Fero Labs

Industrial Use Case Playbook

Vinyl Chloride Monomer Purity Forecasting

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Introduction

Welcome to the **Industrial Use Case Playbook**, crafted by Fero Labs for the forward-thinking professionals dedicated to enhancing factory production optimization.

Whether you're a Data Scientist, Process or Production Engineer, Quality or Plant Manager, this playbook is tailored to equip you with the strategies, insights, and tools necessary to drive transformative change within your organization.

In today's rapidly evolving industrial landscape, maximizing production efficiency and minimizing operational costs are imperative for maintaining competitiveness and sustainability.

Within each of our industrial playbooks, we present a curated collection of use cases designed to address the specific challenges faced by modern manufacturing facilities. Each use case is meticulously crafted to deliver tangible outcomes, ranging from increased productivity and quality to reduced waste and energy consumption to help achieve sustainability goals.

Featured within these pages is a use case which spotlights **Vinyl Chloride Monomer Purity Forecasting for chemical manufacturers**. This case exemplifies how to tackle complex production optimization challenges head-on, leveraging data-driven approaches to drive measurable improvements in operational efficiency and cost-effectiveness.

As you embark on this journey for operational excellence, we encourage you to approach each Fero Labs use case scenario with curiosity, a willingness to embrace innovation and change.

By harnessing the power of your production data, domain knowledge, and collaborative problem-solving, we believe that you can unlock the full potential of your factory's production capabilities.

Together, let's redefine what's possible in industrial manufacturing and pave the way for a future of unprecedented productivity and sustainability.

Welcome aboard,

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Industry Overview

In the realm of chemical manufacturing, ensuring product quality and consistency is essential for maintaining competitiveness and meeting customer demands. Chemical manufacturers operate in a highly regulated environment, producing a diverse range of products crucial for various industries, including pharmaceuticals, construction, and electronics.

Among the essential chemicals produced, **Vinyl Chloride Monomer (VCM)** stands out as a key building block for the production of **polyvinyl chloride (PVC)**, a widely used thermoplastic polymer. VCM production involves complex chemical reactions and purification processes, where maintaining product purity is critical for product performance and safety.

However, achieving and maintaining high levels of VCM purity presents significant challenges for chemical manufacturers due to the **inherent variability in raw materials, process conditions, and equipment performance**. Variations in purity levels can impact product quality, production efficiency, and regulatory compliance, leading to potential quality issues and production disruptions.

One critical aspect of optimizing VCM production lies in Purity Forecasting strategies. This approach involves leveraging historical process data, advanced analytics, and predictive modeling techniques to forecast VCM purity levels during production processes.

By analyzing key process parameters, such as reaction temperatures, catalyst concentrations, and impurity levels, chemical manufacturers can develop accurate forecasting models to anticipate variations in VCM purity and optimize process conditions accordingly.

Vinyl Chloride Monomer Purity Forecasting not only enhances product quality and consistency but also contributes to operational efficiency and cost-effectiveness. By predicting purity fluctuations in advance, manufacturers can proactively adjust process parameters, minimize quality deviations, and reduce the need for costly rework or product recalls.

Furthermore, as regulatory requirements for chemical purity and environmental standards become increasingly stringent, Purity Forecasting aligns with broader industry trends towards sustainability and regulatory compliance. By optimizing production processes and reducing waste, chemical manufacturers can enhance their environmental footprint and meet the expectations of customers and regulatory agencies alike. At Fero Labs, we refer to this as Profitable Sustainability.

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Industry Challenges

In Industry 4.0, the promise of digital transformation often gets stuck in **"pilot purgatory,"** with **70% of initiatives failing to progress beyond testing phases**. McKinsey's research highlights that the choice of use case significantly impacts this phenomenon.

Selecting use cases that lack strategic alignment, clear value propositions, or encounter technical barriers contributes to pilot initiatives' failure.

Pilot purgatory not only wastes resources but also risks eroding confidence in digital transformation efforts. To navigate this challenge, organizations must strategically select use cases closely aligned with their objectives, offering clear pathways to value creation and scalability.

In each **Fero Labs Use Case Playbook**, we explore industrial use cases designed to address modern manufacturing challenges. Leveraging advanced analytics, AI, and machine learning, these use cases aim to drive tangible improvements in operational performance, cost-effectiveness, and sustainability.

By focusing on strategic and transformative use cases, organizations can break free from pilot purgatory and unlock new opportunities for growth and innovation.

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Use Case Description

Background

The production of vinyl chloride monomer (VCM), used to synthesize poly-vinyl chloride (PVC) involves a continuous, multistep process: chlorination of ethylene to produce ethylene dichloride (EDC), oxychlorination of ethylene, EDC purification, EDC cracking, and VCM purification. This last step is crucial as it ensures the quality and purity of VCM, determining its suitability for storage and subsequent polymerization into PVC in downstream processing. High purity levels are important for achieving desired properties in final PVC production.

