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The New Automation Technology Magazine
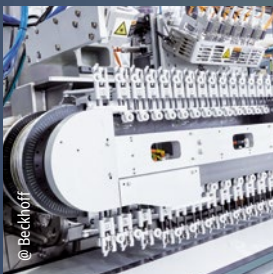
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PLC++

TwinCAT®

TwinCAT PLC++: Significant leap in engineering and runtime performance

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Beckhoff at SPS 2024

From November 12 to 14, 2024, Nuremberg's SPS (Smart Production Solutions) exhibition will open its doors once again. With its New Automation Technology, Beckhoff will present the complete range of PC- and EtherCAT-based control technology for smart automation solutions and digitalized machine and plant processes. Among the numerous new products and exciting technology demonstrations, the new TwinCAT PLC++ PLC generation, efficient drive technology, the MX-System solution for control cabinet-free automation and the use of industrial AI, e.g. with TwinCAT Chat, will be the focus of the trade show presence at Booth 406 in Hall 7. The event will also be covered by the popular Beckhoff Live + Interactive livestream, which will be broadcast daily from 10:00 a.m. right from our booth.

More information, tickets, live TV:
www.beckhoff.com/sps

The decentralized MX-System is the first to achieve completely control cabinet-free automation of machines and systems. The benefits include simplified engineering phase and reduction of machine footprint and cable paths as well as fast and clear system diagnostics during operation.

Beckhoff integrates machine learning into the TwinCAT 3 control software, recognizing that a successful method for automating processes has to be understood as an integral part of a machine's control behavior. Exemplary solutions are TwinCAT Chat and TwinCAT Machine Learning Creator.

The broad IPC portfolio is finely scalable in terms of form factor and computing power and offers a further leap in performance through consistent use of the latest 12th and 13th generation Intel® Core™ processors. For example, the C6043 is equipped with up to 24 processor cores despite its compact design.

The diverse Beckhoff drive technology covers all automation areas with rotary, translatory and linear systems as well as the XTS and XPlanar transport systems. With numerous further developments, such as a larger XPlanar tile, it can be adapted even better to individual requirements.

With TwinCAT PLC++, a new PLC generation is available within the TwinCAT system. Performance leaps in runtime and engineering, along with an easy migration while maintaining existing TwinCAT functionality, create significant added value – the "plus plus" – for the user.

" With a full product portfolio and innovative approaches, we are ready to emerge from the current economic situation even stronger than before."

With energy and optimism into the future

Beckhoff Automation, like so many other businesses, is currently facing economic challenges. But the company is responding with energy and an optimistic outlook: TwinCAT PLC++ is a new generation of PLC in the TwinCAT system that enables a quantum leap in runtime and engineering performance. The new, high-performance, cost-effective AX1000 drive technology is a strong response to the offerings of Asian competitors. Hans Beckhoff, Managing Director of Beckhoff Automation, talks about these and other innovations to Ronald Heinze, editor-in-chief of Open Automation.

Managing Director
Hans Beckhoff
of Beckhoff Automation

"Automation is developing in line with the world's gross national product. There is no growth without automation," says Hans Beckhoff optimistically. "In addition, PC-based control technology is continuing to gain market share."

However, the forecast for the current year is cautious, as Hans Beckhoff emphasizes. "We are experiencing a strong double-digit decline in sales," he clarifies. "In fact, this figure could even start with a 2. This means we are losing one to two years of growth." After an exceptional order pattern in recent years, with sales growth of around 80% in total over the past three years, the current economic situation is slowing the company down noticeably.

Three challenges
In addition to the stock crisis, the managing director mentions two other major challenges: the looming economic crisis in the capital goods sector and increasing competition from Asia, especially China.

For Beckhoff, however, these challenges are no reason for despair. "Our incoming orders are showing slight signs of recovery," Hans Beckhoff continues. "Our customers' warehouses are slowly emptying and we expect them to have worked off the overstocking effect by the first quarter of 2025 at the latest," he predicts.

"This is the fifth economic crisis that I have experienced; they occur fairly regularly every five to eight years based on the 'pig cycle' theory. Capitalism is a self-regulating system that depends on many parameters. Unfortunately, anomalies occur time and time again, which we then experience as a boom or a crisis. Fortunately, however, the market has self-healing powers, which means that every crisis, like every boom, comes to an end. "We know this and are prepared for it. It's a little bit like being a farmer who fills their barn as a precaution when winter approaches. In other words: We are prepared," adds Hans Beckhoff with a smile. He expects growth of around 10% again next year. The development departments at Beckhoff are working with renewed commitment, as are sales and marketing, and there is no short-time working in production.

According to Hans Beckhoff, there has been an increasing number of manufacturers offering individual automation components in China for many years. "System manufacturers were seen more rarely," he continues. "This is changing now. Providers with a system architecture are gaining ground."

He explains: "The situation has changed dramatically in recent years. Asian manufacturers, especially from China, are increasingly taking on the role of system provider and challenging us," says the company founder. But despite this competition, he remains confident: "German manufacturers, including Beckhoff, still have technical advantages, and our customers are prepared to pay higher prices for quality and innovation in order to be able to solve complicated technological tasks."

Beckhoff is responding to the increasing competition from China with innovative strength, which also includes cost optimization. "We also have to be competitive when it comes to individual components," he emphasizes.

New generation of control technology
Beckhoff Automation will be presenting a number of technological highlights at the SPS – Smart Production Solutions – exhibition. Particularly noteworthy is the new generation of control technology: TwinCAT PLC++ is a completely new development that enables a significant leap in engineering and runtime performance – in combination with the well-known TwinCAT advantages of end-to-end integration of all automation functions, compatibility, and openness. "We have invested in a completely new technology here which allows us to achieve the best performance values," says the managing director. "A huge advantage for our users, because when it comes to high-performance machine controls, the productivity of the machines can be increased significantly by faster control technology!"

"With TwinCAT PLC++, we can execute the control code up to twice as quickly compared to previous solutions, thus pushing the previous performance limits to a considerable degree," explains Hans Beckhoff. "As an additional highlight, the new TwinCAT PLC++ compiler makes it possible to further optimize the control code in terms of execution time, thus achieving another significant increase in execution speed, with a special performance option. An additional gain by a factor of 2 (or more) can be achieved in typical applications."

The software is based on the languages described in IEC 61131-3. "We support four of the programming languages defined in the standard; we have dispensed with Instruction List, however," says Hans Beckhoff. "Our 30 years of experience with IEC 61131-3 has been incorporated into the new software." As a member of the German IEC group, Beckhoff has a direct influence on the latest developments and best practices in standardization. The special thing

With the new XPlanar APS4244 (left) and APS4242 (right) tiles, the Beckhoff planar motor system can be used in an even more flexible and cost-optimized manner.

With the Intel® Core™ processors from the 12th and 13th generation, the ultra-compact C604x Industrial PCs (C6040 shown here) now feature 24 cores within extremely small dimensions and can therefore offer the same high computing power that was previously only available from "big iron" many-core computers.

According to Hans Beckhoff, the MX-System will revolutionize automation in much the same way that the bus terminal has become a basic building block of automation since the mid-1990s.

TwinCAT Machine Learning Creator facilitates the automated training of AI models for industrial applications.

are available as 1-channel and 2-channel variants. AM8000 synchronous servomotors with OCT as well as asynchronous and reluctance motors with or without position encoders are supported.

At the same time, Beckhoff is launching the AF1000, a variable frequency drive for simple applications such as conveyor belts, fans, and pumps. The cost-effective drive amplifier is available in two different versions: a single-phase AC 1 x 230 V supply with a power range of 0.37 kW to 0.75 kW and a three-phase AC 3 x 400 V supply with a power range of 0.37 kW to 3 kW. Despite its compact dimensions, it features an integrated power supply, DC link capacitors, ballast circuit and, in most variants, a ballast resistor. As with the AX1000, the control voltage is generated from the DC link. Both versions are available as 1-channel and extremely cost-effective 2-channel variants. Synchronous servomotors as well as asynchronous and reluctance motors without position encoders that are operated with voltage/frequency control or vector control are supported. "With the AF1000, we can offer a cost-effective drive solution that is fully integrated into the TwinCAT system via EtherCAT and offers maximum convenience during commissioning and diagnostics," explains Hans Beckhoff. As with all servo drives from Beckhoff, commissioning of the AF1000 drive is carried out with the well-known Drive Manager 2.

Various products optimized for price and performance
According to the managing director, other products have also been optimized in terms of price and performance. The field of I/O terminals, for example, has seen some new developments. "With the new EL14xx and EL24xx series, we have completely overhauled the portfolio of digital terminals for standard signals," says Hans Beckhoff. "They now offer 16 bit resolution at a 12 bit price level – a significant step forward while maintaining the same universal application possibilities." The new series complements the existing range. The

Managing Director Hans Beckhoff of Beckhoff Automation:

" **The AX1000 is a highly optimized servo drive that is fully integrated into TwinCAT on the software side."**

analog terminal series has also been redesigned and optimized in terms of price and performance.

The range of industrial PCs is being expanded continuously too. "We are now integrating the 11th, 12th, and 13th generation of Intel CPUs into our computers. This means that even the ultra-compact C604x Industrial PC can now be equipped with 24 cores." He adds: "Just a few years ago, we referred to computers like that as 'big iron'. Today, this equipment is in our standard computers."

For the XPlanar planar motor system, new tiles measuring 320 mm x 320 mm are being introduced. The previous size was 240 mm x 240 mm. "The new motor tiles feature new electronics with an even finer resolution," emphasizes Hans Beckhoff. They are therefore faster, more precise, and can transport more load.

The XTS linear product transport system has been expanded with a new Eco-Line motor module, which also features redesigned electronics. "This 50 cm long module is ideal for implementing cost-sensitive standard applications," he adds. "Due to the inexpensive price, it can be used for significantly more applications – including those in conveyor technology, for example."

The TwinCAT OPC UA Nodeset Editor is a piece of software for displaying, customizing, and creating the XML-based description files of OPC UA information models. "This makes it easy to read companion specifications or customer-specific information models into machines," says Hans Beckhoff.

Another much-debated topic is virtual controls. "We have been proficient in virtual controls for many years," Hans Beckhoff clarifies. "Up to now they have only been used in special applications. When it comes to direct control

of machines, virtual controls do not offer any real advantages." In his opinion, intelligence incorporated directly in the machine delivers better performance. In the field of IoT applications, however, virtualization can lead to cost savings and maintenance benefits.

The game changers of automation
Hans Beckhoff regards control cabinet-free automation with the MX-System as one of the game changers of future automation. "The MX-System will revolutionize automation in the same way that bus terminals have become a basic building block of automation since the mid-1990s," he explains. The first 42 module types will be available from as early as January 2025, and 100 should be available by the end of next year. The complete modular system with up to 150 modules should be available by 2026, further increasing flexibility and efficiency in automation. "The first machines with our MX-System are already in the field," reports the managing director.

Another forward-looking topic is the use of artificial intelligence (AI) in automation. "We hope that our TwinCAT Machine Learning Creator platform, which can generate efficient neural networks largely automatically, will drive the spread of ML technology for the purpose of machine control and data analysis. This will significantly lower the hurdle for the use of AI in automation. To put it in a nutshell: Excel knowledge and our TwinCAT Machine Learning Creator tool will be enough to make a machine intelligent," says Hans Beckhoff. The new products will be combined with a prepared platform that integrates both software and finely tuned hardware. "This enables us to create a cost-effective, high-performance solution that is easy to implement in practice."

According to Hans Beckhoff, large language models (LLMs) have a major influence on automation. "We have already integrated LLMs into our TwinCAT Engineering environment as standard, so that users can improve their productivity and quality with this tool chain. And we are working on solutions in which LLMs support the control system directly on the machine," says Hans Beckhoff.
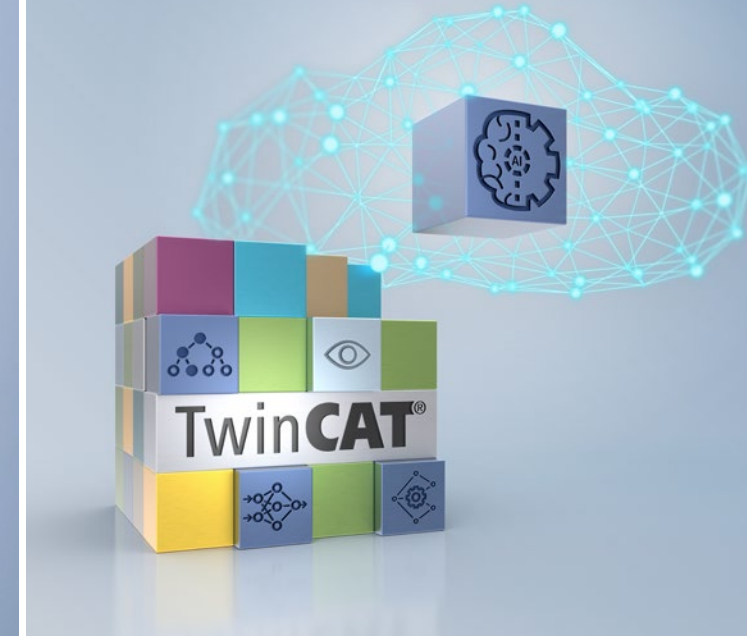
LLMs could also be run locally soon. Hans Beckhoff is convinced that humans and machines will speak the same language in the future.

Outlook
With an impressive portfolio of innovative products and technologies and a clear strategy for the future, Beckhoff Automation is positioning itself at the SPS – Smart Production Solutions – exhibition as a leading supplier in the field of automation technology: ready to drive the market forward even in difficult times. "How will Germany, Europe, and the whole world get out of the crisis? With energy and optimism!" emphasizes Hans Beckhoff. "And that applies to Beckhoff too!"

"We have always gained new customers in times of crisis. We have developed competitive products, and we want to secure new projects and orders at SPS. As Winston Churchill said: 'Never waste a good crisis'," says Hans Beckhoff. "We are well prepared." With a full product portfolio and innovative approaches, the company is ready to emerge from the current situation even stronger than before.

More information:
www.beckhoff.com/sps

New PLC generation with a leap in engineering and runtime performance

TwinCAT® PLC+⁺

TwinCAT PLC++: Next generation PLC technology

Engineering and runtime with a significant leap in performance

Based on well over 40 years of experience with state-of-the-art automation technology, Beckhoff presents the newly developed TwinCAT PLC++, enabling control engineers to make a real leap in project performance. Both engineering and runtime can be accelerated, while the well-known TwinCAT advantages of consistent integration, compatibility and openness continue to be delivered.

TwinCAT PLC++ is a completely new development from Beckhoff that integrates seamlessly into the existing TwinCAT ecosystem. Of course, TwinCAT PLC++ continues to be based on the languages described in IEC 61131-3. Due to – but not limited to – the advanced compiler technology and the new architecture used, a significant leap in engineering and runtime performance can be achieved. Beckhoff is consistently pursuing the path of merging automation and IT that it has taken from the outset. Although the company has retained familiar and proven features, it has redeveloped key components of the development environment such as editors and compilers based on IT models. What's more, Beckhoff has placed particular emphasis on the possibility of using DevOps principles to implement continuous integration and continuous deployment, for instance. In general, there was a particular focus on the specific needs of users. The result: A PLC that is extremely advanced in terms of technology and perfectly tailored to practical requirements.

Performance gains in engineering and runtime

TwinCAT PLC++ offers significant performance advantages in the runtime compared to the previous TwinCAT PLC. With TwinCAT PLC++, the same control code can be executed up to twice as fast as before. As a highlight, the new compiler makes it possible to further optimize this control code in terms of execution time. This option – known from the IT world – leads to a further significant increase in execution speed. This means that an industrial PC with less computing power may be sufficient for the previous machine control system, thereby reducing hardware costs. If the hardware platform remains unchanged, the freed-up computer resources can be used to implement more control functionality or to increase the productivity of the machine by minimizing cycle times.

Dr. Josef Papenfort, TwinCAT Product Manager, Beckhoff Automation

TwinCAT Engineering (XAE)

TwinCAT System Manager	TwinCAT PLC	TwinCAT PLC++	C++	MATLAB®/Simulink®
	Editoren	Editoren	Editor	Blockeditor
	Compiler	Compiler	Microsoft C++ Compiler	

TwinCAT Runtime (XAR)

| TcCOM | TwinCAT PLC | TcCOM | TwinCAT PLC++ | TcCOM | C++ | TcCOM | MATLAB®/Simulink® |
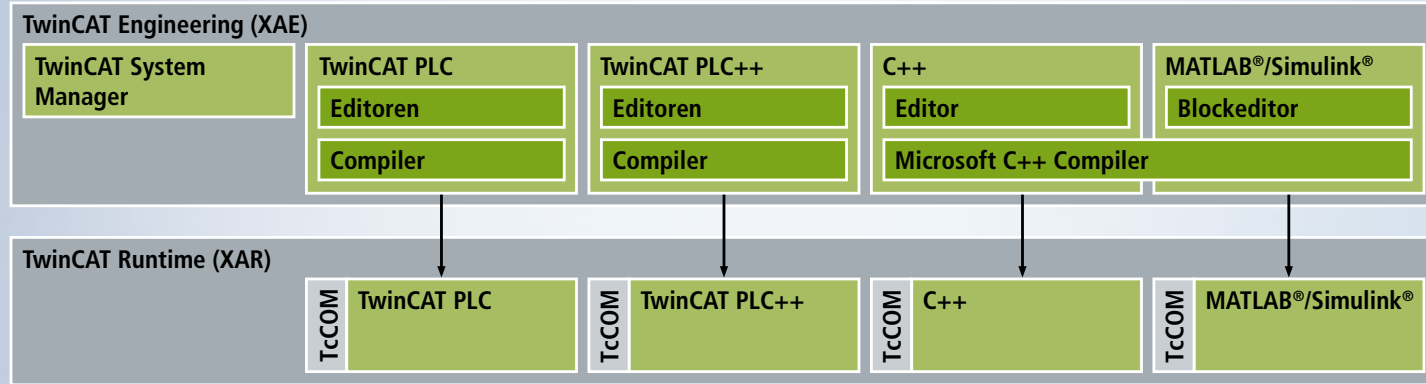
TwinCAT PLC++: Fully integrated into the TwinCAT architecture with new editors and compilers

Further performance gains can be achieved by combining the product with TwinCAT MC3, the new motion control generation from Beckhoff presented at the SPS 2023 trade show. TwinCAT MC3 features an advanced engineering and runtime architecture. When both TwinCAT basic functions are used together, sophisticated applications and processes can be effectively controlled and monitored, which increases the competitiveness of the customer solution.

