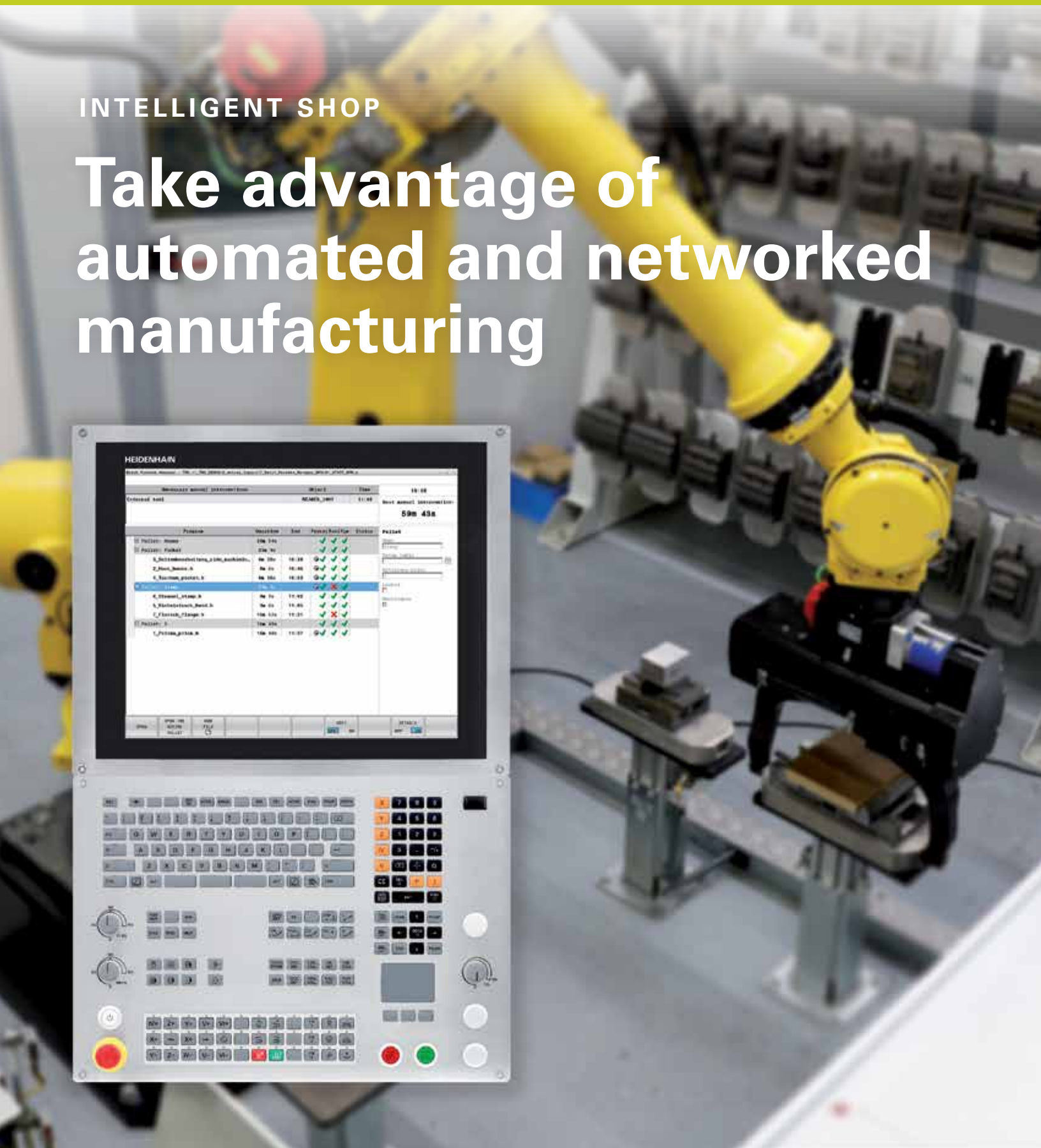
Klartext

HEIDENHAIN

INTELLIGENT SHOP

Take advantage of automated and networked manufacturing



Editorial

Dear Reader,

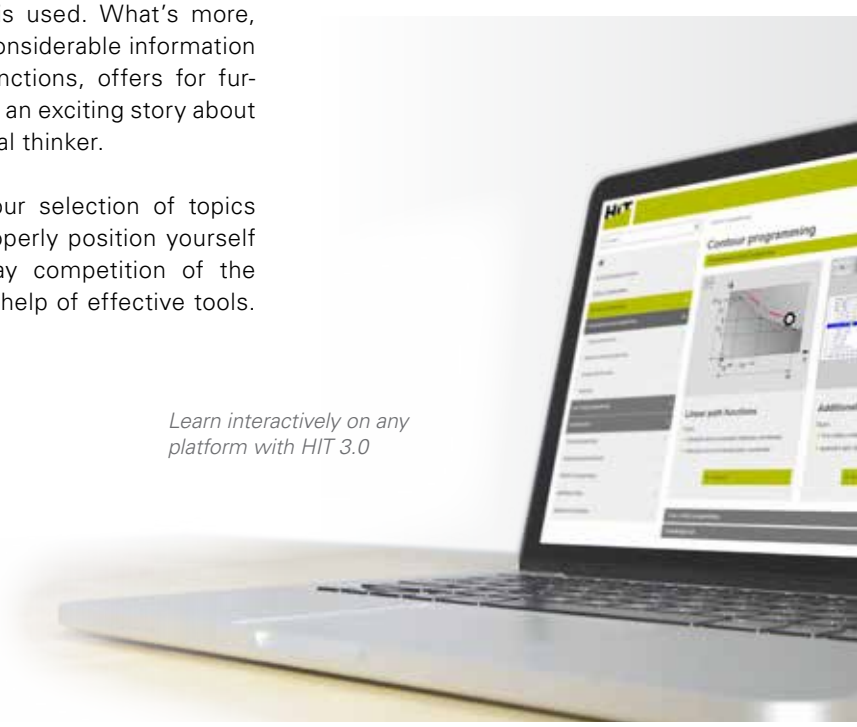
Automation and digital networking are the buzzwords being bandied about everywhere in the trade media and at trade shows. Is it much ado about nothing? Or should you be listening attentively? You may have already been riding this wave of the future for some time now, or will be riding it at some point in the near future. And what do you need in order to master it?

The machining specialists at Trimatec, from the Münster region in Germany, have already answered this question for themselves in the form of an intelligent automation solution. Starting with a batch size of one, they manufacture with full automation in series, using, among other things, the HEIDENHAIN DNC interface from the Connected Machining package of functions.

In our reports on the StateMonitor software and networked production, we will be showing you how, despite all of this digitalization and networking, customization isn't overlooked, and how you can maintain mastery over your data and the way it is used. What's more, you'll also find considerable information on new TNC functions, offers for further training, and an exciting story about an unconventional thinker.

We hope that our selection of topics will help you properly position yourself in the day-to-day competition of the market with the help of effective tools. Happy reading!

Trimatec has implemented fully automated, six-sided milling in its production setup, starting with a batch size of one.



Learn interactively on any platform with HIT 3.0

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Publisher
DR. JOHANNES HEIDENHAIN GmbH
Postfach 1260
83292 Traunreut, Germany
Tel: +49 8669 31-0
HEIDENHAIN on the Internet:
www.heidenhain.de

Editors
Ulrich Poestgens (responsible),
Judith Beck, Frank Muthmann
Klartext on the Internet:
www.klartext-portal.com

Layout
Expert Communication GmbH
Richard-Reitzner-Allee 1
85540 Haar, Germany
E-mail: info@expert-communication.de
www.expert-communication.de

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Content

In HEIDENHAIN's service training courses, do-it-yourself repairers learn how to use numerical controls for the servicing and maintenance of machines.

Manufacturing single parts in series without setup time

Trimatec has implemented an intelligent automation solution for its production environment with the help of Fastems and HEIDENHAIN.

Fully automated, six-sided milling starting with a batch size of one: this is how the production processes of the future look at Trimatec. With persistence, a large reservoir of practical experience, and support from the automation specialist Fastems, these experienced machinists from the Münster region in Germany are making their vision a reality. Two DMC 60 H machines with the latest HEIDENHAIN TNC 640 control are loaded from a storage lift system by a robot that even clamps the workpiece blanks and semifinished parts.

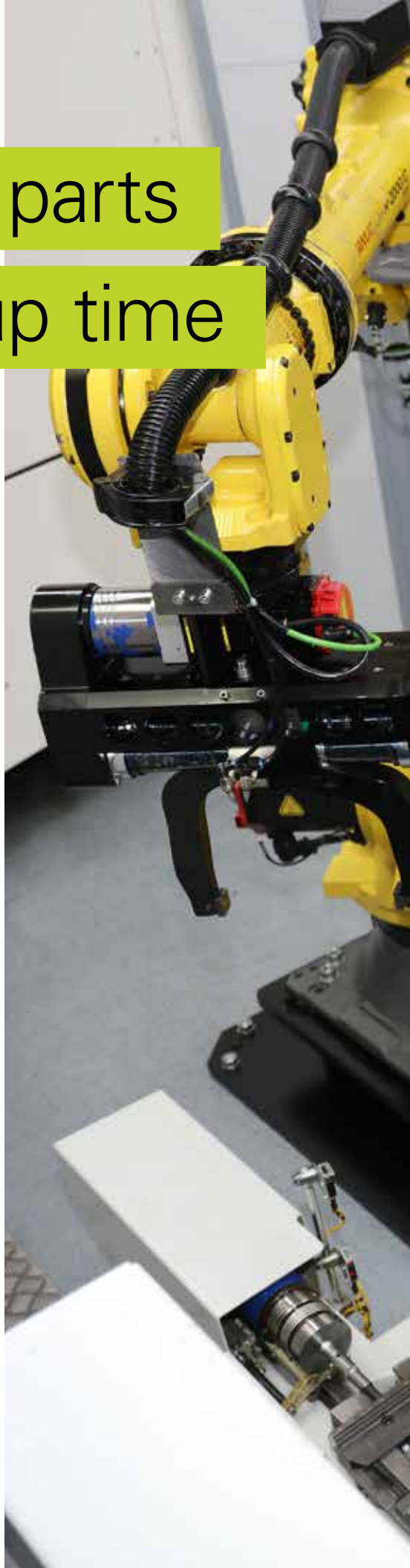
"Our vision is a manufacturing environment that does not require an employee to intervene manually to do things such as rotate a workpiece by hand for the machining of its sixth side," says Oliver Schöning, production manager at Trimatec, in summarizing the idea behind the company's automation solution. Carlos Beja, sales manager at Trimatec, adds that "we are now in a position to machine a wide variety of jobs with a batch size of one overnigh. At the same time, we can even provide our employees with good working hours without shift work." It's a brave new world for manufacturing! How did Trimatec manage to pull it off?

