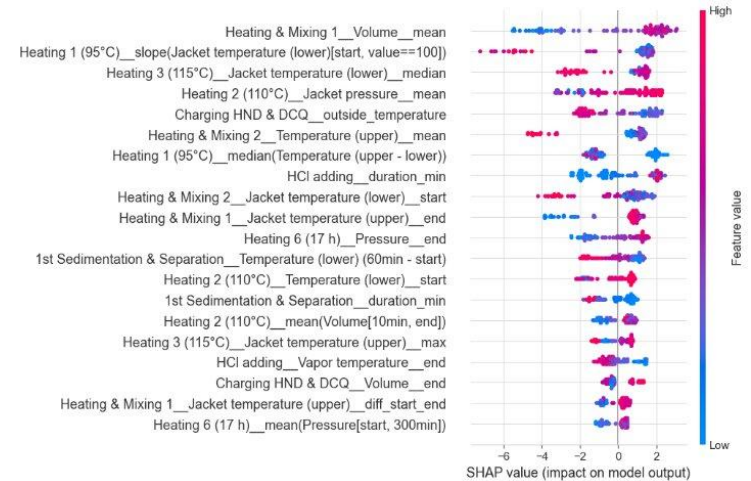


Feature list	Recommendation	Effect on target KPI
HCl adding duration	increase	0.4 %
HCl adding inner temp start	decrease	0.03 %
Heating 1 jacket temp slope	decrease	0.6 %
Heating 1 mixing speed	increase	0.1 %
Material transfer duration	increase	0.2 %
etc.		

- HCl adding duration
- HCl adding inner temp start
- Heating 1 jacket temp slope
- Heating 1 mixing speed
- Material transfer duration
- etc.