Béla Höfig,
TwinCAT Product Manager,
Beckhoff Automation

From an engineering perspective, TwinCAT PLC++ achieves shorter throughput times all the way from control development and commissioning to the entire machine life cycle. This is achieved by reducing operating times with the help of shorter project loading times and an improved translation process. The minimized project lead times significantly reduce costs and also enable new machines and systems to be launched more quickly.

Increased user-friendliness
Beckhoff was able to incorporate almost 30 years of TwinCAT experience into the development of TwinCAT PLC++. The feedback from over 20,000 TwinCAT users worldwide played a major role in perfecting the implementation, resulting in an optimized, intuitive user interface as well as improved functions that make work easier for users.

Enhanced support for developers is provided by a programming assistant based on TwinCAT Chat, expandable code snippets, smart shortcut functionalities for guided code creation, an online-offline code comparison, and a favorites pool. This allows developers to work even more efficiently than before, thereby shortening the development cycle and reducing time-to-market.

Full IEC conformity and high code quality
As a member of the German IEC group, Beckhoff has a direct influence on the latest developments and best practices in standardization. TwinCAT PLC++ is almost fully compliant with the fourth edition of IEC 61131-3 and in this way meets the highest international standards. The corresponding portability facil-

itates exchange and collaboration between different automation systems. In addition, it is possible to use standard-compliant object orientation including classes and access modification for variables, among other things.

Conforming with the IEC standard offers additional safety aspects for programming, which are supplemented by extended type checks in the compiler. TwinCAT PLC++ also supports a secure online change where pointers and references are automatically adjusted. This prevents the implementation of potentially error-prone code and ensures that the application is more reliable and secure. With the help of an emergency mode, it is possible to define explicit responses to an exceptional state of the machine, such as the execution of separate code for a safe shutdown.

Seamless integration into DevOps workflows
With TwinCAT PLC++, the program code is stored in plain text at file level for the first time. This simplifies the use of source code management systems such as Git, as the synchronization of different code versions is particularly easy and intuitive. What's more, the new compiler is available as a stand-alone component and can be called up automatically via a command line interface. Given that a complete engineering instance is no longer required, this allows automated processes for creating and testing program code in unit tests to be greatly optimized in terms of time.

Therefore, TwinCAT PLC++ offers an excellent foundation for seamlessly integrating PLC code development into DevOps workflows and for checking and

ensuring code quality through automated test procedures. Automated tests not only increase the reliability of the control system, but also boost the efficiency of the testing process. As result, products can be launched more quickly and the risk of errors in the field is ultimately reduced.

Assured continuity and compatibility
TwinCAT PLC++ is based on the familiar TwinCAT architecture and is fully integrated into the proven TwinCAT ecosystem. Complete compatibility with the existing TwinCAT Functions is ensured and the new PLC generation can also be used in parallel with the existing TwinCAT PLC if required. The available PLC libraries can also be used to their full extent. On the one hand, this enables a step-by-step changeover with parallel TwinCAT PLC and TwinCAT PLC++ operation. On the other hand, an integrated converter enables the efficient transfer of existing program code, so that existing expertise is easily available in TwinCAT PLC++. For example, existing TwinCAT Scope and TwinCAT HMI applications can continue to be used unchanged. Switching therefore involves little effort.

Integrated deeply into the TwinCAT world
The new TwinCAT PLC++ architecture also enables deeper integration of TwinCAT Functions. For example, TwinCAT HMI and TwinCAT Target Browser can access the PLC variables directly without the program code having to be compiled and executable beforehand. Furthermore, a programming assistant based on TwinCAT Chat can be integrated. This assistant supports the generation of both textual and graphical code. In this way, the extensive potential of

TwinCAT PLC++: New Structured Text Editor in the familiar split view (l.) and in the file view (r.)
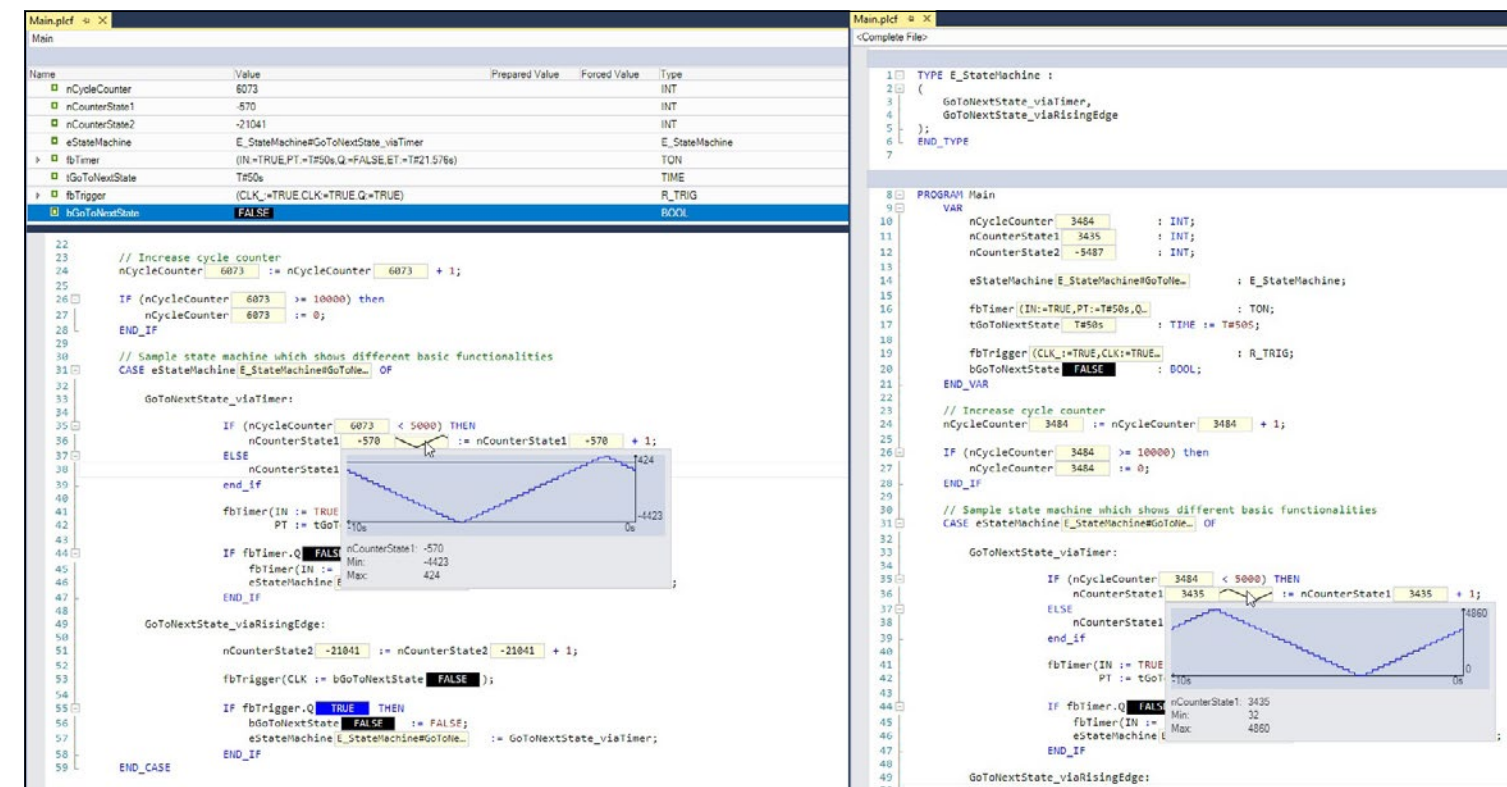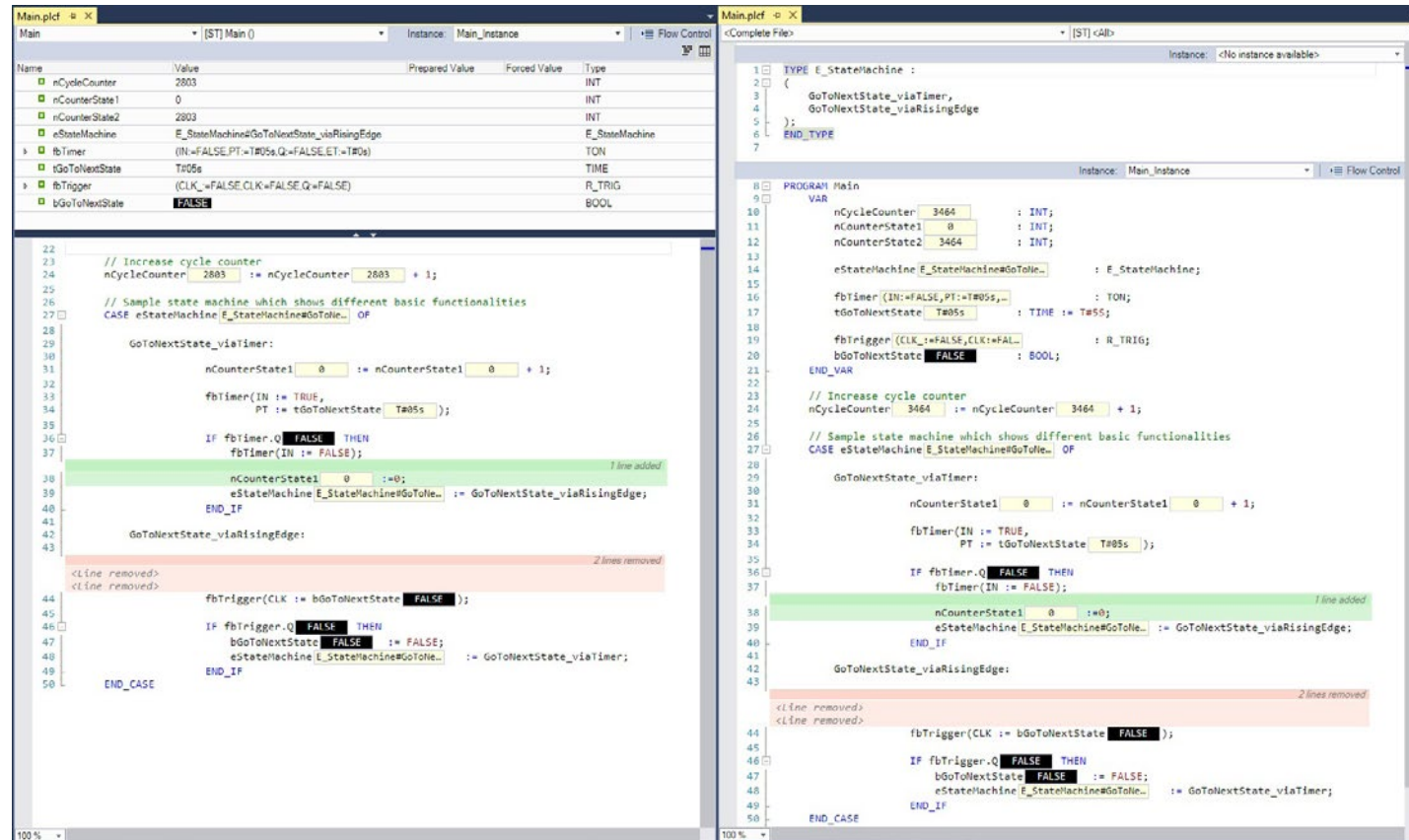
TwinCAT PLC++: Online-offline code comparison in the split view (l.) and in the file view (r.)

TwinCAT 3 CNC is now complemented by new functions and two technology packages.
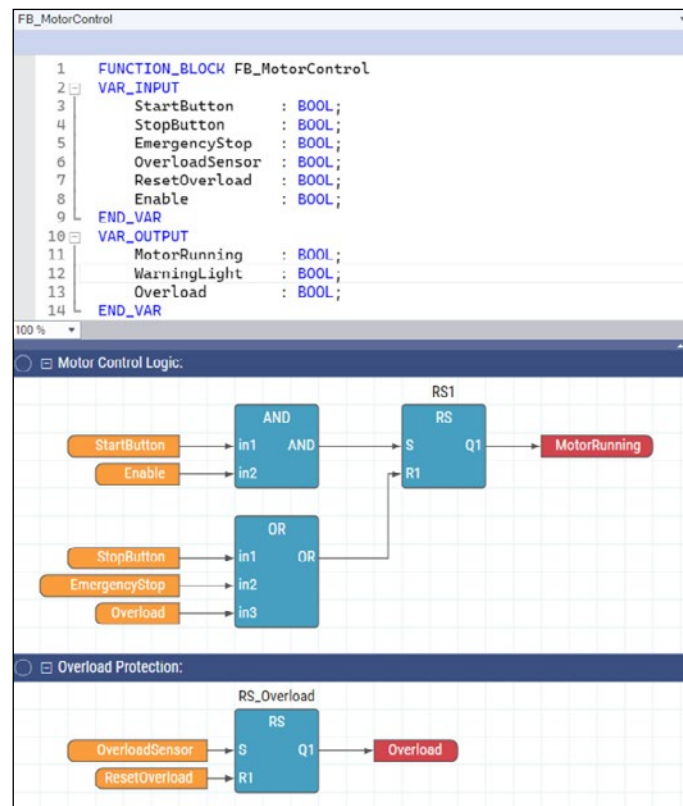
TwinCAT PLC++:
Advanced
graphical editors

the TwinCAT world can be fully exploited and the efficiency of the entire engineering process can be increased.

In a nutshell, TwinCAT PLC++ is the latest PLC generation available in the TwinCAT system. The runtime and engineering performance is improved, creating significant added value, and the switch is easy to make while preserving current TwinCAT functionality – a real "plus plus" for the user.

More information:
www.beckhoff.com/twincat-plcpp

TwinCAT CNC: Effortless access to high-performance CNC solutions for EDM and additive manufacturing

With two new functions and two additional technology packages, Beckhoff streamlines the specific application of TwinCAT 3 CNC (TF5200) for EDM and additive manufacturing. These latest features include online adaptation and extended interpolation, plus a technology package for additive processes and another for wire-erosion and die-sinking EDM machines.

TwinCAT 3 CNC Online Adaption (TF5262) offers TcCOM interfaces for integrating customer-specific modules for the online control of interpolation functions:
–   Dynamic contour control (DCC) compensates for contour errors caused by physical deformation of the toolbox by modifying the tool center point path based on the current and previous contour elements. The normalization factor, compensation direction, and compensation factor are all calculated within the TcCOM object.
–   The tool radius compensation function offers online tool radius compensation based on factors such as the current tool radius, path position, and path tangent. Two-path interpolation is also supported here.
–   The geometric feed rate adjustment is used to calculate a feed override factor to achieve a constant surface feed.

TwinCAT 3 CNC Extended Interpolation (TF5263) enables two-path interpolation, allowing two independent contours to be described in a single NC channel, which is particularly advantageous for EDM wire erosion. With conical coupling, the synchronization of path 1 and path 2 can also be used to compensate for additional blocks inserted by the tool radius compensation. The originally programmed connection between the two paths remains unchanged.

TwinCAT 3 CNC AM Plus (TF5291) is a technology package for additive processes. Its extended contour preview makes programmed contour elements available to the PLC in advance and can be activated in the NC program or via the PLC interface. The TF5291 also makes it possible to access future dynamic data, such as axis positions, velocities, and accelerations, at configurable intervals.

TwinCAT 3 CNC EDM Plus (TF5292) is a special technology package for wire-erosion and die-sinking EDM machines. It combines functions from the TF5262, TF5263, and TF5292 with cylindrical compensation for EDM wire erosion, a single real-time cycle per channel, and retraction strategies for die-sinking EDM.

More information:
www.beckhoff.com/tf5200

Test packs with
plastic caps glued on

© Beckhoff

XTS for increased flexibility and performance in the production of beverage packaging

The "magic machine":
a software-enabled, highly efficient
and reliable capping application

Two XTS linear transport systems installed parallel to each other enable extremely fast and highly precise joining of the plastic cap and carton packaging – supported by additional movement axes implemented with AM8000 servomotors (top).
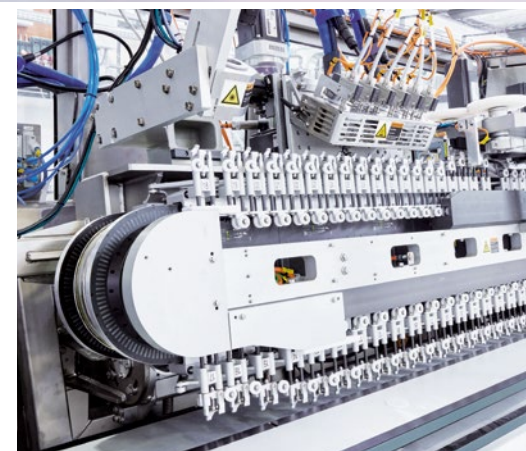
The typical beverage cartons that Tetra Pak produces for milk, fruit juices, and more are familiar to virtually all of us. Although they are efficient and robust to transport and use, they place significant demands on production technology. Key to the company's processes are quality, system output, and process flexibility – and the Development & Technology experts at Tetra Pak in Modena, Italy, have used the XTS linear transport system from Beckhoff to achieve all of these in a new machine for cap application onto carton packaging. The system has been so successful that Tetra Pak's pilot customer, impressed by its reliability, performance, and flexibility, has described it as a "magic machine."

Tetra Pak is a world leading food processing and packaging solutions company. Its aim is to work with customers and suppliers to give hundreds of million of people in over 160 countries access to safe and nutritious food, every day – with minimal environmental impact. At the company's Modena location, the team has achieved this with the Tetra Pak® Cap Applicator 40 Speed Hyper. The solution is able to apply caps as needed to as many as twenty-five thousand beverage cartons per hour. Gianmarco Di Eusebio, Product Owner at Tetra Pak, explains: "When it comes to new developments, we believe it is always very important to listen to our customers carefully. In this case, a more flexible machine with reduced space requirements and a higher system output was needed. Current solutions for portion packages run at 9,000 units per hour – so achieving the required twenty-five thousand would have meant installing three machines, each with a feeding system and so on, and finding the space to go along with that." He adds that the requirements placed on the new machine were very demanding, partly due to the high processing rate and partly due to the 3D geometry of the cap, which requires extremely high quality standards to be met when applying the adhesive.