Automation doesn't begin with the robot

"Our system wasn't created two or three years ago—that's actually when we started the implementation phase. We began tackling automatization much earlier," says Carlos Beja, describing the long process. "Automation doesn't begin with the robot; the robot is where it actually ends," says Beja, summarizing the experience that Trimatec gathered during his automation project. He goes on: "Using a robot works only when you've done all of your homework beforehand."

Trimatec's homework primarily involved perfectly mastering the production process itself. "Before you start thinking about automatization, you have to make sure that all of the programs run smoothly in normal manual operation. You should also know your tools and have mastered the process of tool monitoring. Tool clamping must function perfectly. You need to have the cleaning of workpieces and pallets under control, and much more besides," says Beja regarding the long learning phase.

But how does Trimatec's automated system work in practice? When standing in front of it, one mainly sees the enormous storage lift system that can accommodate 374 workpieces in 17 drawers. The drawers themselves are



> “We implemented our entire expertise from over 20 years of milling in this system and robot.”
>
> Carlos Beja, sales manager at Trimatec

Taking center stage:
The work envelope of the robot, with its access to the storage lift system, the vise shelf, the vise station, the centering station, and the buffer station.

further subdivided into sections for workpieces ranging in size from 110 mm x 120 mm to 250 mm x 280 mm, with a maximum height of 80 mm. To the left of the storage lift system stands a host computer that controls the entire system. The robot is located centrally behind the storage lift system. Clustered around it, besides the storage lift system, are the two DMC 60 H machines, the vise station for workpiece clamping, a vise shelf, a centering station, a turnover station, and two buffer stations for preclampled workpieces—all within reach of the robot that performs its work autonomously.

A day at Trimatec has 32 productive hours

"Thanks to the space for 374 workpieces in the storage lift system and 243 tools in both machines, we can perform six-sided machining for 72 hours without interruption—on 374 single workpieces if need be," says Oliver Schöning, listing the system's facts and figures. "In a normal eight-hour shift, our employee on the machine can load the system, enter the jobs, supply both machines with the necessary tools and cooling lubricant, and carry out the required maintenance work," says Carlos Beja. "Subsequent to and even partly during all of this, each machine runs productively for at least 16 hours. With our automated system, one man can achieve 32 production hours on a single day." Or he can enjoy a relaxing weekend and be highly productive at the same time.

The employee on the machine is supported by the automated system's host computer, with its helpful information and many useful tools. The host computer does much more than simply control the robot and the storage lift system. The entire automated system is set up as its own network that is independent from the corporate network. Thus, the host computer uses cyclical requests to fetch the job data along with the NC programs from a network folder. Based on this data package, the FastWizard software from Fastems generates the job. The host computer then rechecks whether the required tools are available and whether they have sufficient tool life, as well as whether the correct workpiece blanks or semifinished parts are available in adequate numbers. In addition, the host computer gives a prognosis regarding the duration of the planned jobs and the estimated starting time. If any resources are missing, the host computer does not start the job. Instead, it automatically moves on to the next entry in the job list and, of course, provides information to the machine operator as to why the job was ignored and what needs to be done about it. The machine operator can intervene at any time and manually modify the priorities. In this manner, urgent jobs such as replacement part orders can be pushed through individually.

Strong partners for an innovative automated system: Oliver Schöning from Trimatec and Fastems project manager Johannes Louven on the TNC 640 control of one of the two automated DMC machines.

Jobsharing between machines

The standard tools available in both machines allow for a certain amount of flexibility. If capacities and tooling permit, the host computer can change plans and split up jobs with standard machining operations between machines. The data on the tools in the machine come from a tool measurement system specifically set up for the automated system and are forwarded directly to the host computer and the control.

In order for machining accuracy to be in the required hundredths range, the workpieces are measured with a touch probe in order to compensate for inaccuracies that may arise from the clamping process. For this purpose, Trimatec uses the touch probe cycles of the TNC control.

The CAM programs for the system come from the production planning department. In this department, the programs are also fully simulated on a virtual machine in the CAM system prior to being sent out. This additional work allows Trimatec to ensure in advance that the work steps within the automated system will execute smoothly. Ideally, once a project has been uploaded into the automated system, no further interventions should be necessary.

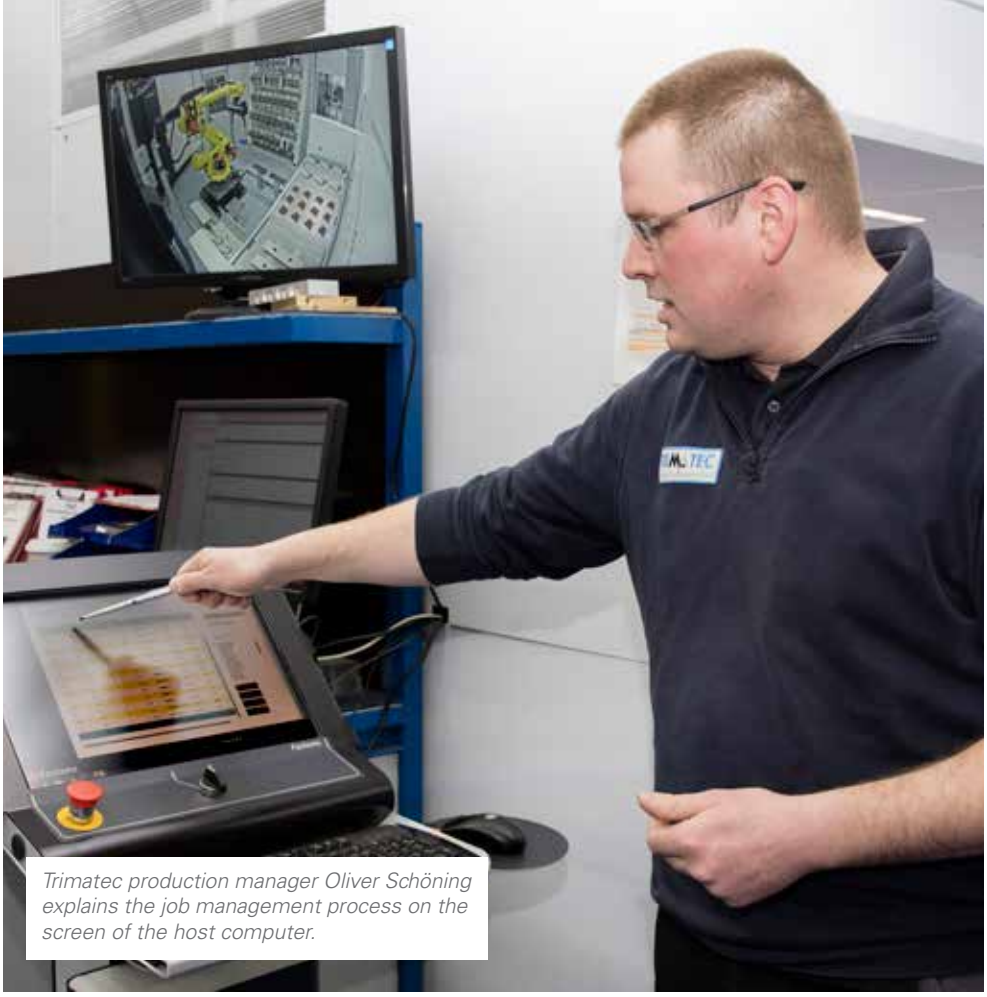
In addition to the machining program, a program header with data for the controls of the robot is also always included. This header contains a total of 27 parameters that enable the error-free handling of the workpieces by the system. In addition to the dimensions and weight of the

workpiece, the maximum gripping force of the robot and the maximum tensioning force for the vise are also included.

At Trimatec, HEIDENHAIN controls were a sure deal

Even though the control of the system takes place entirely over the host computer, and nobody works directly on the controls, the question regarding the type of machine control for the automated system was readily answered by Trimatec. "The fact that both DMC machines would be equipped with TNC controls was a sure deal from the get-go," says Carlos Beja.

Oliver Schöning adds: "When it comes to milling, for which nearly all of our programs come from the CAD/CAM system, the consistent control design offered us the advantage of a standardized interface and therefore the need for only a single postprocessor. This significantly increases process reliability during the generation of NC programs. When creating programs, we also make use of the HEIDENHAIN cycles." Carlos Beja mentions another interesting argument: "When looking for additional staff, it is relatively easy for us to find highly qualified personnel. That's because HEIDENHAIN controls are so widely used in demanding applications and, as a result, a lot of people with a great deal of expertise are either trained on or have experience with these controls."



Trimatec production manager Oliver Schöning explains the job management process on the screen of the host computer.

> "We have HEIDENHAIN controls on all of the machines. When it comes to milling, there's nothing better, especially for 5-axis simultaneous machining. And when it comes to turning, its operation and the creation of programs are incomparably easy and user-friendly."
>
> Carlos Beja, sales manager at Trimatec

At Fastems, the project manager Johannes Louven was pleased with how easy it was to connect HEIDENHAIN controls to the host computer via the HEIDENHAIN DNC interface and to the machine via PROFINET. He explains: "The documentation and interface descriptions for the HEIDENHAIN control are very trustworthy; the interface descriptions really do reflect what is physically available. Unfortunately, that is often not the case with other products," he says, speaking from experience in other projects. Louven goes on: "What's more, HEIDENHAIN provided excellent support in answering questions of detail and in application-specific adjustment. We were able to quickly get in touch with the R&D departments and therefore receive the best-possible guidance and comprehensive expertise. There weren't any problems in integrating communication with the HEIDENHAIN DNC interface directly into the host computer with our Fastems FastWizard software."