Problem

The purity of VCM can vary based on a number of process conditions including EDC concentrations, reaction temperatures, distillation tower temperatures and heat duties, reflux ratios, and the degree of subcooling. These fluctuations present a considerable challenge for **plant operators** in maintaining high VCM purity while avoiding unplanned maintenance on the production process. Moreover, operators are required to adhere to strict operational safety protocols due to the high flammability and toxicity of VCM, limiting the adjustments they can make to process parameters. This constraint, coupled with a limited understanding of the root causes behind low production quality, complicates the task of determining appropriate strategies to drive the process and when to perform necessary maintenance.

Problem Summary

Proactively intervene on process conditions by forecasting future values of the vinyl chloride monomer concentrations based on present variable operating conditions.

Failure to maintain high purity levels of VCM can lead to **significant reductions in downstream PVC yields** and increased operational costs associated with the removal of byproducts and unreacted VCM, prompting plant operators to adopt a conservative maintenance protocol including aggressively scheduled maintenance activities. Such a strategy often results in frequent production stops, incurring substantial operational expenses. These costs could be minimized if control operators were able to make well-timed interventions before observing declines in VCM purity levels.

Fero Solution

With Fero software, plant operators can closely monitor and forecast VCM purity during the purification process under various operating conditions. More specifically, Fero pinpoints the key

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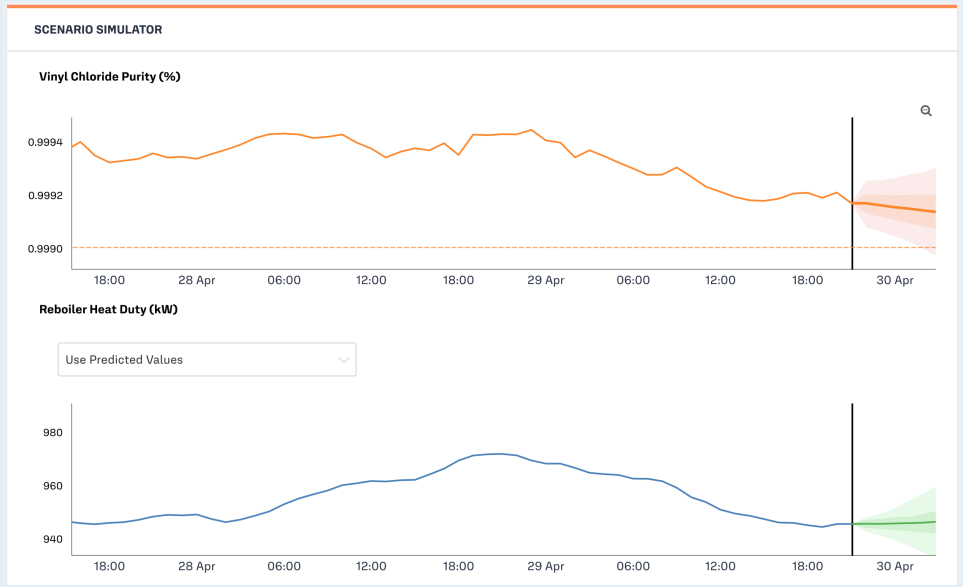
operating parameters affecting VCM purity based on root cause analysis and leverages machine learning-based forecasting methods to project future values of VCM purity, providing timely alerts for when interventions are needed to mitigate low purity levels. This proactive approach ensures optimal production efficiency and maximizes production throughput for each operational campaign.

A "Live Fero Asset" for this use case presents the following interactive screen:

- Forecast view: in the top panel, **plant managers and control engineers** can monitor past VCM purity levels and observe forecasts, with the transition from historical to forecasted data marked by the solid black vertical line. Here, Fero projects how past and current operating conditions and VCM purity might evolve, highlighting potential decline in purity that may necessitate corrective action. To aid in decision-making, Fero provides **forecasts surrounded by confidence intervals**. Should there be a need for proactively adjustments to maintain VCM purity within specification, operators are guided to adjust the key operational parameters, such as distillation reboiler and condenser heat duties. In scenarios where such interventions are insufficient to restore VCM purity to acceptable levels, Fero's forecasting model aids in strategic planning by suggesting a cost-effective maintenance schedule.

- Scenario view: in the bottom panel, **plant operators** can monitor the corresponding past operational parameters and observe their forecasts. This allows for the adjustment of forecasted values to assess their impact on projected VCM purity displayed in the top panel. This enables operators to simulate adjustments in operating parameters or set-point values based on anticipated changes. Moreover, this simulation capability supports the exploration of strategic operational adjustments that could reduce production halts due to purity levels falling out of specification.



