Using Basetwo for Predictive Quality Control in Monomer Production

A soft sensing approach to support real-time quality monitoring and control.

Basetwo

Problem

As demand for high-performance adhesives increases, forward-looking manufacturers must consistently produce crosslinking monomers that meet tight specifications to ensure reliable downstream polymer properties.

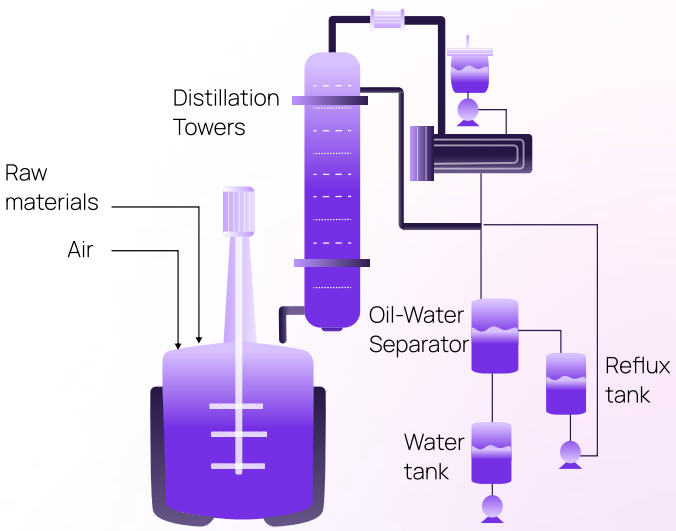
Producing these monomers at consistent specification is challenging, particularly within reactive distillation systems, where reaction and separation occur simultaneously. These operations are highly sensitive to raw material variability, kinetic uncertainties, and plant disturbances. Minor deviations can significantly impact critical quality attributes (CQAs) such as purity, viscosity, and density, all of which directly influence the performance of the resulting polymers and adhesives.

Historically, this Basetwo customer has relied on offline lab measurements and experimental trials to monitor monomer quality. This approach introduces several limitations:

- **Delayed quality visibility:** Lab analyses provide insight only after samples are processed, making it difficult to correct deviations.
- **Prolonged cycle times:** Experimental runs and lab testing slow down decision-making and extend batch durations.
- **High operational costs:** Rework, extensive sampling, and conservative operating strategies increase energy usage and raw material consumption.

This lack of real-time insight ultimately limits the ability to proactively control product quality, optimize cycle time, and improve energy efficiency within the reactive distillation process.

Reactive distillation process for the production of specialty monomers:



Objective

This manufacturer's goal was to develop a predictive digital twin capable of delivering real-time insight into product quality and monomer process performance within their reactive distillation process. Specifically, the digital twin needed to:

- Predict key quality attributes in real time
- Reduce cycle time, raw material consumption, and energy usage
- Proactively mitigate batch quality issues

Solution on Basetwo

Data Integration & Transformation

Basetwo's digital twin platform integrated the chemical manufacturer's historical reactive distillation process data from process historians, ELNs, and LIMS systems. Key datasets included:

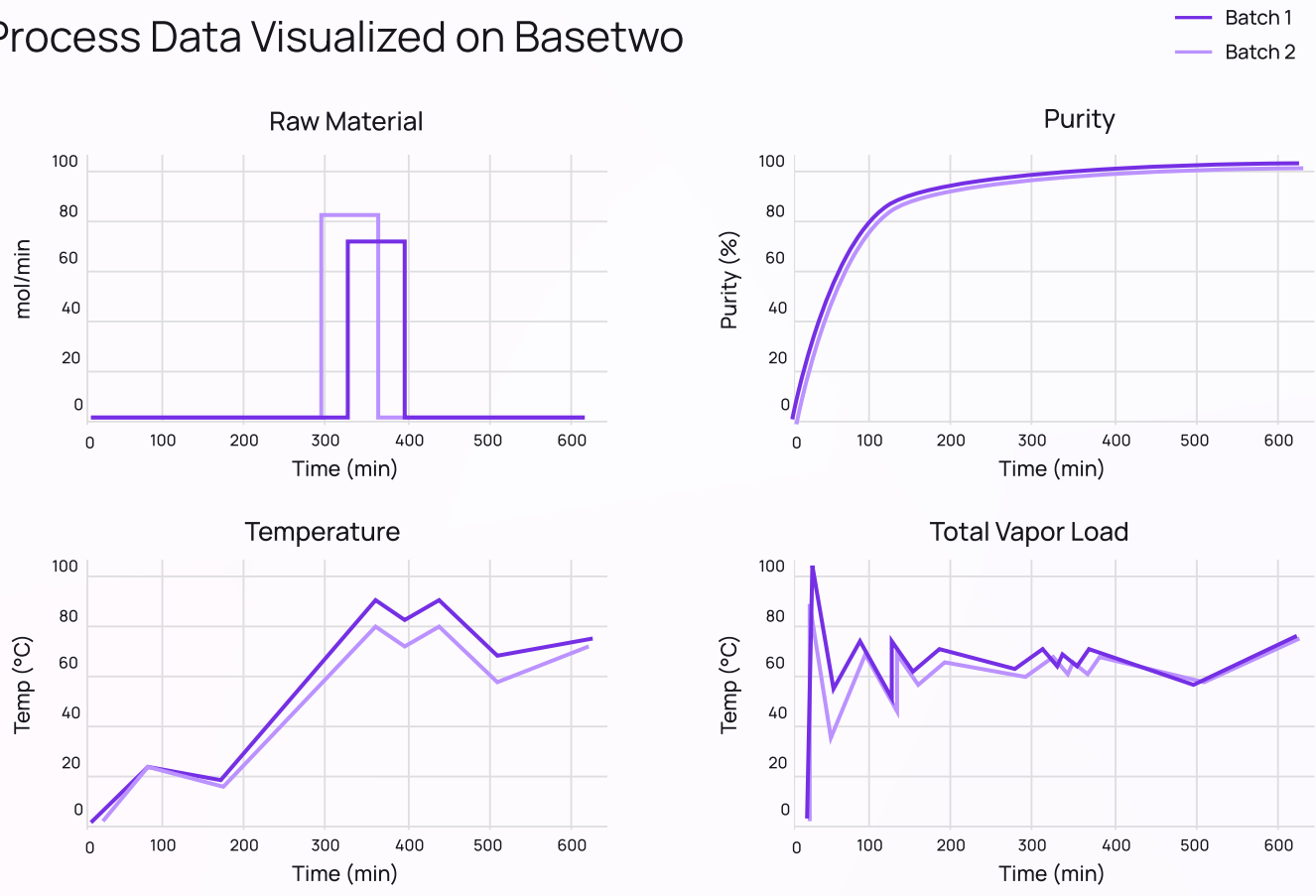
Process parameters: pressure, flow rates, temperature, etc.

Lab quality data (measured end-of-batch or intermittently): viscosity, GC for reaction ratio, density, purity

Equipment specs: diameters, height, tray details, etc.

Using Basetwo, they were able to seamlessly integrate their data and build a model that identified deviations in their process and quality performance metrics in real-time.

Process Data Visualized on Basetwo



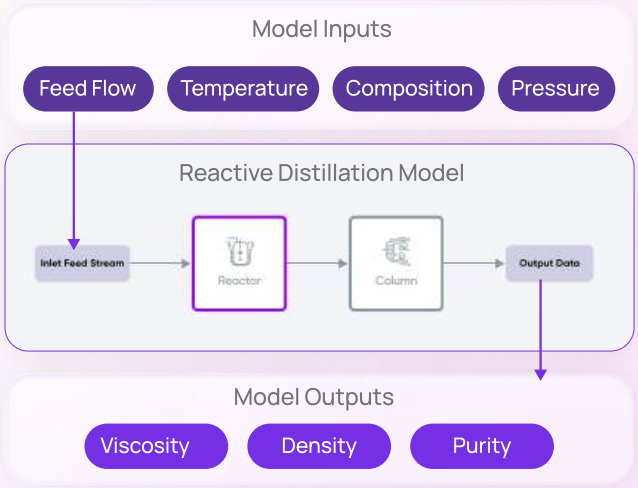
Solution on Basetwo

Model Development

A hybrid modeling combining mechanistic and machine learning approaches was used.

