Accelerate the development of personal care products with Basetwo

A digital twin approach to predict complex quality attributes and optimize emulsion mixing controls across scales

Basetwo

Problem

As part of their broader digital transformation initiatives, many personal care product companies are identifying opportunities to modernize and optimize their mixing and scale-up workflows through digitalization and advanced modeling.

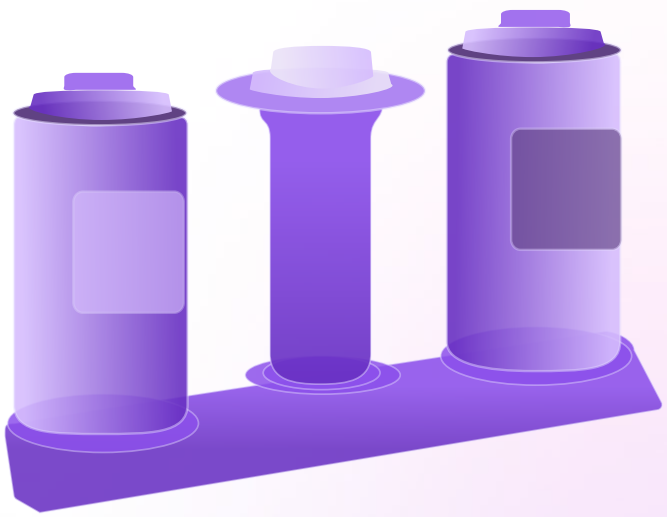
The development of products such as conditioners, creams, lotions, and other emulsions requires precise control of key quality attributes, such as viscosity and particle size distribution (PSD, to meet formulation, performance, and market requirements. Today, these outcomes are often determined through manual experimentation, which can be slow, costly, and difficult to scale across diverse product lines.

Traditionally, personal care R&D teams have relied on offline lab measurements and experimental trials to understand and monitor their mixing processes. This approach has several limitations:

- **No predictive insight** into viscosity or particle size development during mixing.
- **High experimental load** during process development and scale-up.
- **Inability to simulate process scenarios,** such as alternative equipment or formula tweaks.
- **Difficulty transferring learnings** between products, formulas, and mixer types.

Without digital modeling, manufacturers can't predict how mixing choices impact quality or scale-up behavior, slowing innovation and raising development costs.

Commercial scale mixing process:



Objective

A leading personal care manufacturer partnered with Basetwo to explore how digital twins could accelerate process optimization and verification across their mixing workflows. Beginning with one product (e.g., a hair conditioner) and production mixer, the initiative focused on three objectives:

- **Predict** viscosity and particle size distribution process characteristics
- **Optimize** to achieve target viscosity and PSD profiles with fewer experimental trials.
- **Enable scale-up** across formulations and equipment sizes.

Basetwo Solution

Data Integration & Transformation

The Basetwo platform integrated the manufacturer's historical mixing data from process historians, ELNs, and LIMS systems. Key datasets included:

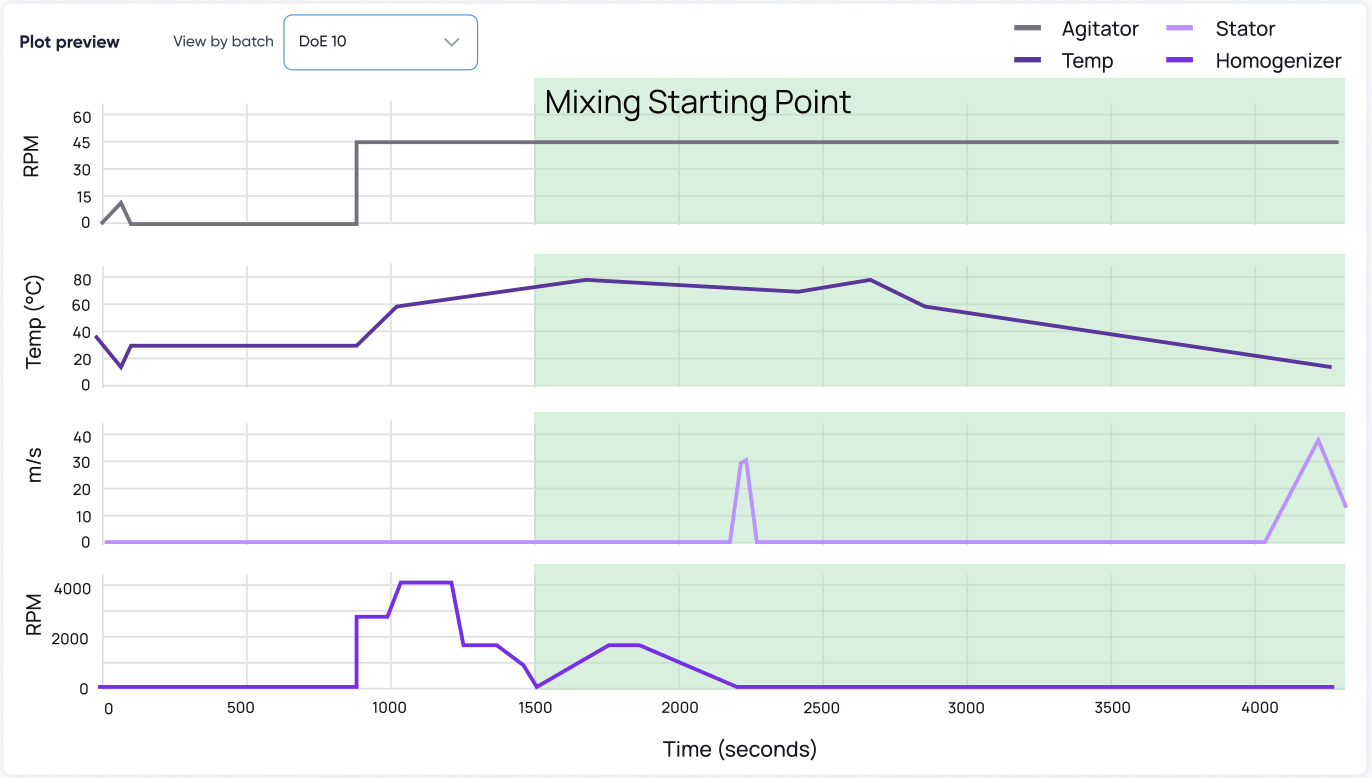
Process parameters:
mixer speed, cooling profile, Batch turnover

Formulation data:
oil phase composition, water phase, additives, physical properties

Equipment specs:
mixer and impeller dimensions, geometry

Using Basetwo, the manufacturer seamlessly integrated and analyzed the datasets. To prepare the data for modeling, they used the Data Labeler tool to identify the true start of the mixing process. By detecting a process signal that reliably drops to zero when mixing begins, they were able to isolate and partition the relevant data to form the foundation of their digital twin model.

