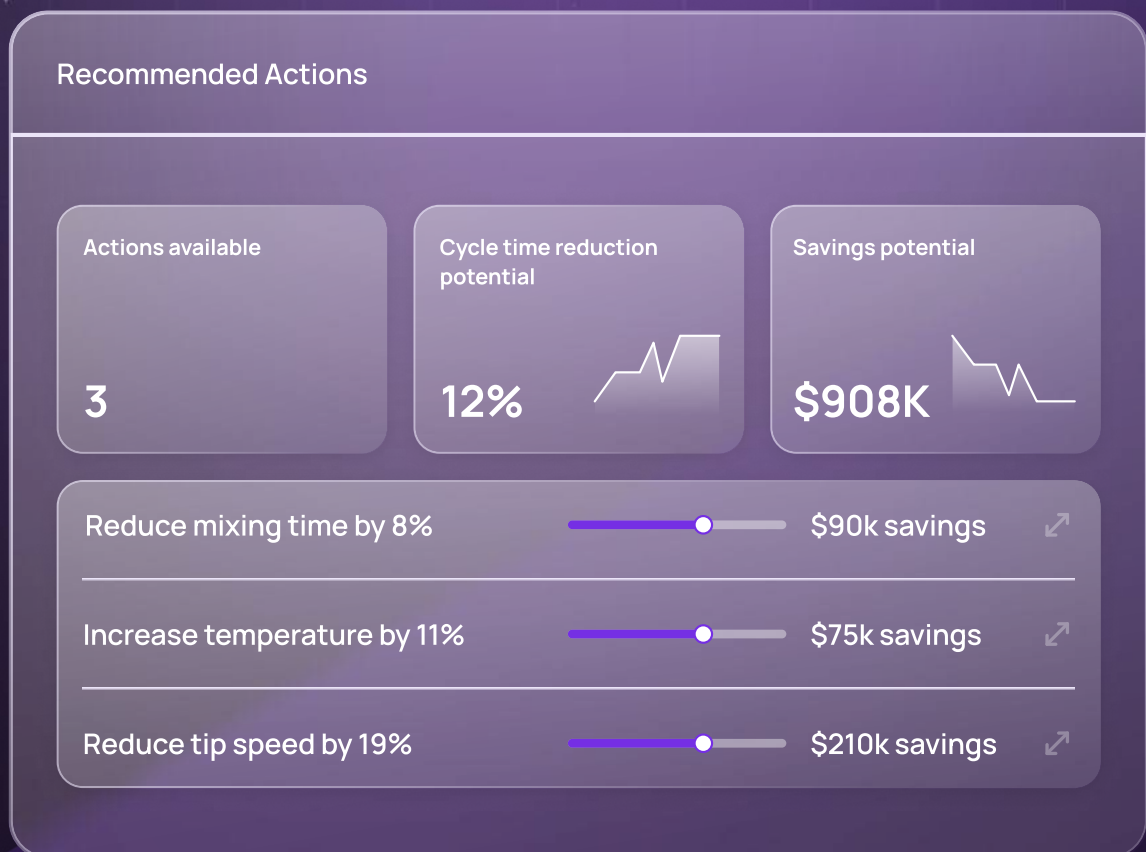


Virtual experimentation for process optimization in personal care products

Applying digital twins to evaluate process scenarios and identify optimal operating windows



Problem

Personal care manufacturers must balance product quality, development speed, and process robustness when developing emulsions such as conditioners, creams, and lotions. Achieving target viscosity and particle size distribution (PSD) typically requires extensive physical experimentation, particularly during formulation optimization and scale-up.

Traditional trial-and-error approaches rely on iterative lab and pilot runs, making it difficult to understand how individual process parameters influence final quality. This results in high experimental load, limited insight into process sensitivities, and increased risk when transferring formulations across equipment or scales.

Basetwo Solution

Basetwo enables personal care manufacturers to build hybrid digital twins that provide predictive insight into how mixing processes influence key quality attributes such as viscosity, emulsion stability, and droplet size distribution (PSD). By integrating process, formulation, and equipment data, the digital twin creates a foundation for virtual experimentation and process optimization.

Data Ingestion:

Historical and experimental data are integrated from process historians, ELNs, and LIMS systems, including process parameters, formulation information, and equipment details. Data preparation tools are used to identify mixing start points, clean signals, and standardize datasets for modeling.