Reactive Distillation Digital Twin: The Hybrid Model

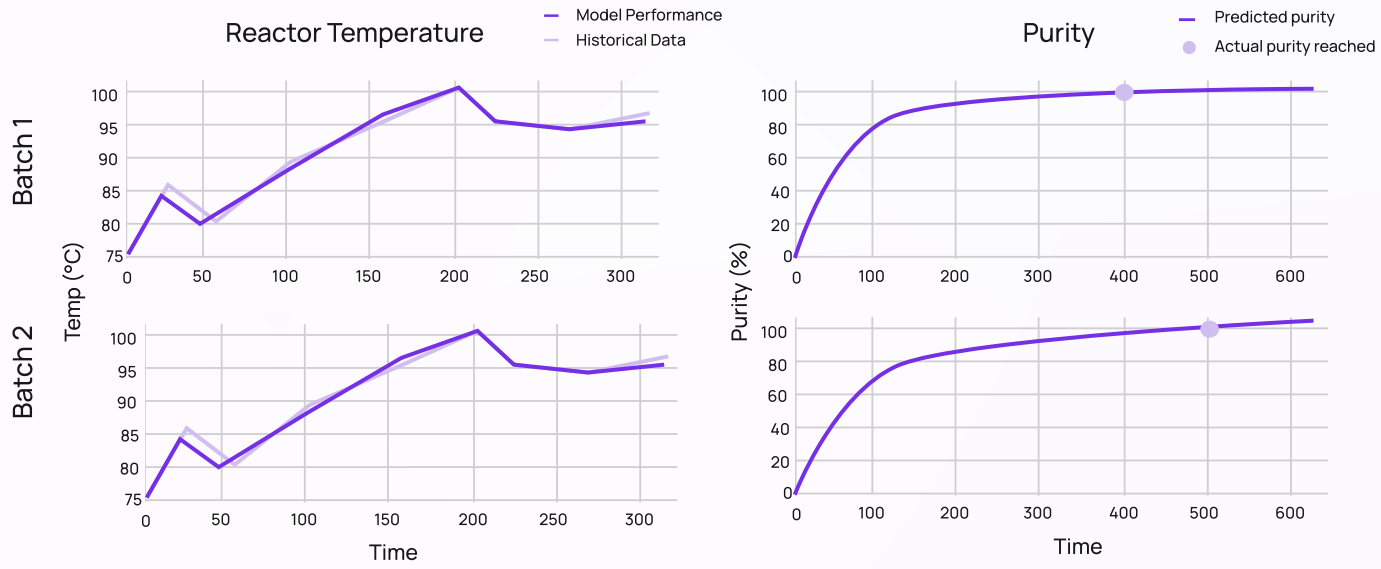
The hybrid model enables accurate process simulation even when data is sparse, kinetics are unknown, or processes exhibit complex nonlinear behavior.



Modeling Results

Model validation confirmed a high degree of accuracy and scalability, with predictions closely mirroring real-world process outcomes. The digital twin achieved over a 94% accuracy in predicting distillation dynamics (temperature) and product quality (purity).