PC-based solution overcomes limitations and increases data transparency

Tetra Pak opted for PC-based control technology from Beckhoff due to its high computing power; this was a significant factor in the decision. Paolo Scarabelli, Director Innovation, Analytics & Line Solutions at Tetra Pak, mentions an important aspect of this: "Our customers are increasingly demanding systems with a high degree of digitalization and connectivity. The PC-based control technology from Beckhoff forms the ideal basis for this. XTS also makes it easy to replace work that used to be mechanical with software functions, representing an additional step towards creating a digitalized machine. With the Tetra Pak® Cap Applicator 40 Speed Hyper, for example, we were able to shift the boundary between digital and mechanical machine components in favor of digitalization. In our specific case, this means that we have full digital control of more machine functions and can therefore operate the system more reliably."

Overall, the higher level of digitalization offers great data transparency, leading to significantly faster product changeovers and improved quality, as Fabio Bassissi, Technology Specialist at Tetra Pak, explains: "The XTS movers can be controlled as individual servo axes, allowing new product formats to be introduced very easily and quickly, leveraging software flexibility. In addition, we can compensate for any mechanical tolerances very effectively in conjunction with the vision system for adhesive monitoring." If the visual inspection reveals that the adhesive is no longer being applied in the ideal position, the software switches to other cam plates for the coupled mover pairs during operation and the adhesive is applied on the desired path again. Fabio Bassissi continues: "We also use asset health monitoring to check the state of our equipment. All of this is crucial to quality assurance and, as such, to the success of the product. Ultimately, beverage containers can only be sent to end customers if they are completely leak-tight and reliably sealed."

Reliable control of highly complex motion sequences

Even the high number of axes associated with the Tetra Pak® Cap Applicator 40 Speed Hyper – over 120 real axes and ten virtual master axes – illustrates how complex the motion control process is. The majority of the axes use two parallel XTS tracks, each 4.5 m long and with fifty-five movers. There are also around ten rotary servo axes used for tasks such as packaging transfer and hot melt application.

In order to glue on the cap correctly, given its 3D geometry, the movements of the XTS movers and the various rotational movements in the X, Y, and Z directions must be synchronized precisely. The special feature here is that each pair of movers is connected by the tool structure, but runs on the two XTS units mounted in parallel to one another. It does not matter whether the movers are on one system arranged in a row or on two different systems, and the control software takes advantage of this – it always moves the movers in complete synchronization with each other. According to Stefano Flore, Director Packaging Lines Embedded Automation at Tetra Pak, XTS generally offers a very high degree of flexibility due to its modular design and excellent software functions. The ability to change the XTS track length and the number of movers, for example, means that hardly any work is involved in creating machine variants with a higher or lower product output. It is also very easy to change

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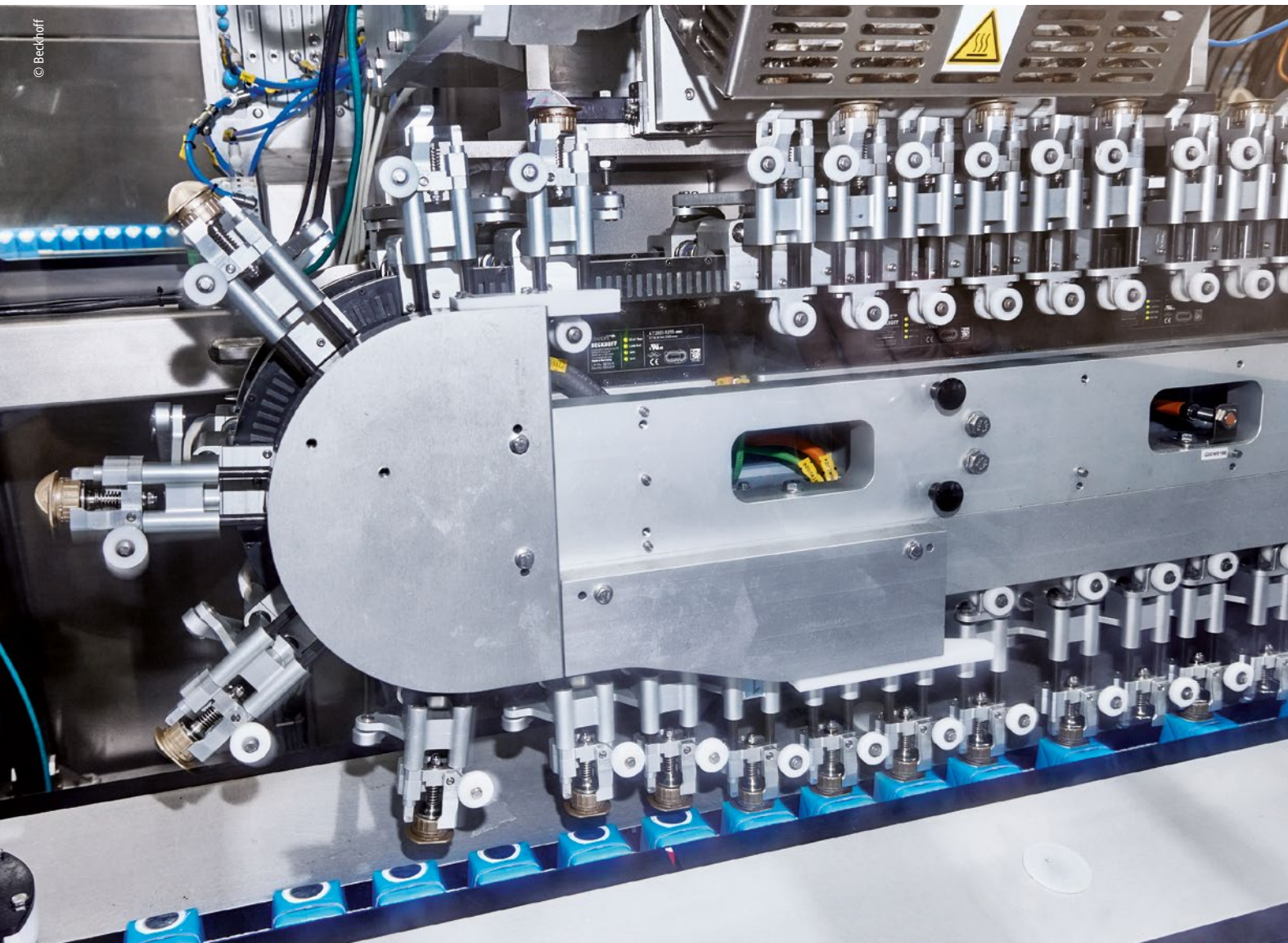
Fabio Bassissi, Technology Specialist at Tetra Pak:

" The XTS movers can be controlled as individual servo axes, allowing new product formats to be introduced very easily and quickly and additionally any mechanical tolerances to be compensated very effectively."

Picture left:
Adhesive is applied to the plastic caps in the upper XTS area, and the plastic caps are then glued to the packaging with high precision in the lower area – in a process that's almost invisible to the naked eye at full speed.

© Beckhoff

over to different packaging formats to accommodate other fill quantities and differently shaped pack tops or caps, for example. In the software, new settings only need to be configured for the distances between the coupled movers and the movement specifications on the two XTS systems.

Stefano Flore also makes it clear that the XTS movers with individual control offer far more functionality than just product transport: "After the caps have been picked up by the corresponding brackets on the movers, up to six synchronized movers form a batch in order to apply the adhesive profile. For this purpose, the cap bracket moves on the X-axis and Y-axis by means of a mechanical coupling with the associated mover of the parallel XTS system. At this point, the system compensates for any tolerances, such as those caused by the adhesive nozzle. The cap is then applied to the carton packaging with precision and monitored by means of image processing. XTS also assists in making the gluing process error-free by maintaining the correct contact pressure using a precisely defined level of transverse force in the mover." This force is generated by the precise interaction between the two coupled gantry movers. Another major advantage of XTS over mechanical systems is that a large amount of information is available centrally in the software. Deviations from the system parameters can not only be localized very quickly, but also completely avoided by taking countermeasures. On the subject of faults, Gianmarco Di Eusebio adds: "The mean time between failures (MTBF) has more than doubled with this system."

Control technology offers consistently high performance
Tetra Pak also chose to use control technology from Beckhoff because all of the system-related components are available from a single source, guaranteeing seamless and efficient integration. At the heart of the machine control system are two C6032 ultra-compact Industrial PCs for the HMI applications, the two XTS systems, motion control with TwinCAT NC PTP, and TwinCAT PLC. In addition, a wide range of functions can be combined in a single control unit, including machine simulation. Additionally, the selected hardware platform offers plenty of potential for adding more functions in the future. What's more, Beckhoff provides an extremely wide, finely scalable portfolio in terms of computing power, memory expansion, and even form factor, ensuring that systems stay fit for the future.

When discussing his experience with TwinCAT software, Paolo Scarabelli says: "TwinCAT allows the potential of PC-based control to be exploited to the full. This ranges from a wide variety of programming languages, including object-oriented languages, to integration in Visual Studio and comprehensive network configuration options, all the way through to excellent multi-core support. In addition, the software is well structured and its open nature makes it possible to not only use the extensive Beckhoff function libraries, but also seamlessly integrate your own libraries to create machine-specific condition monitoring. We also make intensive use of TwinCAT Scope for development-related analyses. Overall, TwinCAT gives us the best possible support, including when it comes to achieving our goal of standardized software development."

Stefano Flore, Director Packaging Lines Embedded Automation at Tetra Pak:

> " XTS generally offers a very high degree of flexibility due to its modular design and excellent software functions."

He adds that the openness and flexibility of PC-based control play a major role in this area as a whole: Ideal support is provided by the powerful and open EtherCAT communication system, which seamlessly integrates the I/O terminal segment, functional safety, and drive technology. As Stefano Flore states: "The AX8000 offers clear advantages due to the very high dynamics and precise control of the motion sequences. In addition, the modular design is extremely compact and flexible, allowing additional axes to be added easily if required. This is supported by the wide range of AM8000 servomotors, whose motor type, power, winding type, and other aspects can be finely scaled."

Comprehensive support and outstanding future potential
Davide Borghi, Manager of Advanced Analytics for Equipment at Tetra Pak, confirms that the automation partner's support is also vital when it comes to such demanding applications: "Support is particularly important when changing the machine concept. For the Tetra Pak® Cap Applicator 40 Speed Hyper,

The large team of experts at Tetra Pak – second from left to right: Davide Borghi, Paolo Scarabelli, Francesco Venturi, Stefano Flore, Andrej Burieta, Stefano Mittarelli, Pierluigi Canalini, Paolo Goldoni, Andrea Lestini, Elena Sachetti and Gianmarco Di Eusebio – as well as Alexander Mönchmeier, Beckhoff Key Account Manager (left), in front of the Tetra Pak® Cap Applicator 40 Speed Hyper

this came into play right from the point when feasibility testing was performed, and was especially useful for configuring the XTS system and its huge range of functions. Support was provided flawlessly in all cases – on-site with Beckhoff Italy and the experts in Germany, and right up to each of the management levels involved."

The strong collaboration is set to continue in the future, as Stefano Flore continues to see great potential for the use of PC-based control in Tetra Pak®

equipment: "We believe that No Cable Technology (NCT) is a promising further development for XTS. We are already testing the possibilities that XPlanar can bring to a number of applications. We also see attractive advantages of the MX-System for control cabinet-free automation and of TwinCAT Runtime for Linux®. So there is a great deal of potential to surprise users – like the pilot customer in this case – by giving them a 'magic machine'."

Left: The AM8000 servomotors in the machine are controlled via the AX8000 multi-axis servo system.

Center: A C6032 ultra-compact Industrial PC is responsible for complete machine control, while the second computer provides the visualization.

Right: Numerous Beckhoff PS3031 power supplies are also used in the Tetra Pak® Cap Applicator 40 Speed Hyper.

More information:
www.tetrapak.com
www.beckhoff.com/packaging
www.beckhoff.com/xts

Production optimization with real-time data and dashboards

IIoT and edge computing in the coffee roastery

Illycaffè leaves nothing to chance when it comes to coffee production: as part of a strategic project, an IIoT and edge architecture was implemented on the basis of PC-based control from Beckhoff and Microsoft Azure™. Real-time data from production, TwinCAT Analytics, machine learning and cloud services now enable detailed evaluations.

The Italian coffee producer Illycaffè uses PC-based control in its production facilities to record and evaluate production data.

Making a good espresso or cappuccino isn't just about using good coffee beans as the raw material. The roasting process, the blend of the different varieties and the packaging – which must maintain the product properties over a long period of time – are just as important. In order to be able to export his coffee without compromising on taste, company founder Francesco Illy developed a revolutionary system for pressurizing the packaging with inert gas. The process patented in 1934 is still used by Illycaffè today to preserve the coffee aroma in the characteristic tins. Founded in 1933, the company has more than 1,300 employees and is active in over 140 countries worldwide.

As part of its Digital Factory project, the company decided to automate the processes for recording and consolidating production data at its plants in Trieste. The intention was to replace the previous manual, Excel-based procedure for calculating plant performance, which had a number of limitations ranging from possible input errors to different descriptions for identical anomalies.

Process optimization requires real-time data
A diverse team of process and IT specialists was put together to develop an infrastructure for automatic data collection and a reporting system for the

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Architecture of the cloud services: The data from the edge devices is TSL-encrypted and is sent via HTTPS, MQTT, or OPC UA to the cloud platform.

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System architecture of Illycaffè's IIoT and edge computing project with a CX2062 Embedded PC with TwinCAT/BSD and TwinCAT Analytics as the edge device
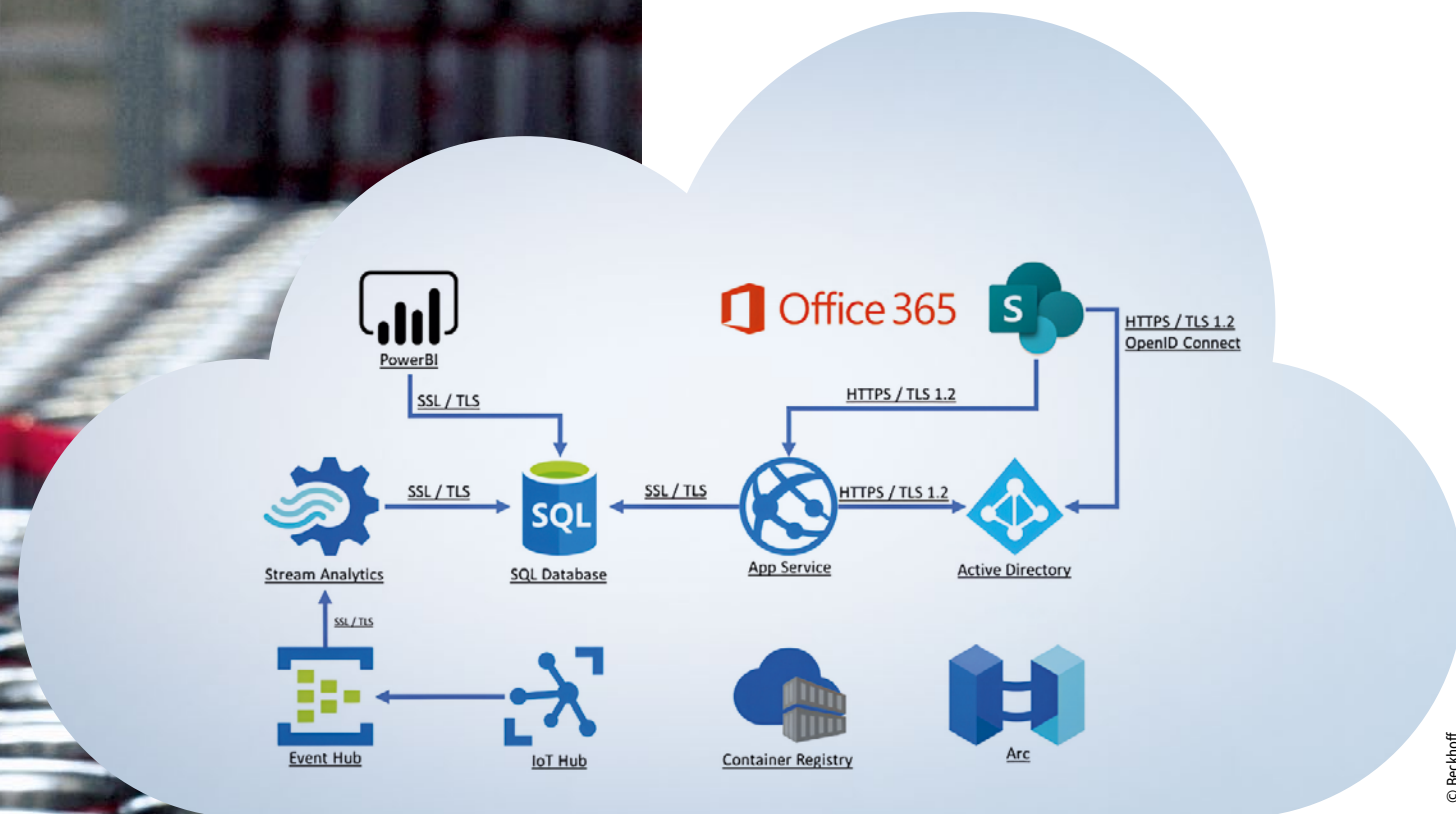
corresponding analyses. The main aim of the project was to monitor and optimize the production processes. For this purpose, various pieces of data from production had to be recorded and processed in real time. These included:
– the number of units produced in accordance with the quality criteria and the number of units with complaints and their causes,
– the first-level and second-level machine states with precise timestamps, and
– various pieces of process data such as pressure, dimensions, performance, and consumption.

Embedded PC as the edge device
A hybrid approach was chosen for the project, combining edge devices close to the machines (OT) with tools in the Microsoft Azure™ cloud. The first obstacle hindering implementation was the heterogeneous machine park with its outdated control systems and lack of IT connection options. A solution was therefore needed that could collect data from controllers from different manufacturers and different fieldbuses such as EtherNet/IP. Each edge is based on a CX2062 or CX2042 Embedded PC with TwinCAT/BSD as the operating system, chosen for their high computing power, modularity, flexibility and robustness. TwinCAT/BSD in turn supports the use of virtual machines with Windows 10 and Linux® on the same platform. The container technology used enables interaction with the cloud's software instances, which are managed using the Azure™ Container Registry.

In addition to visualizing the data in real time, the company needed to be able to store and archive it to enable analysis of the production line's performance over individual shifts, days, weeks, and even months and years. The interfaces, diagrams, and dashboards needed to be flexibly customizable by personnel without special IT knowledge so that both maintenance technicians and production staff responsible for creating the KPIs could make changes using tools such as Power BI.

All answers on one platform
The real-time analyses of the machine data are generated automatically with TwinCAT Analytics One-Click Dashboard, without the need for any special programming. The relevant configuration settings are made at an early stage when designing the analyses in the Analytics Workbench. The dashboard is then created automatically and can be flexibly modified for new dashboards. This provides an interpretable visualization of the data and analysis results integrated into the visualization TwinCAT HMI, which is also an intuitive user interface.

