

C4INSIGHTS®

Evonik Oxeno News & Updates

**SPECIAL:
INNOVATION &
TECHNOLOGY**



"Think about tomorrow today – with the help of our new technologies and thanks to our intensive, groundbreaking innovation work, we will continue to be a reliable partner for our suppliers and customers in the future!"

FRANK BEIßMANN,
MANAGING DIRECTOR OF EVONIK OXENO



FOREWORD

Dear Readers,

I am delighted to present to you our special edition of C4Insights® focused on the theme of innovation and technology. Innovation and technology are essential to realizing our vision of 'Chemistry4Future – We sustainably increase the value of C4Chemicals'.

Our research department is at the heart of this mission. In an insightful interview, Harald Häger, Vice President Innovation, shares how our work is comparable to the creative process of building with Lego. At Oxeno, we are dedicated to advancing existing technologies and creating new, innovative products that meet evolving market requirements.

Sustainability is a core focus for us, particularly the use of CO₂ as a raw material. Projects such as PlasCO₂ and COBRA demonstrate our ability to transform CO₂ into valuable chemical building blocks, contributing to climate protection and paving the way for a sustainable future for the chemical industry.

Digitalization is another cornerstone of our strategy. By embracing process automation and data-driven

decision-making, we enhance efficiency and reduce CO₂ emissions.

With innovative products like ELATUR® DINCD, we are setting new standards in the plasticizer industry.

Our commitment to sustainability is further exemplified by the use of Advanced Process Control (APC) systems, which optimize the performance of our production plants, minimize waste and increase product quality. Additionally, our 'auto pilot' tool in our control room, automates recurring processes, saving both time and resources while increasing quality constantly.

I am immensely proud of the progress we have made as a team, together with our partners, and I am convinced that we will continue to thrive and innovate sustainably in the future. Together, let's shape the future of C4 chemistry!

Kind regards,
Frank Beißmann



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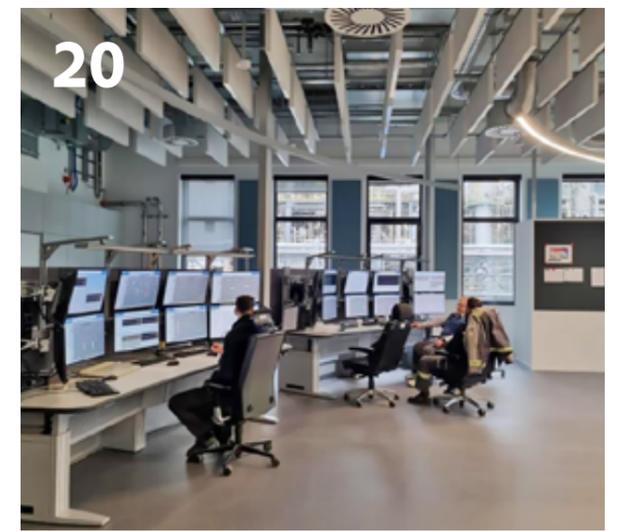
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RESEARCH AT OXENO: BRIDGING SCIENCE AND INDUSTRY

Interview with Harald Häger



DR. HARALD HÄGER
VICE PRESIDENT INNOVATION
AT EVONIK OXENO

Hello Harald, can you paint a picture of what the research work at Oxeno is like?

Imagine a bag full of colorful Lego bricks. This represents the raw materials we receive. In our Verbund, the individual bricks are sorted, converted and refined in terms of color and shape so that our customers can continue to use them in a value-adding and uncomplicated way. C4 and FCC-C4 are turned into products such as isobutene, MTBE, oxo-alcohols, the plasticizer group and much more. The special feature: Everything is used, we leave no bricks remaining.

In research, we take care that we gain a better understanding of our production processes, and we achieve continuous optimization of our manufacturing processes. Additionally, we look for new applications and develop innovative products that meet the requirements of the constantly changing market. You could say that we are continuously designing new blueprints for creative and stable constructions with our Lego bricks.

What is special about Oxeno from a researcher's point of view?

We are one of the few non-backward integrated C4 players worldwide that fully convert C4 olefins into sales products. Our research focuses on understanding and continuously improving existing technologies, as well as developing and advancing our proprietary technologies. We achieve this in close cooperation with our partners.