Digital Twin Development and Validation

A hybrid digital twin is built by combining a mechanistic model with a Machine Learning (ML) model for PSD prediction and viscosity estimation. The digital twin is validated against historical batches to confirm accurate prediction of key quality attributes before being used for virtual experimentation.

Modeling Workflow: PSD and Viscosity

Extract & merge
process and lab data

Use data to fit Mixing
model

Validate model
against historical data

Retrieve validated particle size distribution (PSD)
metrics (d10, d90, etc.)

Machine Learning (ML) uses the PSD metrics to
predict viscosity evolution over the batch

Determine optimal mixing speed and time,
to achieve target PSD and viscosity

Virtual Experimentation

Using the digital twin, teams can run virtual experiments to evaluate the impact of process parameters such as mixing speed, batch turnovers, cooling profiles, and formulation characteristics on PSD and viscosity. Rather than testing one variable at a time through physical trials, users can perform sensitivity analyses across multiple parameters simultaneously.

These virtual experiments generate quantitative insight into which variables most strongly influence quality outcomes, how parameters interact, and where robust operating windows exist. This enables teams to identify optimal process settings, evaluate alternative equipment or scale scenarios, and assess risk before running physical batches.

1 Select inputs and desired experimentation outputs

Define Input and Output Space

Select input(s) to vary
Choose the model parameters or variables to vary in the analysis. Any non-varying input values will be retrieved from the model configuration.

Input
Tip Speed RPM

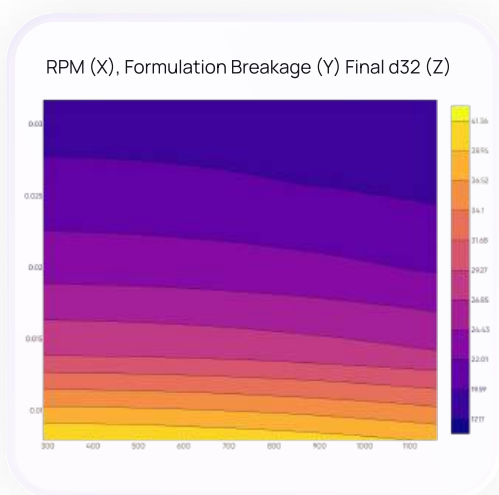
Specify constant values
 Scale upstream data

Sampling Method
Linear Sampling

Linear sampling allows you to explore a parameter space evenly across a specified range.

Number of samples	Lower Bound	Upper Bound
4	-5 %	10 %

2 Explore results

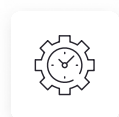


The Result

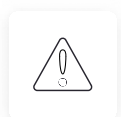
Sensitivity analysis through virtual experimentation provides a high-resolution understanding of how product quality responds to process changes. This result illustrates the impact of mixing speed and formulation breakup behavior on final particle size, helping teams identify optimal operating regions without running physical experiments.

Impact of Virtual Experimentation

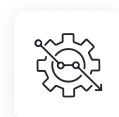
With the deployment of Basetwo's hybrid digital twin for process optimization and experimentation, personal care teams now have a scalable, more efficiency way to accelerate personal care product development and manufacturing.



Accelerate time to market through reduced cycle times and faster changeovers



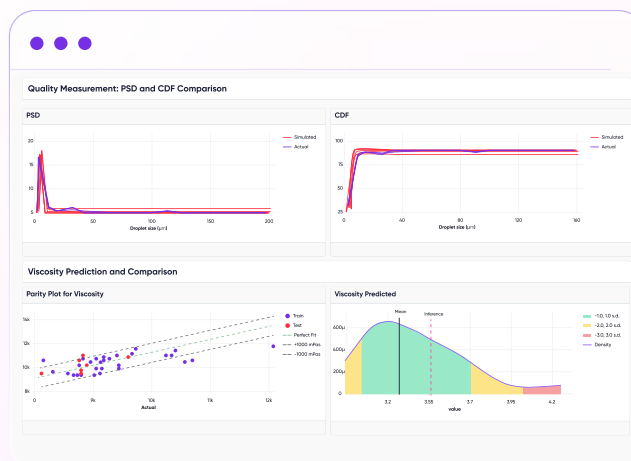
Reduce development and scale-up risk by evaluating scenarios virtually before execution



Optimize process conditions to meet quality targets while minimizing energy and 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



Explore digital twins for improved efficiency in your personal care processes

Reach out today →