Once the machine data has been collected, processed, and analyzed, it is TSL-encrypted and sent via HTTPS, MQTT, or OPC UA to the cloud platform. The data is then available for further aggregation and second-level analyses such as statistical evaluations and projections of KPIs, which can include both management and technical aspects.

Once the data has been collected, organized, and processed in the cloud or locally, it is made available to technicians, production staff, and managers via specific, task-related dashboards.

Reduced downtime, increased productivity
Based on the analyses, Illycaffè was able to identify and eliminate the causes of problems, reducing downtime and increasing overall production efficiency. Analyzing process data in real time has led to significant improvements in the production process and ensures the consistent quality of the end product. In addition, Illycaffè uses the collected data to optimize the energy consumption of the systems and can replace critical components as part of predictive maintenance before failures occur. Illycaffè plans to roll out the comprehensive monitoring system to other equipment in order to further optimize internal processes, and will use the data already collected to implement further measures.

More information:
www.illycaffe.com
www.beckhoff.com/iot

A robust and durable CP3916 stainless steel multi-touch Control Panel in a customer-specific design is available for intuitive operation and programming of the dispensing processes.

Below: The dynamic, EtherCAT-based drive technology consisting of AX5203 servo drives and AM8000 servomotors from Beckhoff forms the basis of the highly precise Scheugenpflug dispensing processes.

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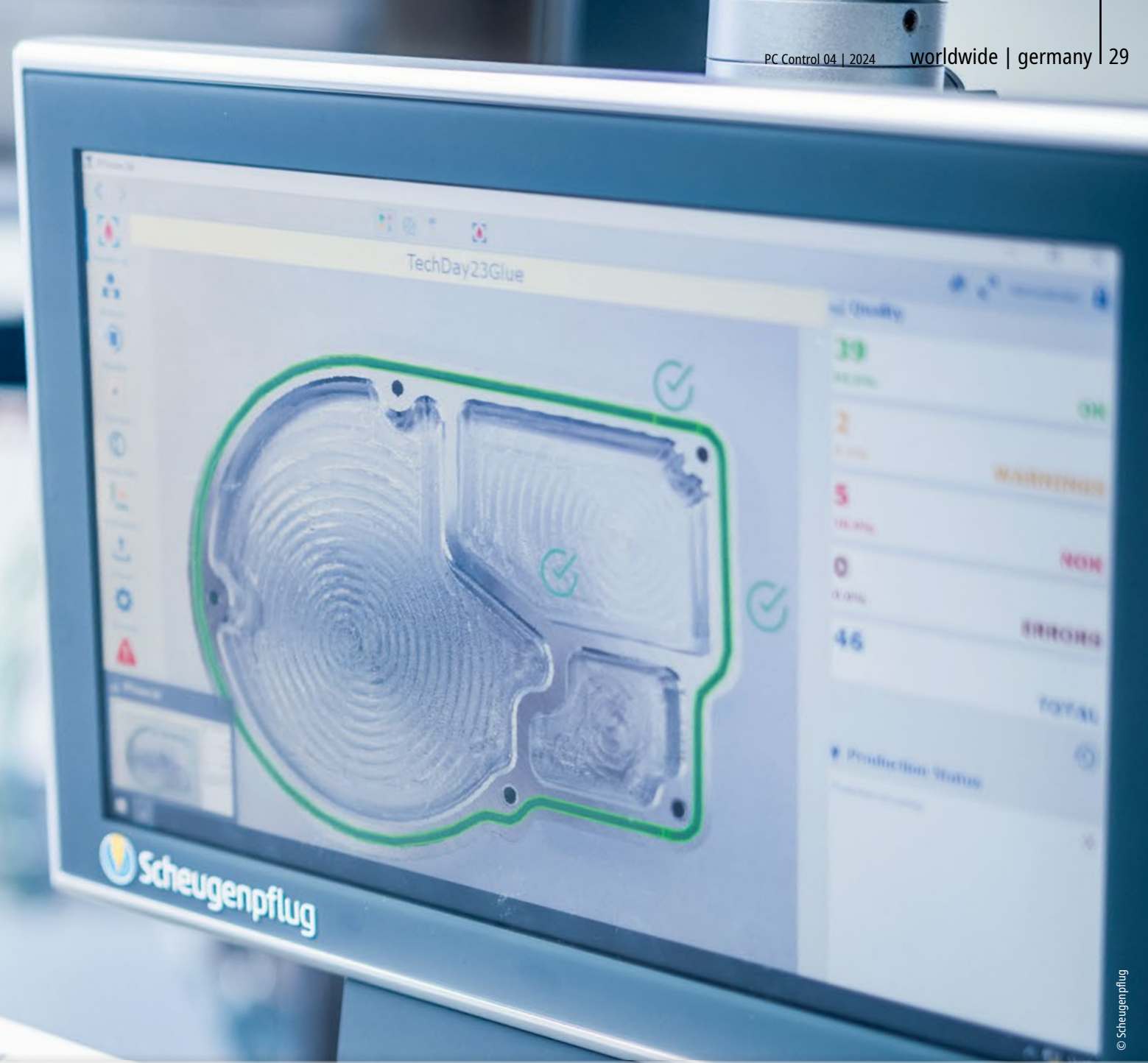
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PC-based control in a multifunctional cell for bonding, sealing and potting

Automated for flexible and precise dispensing technology

The Scheugenpflug ProcessModule axis system forms the basis of Atlas Copco's dispensing and screwing cells and a flexible integration platform for general contractors and machine builders. Precise process sequences are ensured by TwinCAT CNC and servo drive technology from Beckhoff, as exemplified by the DC803 DispensingCell.

Integrators and automation specialists require powerful dispensing solutions that can be flexibly adapted to a wide range of project requirements and integrated using the plug-and-produce solution. The Scheugenpflug ProcessModule and the DispensingCell DC803 were developed with these requirements in mind. The focus was on simple integration into a wide range of system designs and flexible data connection, a high level of dispensing quality when processing a variety of materials, short cycle times, and comprehensive process monitoring. All in all, the solutions of the Scheugenpflug product line from Atlas Copco are the result of more than 30 years of expertise in dispensing technology with advanced control technology. PC-based control from Beckhoff has been in use here since 2012. According to the Scheugenpflug experts, this PC- and EtherCAT-based control and drive technology offers an open system,

fine scalability, and a broad product range which individually meets demanding customer requirements.

The central element is the axis system

The Scheugenpflug axis system is quick and easy to integrate reliably into new or existing production lines or production cells using a plug-and-produce solution. All parameters and processes relevant to bonding and potting are perfectly coordinated – independently of the rest of the machine. With its powerful axis and servo technology, the ProcessModule also offers high travel speeds and short cycle times in matrix, bead, and fill potting. Other features include high flexibility in terms of process and component parameters, the simple use of conveyor belts, and various process monitoring options. It also offers a high

degree of repeatability and a precise start/stop, even for demanding applications. The inspection processes integrated into the axis system, such as scales, needle measurement and cleaning, ensure a stable process. A space-saving inspection system integrated with the dispensing head is available for real-time 360° monitoring of dispensing contours.

The ProcessModule is also used in the Scheugenpflug DispensingCell DC803 multifunctional cell. This offers the necessary flexibility to implement the increasingly demanding and individual requirements for bonding, sealing, and potting processes for medium (approx. 40,000 to 200,000) to high (approx. 200,000 to 2 million) quantities. The cell is specially designed for series production with short cycle times, particularly in the automotive, industrial electronics, and medical technology sectors. In addition to the flexible application options and the integrated additional processes, e.g., for process monitoring, it boasts a high axial load capacity and intuitive operation and programming of the dispensing processes.

Sophisticated CNC-controlled dispensing functions
The DC803 is implemented for a number of extensive automation tasks. These include open-loop and closed-loop control of the dispensing head, the high-speed gantry system with interpolated movements, product handling, and the inspection processes. The necessary computing power is provided by the ultra-compact Industrial PC C6030 which, according to the Scheugenpflug experts, was chosen primarily for its compact design as well as its high and easily scalable computing power. A CP3916 stainless steel multi-touch Control Panel connected via the CP-Link 4 one cable solution acts as the

interface, providing the machine operator with a stable and robust operating concept with a long service life. For this customer-specific version, the company opted for branding with a centrally placed company logo and selected a keyboard and mouse tray for ergonomic operation. Beckhoff TwinCAT offers an open and secure architecture: Using the Automation Device Service from Beckhoff, all required data can be sent to Scheugenpflug's own visualization system.

The highly precise movements that are essential for demanding dispensing applications are calculated centrally in TwinCAT CNC on the industrial PC and executed with the servo drive technology, namely for the X-, Y- and Z-axes of the ProcessModule, for the spindle axis of the dispensing head and, if required, for optional additional rotary axes. From Scheugenpflug's point of view, the Beckhoff servo technology – which includes two AX5203 servo drives and AM8000 servomotors – offers the advantage of free and integrated configuration options using interfaces and excellent scalability with additional transformation options. In addition, it is quick, easy, and compact to install due to One Cable Technology (OCT). With its functions for safely reduced speed and a safe stop, TwinSAFE ensures safe system operation. This is implemented using the AX5805 TwinSAFE option card in the servo drive and with the EL6900 and EL1904 EtherCAT Terminals or the EP1908 EtherCAT Box as additional TwinSAFE components.

The Scheugenpflug experts agree that the company benefits from the broad Beckhoff portfolio of EtherCAT I/O components with IP20 and IP67 protection ratings. It enables flexible I/O use both in the control cabinet as well as in

© Scheugenpflug

The Scheugenpflug multifunctional DispensingCell DC803 benefits from the flexible and open control technology from Beckhoff.

decentralized installation directly on the machine, with fast and space-saving wiring as a result. It also provides the necessary system openness to seamlessly integrate PROFIBUS, PROFINET, and EtherNet/IP components into the EtherCAT network with its high performance and comprehensive diagnostic options, and to flexibly integrate the multifunctional cell into larger systems.

This example of a dispensing and potting system illustrates the complexity of the underlying process sequences.
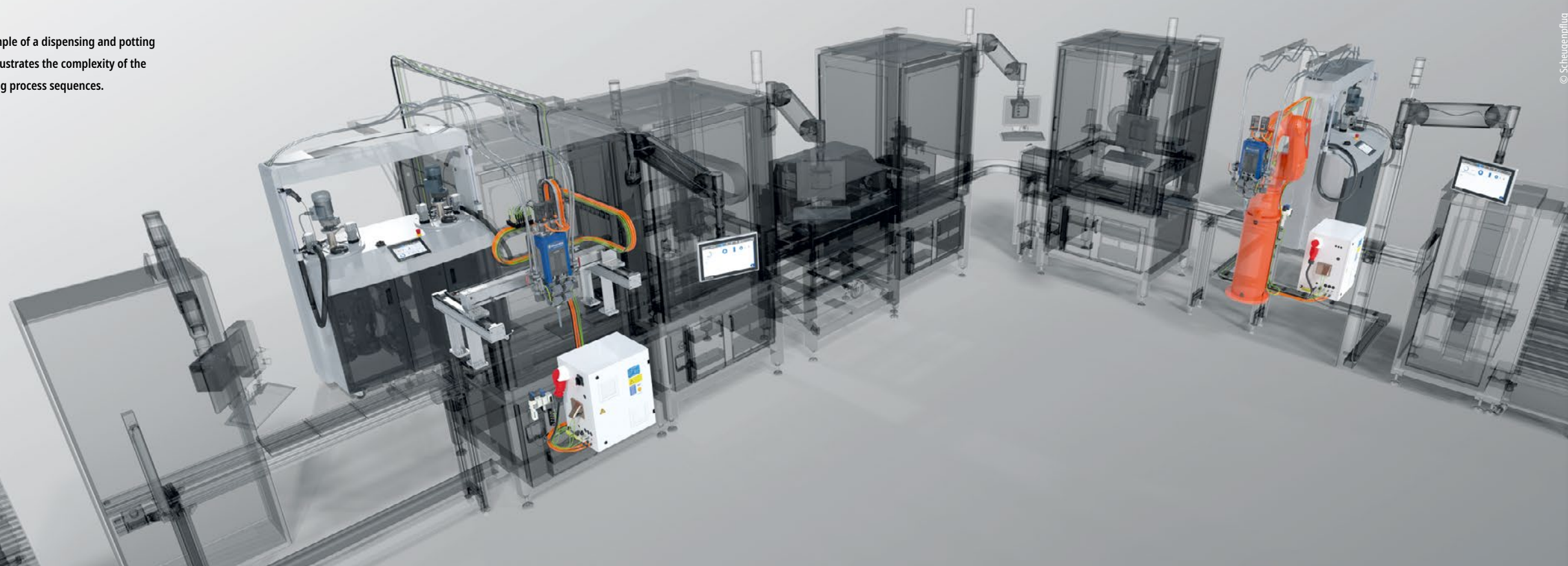
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Scheugenpflug and Atlas Copco

Scheugenpflug, the expert in automated electronic potting, has been operating under the company name Atlas Copco since the fourth quarter of 2024. It is part of the Atlas Copco Group, which brings together people, technologies, innovations, and expertise in global innovation centers. The associated Industrial Assembly Solutions (IAS) division develops technologies and solutions to optimize production processes in the electronics and automotive industries by combining automation and sustainability.

More information:
www.scheugenpflug-dispensing.com
www.beckhoff.com/automotive

PC-based control for all-electric blow molding machines

Plastic Framework increases flexibility and dynamics for more efficient processes

The economical use of all resources is important in plastics processing. BBM, a machine builder specializing in blow molding machines based in Langenberg, Germany, therefore attaches great importance to all-electric machines and innovative process control with the TwinCAT 3 Plastic Framework. Automated with PC-based control from Beckhoff, energy consumption is reduced by producing higher quantities combined with an efficient use of materials.

© Beckhoff

All travel profiles and temperature control sections of the blow molding system are automated using a high-performance CX2033 Embedded PC.

Founded as Berlin Blasform Maschinen in 1998, BBM has been developing and producing its blow molding machines in Langenberg/East Westphalia since 2003. "Around 120 employees develop and produce high-performance systems on 6,000 m², " explains Felix Schulte, who is the second generation of the family to head the company as technical managing director. Since 2006, the company's focus has been on all-electric machines and continuous further development of existing technologies with partners such as Beckhoff. "At BBM, systems engineering from Beckhoff acts as an extended workbench, creating the application software based on the TwinCAT 3 Plastic Framework for example, as well as configuring and assembling the system-specific control cabinets, and commissioning the systems at BBM," says David Derksen, head of the custom machines group in systems engineering at Beckhoff, thereby highlighting the deep and trusting cooperation.

"Felix Schulte and his team always provide us with valuable impulses and ideas that are incorporated into the TwinCAT 3 Plastic Framework," emphasizes Christian Gummich, plastics processing and hydraulics application industry manager at Beckhoff. The Plastic Framework brings together the many years of Beckhoff expertise in plastics processing, seamlessly integrating important industry-specific control functions in TwinCAT. "We therefore offer both software packages and application solutions for PLC and HMI which act as a launchpad for developing customer-specific application solutions," adds Christian Gummich.

Flexibility and openness

The openness and flexibility of PC-based control is very important to custom machine builder BBM: The systems often have to be adapted to the customer process or the items which are manufactured on them. "PC-based control in particular offers us the flexibility and modularity to implement what are, at times, very different requirements in the application," explains Felix Schulte. The applications range from small eye-drop bottles or 6500-liter tanks to small systems with a footprint of just four square meters or systems that fill an entire hall. "We would not be able to cover this broad spectrum without flexible automation technology and software," emphasizes the technical managing director.

The fully electric double-station blow molding machines use PC-based control to increase production output while reducing material and energy consumption.

© Beckhoff

In addition to the PC-based control system, BBM also uses I/O terminals, drives, and motors – in other words, a large part of the Beckhoff portfolio. "The EcoBlow EB5 double station was completely automated using Beckhoff products," describes Christian Gummich. In addition to a customer-specific CP3919 multi-touch Control Panel and a CX2033 Embedded PC, all drive axes in the application are driven by AM8000 synchronous servomotors or controlled by AX5000 servo drives.

The EcoBlow EB5 has a clamping force of up to 12 t and can produce containers with a volume of up to 7 l. "This high clamping force is needed to press the plastic tightly at the seams of the mold," says Felix Schulte. As a special feature, the machine is set up as a double station: The machine has two molding posts that move alternately under the extruder head. This provides the advantages of significantly higher machine output in relation to the footprint and a lower price compared to two individual machines. It also reduces the changeover effort and the design is very interesting for higher volume production. In addition, the machine can be equipped with up to six extruders. This is an advantage if the container wall is to contain a barrier layer, for example, or if recycled material is used.

Dynamic control for high volume production
High-performance control, short communication cycles, and dynamic drives are crucial for high throughput and high quantities to avoid downtimes in the process. "This was definitely a benefit and had a significant impact on cycle times," says Felix Schulte. BBM's managing director sees further potential here in the water-cooled AM8300 servomotors, which provide a significantly higher power density and greater torque for the same size.

The more dynamic the control, the more interpolation points can be used for partial wall-thickness control, for example. This reduces the consumption of material without affecting the rigidity of the canister. To improve the stability, it is important that there is more material in the corners than in the side walls. This is ensured by the partial wall-thickness control: BBM has installed two optional actuators in the area of the extrusion head. These are used to reduce the wall thickness on the surfaces and to press the material in specific areas – the corners – to provide additional stability.

Simple operation of sophisticated processes
According to Felix Schulte, the TwinCAT 3 Plastic Framework also featured an impressive user interface. Operation is straightforward using the simple visualization, which is similar to using smartphones. This is an important factor, given that end users are often struggling to find well-trained system operators. What's more, the products are becoming increasingly sophisticated and need to be produced in large quantities using as little material as possible. "TwinCAT HMI offers a good compromise between ease of use and sophisticated setting options," says David Derksen.

In addition to ease of operation, the issue of sustainability is becoming increasingly important in the plastics industry. BBM is doing its fair share of enabling customers to increase the proportion of recycled content in their products and reduce energy costs. According to BBM, switching from hydraulic systems to all-electric machines alone reduces energy consumption by around 50%. BBM can provide evidence of this using the energy data acquisition integrated in PC-based control with SCT2111 ring-type transformers and EL3443 EtherCAT Terminals for power measurement. An all-electric system from BBM consumes between 0.25 and 0.3 kW/kg of plastic. It is also possible to convert the energy consumption per unit, which is important information for calculating orders given today's energy prices.