In addition to numerous individual improvements, we are currently working on five major publicly funded projects aimed at creating something new.

What do you think are the key arguments for customers?

First and foremost, of course, quality and reliability are paramount. Our customers and suppliers highly value this.

We offer a diverse product portfolio that includes both petrochemical products and specialties. For example, our plasticizer product range is constantly being expanded through joint developments with our customers.

Can you provide some key data on the research activities at Oxeno?

Absolutely. At Oxeno, we have a dedicated team of approximately 800 colleagues, with about 10 % of them actively working in research. One important metric to highlight is the number of patents. Each year, we create around 35 invention disclosures and to date we have collected over 2,500 patents and patent applications. Notably, around 40 % of these are less than five years old, which shows that we are not resting on our laurels, demonstrating our commitment to innovation and staying at the forefront of our field.

Please give us a glimpse into the future.

In future, the avoidance and use of CO₂ will be a key issue. We are exploring the electrification of processes within the

Verbund, considering renewable energies and investigating how we can use CO₂ as a raw material. It is important to note that using CO₂ as a raw material requires more energy compared to our conventional C4 raw materials. This is also the challenge for us as a company: We must identify and implement economically viable projects in order to meet society's interests.

Another significant focus for us is the use of organic raw materials. We are already making a valuable contribution here with our eCO and RFP (reduced footprint) products and are confident that we will expand these efforts in the future.

What characterizes the work in research?

We all have a drive for implementation. We are industrial researchers and scientists at the same time, striving to improve processes and products to meet the constantly changing needs of customers, society and politics.

There is no guarantee of success, and that's what makes it so appealing. Research involves trying things out, recognizing mistakes and learning from them, starting again, and moving forward. These long paths can sometimes be frustrating and require a lot of stamina, but you learn from them and they can also be incredibly rewarding in the end. Ultimately, our major goal is to see the findings of our research translated into plants and products, in real-world applications. Anyone who feels attracted by this way of working is very welcome to join us.

Dear Harald, thank you very much for the interview!

VERBUND



tion method; it is a core part of our company culture. Through close collaboration, we achieve greater success together and positively impact the world around us.

At Oxeno, we take pride in our Verbund system – an integrated approach to manufacturing that maximizes the utilization of raw materials. Every hydrocarbon in our raw materials is transformed into a range of valuable products. However, our Verbund system is more than just an efficient produc-

The term "Verbund" originates from German and translates to "integrated manufacturing" in English. This concept has been a cornerstone of the European chemical industry since the mid-20th century and is now recognized and implemented globally.



INNOVATIVE STRENGTH AT EVONIK OXENO: PUBLICLY FUNDED PROJECTS

Carbonylation of olefins is one of the most important homogeneously catalyzed reactions in industrial chemistry, hailed as one of the most significant advancements of the 20th century. This process involves reacting olefins with carbon monoxide and hydrogen or other nucleophiles to produce aldehydes or carboxylic acid derivatives.

These derivatives are crucial in making a wide variety of everyday products. They serve as intermediates in the

production of detergents and cleaning agents, lubricants or plasticizers for polymers. You will also find them in consumer products like infusion bags, tablet coatings and respiratory masks, floor coverings, sealing materials and special food packaging.

At Evonik Oxeno, we're actively involved in publicly funded projects aimed at finding sustainable ways to enhance various carbonylation processes.

INDIVIDUAL PROJECTS

MACBETH – MEMBRANES AND CATALYSTS BEYOND ECONOMIC AND TECHNOLOGICAL HURDLES



combine these steps into one streamlined process using a catalytic membrane reactor. Early tests in the pilot plant are promising, indicating up to 70 % of energy savings and a potential 35 % reduction in CO₂ emissions.

In mid-July 2023, Evonik's MACBETH research project reached a major milestone. A new demonstration reactor was built at the Evonik Oxeno site in Marl, where Evonik also leads the project consortium.

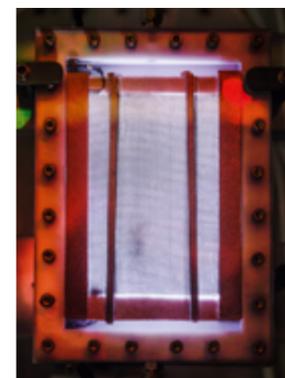
The MACBETH project aims to revolutionize key large-scale chemical reactions, like hydroformylation, which Evonik Oxeno uses to produce oxo alcohols – the essential building blocks for many plasticizers.