Meanwhile, the automated system has been running at full production since the middle of 2017. The Trimatec formula for success: eight hours of greater productivity per day + highly flexible, automated manufacturing capabilities for demanding parts starting with a batch size of one = satisfied customers + relaxed employees. Now that's a success story!

The StateMonitor software provides you with a good overview of the status of your machines.

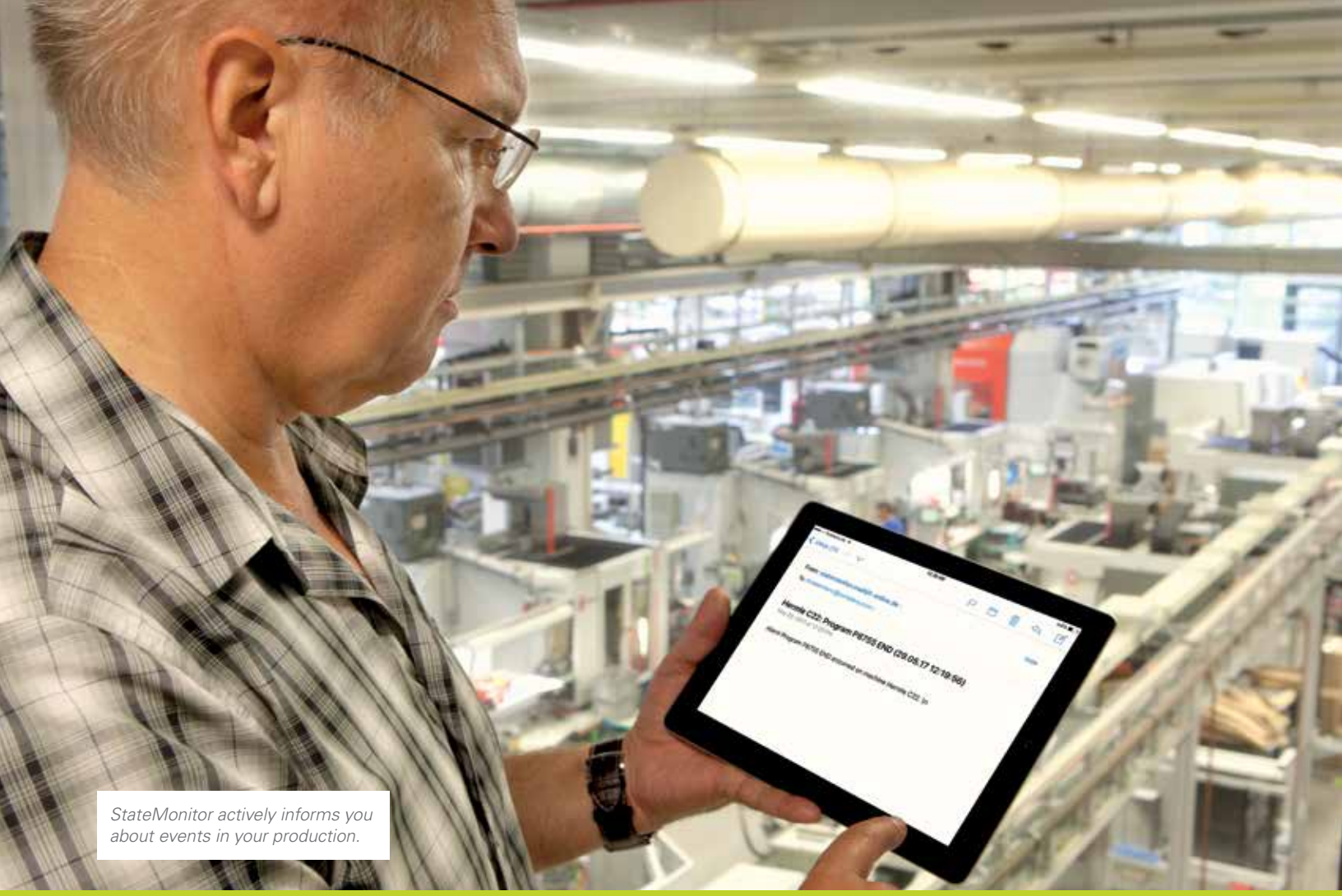
Window into the workshop

StateMonitor captures and visualizes important information from machines—now also independently of machine model and control.

Times are changing. Window shopping used to be the best way to become informed about new developments and trends. Nowadays, we find this information online on a PC, tablet, or smartphone. It provides us with options to evaluate and compare, in order to decide what suits us best. What does all this have to do with you, your work, and with HEIDENHAIN? A lot, actually...

In many companies, a regular tour through the machine shop is still one of your tasks as a production employee. It's how you track the current status: running orders, machining progress, any necessary tool changes, the fill levels of chip containers and cooling lubricant tanks, the stock of blanks, the quantity of finished workpieces on the machine tools, etc.

Much of this is superfluous because all this information could come to you directly via a thoroughly digitalized production environment. In addition to integrating your machines to the company network, e.g. via Connected Machining, you also need an intelligent software that collects the requisite data, and displays it graphically. StateMonitor provides you with a window into your workshop.



StateMonitor actively informs you about events in your production.

HEIDENHAIN StateMonitor

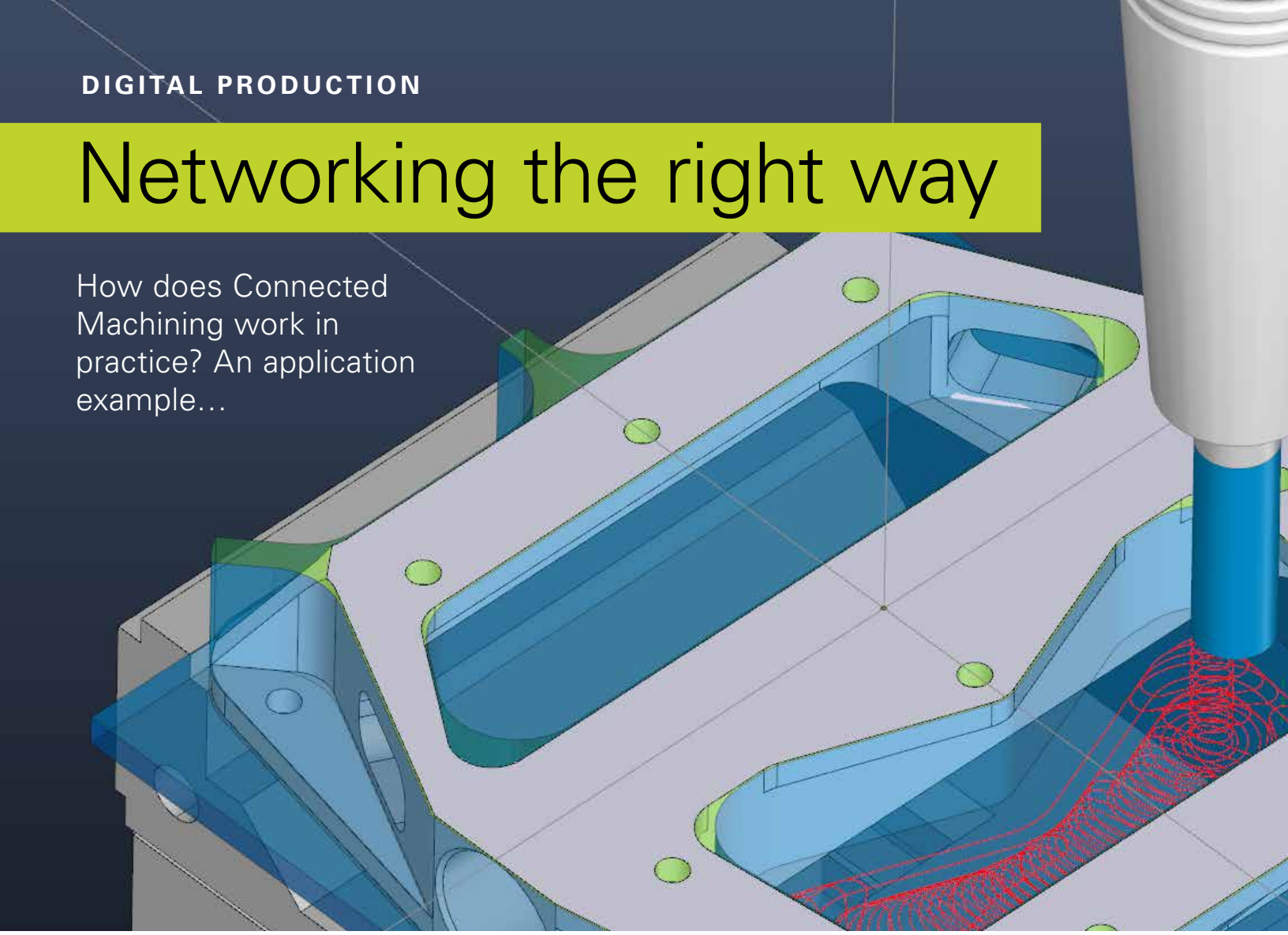
+ For your direct connection to StateMonitor, see www.klartext-portal.com/statemonitor

StateMonitor gives you a real-time view of each machine's status. But that doesn't only apply to machines with HEIDENHAIN controls. You can connect machines with the following interfaces: HEIDENHAIN DNC, OPC UA, MTConnect, or Modbus. Depending on the interface and machine controls, information that can be displayed includes the status of the operating mode, program, machine messages, and overrides.

You can then quickly and simply evaluate this data with StateMonitor for improving your efficiency and productivity. The capture and feedback of job data also enables the order-related analysis of the machine data. You're the master of your data, because you completely configure the StateMonitor software according to your needs and the needs of your manufacturing environment. You determine the extent of the evaluations. You authorize access rights to your data. You define the storage locations as you see fit. And you also provide the data for the MES and ERP systems. StateMonitor adapts to your requirements—not the other way around.