Process Data Visualized on Basetwo



Basetwo Solution

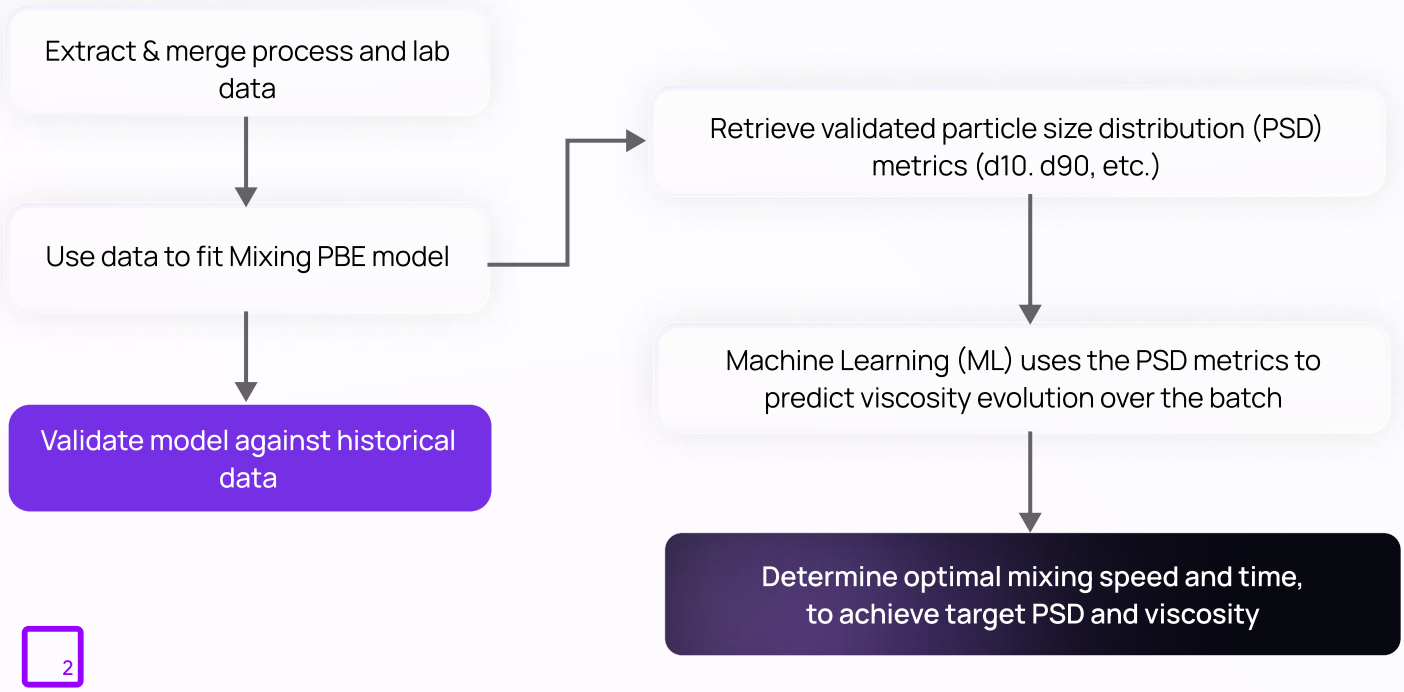
Model Development

The personal care manufacturer used Basetwo to build a hybrid digital twin by combining data preparation tools, a mechanistic population balance (PBE) model, and a machine learning–based viscosity model to simulate their mixing process.

In emulsions such as conditioners, creams, and lotions, particle size distribution (PSD) plays a critical role in determining texture, stability, and viscosity. The PBE model captures how droplets break up and coalesce under shear, enabling the manufacturer to predict how mixing speed, equipment geometry, and batch turnovers influence PSD over time.

A downstream ML model then maps PSD metrics (d10, d50, d90, packing factor) to final viscosity, creating a complete, predictive understanding of how process conditions drive product quality.