Traditionally, synthesis and product separation have been separate process steps. MACBETH plans to

[READ MORE HERE](#) 

<https://www.macbeth-project.eu>

PLASCO₂ – PLASMA-INDUCED GENERATION OF CARBON MONOXIDE FROM CARBON DIOXIDE AND ITS CHEMICAL UTILIZATION



Carbon dioxide emissions are seen as the main cause of global warming. To tackle this, global research

efforts are not only focused on reducing CO₂ emissions, but also on finding new ways to use CO₂ as a valuable raw material. This is where PlasCO₂ comes into play: This innovative project aims to convert carbon dioxide (CO₂) to carbon monoxide (CO) using hydrogen. The project leverages low-temperature plasmas as a new type of energy source for this transformation.

The resulting CO or synthesis gas (mixture of CO and H₂) generated in this way can then be used as a C1 building block for producing various organic compounds essential for fine and bulk chemistry. Evonik Oxeno is the coordinator of the PlasCO₂ project.

[READ MORE HERE](#) 

<https://co2-utilization.net/de/projekte/co2-als-baustein-fuer-chemische-grundstoffe/plasco2>

COBRA – CO₂ BASED ALKOXYCARBONYLATION REACTIONS

The COBRA project is on a mission to develop new homogeneous catalyst systems for the direct (regio-) selective carbonylation of olefins using CO₂.

By combining catalytic synthesis and membrane separation into one process, COBRA aims to significantly reduce greenhouse gas emissions in large-

scale industrial alkoxy carbonylations. This approach not only boosts raw material efficiency but also pioneers the use of CO₂ and renewable hydrogen as new C1 sources in carbonylations.

<https://materialneutral.info/en/project/cobra/>

INNOVATIVE STRENGTH AT EVONIK OXENO: PUBLICLY FUNDED PROJECTS

CO₂PERATE – COOPERATION FOR A SUSTAINABLE CHEMICAL INDUSTRY

While CO₂ has significant chemical potential, the range of products that can currently be produced from CO₂ is still quite low. In particular, the number of syntheses that create carbon-carbon (C-C) bonds from CO₂ is limited, even though C-C bonds are the backbone of all organic molecules.

The CO₂PERATE project aims to change this by focusing on using CO₂ as a starting material for the formation of

C-C bonds for industrial applications. To develop sustainable processes, the project converts CO₂ with starting materials derived from biomass using catalysts made from inexpensive non-precious metals.

Evonik Oxeno is specifically investigating methoxy-carbonylation in this project.

<https://co2perate.eu>

POWER2VALUECHEMICALS

Demonstrating a climate-friendly value chain for producing chemicals from renewable CO₂ and electricity

The chemical industry currently relies predominantly on fossil resources like crude oil, natural gas and coal.

However, the "Power2ValueChemicals" demonstration project has the potential to play a decisive pioneering role in the transformation of the chemical industry. The project leverages the direct electrochemical reduction of CO₂ to CO without the need for costly separation of CO from synthesis gas. This method not only avoids competing uses, such as biomass, but also

expands the range of alternative, electricity-based technologies available to the chemical industry. Evonik Oxeno's role in this project is to evaluate the use of carbon monoxide sustainably produced from CO₂-to-CO electrolysis technology in value chains for catalytic methoxycarbonylation reactions from a technological, economic and ecological perspective.

<https://www.fz-juelich.de/de/iet/iet-1/projekte/p2vc-power2valuechemicals>

Digitalization at Oxeno: Boosting efficiency and collaboration

Digitalization is at the core of Evonik Oxeno's future strategy, aimed at driving the company's success through a comprehensive and value-enhancing transformation. Central to this effort is the guiding principle of the Verbund, which emphasizes the importance of close collaboration between all specialist departments and external partners along the value chain.