Networking the right way

How does Connected Machining work in practice? An application example…

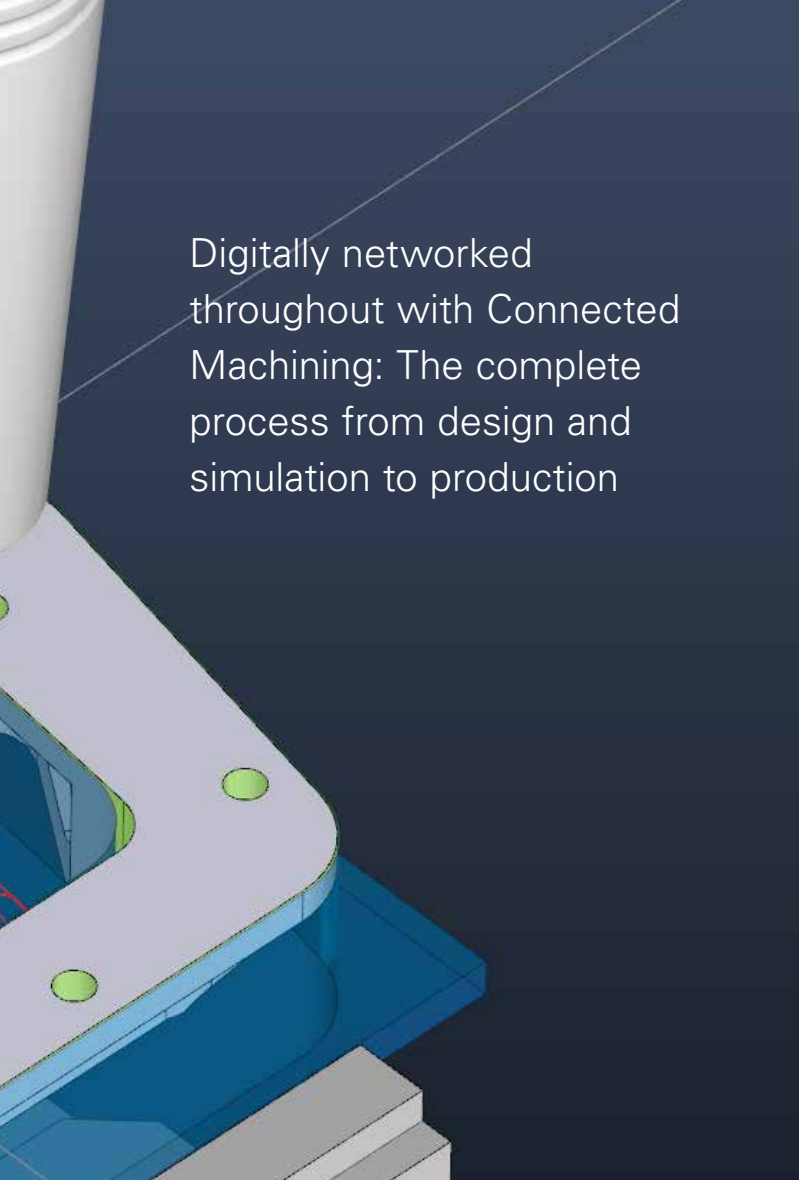


Digitalization. Networked production. Intelligent factories. These and several other buzz phrases are hot topics the currently discussed in manufacturing industries. We would like to explain how we view these topics and which solutions we offer with Connected Machining by way of an example—the production of a bicycle pedal.

What might a production infrastructure look like in which all work steps are digitally networked via Connected Machining, from construction to the ready-to-deliver component? At first glance not so different to traditional production in fact, because the participants are the same. Only the data flow between the individual stations is now digital and completely paper-free—in the case of Connected Machining with the HEIDENHAIN control on the shop floor as the central pivot of communication.

The networking protagonists usually consist of:

- Design including CAM programming and simulation
- Tool preparation and tool provision
- The workshop with machine tool and HEIDENHAIN control
- Quality inspection
- Procurement logistics for blanks and tools
- Supply logistics for the shipping of finished products
- Job planning and processing



Digitally networked throughout with Connected Machining: The complete process from design and simulation to production

At the center of the digital network: The HEIDENHAIN control

Using our example of digitally networked production, let's start where the actual added value is generated—on the shop floor. The secured blanks are lying on a pallet at the machine for pending work. But how do you, as the machine user, know what to do?

Usually you are given a folder or order pouch with all possible information on a few (or sometimes many) sheets of paper: drawings, parts lists, tool lists, deadlines, etc. And then you get going—trying to find something in the documents. They're seldom sorted so you can gain a quick insight into the production-relevant data.

You won't need this folder anymore in a digitally networked production environment with Connected Machining. Via the control, e.g. a TNC 640, you have direct access from the shop floor to all of the company's relevant production data, which in turn is also networked.

connected + machining

Direct exchange: Construction data and NC program

With HEIDENHAIN's Remote Desktop Manager option you can directly access the CAM system from the HEIDENHAIN control. The CAM system on the other hand utilizes the information from the tool database for program creation.

Stay informed: Job planning

Using the Batch Process Manager of the TNC 640 you can now schedule a production job's execution right on the machine. NC programs and the position of the workpiece fixture on the pallet are linked according to the specific job. Batch Process Manager also provides you with information about the machining duration. It can also be used for order planning, such as scheduling further logistics of the finished parts or subsequent jobs for the machine.

All information at hand: Tool data and tools

Calibrated tools are already loaded in the machine's tool magazine. They are clearly identified by a code on the tool holder. You have conveniently used a scanner to read this code while filling the tool magazine. The TNC 640 therefore knows immediately which tools are in the machine. The data comes directly from the tool management system via Ethernet.

For safety reasons the control automatically compares the tools used in the NC program with the tools actually available on the machine. The control then reports any tools that are missing, and states the estimated machining time. You can output a list of tool differences that contains only those tools you still need to prepare.

The finished workpiece:
A bicycle pedal for downhill bikes

On time and networked: Tool reordering

The data from job planning is used together with tool management data to order new tools. The tool preparation station immediately receives orders for any additionally required tools. Based on the data stored in tool management, the tool preparation station can then promptly prepare new tools in the tool presetter for calibration.

In this case as well, the exact tool settings data is sent to tool management. The pre-set tools are given their own unique code on the tool holder for clear identification. Then the CAM program and virtual machine also have access to this data.

Consistently better processes: Quality assurance

At the end, automatic calibration of the workpiece on the machine provides you with important data for quality assurance purposes. With the help of the control you can then simply archive the data or directly evaluate it. Naturally the data is also centrally available to all other systems, meaning that from the NC program to the tools, all links of the process chain can be optimized.

Into the third dimension

For roughly ten years, you've been able to open DXF drawing files directly on your TNC control and transfer data to your NC program. The new CAD viewer now opens the third dimension.

For a long time, the DXF file format was the established means of exchanging 2-D design data. Just as 3-D movies have become the measure of all things in theaters, you mainly design models in 3-D. After all, 3-D makes it significantly easier to envision complex workpieces. So it's only logical that HEIDENHAIN makes its TNC control fit for CAD data of the third dimension.

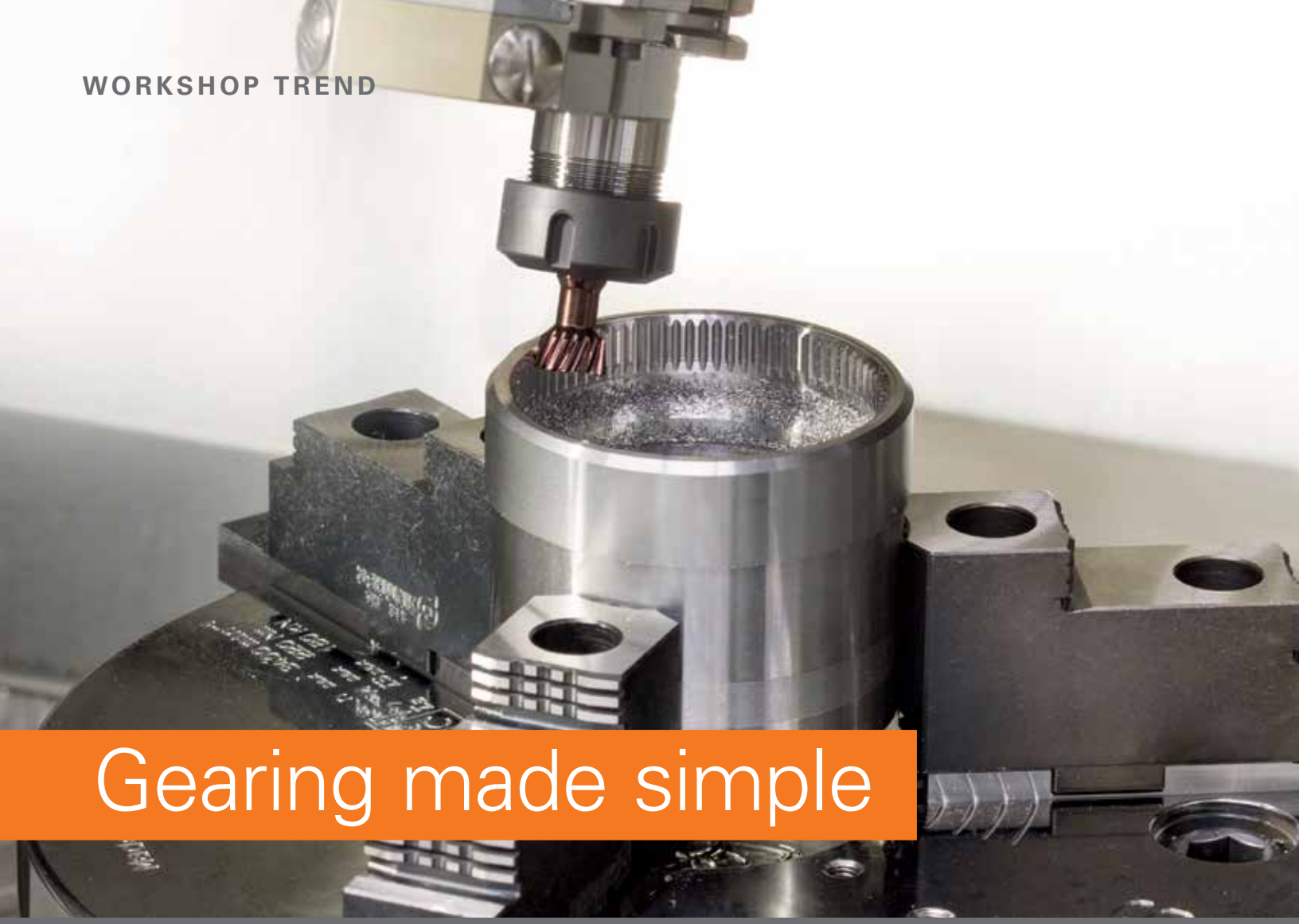
TNC controls provides a CAD viewer for working with 3-D data. It has been a standard function of the TNC 640, for example, since software version 05. The CAD viewer allows you to open and view data from STEP, IGES, and DXF files right on the control. If you run into issues, you can look up the dimensions in the drawing, for example, or open modified drawings on the control to check the data. As an extension of the CAD viewer, the CAD import function (option 42), from the new software version 08, enables the convenient loading of data from the above-specified formats directly into the NC program.