The roadmap is in place
Migrating the control architecture to other series is planned for the future. Felix Schulte comments: "With the hardware and software from Beckhoff, we've developed an excellent, high-performing overall package using which we can achieve our ideas in close cooperation with the Beckhoff experts."
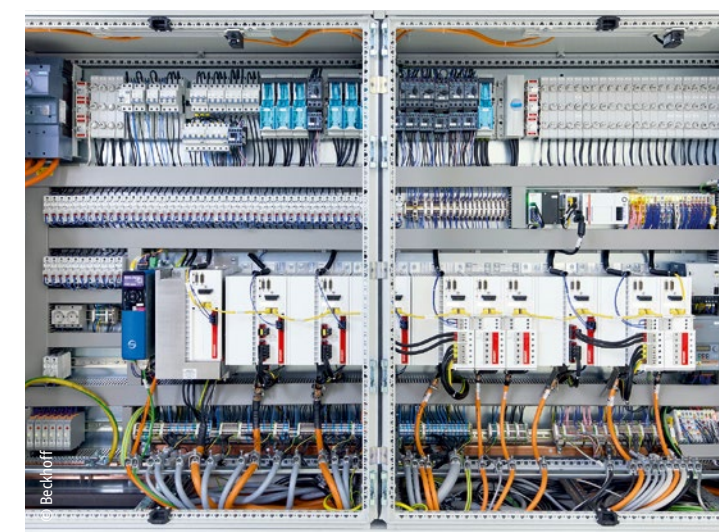
Left: Energy consumption is an important cost factor in the plastics industry. BBM is able to precisely measure energy consumption using SCT2111 ring-type current transformers and EL3443 energy measurement terminals.

Right: Control cabinet of the blow molding machine with AX5000 servo drives

Important topics for BBM include AI and algorithms that relieve operators of increasingly complex systems and control machines independently. The reasoning behind this is that blow molding – unlike injection molding – is an open process: opening the hall door or varying the batch material can have a noticeable effect on the process. "In future, our systems will be able to detect such influences and readjust the process independently.

Another aspect revolves around optimizing the system efficiency: The movement profiles of the drives can influence both energy consumption and cycle times. If an order urgently needs to be processed and finished, energy consumption is not the most important factor at this time. However, the system must apply the shortest possible cycle time.

So why not store several movement profiles (Eco, Standard, Speed) for the drive axes in the HMI and call them up as required to save time or energy? Predictive maintenance is another topic which BBM would like to manage to a greater extent using the control system in the future. The trend in motor current consumption is a good indicator when it comes to mechanical wear. Jerking in the movement profile is a clear indicator of worn bearings. All these measures help BBM's customers to produce items in a more sustainable manner: A well-maintained system produces more efficiently. With PC-based control, such functions can be easily integrated and implemented in the existing control architecture.
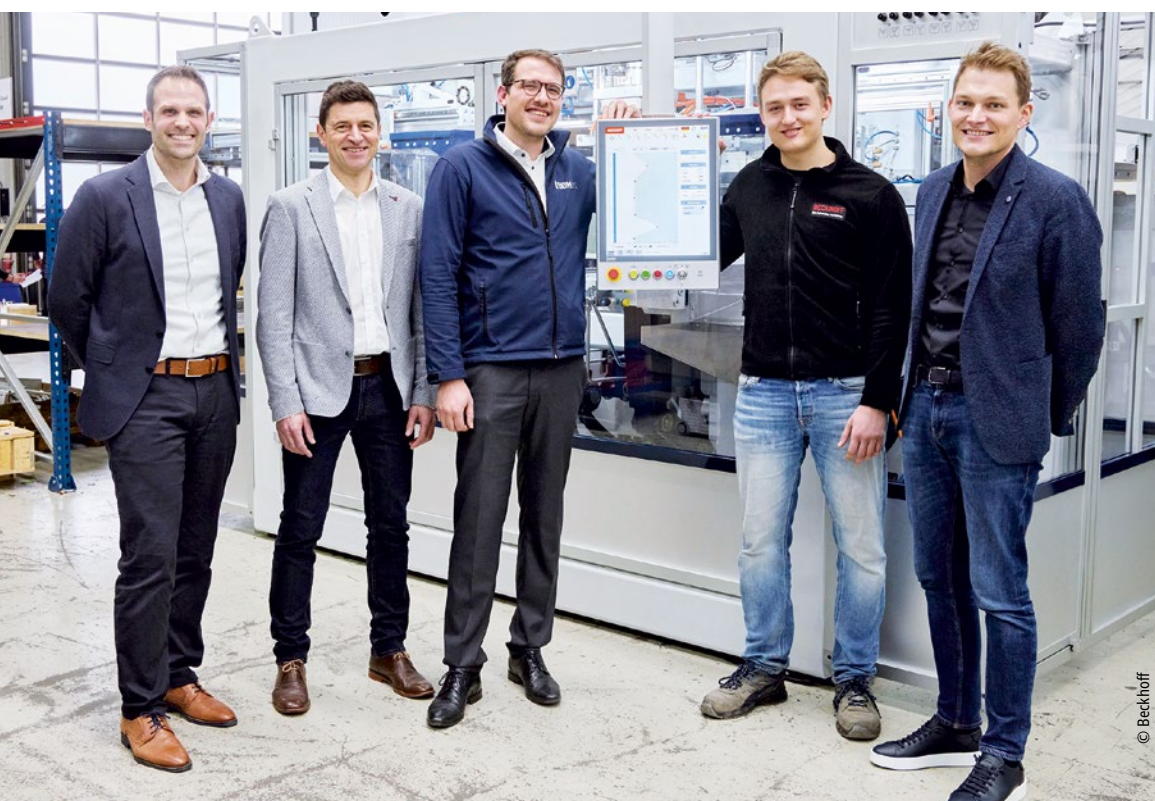
Christian Gummich, Plastics Processing and Hydraulics Applications Industry Manager, and David Derksen, head of the special machines group in systems engineering (both Beckhoff), as well as Felix Schulte, technical managing director of BBM, Jan Beckervordersandforth, Beckhoff application engineer and Michael Nienkemper, Beckhoff sales (from left to right)
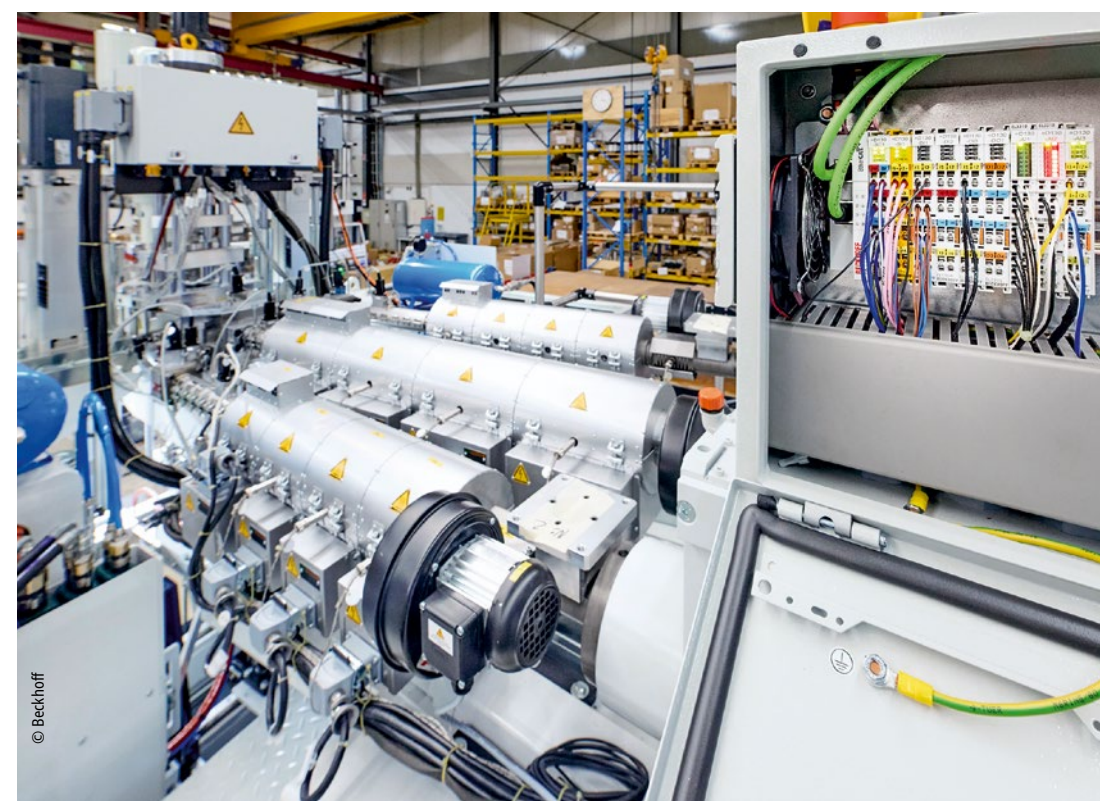
The heating zones of up to six extruders in a blow molding machine can be flexibly integrated into the modular control architecture.

More information:
www.bbm-germany.de
www.beckhoff.com/plastic

The compact drive technology used in the system includes AM8100 series servomotors from Beckhoff with One Cable Technology which minimizes the effort and space required for cabling.

Compact drive and control technology in a cosmetics filling system

Flexibility for the future and 40% cut in control costs

When custom machine builder Lehnen Industrial Services introduced a filling machine for lip balm, the company was surprised by the amount of interest in this premium system. In order to meet this demand, they decided to standardize the machine. The necessary adaptability is provided by the scalable control technology from Beckhoff. With an impressive range of functions on a small footprint, the system closes a gap in the life sciences market, according to the provider.

The ProFill SF lip balm filler from Lehnen Industrial Services combines loading, in-parallel filling, cooling, capping, labeling and coding into one compact system.

© Beckhoff

Founded in 2001, Lehnen primarily serves customers in life sciences. "Our niche is purpose-built equipment for cleanroom environments with small footprints. That involves significant design optimization to condense extensive functionality into small spaces," President Peter Lehnen says. When the company completed its first lip balm filling system, he figured it would be the last. Sure, it combined a host of features – container loading, in-parallel filling, cooling, capping, labeling and coding – into one compact machine. But the system did not fit into any category. "With this type of filling equipment, typically one class is low cost and low speed. Then, an industrial class offers high throughput but costs millions of dollars per installation," Peter Lehnen says. "There are few options in that middle space."

However, when Lehnen posted a video of the ProFill SF system online, the company received inquiries right away from potential customers looking for solutions between ultra-low end and ultra-high end. As the custom machine builder from Keene, New Hampshire, decided to make the machine a standard product, the engineering team needed to answer a new challenge: how to optimize and future-proof the automation platform. Lehnen felt locked into by a legacy PLC platform that impeded innovation. "At a time when memory is so inexpensive, it's mindboggling that a $3,000 PLC has only 4 MB of storage. So many times, I've been forced to delete code comments from programs just to free up enough bytes," Head Software Developer Chris Lehnen recalls. "That, as well as arbitrary caps on I/O and motion axis counts, is why we started looking at more modern options."
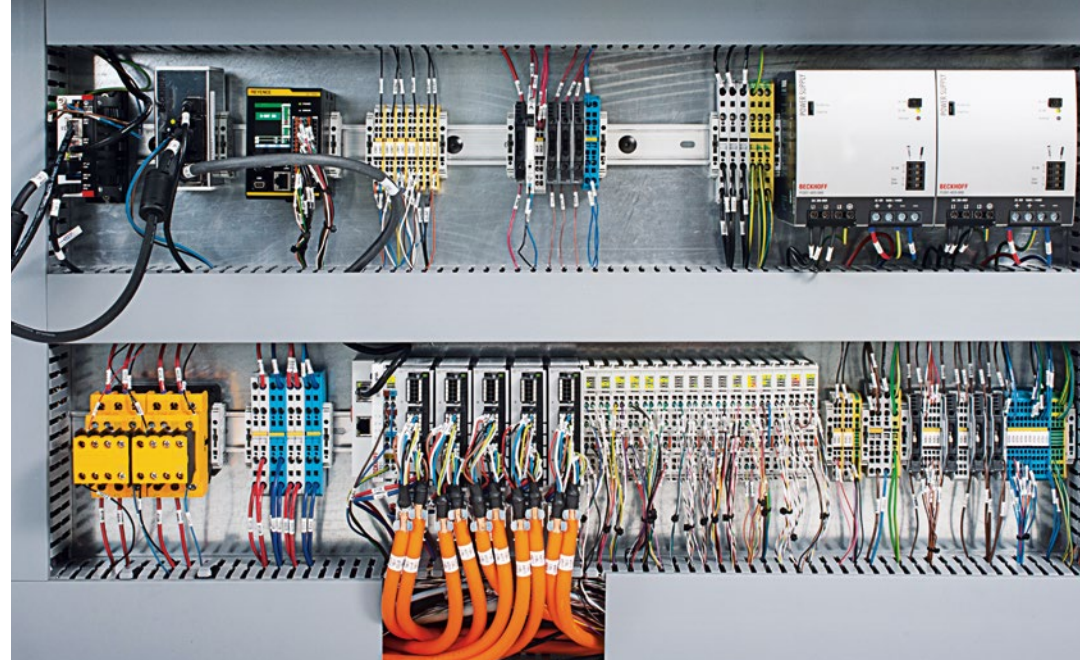
The Lehnen team first encountered Beckhoff at a trade show in 2015, but at the time they weren't ready to navigate a platform shift that was not going to be easy in the strongly regulated life sciences industry. Then in 2020, as many vendors struggled to supply components, they found out how flexible the Beckhoff platform can be adapted by making component substitutions. These factors allowed them to migrate some customer projects to Beckhoff – at the same time as the machine builder started considering manufacturing standard filling systems.
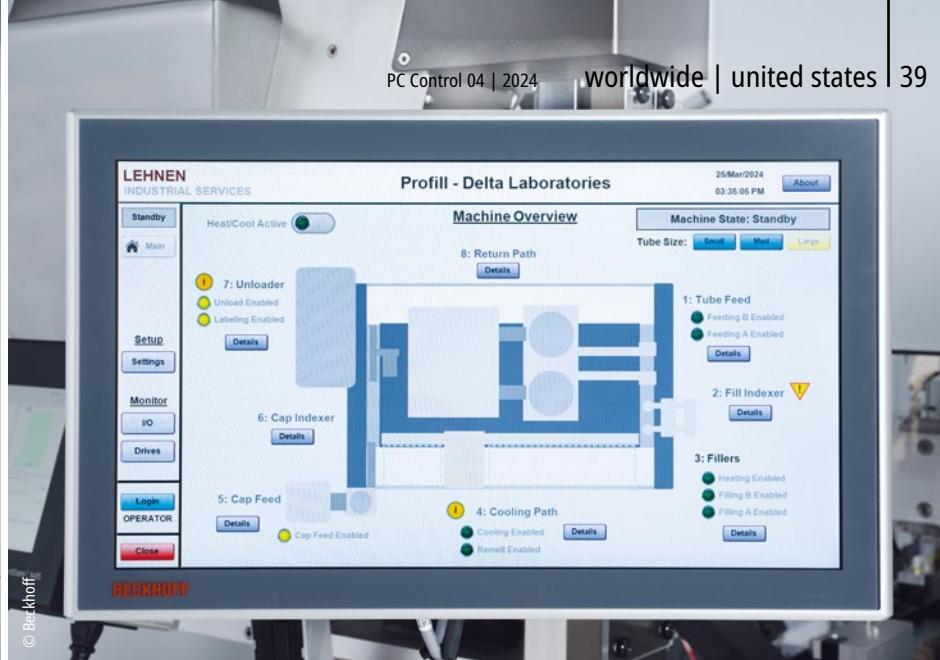
Left:
By switching to Beckhoff, Lehnen freed up space in the electrical cabinet for future functionality additions while cutting controls costs by roughly 40%.

Right:
The CP3918 multi-touch Control Panel provides an elegant and user-friendly operator interface with an 18.5-inch display for the filling system.

© Beckhoff

The innovative team at Lehnen Industrial Services, including (from left) Controls Engineer Rick Fuller, Head Software Developer Chris Lehnen, President Peter Lehnen, and Director of Business Development Kelly McKenney.

© Beckhoff

Innovation through flexible automation
The ProFill system brings all processing steps into a self-contained unit measuring just 11 feet 8 inches by 5 feet 5 inches (308 x 142 cm). Even with its sturdy stainless steel construction, the portable system can move on casters to work in any location with compressed air and 240-V AC connections. In addition, the design simplifies filling head changes, whether for cleaning or product changeovers.

During the development process of a standard system the engineers wanted to ensure that the machine would maintain its small footprint and high-precision filling to avoid dripping hard-to-clean, waxy liquid on conveyance equipment. Working with the local team from Beckhoff USA, including Regional Sales Engineer Brian Buck and Applications Engineer Matt Kleven, Lehnen began the redesign in January 2023.

The system relies on a C6015 ultra-compact Industrial PC (IPC) as its machine controller. Beyond its extremely space-saving dimensions, the IPC's memory options range from 40 to 320 gigabytes. A CP3918 multi-touch Control Panel from Beckhoff brings intuitive smartphone-style operation even to tough production environments.

Programming of the HMI, PLC and motion control takes place in TwinCAT 3 automation software. As an end-to-end engineering and runtime platform, TwinCAT incorporates all functionality needed for machine control with flexible

Chris Lehnen, Head Software Developer at Lehnen:

" TwinCAT simplifies source code control through incorporation of Git. So our software team can work on the same program simultaneously to speed up development."

options for writing code. The integration into Microsoft Visual Studio means engineers can leverage the programming language that best fits, including:

– IEC 61131-3 standards with object-oriented extensions
– custom function blocks or hundreds of built-in options in TwinCAT libraries
– computer science paradigms, such as C#, C++, Python, and HTML5 or JavaScript for HMI creation

The Lehnen team appreciates the ability to try software in the no-cost TwinCAT engineering environment before buying it. "TwinCAT offers a proper implementation of the IEC standard and object-oriented programming, unlike other vendors' platforms that are technically compliant but more restrictive. This allows us to truly embrace best practices in software development," Chris Lehnen says. "Beyond that, TwinCAT simplifies source code control through incorporation of Git. So our software team can work on the same program simultaneously to speed up development."