MICHEL EICKELMANN

HEAD OF DIGITAL BUSINESS PROCESSES AT EVONIK OXENO

Digitalization at Oxeno is structured into four clusters, each comprising numerous ideas and projects with significant optimization potential. Under the "Digital Verbund" strategy, various ideas and solutions have already been developed to increase the efficiency of business processes, simplify collaboration with our partners and improve the customer experience. Oxeno focusses on process automation and network optimi-

zation, data-driven decision-making, collaborative services and enhancing the digital skills of the workforce.

Oxeno has been continuously working for years on holistic network (Verbund) optimization and expanding automation in production. This approach not only boosts process efficiency but also reduces CO₂ emissions simultaneously. For sustainable network optimization, Oxeno relies on close cooperation between innovation and production.



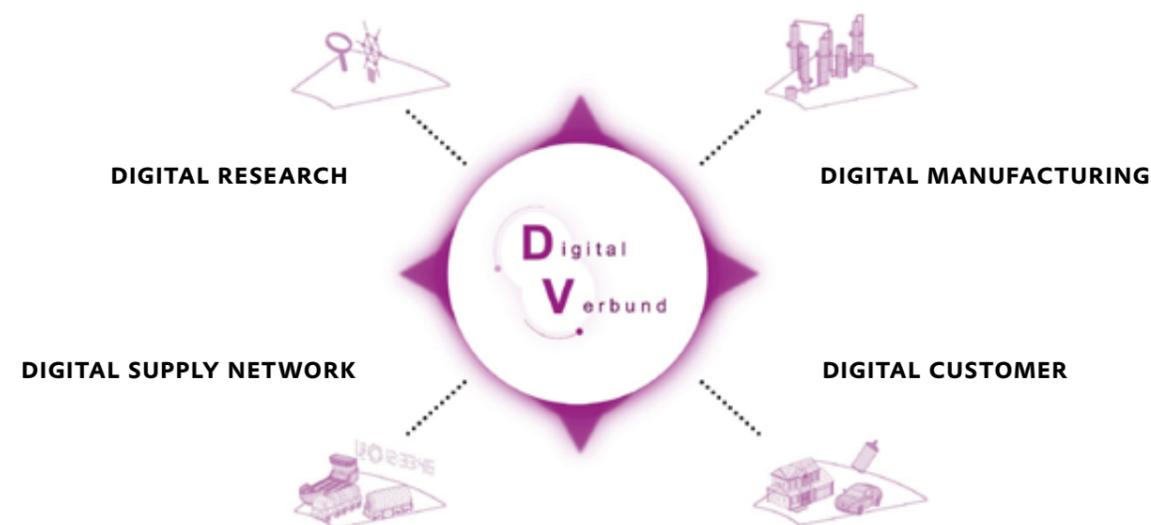
The ultimate goal is to achieve forward-looking, holistic control of the Verbund with the help of artificial intelligence.

Oxeno is increasingly focusing on optimized solutions that are based on data-driven decision-making. Integrated network planning with the OMP+ software already enables mathematical modeling of the supply chain and the mapping of various planning scenarios. Additionally, the ongoing transformation into a data-driven organization is being actively pursued. A data integration platform is being established, which will be used for central sustainability reporting, among other things.

In addition to its internal initiatives, Oxeno aims to further expand collaborative services to enhance close digital cooperation with suppliers and customers. Oxeno plans to implement a digital network

across organizational boundaries to simplify processes, provide expertise and improve the digital customer experience. This approach is already being implemented through platforms like the plasticizer customer portal myFLEXINO® and the collaborative planning of raw material requirements together with selected raw material suppliers.

However, this digital transformation can only succeed if employees also have the appropriate digital skills. To this end, Oxeno is implementing targeted training measures. The "Digital Skill Compass" offers learning opportunities on agile working, digital communication and information security and more. This initiative enables employees to close specific knowledge gaps, strengthen areas of interest and always stay up to date of the latest advancements.



Whether in production and technology, network planning, customer interactions or within the workforce, Oxeno also relies on close cooperation along the entire network when it comes to digitalization.

This approach aligns with our guiding principle: "Chemistry4People® – We are shaping the future of C4Chemistry together with our partners."

"Digitalization is a crucial component of our strategy to fully develop our business potential and secure our competitiveness in a digital future. By working closely with our partners, we aim to harness the full potential of digital technologies to drive innovation and efficiency."