The CAD import option supports workshop-oriented programming

The CAD import allows you to transfer contours and positions from a 3-D data model into an NC program either on the control or on a HEIDENHAIN programming station. The new CAD import also supports the popular STEP and IGES formats. You no longer need to create separate DXF files from existing 3-D models as an intermediate step. In addition to loading the contours and positions, you can also define a datum and tilted working plane in the CAD import. Being able to freely align the coordinate system is also helpful for turning contours in cases when the drawing doesn't match the machining position.

The CAD viewer and its CAD import extension are highly effective tools for workshop-oriented programming. It's not only faster but also significantly more reliable thanks to this transfer of CAD data. Simultaneouslywith workshop-oriented programming directly on the machine, your extensive expertise as a TNC user flows into the NC program.

The 3-D data of a complex component, like this mountain bike handlebar mount (above), can be loaded directly into the NC program.



Gearing made simple

Skiving is the current machining trend when it comes to the machining of internal gear teeth. New cycles now make the programming of complex sequences especially simple.

Gear production is still seen by many machinists as a real challenge and a field of work exclusively for specialists. Three new cycles on the TNC 640 for high-quality internal and external gear teeth change all this. You can simply and economically machine spur or helical gearing systems completely in one setup with skiving or hobbing. The software allows both forms of machining in both milling and turning mode.

Concealed internal and external gearings exist everywhere, such as in automotive vehicles. From bicycles to construction machines and from electromotively supported pedal drives to hydraulic heavy machinery drives, the gear systems of hubs and drives must cleanly intermesh. Gearing manufacture still often takes place on special machine tools, so workpieces need to be laboriously rechucked. Traditional sequences for machining gears are often time-consuming processes. Machining in a single setup using the dynamic gearing cycles provided by a TNC-controlled machine can save much time, effort, and costs.

Simple programming of complex motions

The new Cycle 287 "Gear skiving" supports you when programming complex skiving sequences. You need only define the data for gear geometry and the tools to be used. The TNC 640 executes all other calculations, especially complex synchronization of the movements. As a result, the machining of internal gear teeth is transformed into a simply-mastered standard.

The current success of skiving is based on the significantly higher levels of efficiency and productivity compared to traditional heading. New tool technologies

and the dynamic motion control of the TNC 640 in dual-spindle mode make the complex sequences with skiving possible. The only requirement is a machine that features a workpiece spindle with sufficiently high velocity along with appropriately configured spindle synchronization.

Hobbing made easy

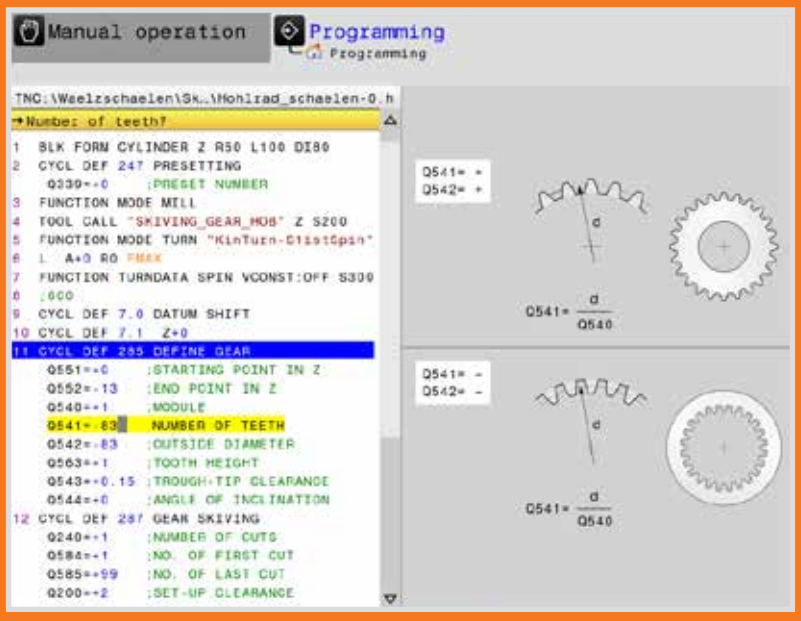
In the same simple way as skiving, i.e. with program generation based on the gear geometry and tool definition, the TNC 640 also makes life easier for you with Cycle 286, "Gear hobbing." Hobbing is mainly suitable for external gearing systems. Its advantages are found in the high levels of productivity and diverse tooth shapes that can be machined with relatively easily produced tools.

Define once, use repeatedly

The basis of the new gearing cycles is Cycle 285, "Define gear." As its name implies, this cycle defines the gear geometry, and the operator need only define the geometry a single time. All requisite machining steps in the subsequent production sequence, e.g. roughing and finishing, revert back to this definition.

Optimum lift-off for more safety

In addition to simple programming, another benefit of the new cycles is the safety aspect. To avoid damage from unexpected program interruptions, e.g. due to power failure, Cycles 286 and 287 support optimized lift-off. These cycles automatically define both the direction and path for retraction of the tool from the workpiece.



Only basic information about the gearing and tool is needed for programming.

Skiving

Sequence for the production of external gears and primarily internal gears on machines with synchronized spindles.

Benefits:

- Complete component is machined in one setup
- No special machines required
- No machine change—saves time and improves quality

Hobbing

Sequence for the production of external gears (internal gears in exceptional cases). The required synchronous motion of tool spindle and workpiece spindle can be realized either mechanically via coupler mechanisms or electronically via coupling in the controls.

Benefits:

- Production of highly diverse and also complex gear shapes
- Wide range of standard tools and simply produced special tools
- Highly productive machining process

Lift-off

Designation for the controlled and collision-free movement of the tool and tool spindle away from the workpiece upon unexpected program interruption.

Benefits:

- Avoids damage to the workpiece, tool, and spindle
- Seamless continuation of the interrupted machining process after restarting
- Automatic sequence—no manual intervention required

+ For more about the topic see: klartext-portal.com

It's the HIT!

Interactive learning with HIT 3.0, the new generation of HEIDENHAIN Interactive Training

HIT is a multimedia learning concept for the NC programming of HEIDENHAIN controls in Klartext, the dialog-guided TNC programming language for workshops. HIT supports first-time users, upgraders, and professionals in their qualified training and follow-up courses—with both self-study and face-to-face teaching. Learning also becomes mobile with the new version.

HEIDENHAIN presented the first version of HIT at the end of 2011. Since then more than 20,000 users have benefited from the interactive training program by becoming familiar with programming in Klartext conversational language. The new version 3.0 can now be used in the office, at home, or away without complex installation and independently of the platform—on PCs, tablets, and smartphones with a standard web browser.

The HIT learning package "Milling 3-axis machining" explains in detail the most important elements of the CNC milling machine and TNC controls in various learning modules, as well as basic functions of the Klartext dialog-guided TNC programming language. An "ISO programming" learning module explains the essential differences from Klartext programming.

HIT is based on successful teaching concepts:

- Videos and animations clearly demonstrate the learning content.
- Guided (simulated) programming and real exercises on the TNC programming station prepare users in a practical way for programming and operating a TNC-controlled machine tool.
- Interactive knowledge tests repeatedly query the learned skills and provide participants with reliable feedback about their learning status.

The HIT components

- The HIT learning software explains all required control functions.
- The HIT Guidebook serves as instructions for the HIT learning software, as a summary of the contents relevant for programming, and as a reference after you have completed the learning package.
- The programming station is the PC-based counterpart of a machine tool control. You can use the free demo version of the programming station to perform all HIT programming tasks and to graphically simulate them. With the aid of a virtual keyboard, the control-specific dialog guidance is possible just as with a real control's keyboard.

The new **HEIDENHAIN learning platform** enables management of the new HIT learning software. It is based on the Moodle learning platform used by many schools and universities and offers various highly useful functions, especially for teachers. With the Premium classroom license for example, self-created content can be stored and made available to pupils in addition to the HIT learning software. Teachers can also generate personalized certificates for pupils if they have successfully passed all knowledge tests.