"The Lehnen team really took advantage of numerous software and hardware solutions we offer, including the precise synchronization with EtherCAT," says

Brian Buck. "For me, an aspect of this application that stands out is their use of the compact ELM7222 servo drives." The dual-channel, 48-V DC servo amplifiers can be installed directly within the EtherCAT I/O segment, as they are EtherCAT Terminals that measure just 30 mm wide, alongside wide-ranging terminals needed for networking the system, such as high-density inputs and outputs, analog temperature measurement and thermocouple modules.

The ELM72xx series servo terminals also support One Cable Technology (OCT) to connect AM8100 servomotors from Beckhoff with a minimized cabling effort. These features further shrink space requirements and simplify commissioning, while ensuring very high performance.

Potential for future expansion
The standardized lip balm filler maintained its high performance and compact footprint. The system processes trays of eight tubes at a time with a throughput of 60 tubes per minute. In continuous operation, the machine can fill, cap, label and serial code 30,000 sticks per day.

With space-saving controls, networking and servo drive hardware from Beckhoff, the machine also freed up space in the electrical cabinet for future functionality additions. "On top of having a better overall system, we reduced costs significantly," Peter Lehnen says. "In terms of control hardware, we saved roughly 40% by standardizing on Beckhoff."

More information:
www.lehnendesign.com
www.beckhoff.com/compact-drive-technology
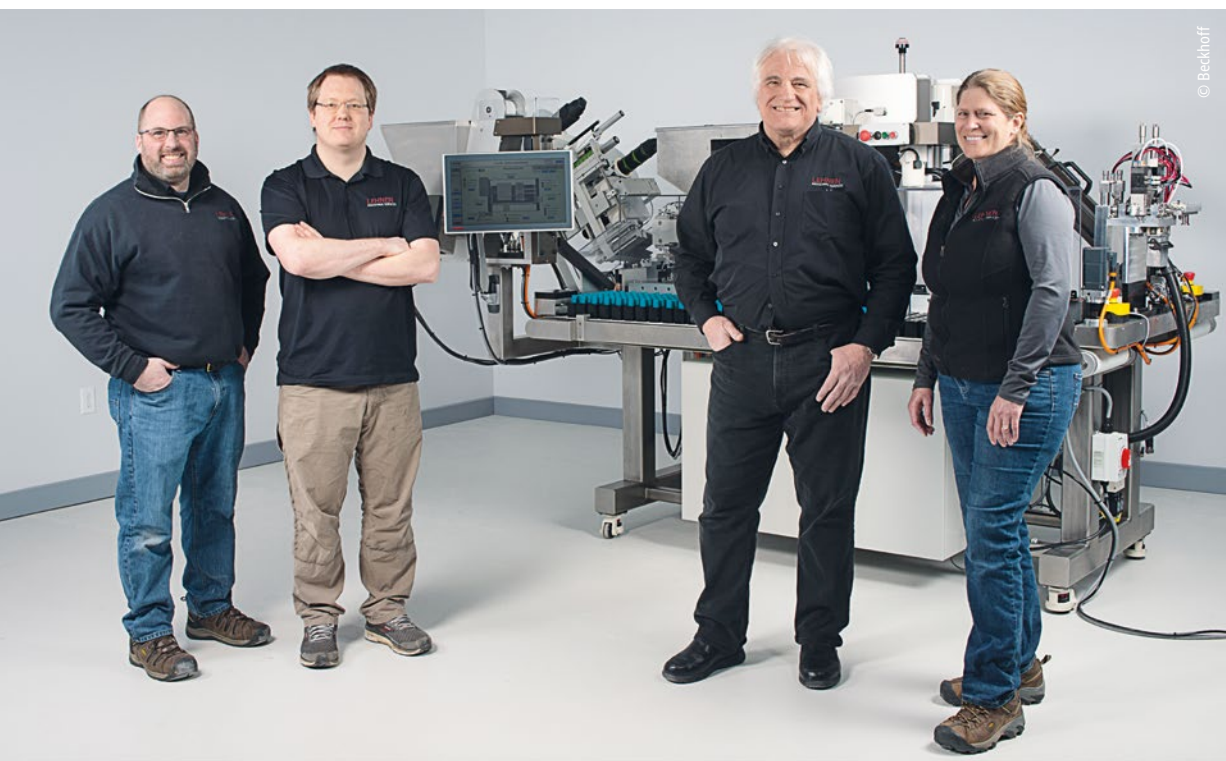
Non-destructive inspection in the aerospace industry

Automation boosts inspection speeds by a factor of 10

© Beckhoff

Innerspec Technologies designed the Twin Robotic NDT System to meet complex inspection requirements for their major aerospace customer.

When Innerspec Technologies was commissioned by a major aerospace end user to develop a non-destructive testing (NDT) system, the company opted for flexible automation with PC-based control from Beckhoff. The open control, motion and networking technologies of the robotic solution facilitate the inspection of a wide variety of part geometries combined with a greatly increased throughput.

Ultrasonic inspection methods – here using rotating headstock and tailstock positioners and a robot – usually require a couplant, such as water or gels.

© Beckhoff

Designing non-destructive test (NDT) systems for aerospace clients can be a challenge. Even when the parts under test aren't confidential, they can change rapidly as companies optimize their designs. "The type of inspection is dictated by part geometry, material composition and the defects it needs to find," says Cory Grant, Director of Systems Engineering at Innerspec. "We may receive a small volume of samples for the acceptance test, but we have to design machines for the huge variety of parts we'll never see. So we work around the unknown parameters and make the machine as universal as possible."

Innerspec has maintained its reputation as a pioneer in NDT systems since its founding in 1989. Based in Forest, Virginia, the company's engineers design custom systems for major players in aerospace, transportation, energy and beyond. They also developed testing technologies such as Electromagnetic Acoustic Transducer (EMAT), which doesn't require liquid ultrasonic couplant. The company supports numerous inspection types, such as Ultrasonic Testing (UT), Eddy Current and Phased Array Ultrasonic Transduction (PAUT) to meet different customer requirements.

To accommodate the expected variety of parts and test methods, Innerspec relied on the flexibility of the open, scalable technology from Beckhoff. "The Beckhoff approach to automation technology resonates with us," Cory Grant says. "They give you open, flexible tools with solid documentation and let you mold the products to fit your application."

Thorough testing of mission-critical components
The Robotic Twin system developed by Innerspec includes a total of 18 coordinated axes of motion and includes two robots mounted on tracks, a turntable for Eddy Current inspections, a linear rotator and a 5,000-gallon (approximately 19,000 l) tank for ultrasonic testing with an immersed turntable capable of handling components weighing up to 3,000 pounds (1,360 kg).

In this system, the automation components need to share test data seamlessly with an industrial server and two third-party PCs – one for acquiring and safely storing data, another for manual analysis by a trained specialist.

© Beckhoff

The project team at the Robotic NDT Center in Forest, Virginia (from left): Manufacturing Manager Jim Fenton, Project Engineer Joseph Ziedas and Director of Systems Engineering Cory Grant (all from Innerspec) with Sales Engineer Rodney Reid and Application Engineer Jack Plyler from Beckhoff.

ies for software-based gearing perfectly sync the motors," Cory Grant says. "When the turntable nears the bottom of the tank, the servo system switches from a position-based mode to a torque-based mode. By turning the motors to a specific torque, we push the frame into the floor of the tank up against wedge hard stops, which lock it in place. That way, giant parts remain stable even when they're spinning at 30 rpm."

Two dual-channel AX5206 Servo Drives power all four Beckhoff motors. They also directly integrate functional safety in the drive components via TwinSAFE. Using Safety over EtherCAT (FSoE) communication, the safety-relevant drive functions STO, SS1 and SS2 are supported.

Cory Grant, Director of Systems Engineering at Innerspec:

❝ As the turntable raises and lowers, TwinCAT libraries for software-based gearing perfectly sync the motors."

The real-time communication with EtherCAT enables precise synchronization among the motion axes. In addition, combining power and communication via One Cable Technology (OCT) helped to reduce wiring time and costs on the 120 foot or approximately 36 m long system. "Native support for EtherCAT also removed any communication barriers with the robots and made it easier to swap our end-of-arm tooling on the fly. Here, EtherCAT's Hot Connect capabilities help us accommodate different inspection types," says Project Engineer Joseph Ziedas from Innerspec.

Performance boost through seamless integration

Innerspec met all of the highly demanding technical requirements for their major aerospace customer. The Twin Robotic NDT System retains peak flexibility to accommodate new parts or processes in the future. The transition to Beckhoff technologies helped ensure greater performance. For example, Cory Grant can write custom C++ code and deploy it via a TwinCAT function rather than use the robot controllers' base functionality for triggering tools: "With KUKA's Fast Send Driver, you can go down to 1 ms per update, but with our software algorithms implemented in the C++ module in TwinCAT, we can do it in about 100 µs. So we can basically trigger instruments 10 times faster than we were able to previously, which dramatically increases inspection speeds and accuracy."

The PC-based control technology from Beckhoff also enhanced operator interaction through TwinCAT HMI – with a built-in view of the EtherCAT diagnostics – and TwinCAT XML Server, Cory Grant explains: "My goals when building systems are, one, to make the machine operators happy and, two, to make the maintenance personnel happy. On the Robotic Twin, we know the operators love the look, feel and interface on the machine, along with its reliable performance and flexibility."

© Beckhoff

Using Hot Connect capabilities in EtherCAT, the Robotic Twin system can quickly change end-of-arm tooling to switch inspection types, increasing flexibility.

© Beckhoff

A CX5130 Embedded PC from Beckhoff serves as the central machine controller for the robotic testing center.

Cory Grant's first experience in building NDT systems was with a systems integrator. There, he saw how EtherCAT and PC-based control technology from Beckhoff provided an incredibly powerful and flexible platform for test and measurement applications. After joining Innerspec in 2021, he worked with the in-house engineering team to begin migrating to Beckhoff. "Even back in 2015, I started searching for control systems that were more flexible and incorporated software development principles, version control, Structured Text and object-oriented programming. Working with Beckhoff continues to be a major advantage in these areas," Grant says.

Automation software promotes development

According to the Innerspec experts, the key to enhancing the NDT system's capabilities and flexibility was the Beckhoff TwinCAT software. Beyond streamlining PLC and PTP motion control, the software provides an end-to-end engineering and runtime environment for all aspects of automation. "TwinCAT is integrated into Microsoft Visual Studio, so it empowers our engineers to program in the languages that best fit the application," says Beckhoff Sales Engineer Rodney Reid. "These include IEC 61131-3 languages with their object-oriented extensions, predefined or custom function blocks, and computer science standards from C# and C++ to Python." Cory Grant took advantage of this to facilitate collaboration between the controls and software engineers. Together, they built the machine's operator interface in TwinCAT HMI, which

supports modern UX creation using web-design standards like HTML5 and JavaScript.

Innerspec's system also benefited from the TwinCAT XML Server. This function provides a PLC library that enables write/read access for XML data that is stored in the PLC as a variable. "In this way, I can add all the configuration settings to the XML file. So whether the customer is setting up for a new part or conducting maintenance, the TwinCAT XML Server increases extensibility, transparency and control," explains Cory Grant.

Central control of the aerospace test center

A Beckhoff CX5130 Embedded PC serves as the machine controller for the entire system. Via directly connected EtherCAT Terminals, the CX5130 acquires data from various sensors on end-of-arm tooling and sends it to the system's server and analysis PCs using OPC UA and MQTT functionality in TwinCAT IoT. The multi-core machine controller's fast cycle times support precision motion for the four servo axes realized with AM8000 servomotors and AX5206 Servo Drives as well as for 16 third-party motors and two robot controllers.

The result is a powerful system that enables submerged inspection of parts measuring up to 100 inches or 250 cm in diameter and weighing 2,500 pounds, equalling more than a ton. "As the turntable raises and lowers, TwinCAT librar-

More information:
www.innerspec.com
www.beckhoff.com/twincat

The 15.5-m long system consists of the FOURCUT machine for counting and cutting the signature sheets into individual sections and the WIRO 500 for binding the calendars.

© Beckhoff

PC-based automated production system for photo calendars

Producing up to 1,800 photo calendars per hour using more than 90 servo axes

Durrer Spezialmaschinen AG, based in Immensee, Switzerland, develops – from the design phase to commissioning and more – a wide variety of special-purpose machines. A new production system for photo calendars proves at first glance the particular importance of comprehensive motion control expertise: AM8000 servomotors and AX5000 servo drives from Beckhoff for over 90 dynamically controlled axes are distributed over a system length of 15.5 m housed in two large control cabinets.

The two-part FOURCUT/WIRO 500 system automates the processing steps between printing and the packaging or logistics line, which were previously often still performed manually. It is highly flexible and can process products in a wide range of paper formats and qualities from both digital and offset printing. In addition to wall calendars, desktop calendars can also be produced directly from the pallet or gathering machine. This is only possible due to a high degree of automation, which ensures short set-up and changeover times, reliable system operation by just one or two people, and a high output of 1,600 to 1,800 calendars per hour.

The system consists of a FOURCUT for counting and cutting the signature sheets into individual sections and the fully automatic WIRO 500 processing line for punching holes and ring binding or stacking and sorting for successive packaging and logistics steps. The WIRO 500 was specially designed for assembling photo calendars and in particular to meet the growing demand for lot-size-of-one production, individualized small quantities, and special product designs – whether for private photo calendars or in the promotional and giveaway sector.

Sophisticated movements and high quality

A total of 93 axes – realized using AX5000 servo drives and AM8000 servomotors – take over the sophisticated process sequences. The system also integrates a gathering machine via digital I/Os and a SCARA robot via PROFINET. In addition, there are numerous testing and monitoring functions to ensure high

product quality, e.g., to compensate for deviations in the printing image from different presses. All of this is automated using PC-based control technology from Beckhoff. According to Patrick Suter, Durrer CTO, the broad and finely scalable product portfolio offers particular advantages for a custom machine builder: "PC-based control technology is also ideal for installing the required third-party software, e.g., for the robot, a QR code reader, or the inspection camera, on a computer. We have consistently relied on Beckhoff Drive Technology for eleven years because it has proven to be a homogeneous and highly coordinated PLC, motion, and safety system."

Nicola Ritzmann, head of mechanical development at Durrer, adds: "The servo drives and servomotors are extremely reliably, which is very important for our

machines. In addition, we've been able to set up every axis and implement every motion application so far, even if the axis requirements have changed during commissioning. Not to mention the fact that we can always count on the experts from Beckhoff Switzerland or Verl for support whenever we need it. The implementation process is also simplified by the fact that Beckhoff continuously develops its software with numerous function blocks. For example, we were able to perfectly optimize a challenging axis in a master-slave network using the new Bode diagram." The One Cable Technology (OCT) provided by Beckhoff drive technology offers tangible cost benefits due to fewer cable routings and smaller drag chains, resulting in less material and assembly time overall.

Ultra-compact and communicative industrial PCs

In line with modular machine building, Durrer uses several Beckhoff computers – which communicate with each other via the EAP protocol – to control the FOURCUT/WIRO 500. According to Patrick Suter, the ultra-compact industrial PCs were chosen for this primarily due to their perfectly scalable computing power, compact design, and numerous communication interfaces: One C6030 each for the FOURCUT and the WIRO 500, as well as one C6015 each for an optional transfer module and OPC UA communication with the higher-level customer system.

Patrick Suter explains his experience with the communication skills in the context of PC-based control: "With its topology freedom, EtherCAT enables us to create a simple fieldbus architecture that is perfectly tailored to the machines. To simplify wiring, over 98% of the signals are recorded directly on the machine using EtherCAT Box modules from the EP series: 62 in the FOURCUT and 52 in the WIRO 500. This explains why we absolutely require such a high-performing and robust fieldbus. Due to the widespread use of EtherCAT, we can also integrate numerous third-party components such as EtherCAT-enabled encoders, directly into the network. And the EAP protocol has also proven to be a fast, simple, and reliable solution for control-to-control communication."

Patrick Suter, CTO Durrer

❝ **The comprehensive and reliable data collection forms the basis for real predictive maintenance."**

Patrick Suter describes another aspect of communication: "The comprehensive and reliable data collection forms the basis for real predictive maintenance. We can quickly localize and rectify faults and evaluate data, for example, to assess the influence of different faults on the duration of machine downtimes. This offers great potential for process optimization." The necessary safety functions are also integrated into the system via Safety over EtherCAT, the EL6910 TwinSAFE Logic, and other TwinSAFE Terminals or box modules as well as the AX5805 TwinSAFE drive option cards: SOS, SS1, SS2, and SLS.

TwinCAT as a universal software solution

Just like the industrial PCs, the Beckhoff TwinCAT software also forms the heart of the system automation system. This is confirmed by Patrick Suter: "All machine sequences are programmed with TwinCAT 3 PLC/NC PTP, and the motion function blocks offer us an almost infinite number of very simple options for designing the movements for the corresponding function. Prime examples of this are master-slave combination, override, electronic gearing as well as MC_TorqueControl to switch an axis NC-guided to CST mode (torque control) and MC_MoveSuperImposed for relative superimposed movements. We're very impressed by how easily the NC axes can be integrated into the PLC." TwinCAT 3 HMI ensures convenient operation of the system.

In addition to the technical performance of PC-based control, Nicola Ritzmann believes that other aspects are also important: "The control and drive technology from Beckhoff offers high quality. This means that we are very rarely faced with system downtimes. And even if our system does come to a standstill, we can count on extremely fast and competent help from Beckhoff Switzerland and also from their headquarters in Verl – not just to ensure smooth system operation, but also during the project engineering phase." Given that Durrer was recently appointed Beckhoff Solution Provider to support other PC-based control users with its comprehensive expertise is proof that this support is not required very often.