~300 features

Ranked feature list



SPA workflow: from raw data to process insight

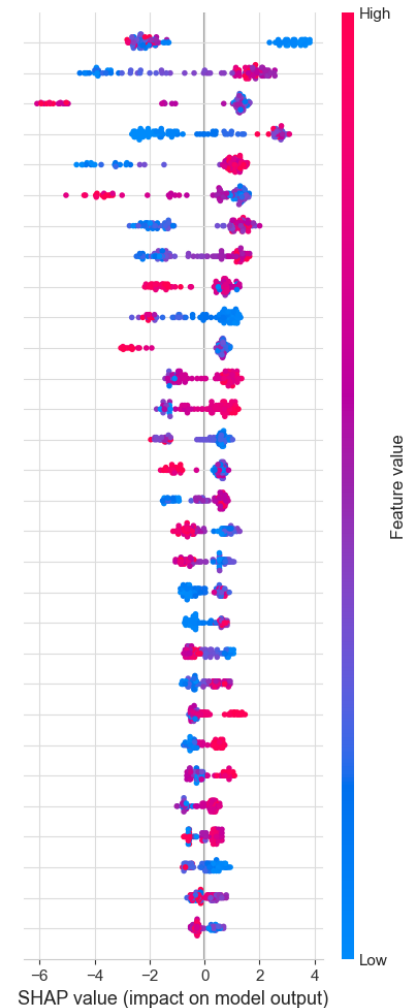


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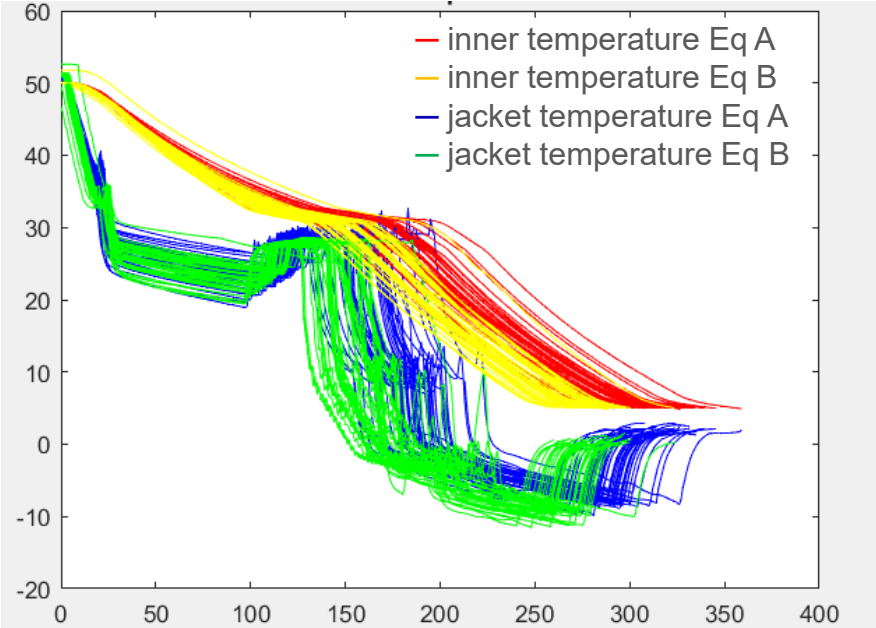


Ranked feature list

- Heating 1 (95°C)__median(Temperature (upper - lower))
- Heating & Mixing 1__Volume__mean
- Heating 1 (95°C)__slope(Jacket temperature (lower)[start, value==100])
- Heating & Mixing 1__Jacket temperature (upper)__end
- * Heating & Mixing 2__Jacket temperature (lower)__start
- Heating 2 (110°C)__mean(Volume[10min, end])
- Heating 6 (17 h)__Pressure__end
- Heating 3 (115°C)__Jacket temperature (lower)__median
- 1st Sedimentation & Separation__duration_min
- Heating & Mixing 2__Temperature (upper)__mean
- Heating 1 (95°C)__median(Jacket temperature (upper - lower))
- Heating 2 (110°C)__Jacket pressure__mean
- Heating 6 (17 h)__Temperature (upper)__start
- 1st Sedimentation & Separation__Temperature (lower)[60min]
- Heating 5 (124°C)__Jacket temperature (upper)__max
- 1st Sedimentation & Separation__Temperature (lower) (60min - start)
- Charging HND & DCQ__outside_temperature
- HCl adding__max(Temperature (upper - lower))
- 2nd Sedimentation__duration_min
- * HCl adding__Vapor temperature__end
- Charging HND & DCQ__duration_min
- 1st Sedimentation & Separation__Volume (max - end)
- Charging HND & DCQ__Temperature (upper)__start
- Charging HND & DCQ__Volume__end
- * Heating & Mixing 1__Jacket temperature (upper)__diff_start_end
- Heating 3 (115°C)__Jacket temperature (upper)__max
- * [Heating 2 (110°C), Heating 5 (124°C)]__duration_min
- Heating 6 (17 h)__mean(Pressure[start, 300min])
- * Heating 1 (95°C)__outside_temperature