MICHEL EICKELMANN
HEAD OF DIGITAL BUSINESS PROCESSES AT EVONIK OXENO

ELATUR® DINCD – Resistance. The toughest for all needs.

In 2022, Oxeno launched ELATUR® DINCD, an innovative plasticizer of the latest generation. This cyclohexanoate is characterized by a combination of sought-after properties such as excellent low-temperature flexibility and high UV resistance, significantly enhancing the weather resistance and durability of end products. ELATUR® DINCD is easy to process due to its low viscosity, making it ideal for demanding exterior and interior applications such as

textile fabrics, roofing membranes, floor coverings, adhesives and sealants as well as paints and coatings. Its very low volatility matches the market standard VESTINOL® 9 and with an excellent emission profile it adds significant value, especially in indoor applications. Curious about how Oxeno discovered these remarkable properties? You can see the journey in the following photos.

OUTDOOR WEATHERING: UV RESISTANCE & WEATHER RESISTANCE



Oxeno lives its mission "Chemistry4People® – We shape the future of C4Chemistry together with our partners" in all functional areas. To support customers in their development needs, Oxeno has introduced new and optimized application tests. As part of this initiative, outdoor weathering stations have been installed on one of the buildings in Marl. These stations enable Oxeno to evaluate the performance of PVC products intended for outdoor use, such as roofing membranes, tarpaulins or coated textiles.

YELLOWNESS DETERMINATION

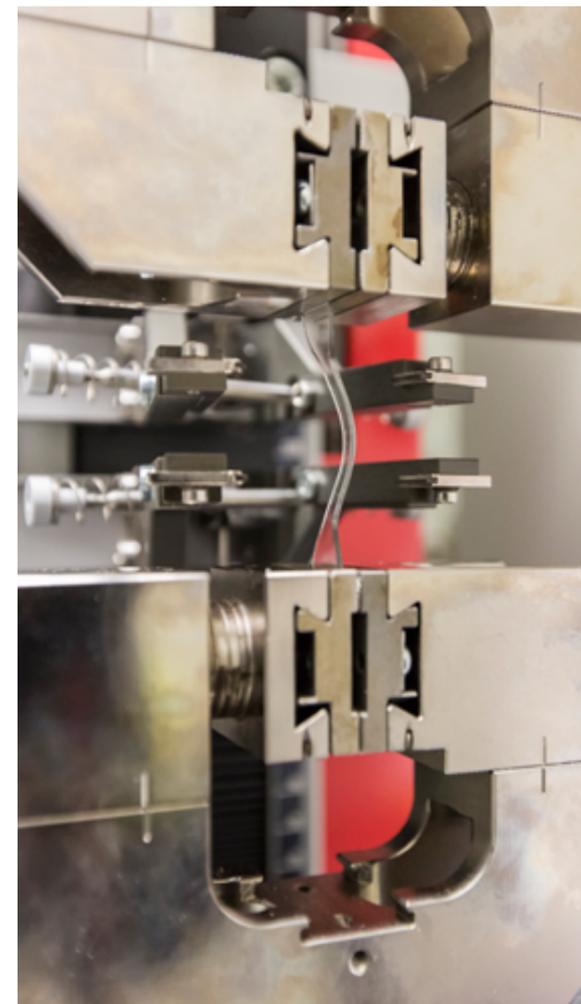


Katrin Basler checks the yellowness of a sample, evaluating PVC tarpaulins for roofs that have been exposed to the elements for nine months. Rain, sun, wind, dirt – all contribute to a natural stress test for these samples. Roofing membranes need to withstand all weather conditions for at least 20 years or longer. Therefore, Oxeno always tests the products under real outdoor conditions in addition to conducting artificial weathering in the laboratory.

MECHANICAL STRENGTH



First, several tension rod samples are taken from the freely weathered specimen. The laboratory technician then clamps a tension rod into the testing to check the tensile strength and elongation at break. To ensure data accuracy, multiple tests are conducted. This process is repeated with new tension rods and the average values are analyzed. This rigorous testing provides application technology experts with a comprehensive understanding of the mechanical strength of ELATUR® DINCD.