The project participants in front of the FOURCUT (from left to right): Nicola Ritzmann, head of mechanical development, and CTO Patrick Suter (both Durrer) as well as Markus Wagner, sales at Beckhoff Switzerland

Numerous AM8000 servomotors ensure highly dynamic and precise process sequences.
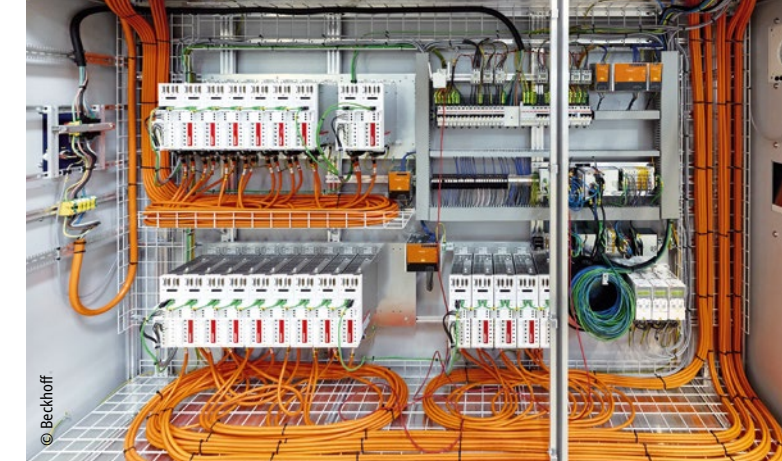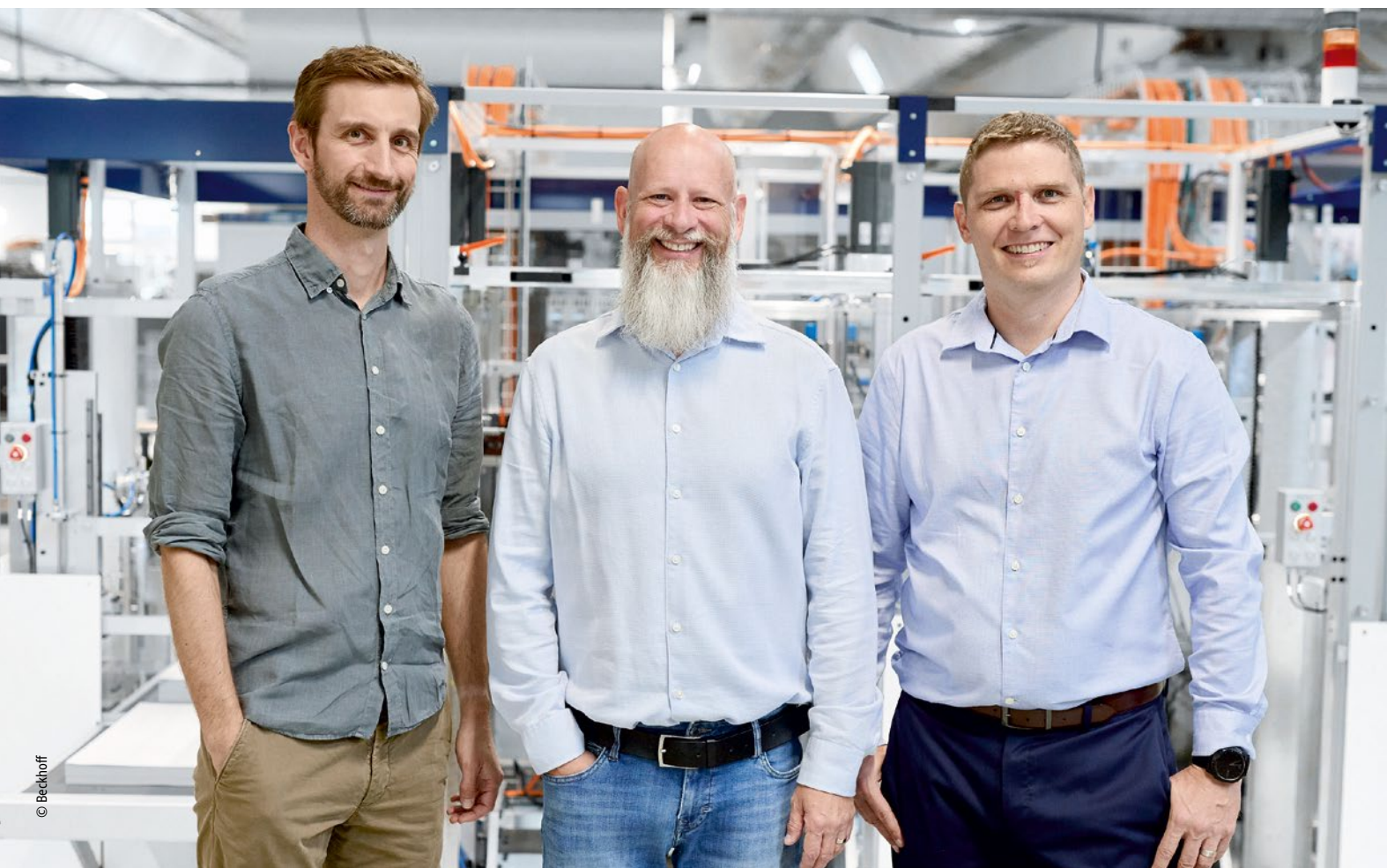
Top: AX5000 servo drives in connection with One Cable Technology (OCT) provide benefits in terms of installation space and are particularly beneficial for systems with a large number of motion axes.

Center: Durrer relies on the decentralized EtherCAT Box modules from the EP series to record around 98% of signals in the FOURCUT/WIRO 500. This also enables the company to efficiently use the assembly space, to consistently modularize the system, and to minimize the cabling effort.

Bottom: Ultra-compact industrial PCs in the WIRO 500 control cabinet: one C6030 (top) as the central control computer and two C6015s (bottom) as an OPC UA gateway to the higher-level customer system and as a controller for the optional transfer module.

More information:
www.durrer.com
www.beckhoff.com/print

PC- and EtherCAT-based control technology for sintering, annealing and sorting in the photovoltaic industry

High connectivity and high performance for the future-oriented solar cell production

For the solar cell production lines developed by XuRi Autowell, EtherCAT- und PC-based control technology helped accelerate the commissioning phase and ensure high productivity in daily operation.

XuRi of the Chinese Autowell Group provides advanced production technologies for the photovoltaics industry and other regenerative energy sectors. In order for manufacturers to stay competitive in these dynamic markets, their equipment must achieve a high degree of automation. With EtherCAT and PC-based control, XuRi seamlessly integrates all third-party systems in its solar cell production lines and ensures high productivity for the end customer through short cycle times.

Founded in 2010, Wuxi Autowell Technology Co., Ltd. (ATW), is a well-known intelligent equipment manufacturer in the PV, Li-ion battery and semiconductor industries with currently more than 4,000 employees. ATW Group has several subsidiaries, such as Autowell Intelligent Equipment, SCEC, ATW Coshin, Leddo and ATW XuRi. Its expanding portfolio serves the four major sectors of the photovoltaic (PV) industry chain: rod, wafer, cell and module production. Subsidiary Wuxi Autowell XuRi Technology Co., Ltd. was founded in August 2021 and is engaged in the R&D, implementation and manufacturing of equipment for PV cell production. In the year of its establishment, Autowell XuRi already succeeded in winning the project

During initial equipment commissioning, EtherCAT diagnostic capabilities helped solve communication issues with third-party slave devices (here the sintering furnace during the debugging process at the plant of Autowell XuRi).

The open and flexible ultra-compact C6030 Industrial PC controls a great variety of third-party devices acting as slaves in the EtherCAT automation network.

Effective troubleshooting and commissioning

Persistent data storage is used for a small number of commonly used parameters. In addition to that, other device and motor parameters are saved by writing XML files. This prevents the loss of device information during system failures and ensures reliable machine operation.

With the EtherCAT communication technology, Beckhoff provides comprehensive diagnostic functions. In addition to the basic "emergency scan" function, users can quickly check for hardware defects in the EtherCAT network topology. It also allows diagnostics of the hardware of EtherCAT ports, enabling fast and accurate identification of the malfunctioning port of a specific slave. During the initial equipment commissioning, these diagnostic capabilities helped the customers solve many communication issues with third-party slave devices and accelerate the commissioning process by quickly eliminating problems at an early stage.

User-friendly programming with TwinCAT

TwinCAT supports all IEC 61131-3 programming languages, allowing users to choose their preferred programming language according to their own experience. In this project, for example, the engineers from Autowell XuRi chose to combine the two programming methods Structured Text (ST) and Function Block Diagram (FBD).

Beckhoff provides feature-rich software libraries for user-friendly programming. The Modbus library, for instance, contains suitable templates to enable convenient communication with frequency converters. The NC library facilitates the programming of motion control functions for the most diverse servo drives. Moreover, for libraries that users frequently call up, the programming efficiency can be further enhanced by creating custom libraries.

The powerful logging system automatically records every detail of machine operation. In case of an unplanned system shutdown or the occurrence of errors during operation, all information on such events can be found in the system, ensuring traceability of production and machine data and providing a basis for future optimization.

of implementing Runyang's N-type solar cell screen printing production line, with a contract value of approximately 130 million yuan. The controllers for each of the production lines are all sourced from Beckhoff. According to customer requirements, the C6015 and CX9020 Industrial PCs were chosen for the sintering and annealing processes, as well as C6030 IPCs for the sorting process. In terms of I/Os, in addition to basic digital and analog input and output modules of the EtherCAT Terminal portfolio from Beckhoff, EL5152 incremental encoder interface terminals are used, which can accommodate two encoders each for motion control. EL6022 EtherCAT Terminals enable communication with third-party instrumentation via Modbus RTU, while EL6652 support real-time communication via EtherNET/IP with other third-party PLCs in the production line. Communication with a third-party touchscreen is implemented via TCP/IP, and real-time communication with another third-party HMI is based on the ADS protocol from Beckhoff. While up to now, TwinCAT 2 automation software is being used, the customer intends to use TwinCAT 3 software in the future for projects with a sufficient number of implementations.

Flexible and scalable control platforms

For the sintering and annealing processes of end customer LONGi in Ordos, the customer selected the C6015 ultra-compact Industrial PC and the CX9020
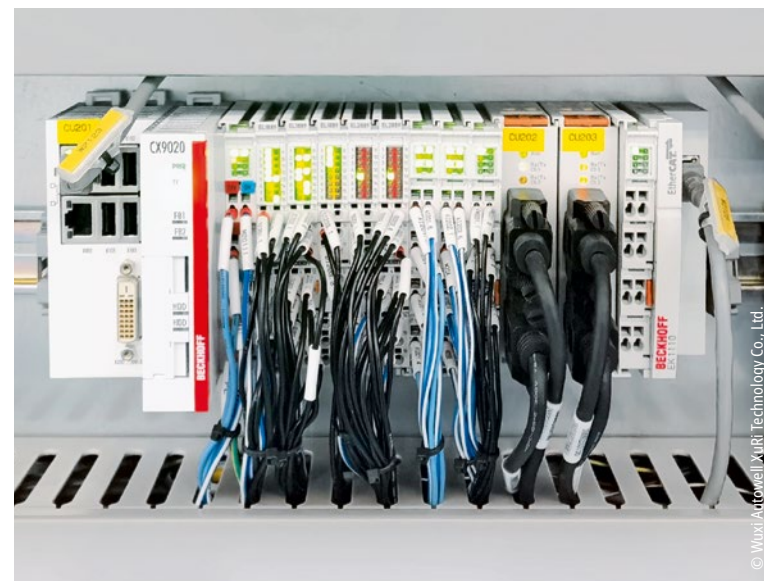
Embedded PC as control platforms. The C6015 features a robust housing made from aluminum and provides advantages such as small size, low power consumption, high performance, and space-saving installation in the electrical cabinet combined with flexible installation options. The two USB ports and two Gigabit Ethernet ports satisfy the user's interfacing needs for daily operation. The CX9020 is a cost-effective embedded controller, which in addition to its RAM integrates 128 KB NOVRAM as non-volatile memory. The DIN rail-mountable Embedded PC allows the direct connection of a great variety of I/O modules, so it is very easy to configure for use in different environments.

For their solar cell sorting process, Tongwei Solar utilizes the C6030 ultra-compact control cabinet PC. This controller is equipped with a 3.3 GHz Pentium® dual-core processor from Intel®, four USB 3.0 ports and four Gigabit Ethernet ports. It uses two Ethernet ports for EtherCAT communication, providing connectivity for dozens of different modules and 80 servo drives, achieving real-time control of all connected slaves in the automation network. When compared to traditional PLCs, the control system from Beckhoff is more open and flexible, and features a higher performance in real-time control. As a result, it can better meet the customer's needs in terms of short cycle times corresponding to a high production output.

With directly connected EtherCAT Terminals, the CX9020 Embedded PC forms a fast all-in-one backbone for all automation functions of the comprehensive solar cell production lines.

More information:

PC-based control for sustainable fertilizer production on an industrial scale

Flexible, automated production of valuable fertilizer from slurry

Whether it's 5 m³ or 40 m³, Byosis automates the systems for ammonia extraction from slurry and other organic materials with PC-based control from Beckhoff.

On a farm in the USA, valuable ammonia is extracted from slurry in a large fermenter and processed into ammonium sulfate. NSI Byosis has transformed this complex process into a modular system concept that can be flexibly adapted to different operating scales and organic raw materials. This modular approach requires an automation solution with flexible scalability in both hardware and software, which this Dutch company has found in PC-based control from Beckhoff.

Biogas is produced by bacteria during the fermentation of organic waste, sewage sludge, and slurry. One resulting byproduct is ammonia, which is toxic to the bacteria and must be removed from the reactors. "We extract the ammonia from the slurry stream and convert it into ammonium sulfate, which can then be spread on fields as fertilizer," explains Dylan Veelers, project engineer at NSI Byosis. The ByoFlex systems from NSI Byosis B.V., located in the Dutch town of Raalte, are commonly used alongside biogas plants, waste and sewage treatment plants, and are also installed in industrial environments.

The current consumption of the system is recorded with SCT2311 ring-type current transformers and used to analyze the energy consumption via an EL3443 EtherCAT power measurement terminal.

© Beckhoff

Reinoud van Bennekum (sales engineer at Beckhoff Netherlands – left) and Dylan Veelers (project engineer at Byosis – right) pictured with the central control cabinet with a CP2921 multi-touch Control panel

© Beckhoff

A large Byosis system was recently installed for an agricultural business in the USA. The dimensions reflect the impressive size of the operation and quantity of slurry: each line of the modular system comprises a 3 x 12 meter frame with three polypropylene towers. "With a capacity of up to 40 m³ per hour, more than 70 percent of the ammonia is extracted and converted into valuable fertilizer," enthuses Dylan Veelers.

TwinCAT replaces graphical engineering tool
Project engineer Dylan Veelers joined Byosis in 2021. "At that point, the company was looking for a new control platform to replace the previous graphical programming system," recalls Reinoud van Bennekum, sales engineer at Beckhoff Netherlands. "The initial tests with a C6017 ultra-compact Industrial PC demonstrated that we could make significant progress in standardizing automation technology with PC-based control – especially with TwinCAT as a development environment," notes Dylan Veelers. Programming with TwinCAT is much more straightforward, far more intuitive, and open to boot. Since EtherCAT had already been used in previous projects, fully switching to Beckhoff's PC-based control was simply the next logical step.

Byosis has been automating the ByoFlex systems with a C6025 ultra-compact Industrial PC ever since. The company uses its three configurable Ethernet ports to read out flow meters and pH transmitters via EtherNet/IP. "The advantage for our customers is that we support any Ethernet-based communication," clarifies Reinoud van Bennekum. Byosis adds an additional Ethernet interface via a CU8880 USB-to-LAN adapter.

The browser-based system visualization is implemented with TwinCAT HMI and runs on a CP2921 multi-touch Control Panel. This means technicians can access the systems remotely from any location as required. The system used for commissioning, diagnostics, and service can be supplemented with Teamviewer, OpenVPN, or Anydesk to suit the customer's preferences. A PC-based platform makes all of this very easy to implement according to

© Beckhoff

The control architecture is identical for all system sizes: a C6025 ultra-compact Industrial PC (right) controls the entire process; depending on the system size, the skids are scaled via an 8-way CU1128 EtherCAT junction (center) and 2-port EP1122 EtherCAT junctions (hot connect) with an IP67 protection rating.

Dylan Veelers, who is impressed by more than just the technology, "The support and service provided by the Beckhoff experts are also quick and efficient." Reinoud van Bennekum sees his role mainly in providing support and advice, "The customer retains full knowledge of the processes every step of the way. We provide the support and training our customers need to plan and program their systems effectively." Dylan Veelers adds: "A few days of training often saves weeks in practice."

**The system determines the topology**
Byosis structures the control architecture with an 8-port CU1128 junction, in line with the modular design of the systems. Comprehensive EtherCAT diagnostics ensure a transparent network by displaying the entire hardware configuration at the push of a button. "Another great feature is hot connect," comments Dylan Veelers. With a decentralized 2-port EP1122 EtherCAT junction, individual EtherCAT segments can be easily disconnected on site to address and resolve system faults. The other parts of the system can thus continue to extract ammonia, allowing the bacteria in the reactors to produce biogas without disruption.

The wide range of I/O modules from Beckhoff is used to connect the various sensors for measuring pressure, temperature, pH level, and flow: in addition to EtherCAT Terminals in the control cabinet, EtherCAT Box modules with an IP67 protection rating are also used for IO-Link communication, for example. As the process is energy-intensive, the systems' energy consumption is determined using SCT series current transformers and EL3443 power measurement terminals. This allows users to check whether the actual consumption matches the target.

One industrial PC for all system sizes
By switching to PC-based control, Byosis has specified a control configuration for all system sizes and developed a single P&ID (piping and instrumentation diagram), ranging from the entry-level demo model at 5 m³ through to the scalable standard systems at 10, 20, or 40 m³. Reinoud van Bennekum remarks, "With EtherCAT as the fastest fieldbus system and PC-based control, we can keep pace with developments at Byosis at all times."

© Beckhoff

Byosis uses the wide range of EtherCAT Terminals from Beckhoff in the control cabinet, as well as EtherCAT Box modules with an IP67 protection rating, to record the sensor signals in the skids.
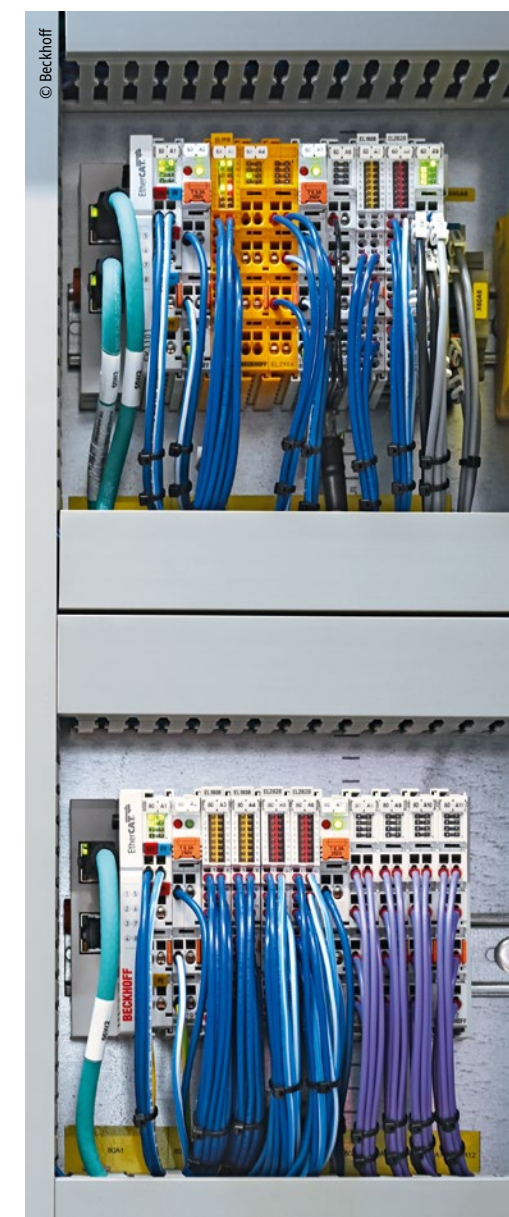
More information:
www.byosis.com
www.beckhoff.com/process

Translatory servomotors in repair systems for wood veneers and chipboard

Highly dynamic linear motors for perfect veneers and wood panels

Wood is a natural and renewable raw material, which means it rarely arrives in pristine condition. This is why the Finnish company Raute, which claims to be the global market leader in veneer, plywood, and LVL (laminated veneer lumber) production technology, also offers repair systems that automatically detect and repair defects. A combination of AL8000 linear motors and AX5000 servo drives from Beckhoff ensure the necessary high precision and dynamics.