Digital Twin Workflow for Modeling PSD and Viscosity

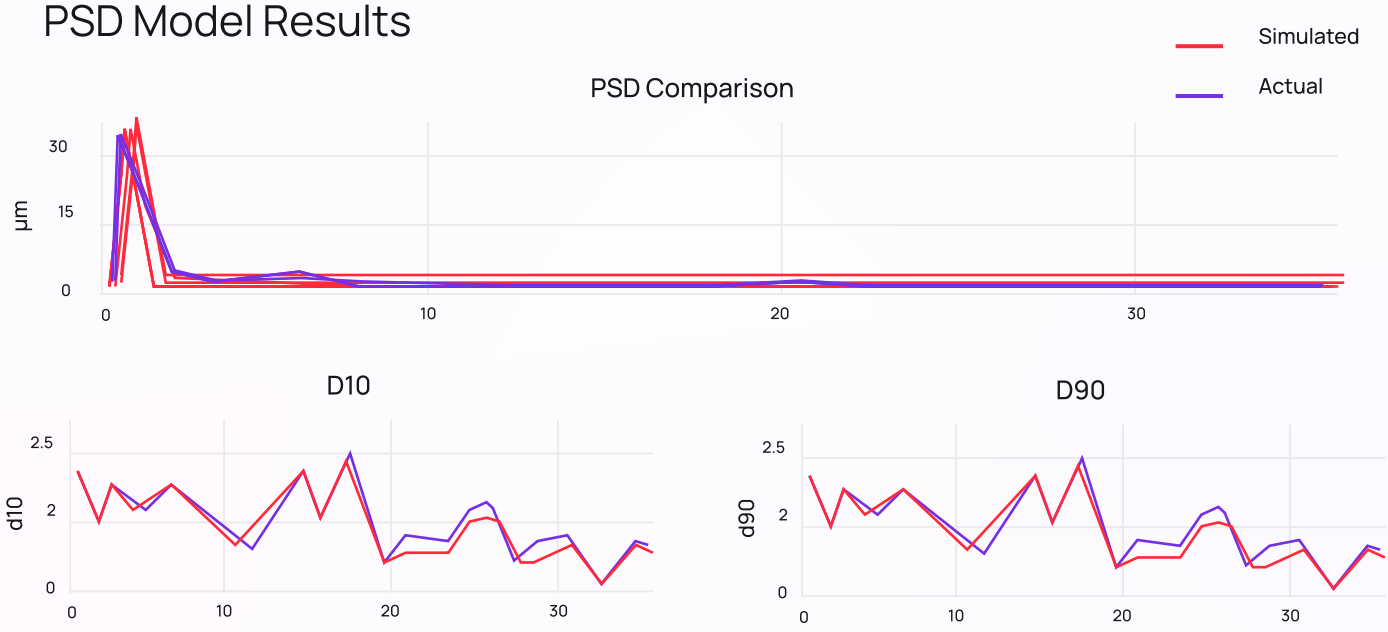


Basetwo Solution

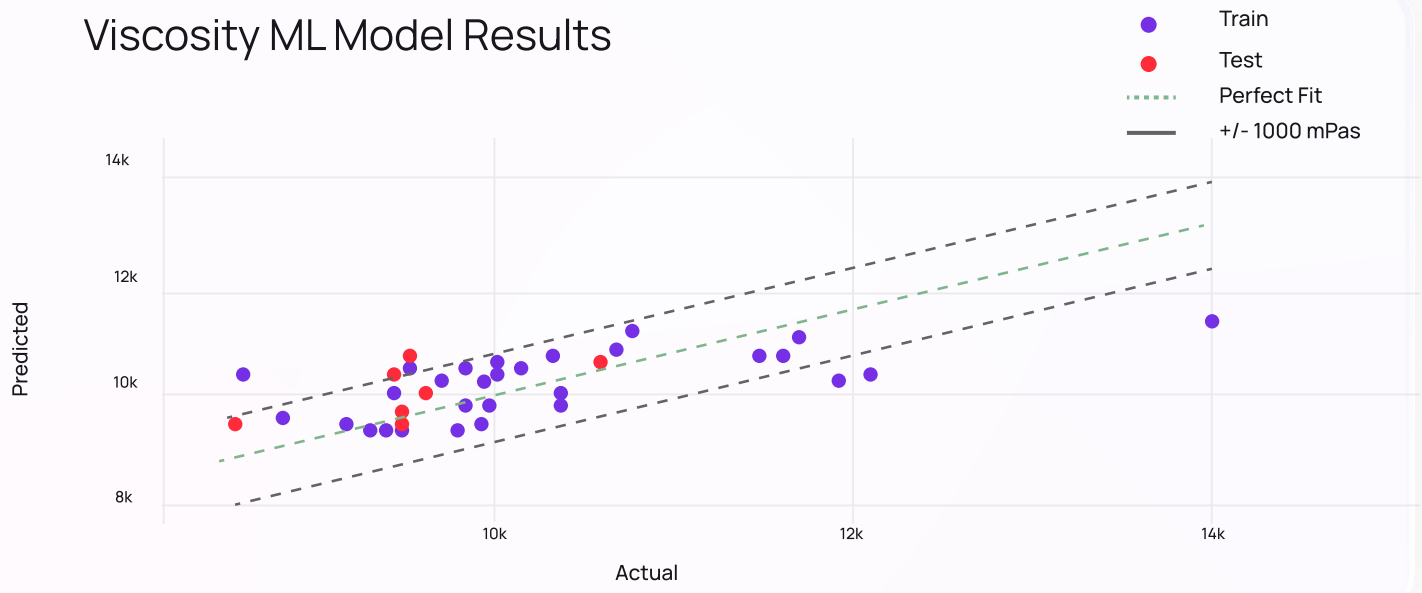
Modeling Results

Model validation showed that the hybrid digital twin could accurately predict key quality attributes in the manufacturer's mixing process, achieving MAPEs below 10%. These results confirmed that the digital twin could be reliably used for process optimization, reducing the number of experimental trials required.