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Process & Business Outcomes

Increased profitability by reducing out-of-spec VCM production

Soft sensors can enable control engineers to make necessary adjustments to operational conditions based on product quality forecasts. This can increase production throughput by **up to 15%.** In a market heavily limited by production capacity, this improvement could also translate into a top-line benefit of **up to 15%**.

Conduct “what-if” simulations to gauge the effects of process modifications

Fero Labs software application enables plant engineers to test **hundreds of different “what-if” operating scenarios** for future time horizons. This is particularly beneficial when operators possess insight into potential adjustments in operating parameters or setpoint values in the **next 5 days** and seek to understand their impact on the forecasted VCM purity. By enabling this level of predictive analysis, operators can identify effective strategies that not only improves production quality, but significantly **enhances overall operational efficiency** and minimizes downtime.

Informed decision-making to mitigate unplanned shutdowns

Plant operators can **gain confidence** in deciding when to initiate a shutdown or make an operational change when process abnormalities occur. In scenarios where interventions are insufficient to restore VCM purity to acceptable levels, Fero’s forecasting model aids in strategic planning by recommending cost-effective maintenance schedules.

With full adoption of Fero Labs software, plant operators can expect to experience up to **36% decrease** in unplanned production shutdowns.

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Fero Labs Adoption Timeline

PVC producers with experienced operators can easily collaborate to set up and deploy Fero. Below is a timeline highlighting typical steps. With Fero's easy-to-use, no-code interface, this can be achieved in a matter of weeks, not months or years.

Time	Process & Quality Engineers	Data Scientists / IT	Operators	Management
Week 1	Pull data	Pull data		
Week 1	Upload to Fero			
Week 1	Configure Fero	Configure Fero		
Week 2	Corroborate results	Receive example report showing accuracy		
Week 2	Set up Fero Prediction	Set up Fero Prediction		Receive example report showing savings
Week 3	Live data connection	Live data connection		
Week 3	Live Prediction screen		Live Prediction screen	
Going forward	Monitor deployment	Monitor deployment	Follow Fero Optimization recommendations	Receive regular reports showing savings
Going forward	Run "what-if" scenario simulations, spot check production, run root cause analyses		Follow Fero Optimization recommendations	Receive regular reports showing savings

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Use Case Data Requirements

The Fero Labs Platform has convenient integrations into common process information management systems, such as Aveva PI System, AspenTech, Wonderware, and SQL databases, as well as laboratory information management systems, such as SAP, Oracle, and other ERP systems. Initial data exploration can be done either through direct integration into these services, or data file uploads in Excel and CSV data formats.

The data requirements for this use case typically involve the following sources:

On-Line Gas Analysis Data

- Source: typically PIMS (e.g., PI system, Aspen)
- Content: VCM Purity, vent gas concentrations (e.g., O2, C2H4, CO, and CO2), direct chlorination effluent concentrations (e.g., FeCl3, Cl2), etc.
- Index: Indexed by time

Process Data

- Source: typically PIMS (e.g., PI system, Aspen)
- Content: flowrates and operating parameters for direct chlorination reactor, oxychlorination reactor, EDC distillation column, EDC cracker, and VCM distillation column parameters, etc.
- Index: Indexed by time

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Activating This Use Case

Consider our **Industrial Use Case Playbooks** as inspiration and tactical ideas for your team to align on to maximize the efficiencies of your plant. Each Playbook has a matching **Use Case Blueprint** which provides detailed steps to activate each use case within the Fero Labs platform.

If you're curious to see these in action please book a use case demo with our team!

Together, let us continue to push the boundaries of what's possible, driving towards a future where industrial manufacturing is not just efficient and sustainable but truly transformative in its impact on society and the world at large.

Thank you for joining us on this journey, and we look forward to continuing to partner with you in your pursuit of excellence.

Sincerely,

Fero Labs

About Fero Labs

Fero Labs helps factories work better together by bridging the gap between the disconnected goldmine of production data and industrial knowledge inside every plant.

The Fero Labs Profitable Sustainability Platform collects data and knowledge, and augments it with powerful Fero ML so factories can make more confident changes that drive profit and sustainability.

Harnessing Fero Labs, a factory creates an augmented workflow which allows for better use of raw and recycled materials, production time, and energy utilization. Teams can work 90× faster, using Fero's AI powered simulated predictions or live optimizations. They can run root cause analyses in minutes, and make continuous process improvements that drive Profitable Sustainability.

Fero Lab's white-box explainable ML makes decisions clearer by showing the context and confidence levels behind every prediction and recommendation. This expands a plant's production knowledge and drives better production results for manufacturers, all while minimizing emissions. Together we'll build a sustainable tomorrow.

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