Reactive Distillation Hybrid Model Performance

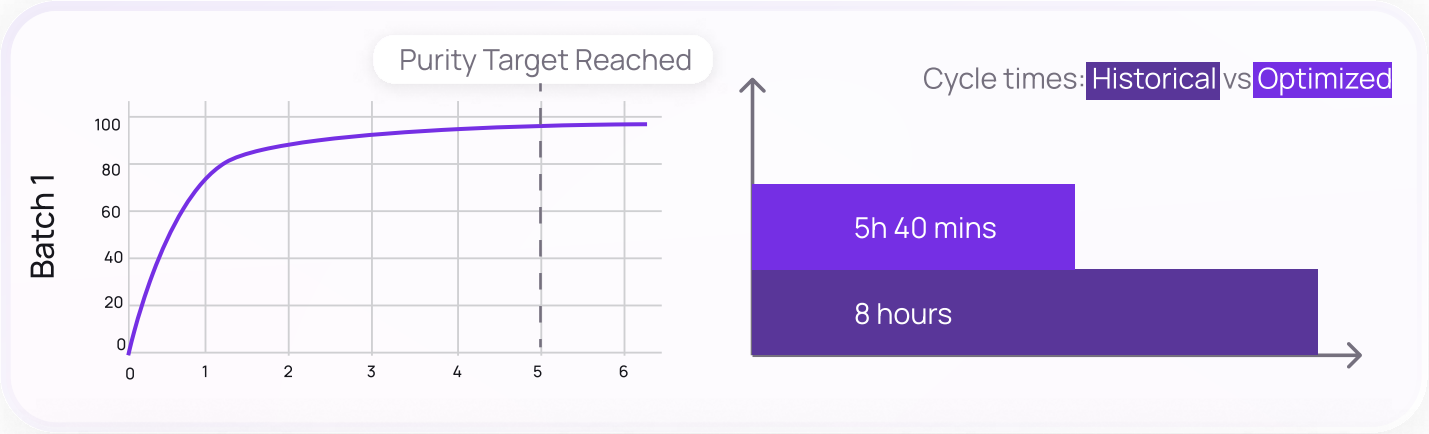


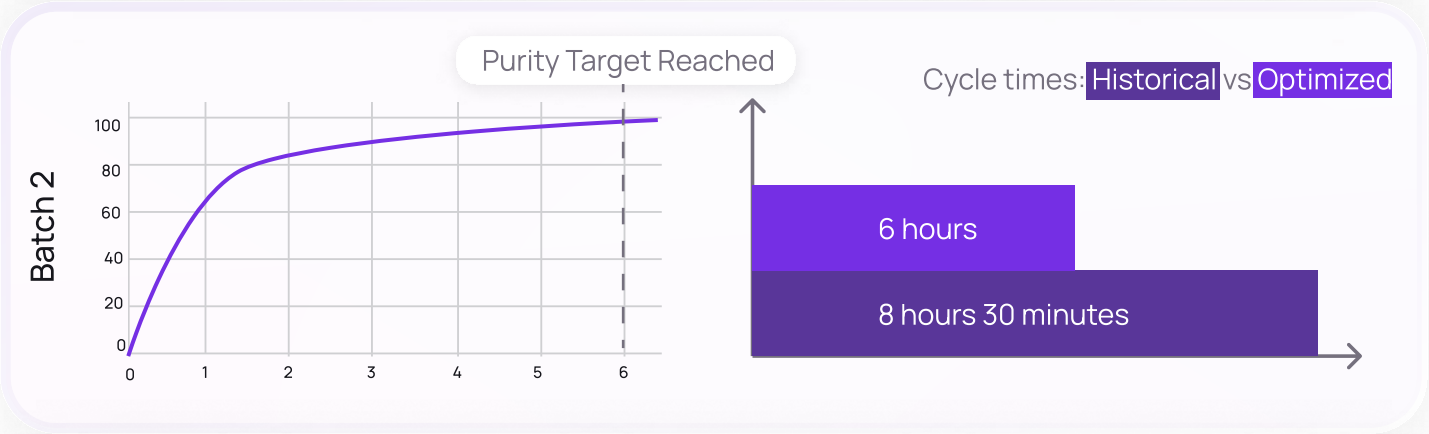
Model Applications

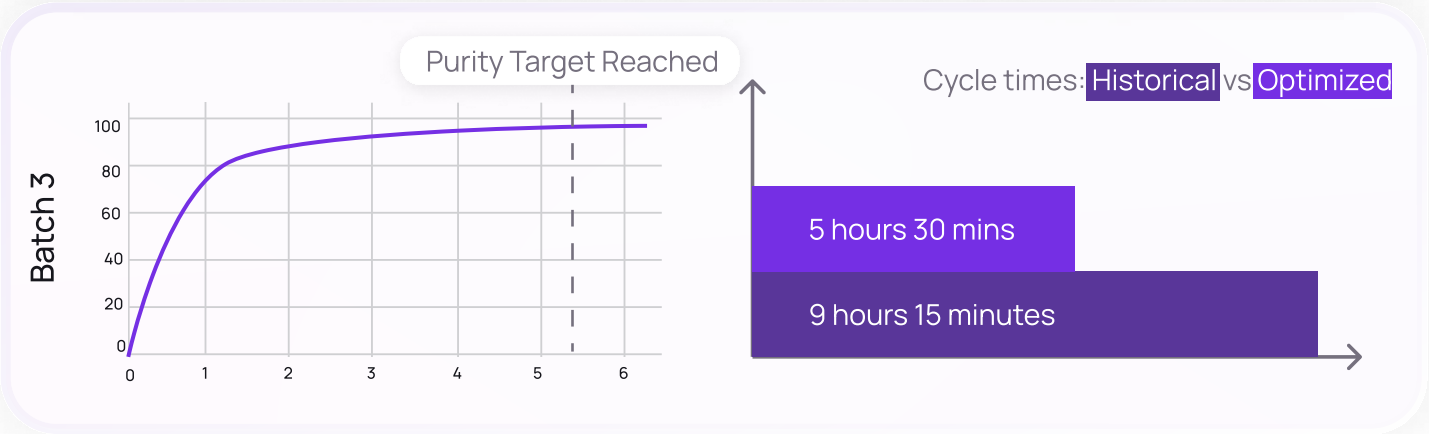
Soft Sensing for Purity Monitoring

Through soft sensing on Basetwo, the manufacturer is able to measure purity over the course of their batches, a variable that was previously only measured at the end of a batch.

The model accurately tracked purity at every stage of the batch process, enabling precise endpoint determination that prevents overrunning and optimizes cycle efficiency. The result was a reduction in production cycle times **by over 30%**.