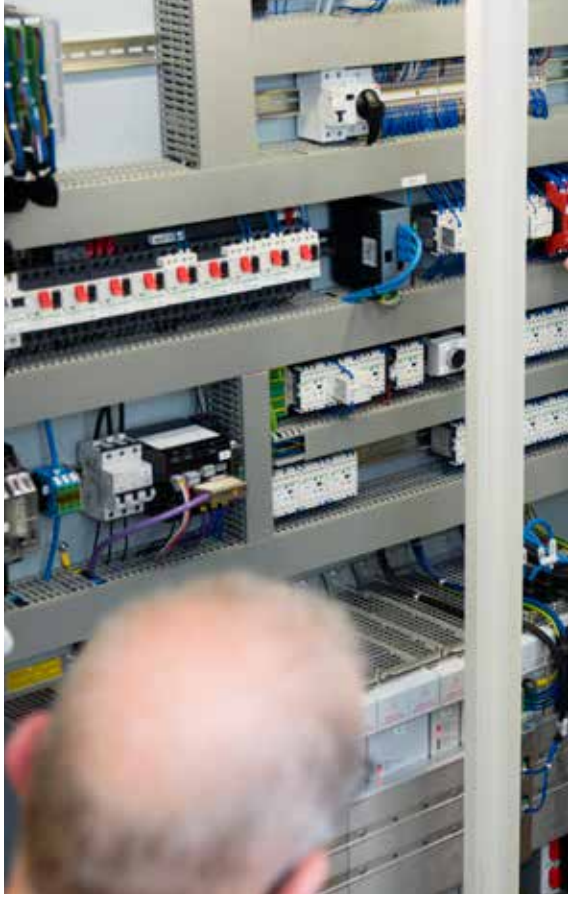
The learning packages

- In the new version 3.0, the HIT learning package "Milling 3-axis machining" replaces the previous "HIT Klartext" and "HIT DIN/ISO" learning packages.
- The new HIT learning package "Milling 5-axis machining" will replace the previous "HIT Tilting 3+2" package during the coming year.

+ For detailed information about the HIT "Milling 3-axis machining" learning package and especially the various licenses, see www.klartext-portal.com/en/training/hit-learning-method

+ Printed HIT booklets can be ordered online here: www.tnc-verlag.de

For do-it-yourselfers



HEIDENHAIN also trains service technicians for its controls. An interesting topic, not only for machine tool builders.

Real-world, informative, and user-oriented. This describes HEIDENHAIN's programming and service courses, and is enthusiastically confirmed by Kenny Magasiner and Christoph Etzelsdorfer, who took part in the "Service for the TNC 640" course.

Five participants, five completely different goals, but one common seminar. In the "Service for the TNC 640" course the participants learn what should be done if a machine does not behave as expected. And mainly: Which role does the control play in this?

A glance into the seminar guide reveals much theory: diagnostic possibilities, error messages, data backup, and encoder interfaces—which doesn't exactly sound exciting for outsiders. But participants see this differently though. "The trainers asked all the participants about their preconditions and expectations of at the start of the course and took that into consideration," revealed Kenny Magasiner, service trainer at the machine tool builder Grob, during a coffee break chat. Christoph Etzelsdorfer from the servicing division of ifw mould tec, an Austrian specialist for injection molding tools, adds: "For me the transfer from theory into practice is especially interesting. In the training room a maximum of two participants share a test bench, and can therefore consolidate what they've just learned in a practical way. They then progress onto the machine to test various situations." For example, highly-theoretic PLC troubleshooting becomes an interesting hands-on exercise in the machine shop of the HEIDENHAIN training center.

Christoph Etzelsdorfer is a milling specialist who spent ten years as a machinist. Four years ago he switched to servicing and is now mainly busy with setting up machines in the company. "I'm definitely not a service expert, but because of my career background I bring along good fundamental knowledge both on the user and technician side of things. I find the training very interesting. I'm also able to harvest a lot of information that I can use with the next machine installation; for example, when making backups of machine parameters."

Kenny Magasiner is a trainer himself, and in the future will carry out training courses for machine users at Grob. Therefore he knows precisely what he's saying when he compliments the course instructors: "I need detailed knowledge about the technical background to answer corresponding questions in my everyday work. It's this knowledge that's clearly communicated to me here."

Intensive preparation for his own training tasks: Kenny Magasiner will soon himself be training the users of Grob machine tools.

The preferential work environment of the practical section of service courses—the technology in the machine's electrical cabinet

Along with examples from practice: Spindle damage on the machine, emergency stop, nothing works any more. The machine, however, has to be moved again so that the spindle can be attached for removal on a hoisting crane. This isn't a problem for graduates of a HEIDENHAIN service training course. They switch the spindle into simulation mode and can then traverse it to the desired position with the remaining axes—despite emergency stop, machine stop, and an apparent blockage of all axes. Although the service training appears to be highly theoretical at first glance, it helps specifically in the everyday operations of the participants.

"For me, the transfer from theory into practice is especially interesting. In the training room a maximum of two participants share a test bench, and can therefore consolidate what they've just learned in a practical way. They then progress onto the machine to test various situations."

Christoph Etzelsdorfer, Servicing Division, ifw mould tec GmbH

+ For the latest information on HEIDENHAIN training courses, see: www.klartext-portal.com/en/training

Off-the-wall thinkers

At LTN Servotechnik a TNC 620 assumes control of resolver winding machines following a retrofit. It's amazing what creative minds can do with a milling control.

The resolver winders at LTN Servotechnik in Otterfing, near Munich, Germany, have been doing their job incessantly for over 20 years. Mechanical wear and tear after this length of time could no longer be ignored in everyday production, and the old DOS control could no longer be programmed. The solution? A thorough retrofit. Three months after implementation on the first machine, many positive effects can be seen.

At first glance a look into resolver production at LTN is more reminiscent of a textile company than high-tech electronics. Machines stand in orderly rows, where feed units with coils running on the machine canopies catch the eye. Coils on which the strands are wound are located in the working space of each machine. Each machine usually has eight parallel winding stations.

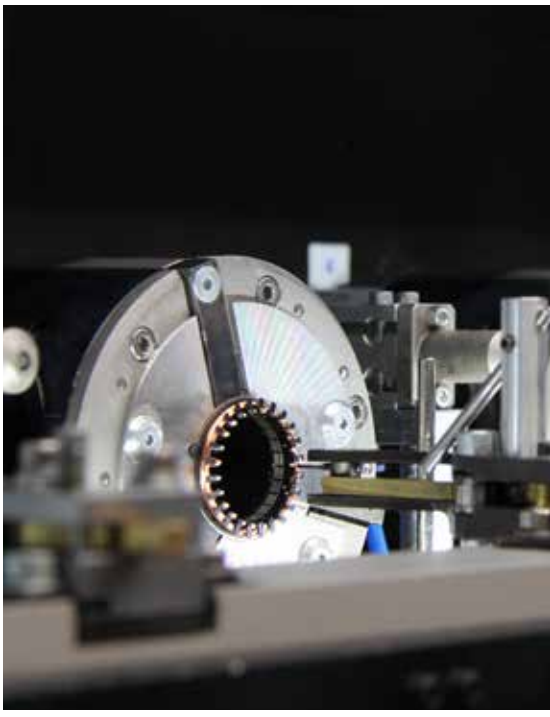
The strands, however, are not twine but extremely fine copper wire. The thinnest wire measures only 50 µm in diameter, with the standard diameter being 70 µm. This makes the wires about as thin as a human hair—and they break just as easily. The copper wires aren't simply coiled, but wired in a complex winding process on stator winding cores. They must, after all, subsequently supply the voltages from which highly accurate information can be derived about the angular position of the axis on which the resolver sits.

For manufacturing equipment designer Andreas Willerer, who managed the conversion project at LTN, it was clear from the beginning that the retrofit could only be rewarding and successful if the old resolver winding machines were upgraded in their entirety. "We didn't want just superficial results, but rather future-capable machinery after the retrofitting." For this reason the technicians implemented a complete clean-up on the first machine to be converted. This included a new drive train, new servo motors instead of the obsolete DC motors, new gear transmission, new control board, and a new multiturn absolute encoder from HEIDENHAIN with serial EnDat interface. "We wanted to know what was possible and how we could then proceed with the other machines. After all, the company has six additional machines for conversion." Also not to be neglected was the problem with the control…

Requirement profile shows the way

There are no special controls for resolver winders. There is, on the other hand, a broad spectrum of controls for every conceivable automation solution, that can also be adapted to this application. To choose the right control, Andreas Willerer initially drew up a requirement profile. "This also included the factors of 5-axis kinematics for motion control of the coils and wire feeds as well as 3-D graphic simulation for meaningful machining previews." And because he

Andreas Willerer particularly likes the simple operation of the TNC 620 on the touchscreen.



A different type of milling operation: The TNC 620 confidently masters the complex 5-axis movements of the resolver winding machine.

A view into the working space: Extremely fine copper filaments wound with high precision on the stator winding cores.

> “The winding itself is nothing other than 5-axis machining. No matterial is removed with a cutter, though; instead copper wire is wound with a needle onto stator winding cores.”
>
> Andreas Willerer, manufacturing equipment designer at LTN Servotechnik