PSD Model Results



Viscosity ML Model Results



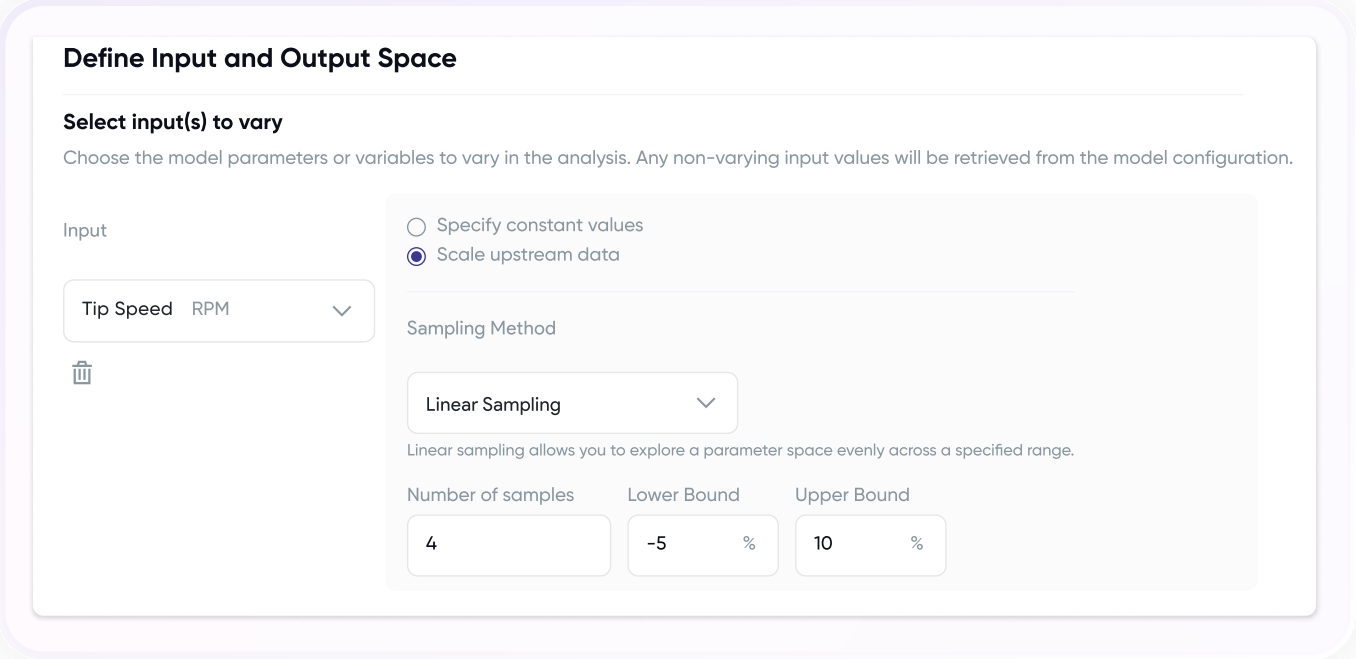
Model Applications

Virtual Experimentation

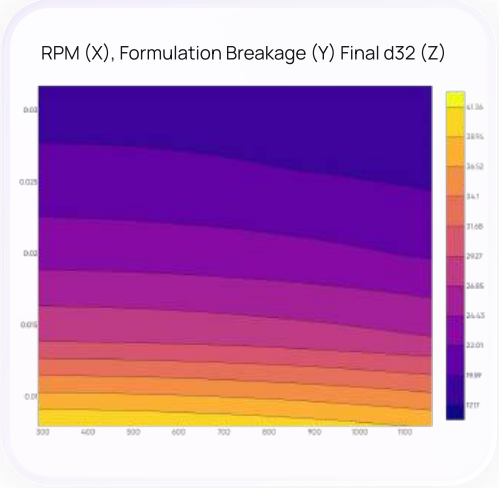
With the validated digital twin, the manufacturer can now run virtual experiments to explore how different mixing parameters influence viscosity and particle size development—without needing to run physical batches on production equipment.

Instead of manually testing one parameter at a time, the team can use Basetwo to perform sensitivity analysis, quantifying how changes in mixing speed, batch turnovers, cooling rate, and formula-specific characteristics affect final quality attributes.