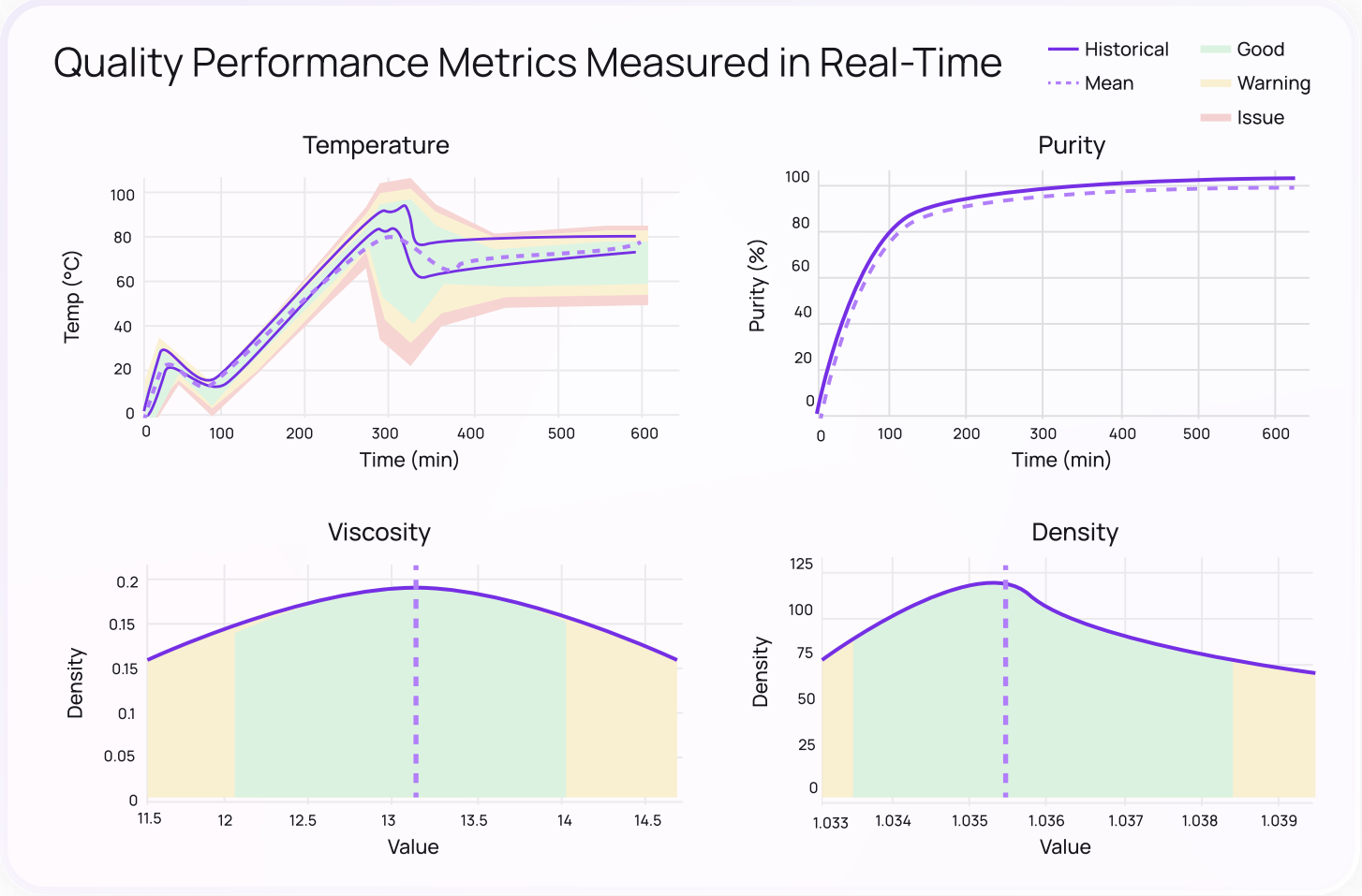


Model Applications

Process Verification

With the digital twin, they could ensure batch quality remained throughout. The process model enabled early detection of parameter deviations and their impact on quality, creating opportunities for proactive intervention.

Resonac leveraged ongoing process verification and advanced process control to ensure each batch meets quality requirements in real-time.

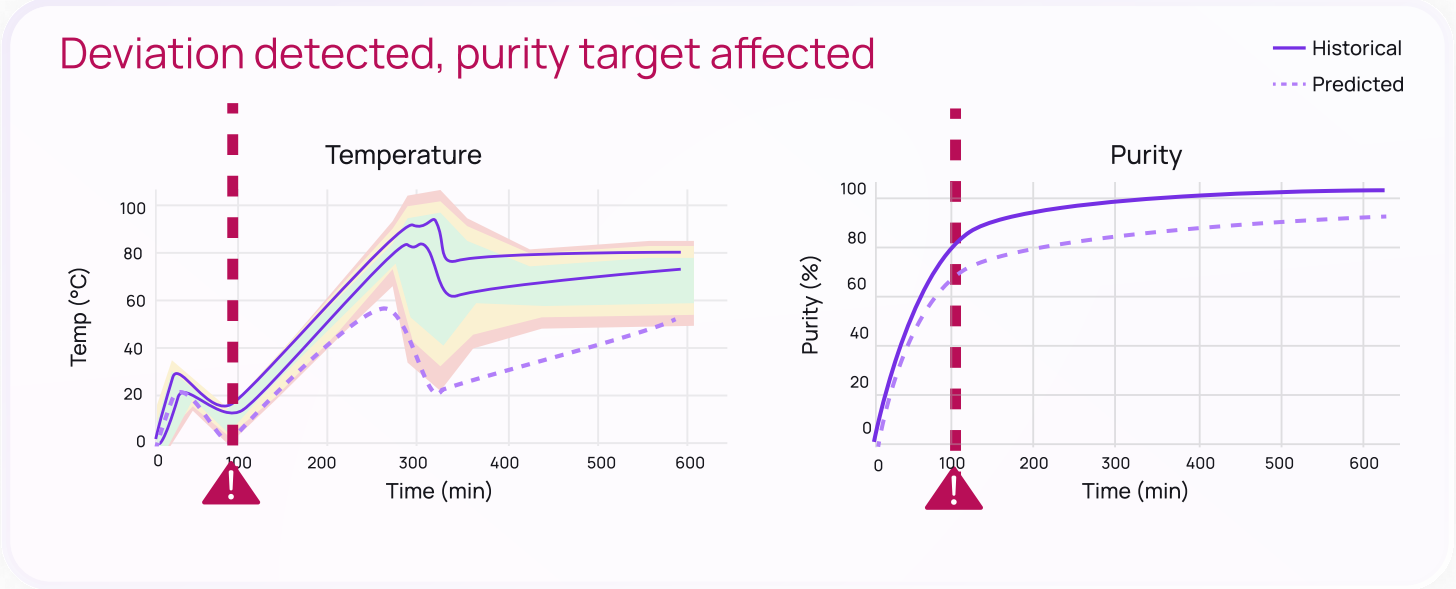


The above figure shows the comparison of real-time metrics to historical performance within the Basetwo platform. The green standard-deviation band represents the normal operating window. The yellow region indicates a warning zone where the process begins to drift, and the red region marks the issue zone where values fall outside acceptable limits and may signal a quality or process deviation.

Together, these bands allow operators to quickly determine whether temperature, purity progression, viscosity, and density remain within safe and optimal limits.

The result was an accurate and proactive detection of product quality using process variables.

This approach enabled an **80% reduction** in batch failures; reducing product waste, rework time, and associated costs.