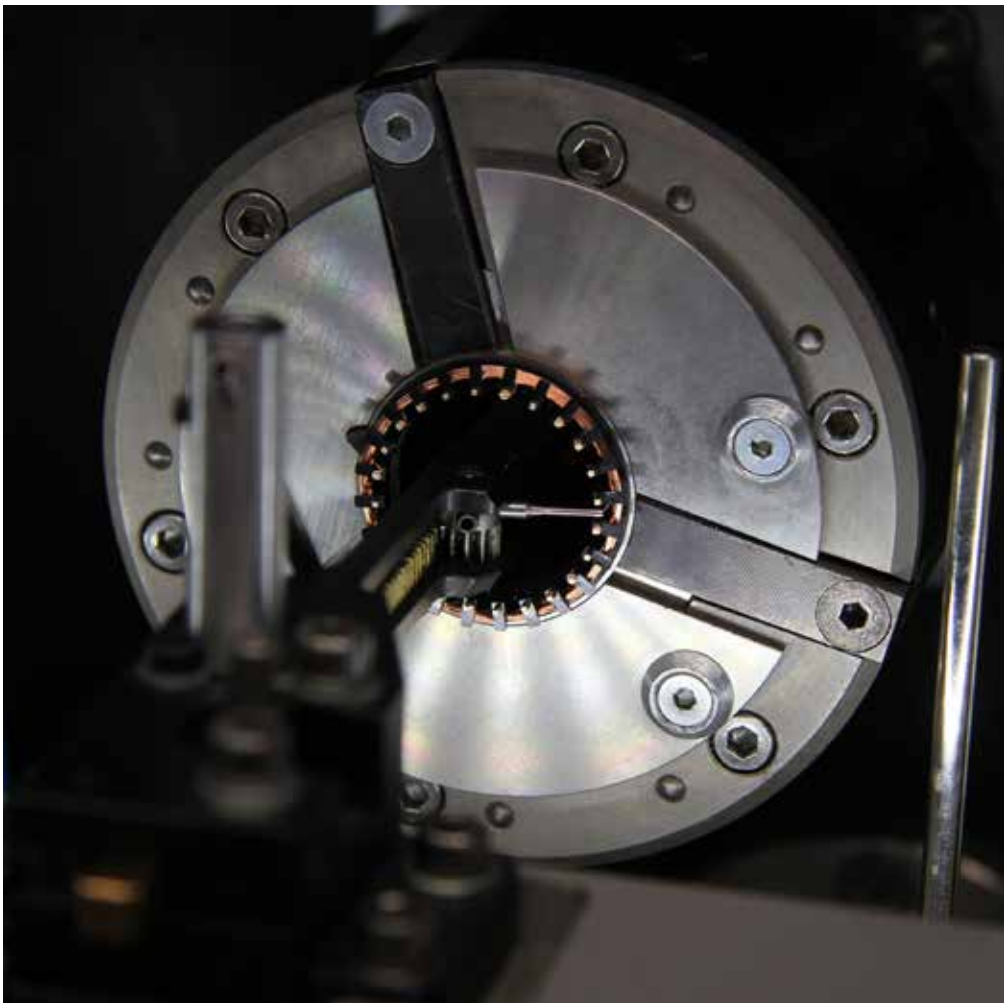
The upgraded resolver winding machine with TNC 620 control is located at the head end, with three of the six systems to be retrofitted by the end of 2019 on the left.

also supervises the mechanical production milling machines at LTN, Andreas Willerer began to ponder. These key features were also two essential characteristics of the HEIDENHAIN TNC controls used on milling machines. But a milling control on a resolver winding machine?

To make certain, Andreas Willerer consulted the users of the HEIDENHAIN controls in mechanical production. "I mainly wanted to know what my colleagues would say about programming the required motion sequences on the control." He was somewhat surprised when his colleagues confirmed what he'd already assumed: "Winding is actually no different than 5-axis machining. No material is removed with a cutter, though; instead copper wire is wound with a needle onto stator winding cores."

The LTN retrofitters also benefited from support via HEIDENHAIN's NC Programming helpline. They carried out the customary and necessary kinematic adaptations of the control to the special characteristics of the machine. "The A and C rotary axes are contained in the kinematics but only the C axis must be considered for motion control," explained Andreas Willerer. "The A axis executes the rotation of the rotor with the C axis alone being responsible for the compensation movements, thus enabling our desired motion control."

Were there any other reasons for a milling control? "Decisive factors were the confirmation from our TNC-experienced colleagues in mechanical production that the Klartext program for producing the windings could be programmed directly on the control. And that we already had the expertise for creating these programs in the company," said Andreas Willerer about the unusual control specification process.



In order to reach the rear side of the stator winding cores, the wire guidance needle kinks laterally to guide the copper wire behind the coil.

Before and after: Finished stator winding cores below and empty ones above.

Simple programming and even more advantages

The resulting and cooperatively developed Klartext program can now be adapted to the various windings simply by entering various core parameters without needing to modify the programming. Any necessary interventions to the Klartext program are now carried out directly on the TNC 620 by the technicians in resolver production, without any help from their colleagues from mechanical production.

The first converted machine has been running productively since mid-May 2018. Implementing the retrofit only required four weeks prior to that—following a fundamental concept and planning phase of almost 6 months. All expectations were exceeded:

- Machining is now more dynamic thanks to the higher-efficiency motors. Run-times for producing windings have been reduced by approximately 30 percent.
- The uniform motion control of the TNC 620 achieves constant winding speed despite the higher dynamics, and therefore also constant wire tension. This reduces scrap caused by wire breakage. The originally considered, highly-expensive wire tension control system is now superfluous.
- Running winding sequences can be stopped and continued at any time, thanks to the absolute rotary encoders on the motors.
- The employees in resolver production quickly came to appreciate the handwheel. Being able to position the wire guide precisely in front of the coil facilitates the setup operations enormously.

Driving forces

Accuracy and surface quality are the goals of superior production processes. Axis motors have a decisive influence.

To lead the way in production quality, machining companies invest a great deal of time and expense in machine tools, controls with special functions and options, measuring technology, tools, and, of course, employee skills. Unfortunately, axis motors don't receive the attention they deserve.

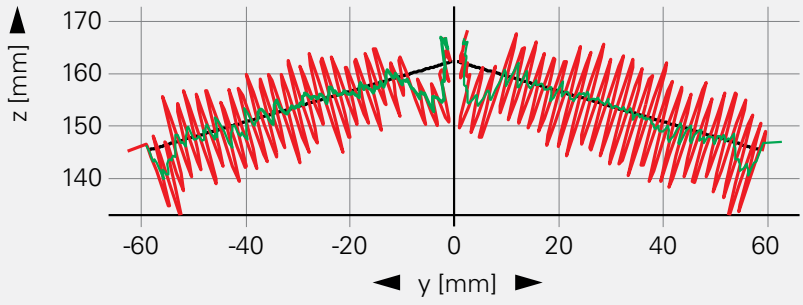
Outstanding results in the machining industry come from the ideal interplay of all components on the machine tool. This also includes the axis motors. Axis motors designed specifically for the machine tool feature not only balanced rigidity and good acceleration capability, but also low torque ripple. A highly-accurate optical encoder and high mechanical rigidity are also very advantageous for use in the machine tool.

Motors made for automation technology, on the other hand, tend to be designed with the acceleration capability of the entire system in mind. Significantly higher torque ripple is also accepted with these motors. When used in a machine tool, this results in visibly poorer surface quality.

Insensitive to disturbances

A lightweight trailer hitched to a large high-torque vehicle will be less affected when exposed to wind gusts or road damage than will a heavy trailer pulled by a lightweight vehicle of the same torque. This is true even though the lighter trailer is obviously much more susceptible to these influences than the heavier one. This means that, for a machine tool, the largest possible motor should be moving the lightest possible table in order to minimize the effect of disturbances on the entire system (such as milling forces or vibrations arising at the table).

Although with a significant difference between the inertias of the motor and the load it is also necessary to lower the loop gains. This reduction would lead to lower rigidity and result in the entire system reacting more strongly again on the load side with disruptive influences. Furthermore, a motor design featuring the highest possible moment of inertia would contradict the highest possible acceleration capability. Because the more inertia a motor has on its own, the more torque it must produce in order to accelerate the entire system, consisting of the motor and the given load, as desired. This, however, has a direct influence on the costs, because the higher the maximum torque should be the more expensive is the motor, due to more or better magnetic materials being required.



Contour errors measured for the machining samples:
HEIDENHAIN axis motor with low torque ripple (green line),
adapted motor with considerably higher deviations (red line)
Magnification factor of the contour errors: 1000

Specifically designed for machine tools: HEIDENHAIN axis motors from the QSY series

Motor speed stability

In addition to disturbances caused by external influences, the motor itself can introduce disturbances into the system that influence the machining and surface quality of a workpiece. Of principle importance in this case is the torque ripple of the motor, i.e. the deviation in the emitted motor torque over one rotation of the motor shaft.

Tests confirm the effect of the torque ripple—not just by virtue of the measurement data but also through the visible effects on the sample workpiece surface. Axis motors optimized for a machine tool produce an evenly angled surface without visible shadings. On the other hand, with axis motors taken from the automation industry and adapted to a machine tool, the effects of the torque ripple are clearly visible in the form of shadings on the oblique surface.

The HEIDENHAIN motor designed specifically for machine tools produces an evenly angled surface without visible shadings.

Workpiece with clearly visible shadings on the oblique surface, machined with a motor from the automation industry and not optimized for machine tools

A tradition of accuracy

What do the Japanese Shinkansen supertrain and closed loop position measurement with HEIDENHAIN linear encoders have in common? Both are traditionally accurate!

The accuracy of machine tools with high dynamics is one of the top topics at this year's JIMTOF trade show in Tokyo. HEIDENHAIN will demonstrate the importance of direct position measurement via linear encoders with the example of two milled Shinkansen models. After all, the Japanese supertrains globally represent the following characteristics: punctuality—in this case meaning accuracy—and dynamics.

While one of the Shinkansen models shines with a perfect surface, the other shows a clearly tangible and visible ridge. The cause of this difference is the method of measuring the axis position within the production process. With the perfect model, linear encoders measured the actual machining position in the linear axes in closed loop systems. The "ridged" model on the other hand was produced on a machine with position detection via the rotary encoder of the servo motor.

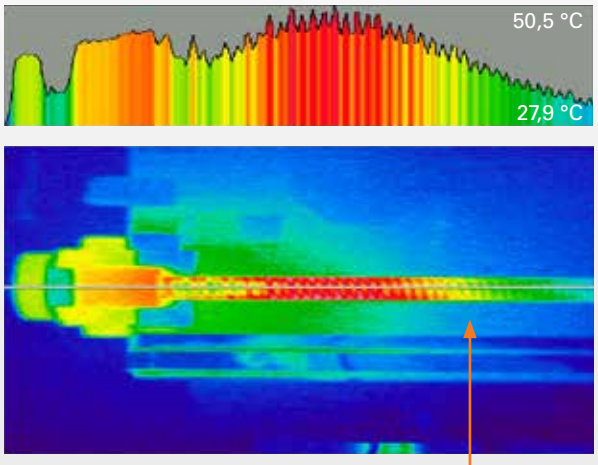
With such semi-closed loop control systems an essential cause of positioning error on machine tools comes into effect: thermally-induced deviations influenced largely by the machining process itself. Analyses of the ball screw show that due to the combined rolling and sliding friction, the temperature of the recirculating ball spindle increases significantly and unevenly, and in relation to the feed rate, to in excess of 50° C.