**ACTIVATED CARBON STORAGE:
LOW VOLATILITY**



Oxeno employees use this test to verify the exceptionally low volatility values of ELATUR® DINCD. In this process, flexible PVC samples with the same formulation are stacked in wire baskets inside a tin can, separated by



coarse activated carbon. These cans are then heated in an oven and the mass loss of the samples is measured by weighing them to determine the amount of volatile substances emitted. The metal cans enable rapid, multiple determination of the volatility values in the respective formulation while protecting the samples from strong air currents. The wire baskets act as spacers between the samples and the activated carbon to prevent the plasticizer from migrating into the carbon.

LOW VISCOSITY



Here, Melike Beyram carries out a test to verify the viscosity of ELATUR® DINCD. This is used to determine the flow behavior of the product, as the viscosity of the plasticizer will always influence the customer's formulation.

In this case, it is important to know the exact flow behavior, as the production processes are precisely coordinated and optimized for a very specific range.

Your gateway to technical services for plasticizer customers

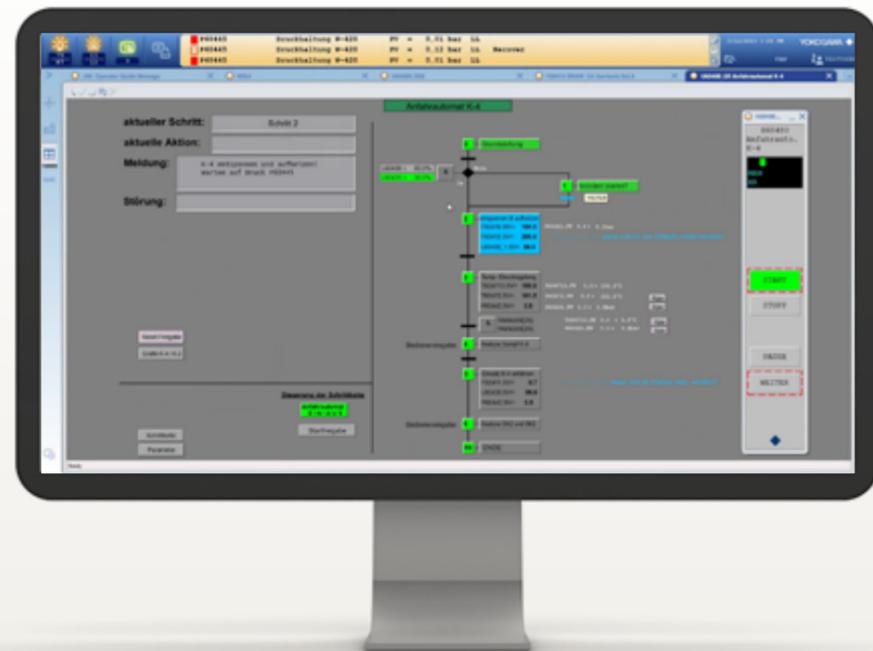
Our innovative digital platform myFLEXINO® provides comprehensive information on the world of plasticizers. Our digital portal centralizes and expands our service offering for our customers, making it your first point of contact for all things plasticizer-related. With myFLEXINO®, accessing our extensive plasticizer portfolio has never been easier. Designed for convenience and efficiency, myFLEXINO® offers a wealth of technical content and documents accessible in one place. The platform combines our existing application technology expertise, allowing you to quickly find answers to your questions and get in touch with our plasticizer experts. Whether you need formulation support, have regula-

tory questions or require a sample order, myFLEXINO® is here to assist you every step of the way.

Experience seamless interaction with Oxeno and elevate your plasticizer knowledge with myFLEXINO®!

CLICK HERE TO REGISTER ON THE MYFLEXINO® ONLINE PLATFORM. [HTTPS://MYFLEXINO.EVONIK.COM](https://myflexino.evonik.com)

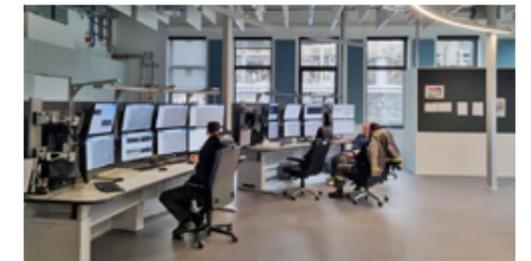
Process automation: Revolutionizing Oxeno production with automated startup systems



Automated startup systems are becoming increasingly common in Oxeno's production facilities. By automating cyclical, recurring processes that were previously carried out manually, these systems save valuable time and resources while reducing the likelihood of faults in operational processes. But how does this transformation actually work?