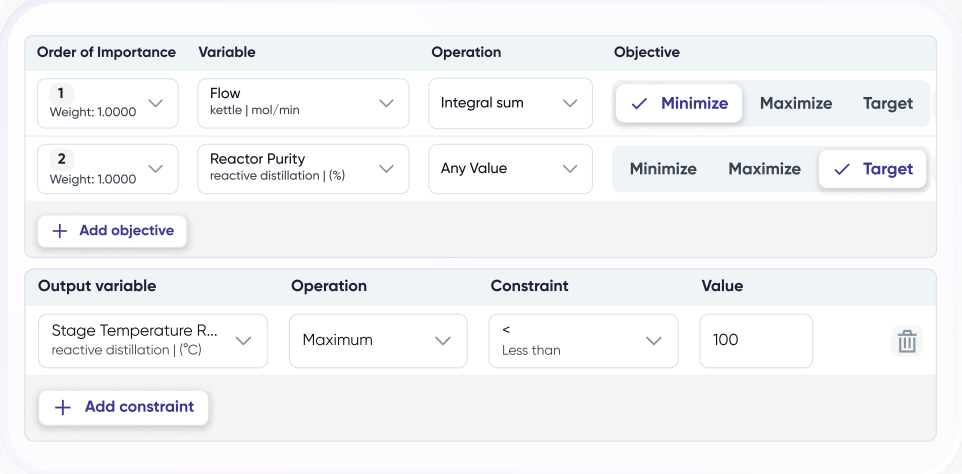


Model Applications

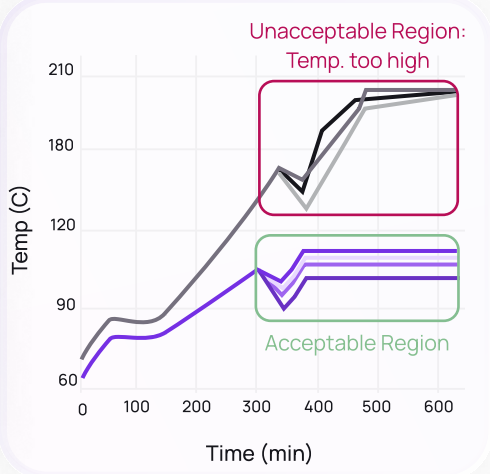
Process Optimization

The manufacturer leverage multi-objective process optimization on the Basetwo platform, reducing chemical usage **by 30%** while maintaining product purity and respective temperature constraints.

1 Configure objectives, targets, and constraints



2 Explore Optimization Output



Solution on Basetwo

Impact of Predictive Quality Control

With the implementation of real-time soft sensing, this customer was able to transition from reactive, lab-dependent quality control to continuous, in-process monitoring. The optimization of their reactive distillation system allowed the manufacturer to maintain stable reaction kinetics, ensure consistent product quality attributes, despite feed variability and plant disturbances.

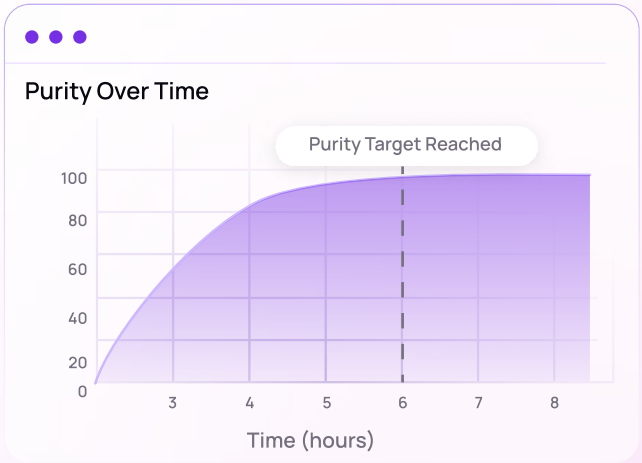
29% reduction in cycle times

80% reduction in batch failures

30% reduction in raw material usage

A Platform Built by Engineers for Engineers

- Rapid cloud-based deployment in weeks.
- Intuitive, drag-and-drop interface; for simplified simulation, monitoring, and optimization.
- Live process models deployed as reusable, scalable workflows



Learn how Basetwo improve the quality monitoring of your specialty chemical workflows

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