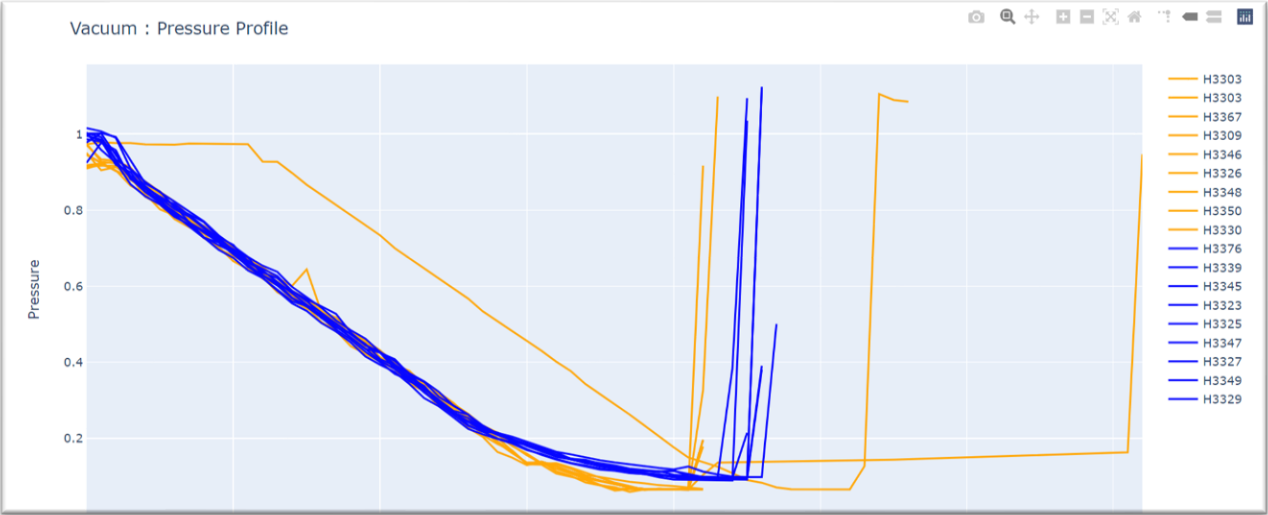


Surprising results – identical vessel ≠ identical behavior

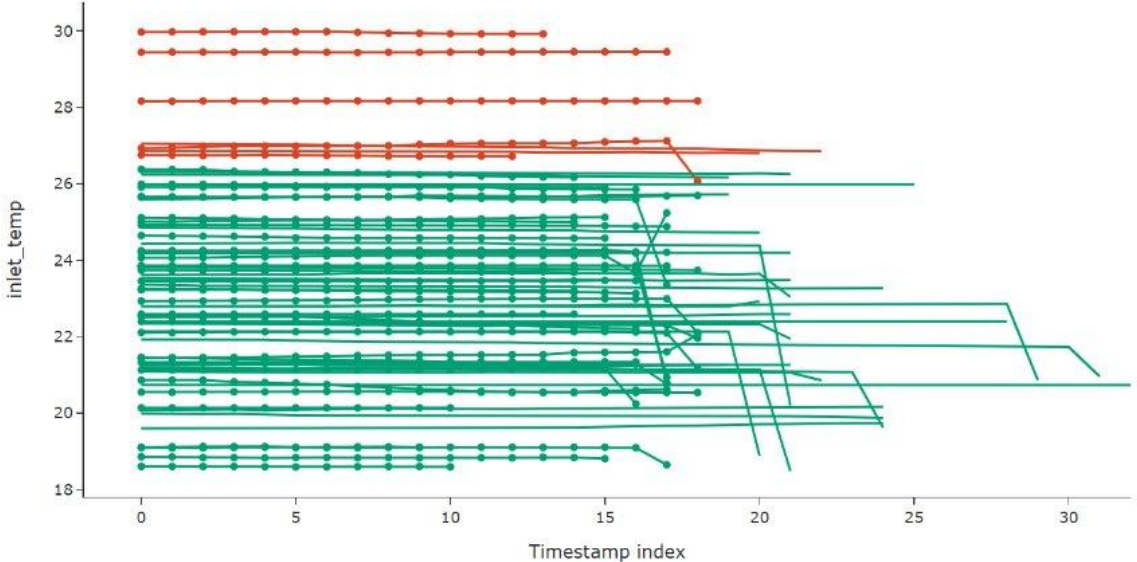


Temperature during crystallization

- ✓ Same setting
- ✓ Same design
- ✗ Different process dynamics



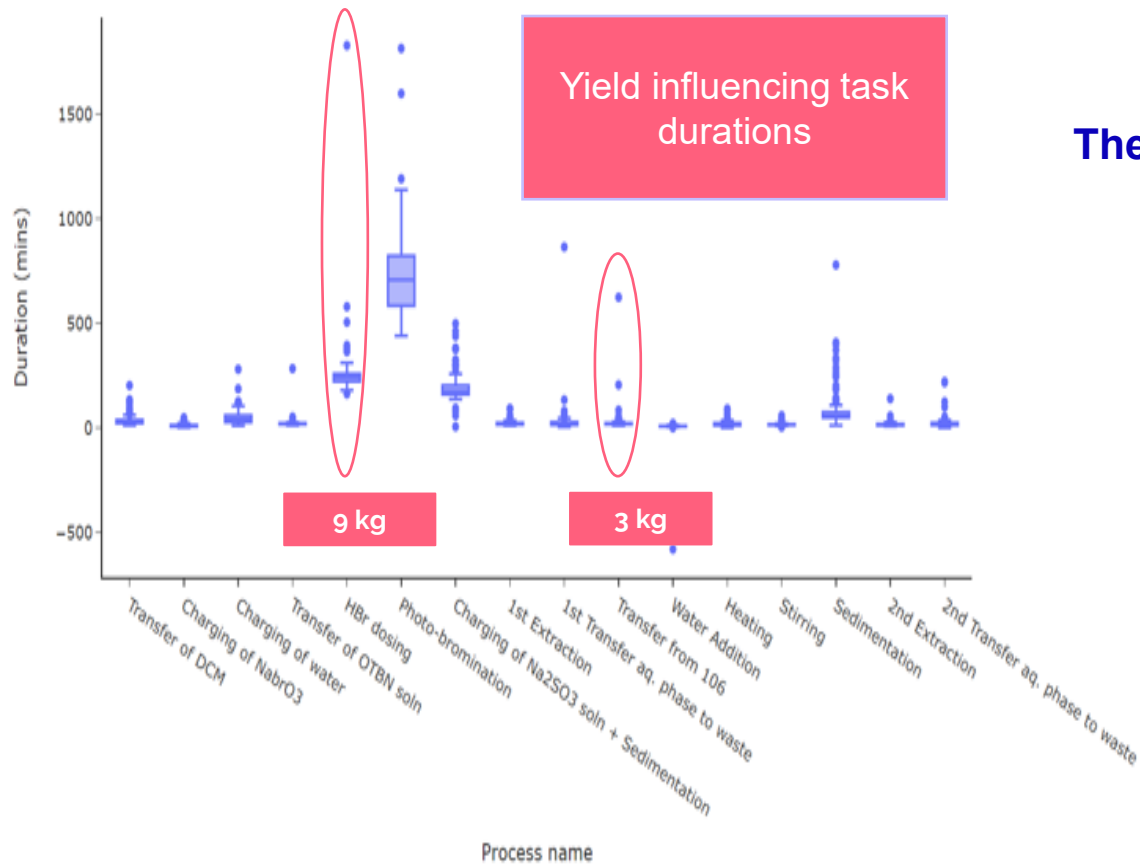
Pressure during drying



Temperature control of an empty vessel

- Seasonality effect
- Higher wall temperature during summer
- Material evaporation during charging

Surprising results – Task duration can also affect the yield



The task with most variation is may not influencing the target KPI

- ✓ Same target conditions
- ✗ Different durations

Summary

1. Yield variability often hides within normal operation
2. Visualization is important
3. Batch processes must be analyzed as time-dependent systems
4. Statistical Process Analysis supports process understanding

data → understanding → better decisions

Thank you!

Merci - Danke - Grazie - Köszönöm - Obrigada - Спасибо - ありがとうございます



Definition of SPA (Statistical Process Analysis)

SPA: A method for evaluating and understanding variability in a process by analyzing data from production or quality control.

Design of Experiments

Lab scale only:
Focuses on testing controlled changes to process variables to understand their impact on output.

Proactive

Statistical Process Analysis

Focuses on **historical production data to identify variations and trends in the process.**

Reactive, diagnostic

Statistical Process Control

Focuses on monitoring and control the process parameters real time through control charts to maintain best outcome

Reactive in real time

It enables:

- Data-driven decision making
- Improvements in efficiency and quality



Challenges in the Chemical Industry:

- High complexity: chemical processes involve complex reactions and dependencies >> **hard to identify isolated causes.**
- Data Volume & Variability: large data sets, multiple sensors require advanced analytics. >> **redundant information**
- Compliance & Safety: strict regulatory standards add complexity to process changes >> **partial correlations**