The journey towards digitizing operational processes begins with identifying repetitive processes that can benefit from automation. One example is the starting and stopping of production systems. Following successful simulation, integration, and test runs, the automated startup system is implemented in the correct operational sequence. In the meantime, this allows the plant operator to focus on other critical tasks. However, human expertise remains essential; the automated startup system relies on employee know-how at key points before it can proceed and continue the process smoothly.

A major advantage of automated startup systems is their repeat accuracy. Once a sequence of steps is programmed, it can be restarted with the push of a button, minimizing errors and ensuring a consistently high standard of quality which is especially crucial for complex start-up and shut-down processes. And it is precisely these processes that are pivotal to our automation strategy at Oxeno.



Automated startup systems have already been in use at Oxeno for several years, particularly in areas where discontinuous processes, such as batch operations are carried out. The hydrogen synthesis gas plant and the plasticizer plant were pioneers adopting these systems, with several already in use. Encouraged by this positive experience, Oxeno is now going one step further: startup systems are currently developed and implemented in the other processing plants as well.

APC technology boosts efficiency in the C4 Verbund

In the chemical industry, optimizing production processes is a constant focus to enhance efficiency and minimize environmental impact. The C4 Verbund in Marl and Antwerp impressively demonstrates how Advanced Process Control (APC) technology contributes to these goals.



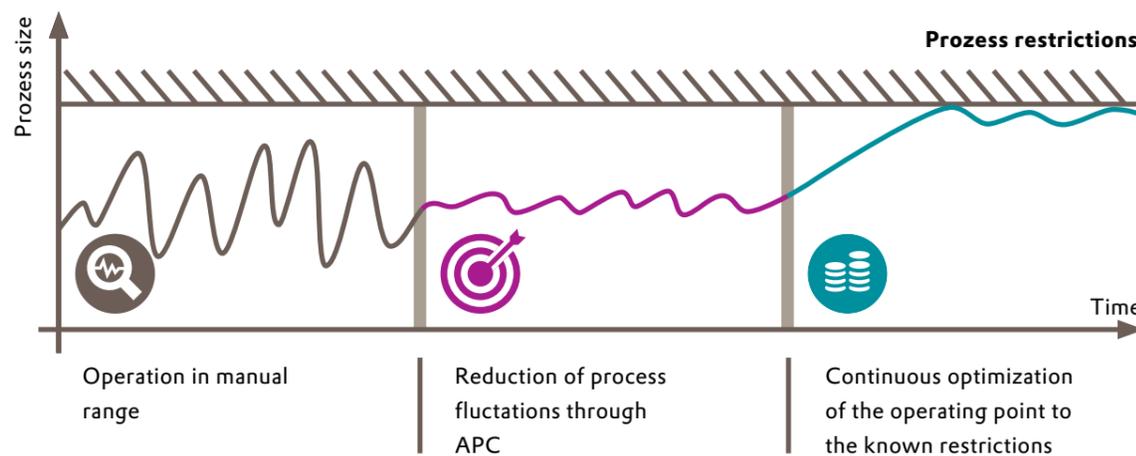
"APC technology significantly improves process control, which could not be achieved with a process control system alone."

UDO SAHLMANN ELECTRICAL, MEASUREMENT AND CONTROL ENGINEER IN THE "SMART PRODUCTION" DIVISION AT EVONIK OXENO

APC systems are extensively used throughout the C4 Verbund production facilities and have led to remarkable improvements. This innovative technology combines the expertise of process and automation engineers with the practical experience of plant operators, leading to more effective and efficient production plant operations.

One of the key strengths of APC systems is their ability to control complex systems while maintaining economic and ecological objectives. Based on sophisticated mathematical models, these systems can predict and calculate the optimal operating conditions for several days in advance. This dynamic process control continuously adapts to real-time data and can flexibly react to changing boundary conditions.

The implementation of APC in the C4 Verbund not only enhances efficiency, but also significantly reduces the CO₂ footprint of products. Additionally, this technology helps in minimizing waste and improving product quality, ensuring compliance with legal requirements and promoting sustainable production practices.



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