1 Select inputs and desired experimentation outputs



2 Explore results



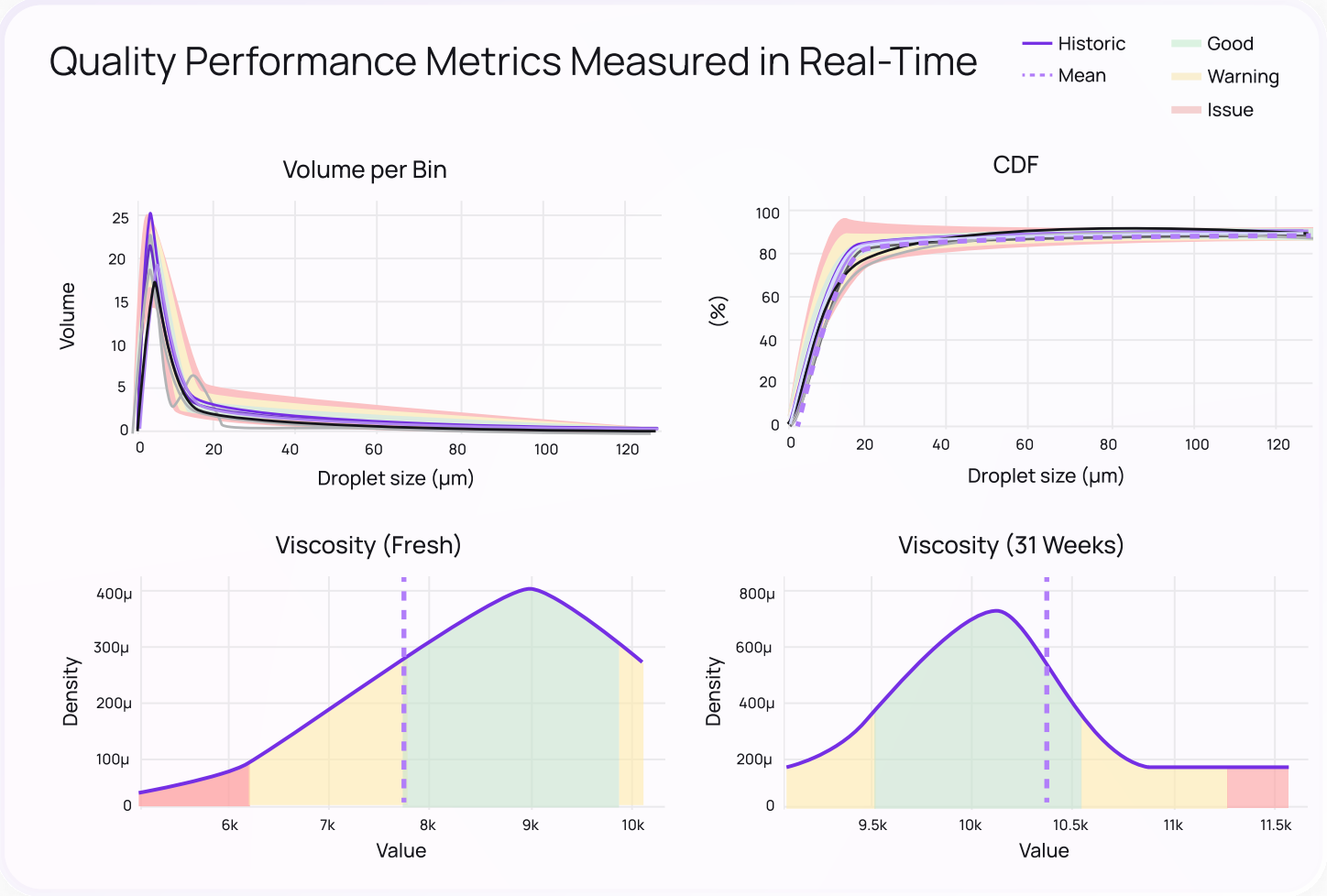
The Result

Sensitivity analysis through virtual experimentation provides a high-resolution understanding of how product quality responds to process changes. This enables smarter experimentation, reduced trial-and-error, and accelerated development cycles.

Model Applications

Deviation Detection

The manufacturer uses the digital twin to continuously verify that each batch is progressing within expected ranges for viscosity and PSD throughout the mixing process. By comparing predicted trajectories to real-time process data, the model enables early detection of deviations that could impact final product quality.



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, PSD distribution, remain within safe and optimal limits.

Basetwo Solution

Digital Twin's Impact

With the deployment of Basetwo's hybrid digital twin and the operationalization of the workflow through Application View, the manufacturer now has a scalable, data-driven framework for accelerating personal care product development and improving batch reliability.

Faster development cycles through predictive modeling and virtual experimentation

Higher batch reliability via real-time process verification and early drift detection

Reduced experimental load for optimized formulas and scale-up activities

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

Explore digital twins for improved efficiency in your personal care processes

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