© Raute

With PC-based control, Raute has increased the performance of its Panel Repair Station and reduced material consumption by 20%.
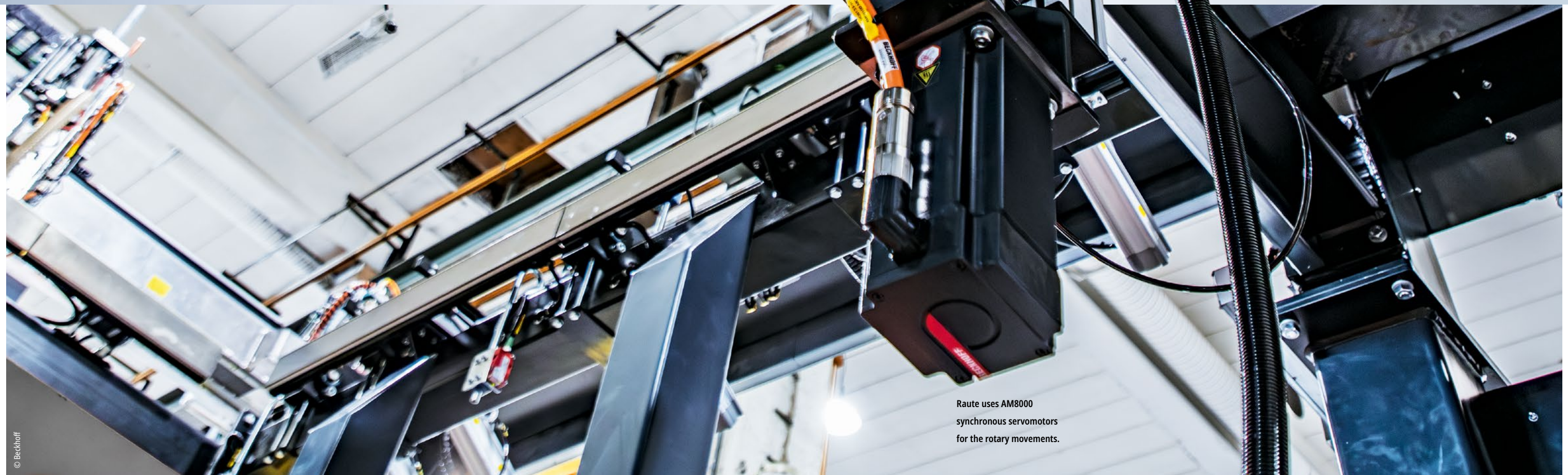
Raute uses AM8000 synchronous servomotors for the rotary movements.
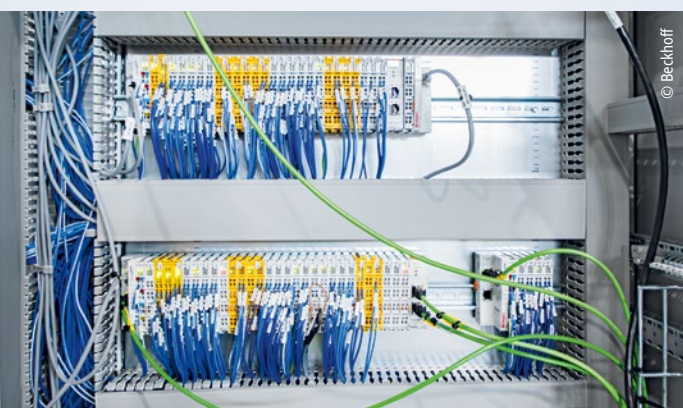
© Beckhoff

The highly dynamic AL8000 linear motors ensure dynamics and precision.

All drive axes are controlled via AX5000 digital compact servo drives.

Control cabinet with C6030 ultra-compact Industrial PC, CU8110 uninterruptible power supply, and various EtherCAT I/O and TwinSAFE Terminals

Erkki Kauranen, Business Line Manager at Raute:

" We chose the AL8000 linear motors and
AX5000 servo drive from Beckhoff because
of their high precision and dynamics."

Raute, headquartered in Nastola, Finland, has built up a comprehensive stock of expertise in all sub-processes of veneer, plywood, solid wood panels and LVL processing since the company was founded in 1908. Its technology spectrum ranges from log handling, turning, and drying to veneer handling, stacking and pressing of veneers, panel handling, sorting, and repair. "Today, more than half of the LVL produced worldwide is manufactured on Raute machines," states Erkki Kauranen, Business Line Manager for Veneer Repair, Panel Repair, and Panel Processing.

High-quality solid wood panels
The Panel Repair Station R5 is Raute's latest innovation. Automated with PC-based control, the system eliminates the need to manually repair solid wood panels and requires only one operator to monitor the process. This allows companies to deploy their qualified personnel elsewhere in production and, at the same time, increase the quality and efficiency of repairs. When dealing with an average of seven defects per side, the system can repair up to 250 panel surfaces per hour. Designed for processing solid wood panels, the system can also repair panels made from all other types of wood.

All process steps are automated with PC-based control. "We chose the AL8000 linear motors and AX5000 servo drive from Beckhoff because of their high precision and dynamics," says Erkki Kauranen. The system is controlled via TwinCAT and a C6030 ultra-compact Industrial PC. The customer-specific control panel communicates with the Beckhoff Industrial PC via CP-Link 4. Raute uses AM8000 synchronous servomotors with planetary gearboxes for the rotary movements. Due to the considerable system size of 8 x 10 m, the sensor signals are collected in a decentralized manner using EtherCAT EP box modules with an IP67 protection rating. TwinSAFE components are used for the safety technology.

A hundred parameters define a knothole
In addition to the highly dynamic and fully automatic processes, detecting and eliminating defects are essential to keeping the systems productive – that is, maintaining the rate at which high-quality wood panels are produced. Raute has therefore combined the technologies for identifying and categorizing defects in veneers and plywood panels in its own dedicated systems known as analyzers, which are based on image processing and AI. Raute has taught the technology to recognize the patterns and shapes of around a thousand knotholes categorized as "healthy". "We detect and document around 100 features in a knothole, such as its shape and color changes," says Erkki Kauranen, explaining the work involved. This means that powerful hardware is required to record the grain and detect the defects in order to keep the repair system performing well. "That's why we carry out camera- and AI-based detection and evaluation of the defects on another Beckhoff control cabinet Industrial PC – a C6650," adds Janne Suhonen, Key Account Manager at Beckhoff Finland.

As a rule, between five and twenty defects are detected per panel. Smaller defects may remain untreated, depending on the desired quality level, the

Erkki Kauranen, Business Line Manager for Veneer Repair, Panel Repair, and Panel Processing at Raute, and Janne Suhonen,
Key Account Manager at Beckhoff Finland, in front of the Panel Repair Station R5 (from right to left)

product in question, and the intended use. This advanced analysis of the wood panels allows the company to use exactly the right amount of repair materials. "We've managed to halve our consumption and reduce waste to a minimum," says Erkki Kauranen. Proof of this is provided by a comprehensive reporting system, which is an important part of the repair systems.

Motion control ensures dynamics
The repair station requires the automation technology to deliver excellent performance. The coordinates of each defect must be associated with the relevant wood panel and transferred to the control system. The AL8000 linear drives are responsible for the dynamic and precise positioning of the tools. To keep system throughput high, several tools process one veneer simultaneously. However, there is also integrated collision detection to prevent damage to the tools. "The complete solution from Beckhoff, consisting of an engineering environment, control, safety, high-performance motion control, and highly dynamic linear drives, has brought us clear advantages in practice – especially during commissioning," says Erkki Kauranen. PC-based control has also solved the interface problems that repeatedly arose in the past.

The company began working with Beckhoff about ten years ago, when it acquired its first drives for lathes and a few I/O terminals, which it used for tasks

such as acquiring signals from SSI encoders. It gradually began using motion controllers and industrial PCs more and more. Teppo Lepistö, Automation Product Specialist at Beckhoff Finland, supported the implementation of the PC-based solution from the very beginning. "That has been a very important factor in introducing new products and control systems, and has accelerated development considerably," says Erkki Kauranen.

Today, Raute uses Beckhoff's complete automation portfolio – motors (rotary and linear), drives, and control elements – for its repair systems. The outdated control system for the lathe is currently being replaced by a powerful control system from Beckhoff. The Panel Repair Station R5 has been in operation for some time now and represents a standard-bearer for technology at Raute, providing a basis for future developments.

More information:
www.raute.com
www.beckhoff.com/wood

A plea for an active fieldbus decision

Your fieldbus matters!

Often underestimated, choosing the right communication network is simply crucial in the design of control architectures for machines and plants. While slow networks require decentralized control loops, high-performance networks offer the flexibility to use both central and decentralized architectures. A widely adopted network enables the selection of components from numerous suppliers. In contrast, using a network dominated by a single manufacturer often limits users to only that manufacturer's products, as controllers and devices from third parties may not be sufficiently supported.

Many system integrators and machine builders do not actively choose their communication network but rather follow their control provider. The decision for a provider is based on various factors: history ("we've always done it this way"), customer preferences, support quality, the provider's reputation, price, quality, user-friendliness, and performance. Others start selecting their control architecture based on the bus technology because they see it as a critical

component for success. Since PC-based control systems have replaced legacy PLC technologies, it is no longer CPU performance but the fieldbus that is the bottleneck for system performance. And, of course, this group of engineers is the focus of fieldbus organizations.

With these factors in mind, EtherCAT impresses this group of users with its unique functionality: Ethernet telegrams are processed "on the fly," meaning the frames are forwarded with almost no delay. In EtherCAT, a single frame usually contains both the input and output data of all participants. This results in a data efficiency rate of over 90%, making the network highly efficient and enabling extremely short cycle times. This leads to more efficient machines, which in turn results in material and cost savings. Not only do fast control loops benefit from EtherCAT. Applications with sequential conditions, where one action is performed only after the completion of a previous one, can also be optimized by the faster network. This increases machine throughput and improves efficiency by several percentage points.

EtherCAT is distinguished not only by its speed but also by its precision. The distributed clock synchronization mechanism allows for synchronous sampling and control of outputs across the entire network with jitter well below one microsecond. This is ideal for synchronized drive control and the integration of advanced measurement tasks within the same network. Moreover, EtherCAT is versatile and cost-effective. It does not require often expensive infrastructure like switches or routers, nor does it demand the IT expertise to configure them. Standard industrial Ethernet cables and connectors can be used, simplifying wiring and saving costs. The special diagnostic features of EtherCAT enable precise fault localization, reducing troubleshooting time.

When it comes to cybersecurity, EtherCAT scores even more points due to its unique features. The chips only allow EtherCAT telegrams to pass through and unused ports can be disabled. Since EtherCAT does not rely on the Internet Protocol, 99% of the attack surface is eliminated, and switches, which are known to be prime gateways for malware, are unnecessary with EtherCAT. Another advantage of EtherCAT is the global acceptance of the technology, which leads to a wide product selection. The EtherCAT Technology Group (ETG), with over 7,900 members from 75 countries, is the largest fieldbus user organization in the world and promotes this development.

EtherCAT networks offer nearly unlimited flexibility in topology, making planning and installation easier. Various topologies, such as line, star, tree, or redundant ring, are possible, as well as the integration of wireless technologies. The Hot Connect function allows nodes or entire network segments to be added or removed while the system is running. The integration of functional safety into control architectures is also facilitated by EtherCAT. In the past, safety functions were implemented separately from the automation network, but Safety-over-EtherCAT (FSoE) enables safety-related and control communication to be handled over the same network. FSoE also enjoys a wider variety of suppliers than any other fieldbus safety protocol.

The migration from older bus systems to EtherCAT is facilitated by a wide selection of fieldbus gateways that already support more than 30 different bus systems. These gateways allow for the integration of countless existing devices into an EtherCAT network and create interfaces to neighboring or higher-level systems.

In EtherCAT networks, manual address setting is eliminated, as addresses are automatically assigned during startup. Even when devices are added later, the original addresses can be retained. Many EtherCAT MainDevices also support automatic topology detection, which compares the actual network configuration with the expected one and automatically downloads all parameters during a device exchange.

When choosing a fieldbus network, openness is crucial for a future-proof implementation. EtherCAT not only offers international standardization and wide availability of software and chips from various suppliers but also provides free implementation support and clear interoperability guidelines. The technology is Ethernet-compatible and allows the use of Internet technologies like web servers and FTP transfer within the EtherCAT environment without compromising real-time properties, as these are tunneled through EtherCAT and thus pose no cyber threat to the network.

In summary, EtherCAT represents an outstanding choice for both users who base their network decision on the control provider and those who focus on the bus technology itself. EtherCAT delivers excellent performance, simple wiring, and its consistent openness leads to the largest variety of suppliers in the market. It sets new performance standards and enables optimal vertical integration thanks to the integration of Ethernet and Internet technologies. With EtherCAT, limitations in topology are a thing of the past, and expensive infrastructure components become unnecessary.

The functional principle makes the difference: Data processing on-the-fly with EtherCAT.

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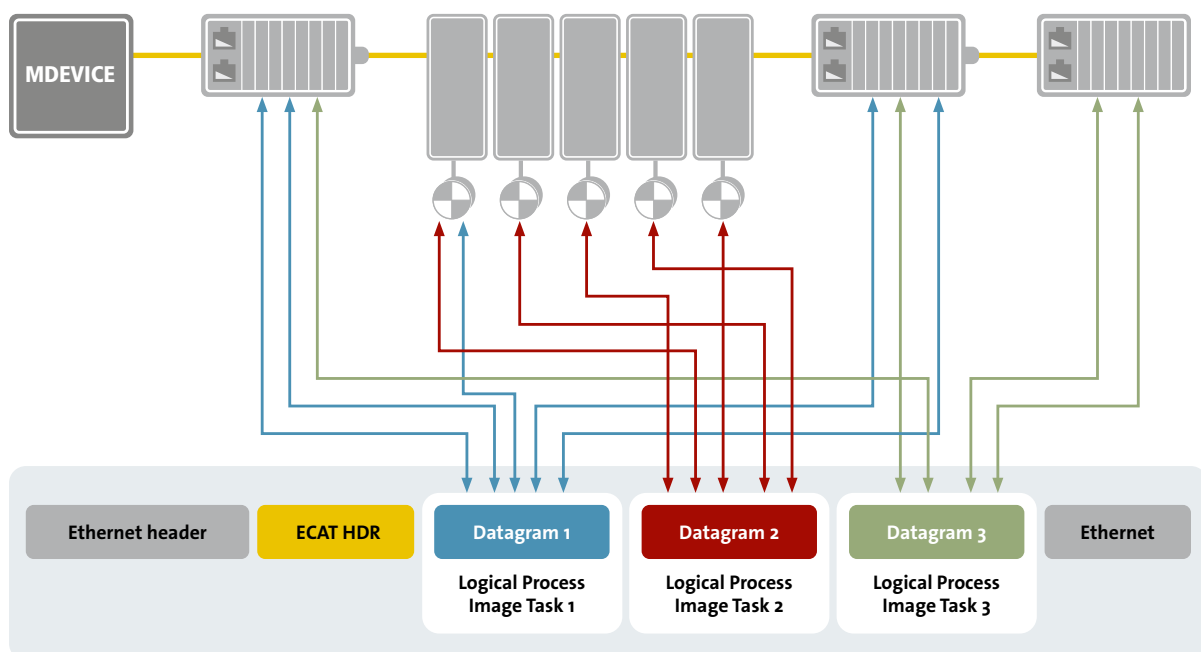
The Distributed Clock mechanism synchronizes highly precise functions.

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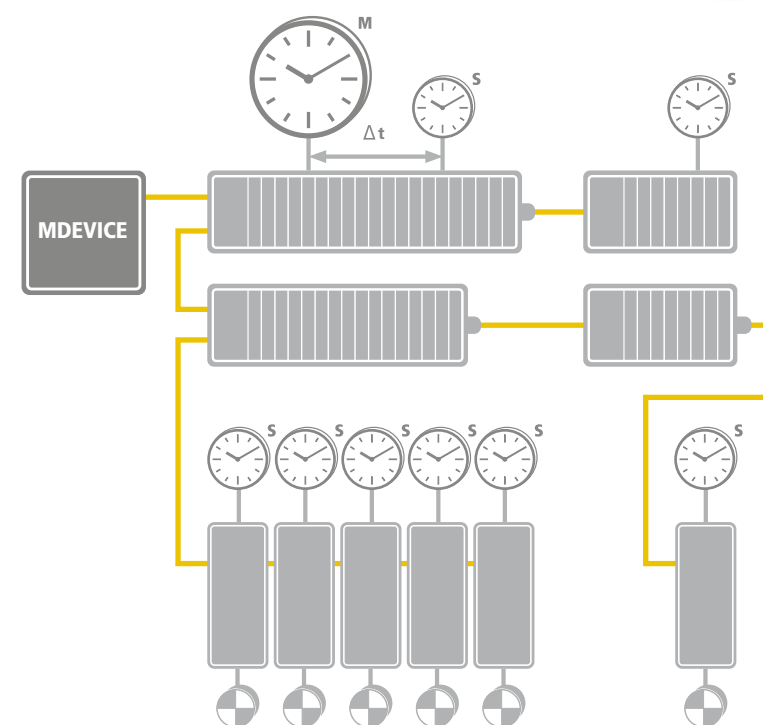
Martin Rostan,
Executive Director of the EtherCAT Technology Group (ETG)

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More information:
www.ethercat.org

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