Because the machine components expand or contract in accordance with the temperature, fluctuations without appropriate error compensation lead to surprising deviations, as can be clearly seen on the Shinkansen model. Without linear encoders, these axially occurring changes that are thermally induced lead to form deviations on the final workpieces.

Of course the use of high-precision linear encoders in closed loop systems does not influence heat generation itself and therefore the axial expansion of the feed components. The linear encoder does not measure the position of the axis based on factors that are distorted by the thermally-induced expansion. Instead, it measures the actual axis position, so that, in combination with the axis feedback control, the thermally induced axial drift of the recirculating ball screw is compensated for.

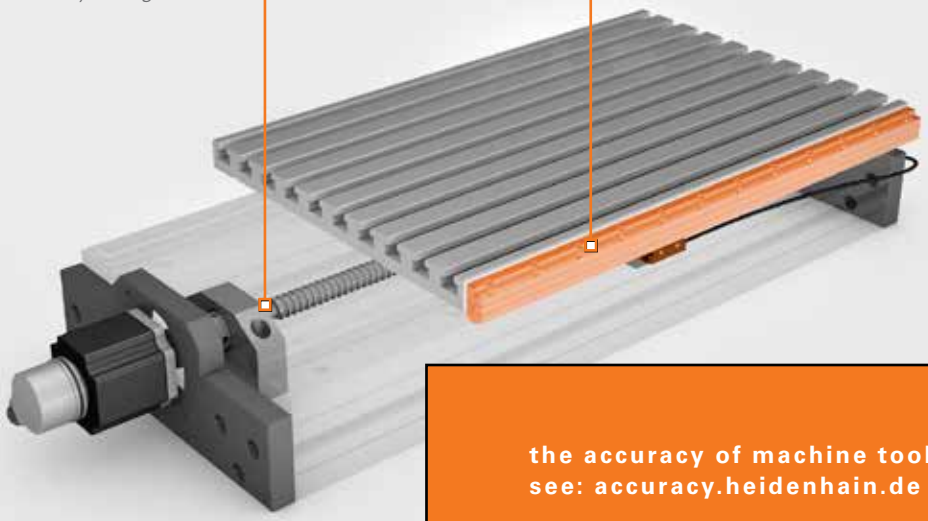
This naturally applies to rotary axes with mechanical gears as well. Here, too, position measurement via gear reduction ratio and a rotary encoder on the motor (semi-closed loop) can be replaced by highly-accurate, thermally-uninfluenced position measurement with the aid of an angular encoder on the machine axis (closed loop). Such closed loop control also leads to significantly higher levels of accuracy and reproducibility on rotary axes.

Two Shinkansens with one decisive difference: A perfect surface when produced in a closed loop control system, but semi-closed loop control produces a ridge on the nose.



Surprising deviations: The recirculating ball screw heats up significantly and very unevenly during operation.

Compensating thermal deviations: Highly=accurate linear encoders for the machine tool in a closed loop system



the accuracy of machine tools
see: accuracy.heidenhain.de

USER REPORT

Digital Manufacturing in action at Krones

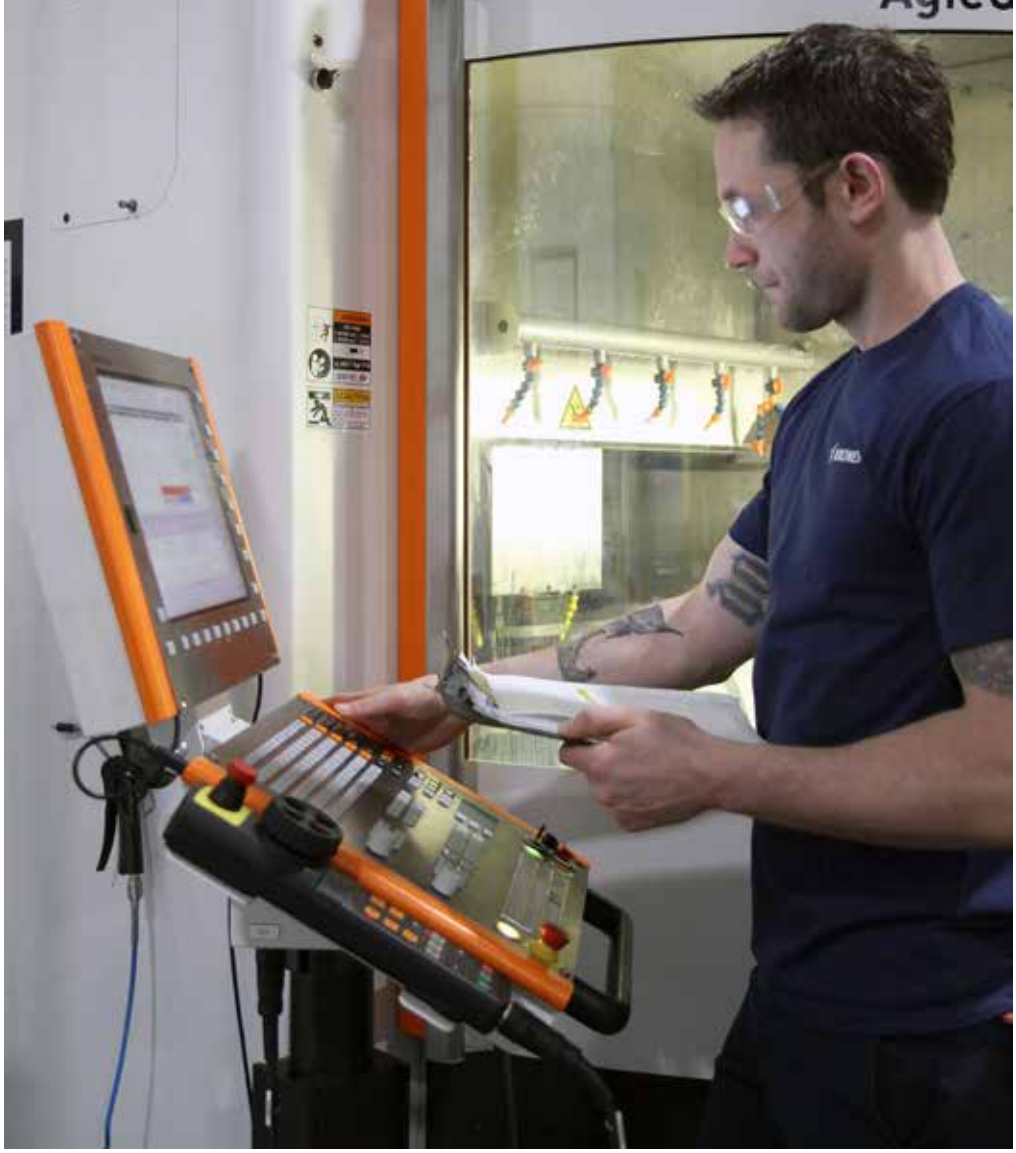
A Krones mold for plastic bottles.

Connecting mold-making machines all over the world

Streamlining its manufacturing processes, world-leading manufacturer of technology for liquid Consumer Packaged Goods (CPGs), Krones Inc. continues to grow by taking advantage of new technologies and connecting systems to work better and faster. Using their mold-making 5-axis machining area equipped with HEIDENHAIN TNC controls as part of a worldwide pilot process for the past three years, Krones Inc. manager John Vincent, based in Franklin, WI, USA discusses how they are now working with these systems in a global manner.

"Since we are a subsidiary of a worldwide company based in Germany, it is common for us to have to manufacture redundant parts in our plants all over the world," explained John Vincent, Head of Manufacturing Technologies for Krones Inc., the North American headquarters based in Franklin, WI. "And we have found a way to streamline this to be more efficient, thus providing optimized parts to our end users faster and better than ever before."

Vincent explains how his approximately 8,000-square-foot mold-making area at the Krones Inc.'s 300,000-square-foot facility is currently equipped with four HEIDENHAIN iTNC 530-controlled machines that make the molds doing the cavity work. This area also includes two smaller auxiliary machines, their own Quality Control department with CMM for inspection work, and an assembly area. Here in Wisconsin, Krones Inc.'s current primary role is to manufacture and supply parts for its large blow molding, filling, labeling, and packing technology installed throughout North America, Central America, and the Caribbean. Common jobs in the mold-making department include manufacturing molds for stretch blow molding machines for PET plastic bottles for water, soda, and other liquid products. Typical part lot size is 40 pieces (20 mold sets) in an average cycle time of four hours.



Krones' Ryan Anderson at mold-making center on HEIDENHAIN TNC.

"We are making very tight tolerance, similar mold parts at all these locations, all requiring high accuracy, as well as highly polished surface finishes down to RA right out of the 5-axis machine," said Vincent. "And by working together, we have been able to incorporate each other's best practices and provide an excellent end-product."

As part of the pilot program that started three years ago, Krones Inc. has undergone steps to connect to its Krones Group affiliates in China and Germany. Utilizing a FORCAM digital software system (similar to HEIDENHAIN's newly introduced StateMonitor), Krones Inc. staff has programmed the HEIDENHAIN controls in each of these three locations to connect and interact with each other when called upon to do so.

"This set up allows us to measure the actual usage of any machine at any time. When they stop, there are protocols provided for next steps including the ability to enter cost codes to track why it stopped, so there's connectivity between all the machines," said Vincent. He explained that there are actually about 65 CNC-controlled machines throughout his entire Wisconsin location.

"I think it is important to note that we have done tests in the mold-making department where we've run programs from both Krones in Germany as well as Krones in China that were selected within our software systems. We were able to run them here in Wisconsin just fine! This is particularly helpful for customer development work.

"For example, we recently had an order for a new bottle on a Monday, so that day we designed a mold for it. Then I sent an email to a Chinese colleague asking for them to design a program for it (their daytime is our night)," explained Vincent. He added that their Chinese mold-making department has six HEIDENHAIN iTNC 530s in use. "So, when we came into work on Tuesday morning, we loaded the program from our Chinese colleague into our iTNC 530 and started running it, and had the part done that same day for customer review. This is a part that probably has a cycle time of five hours, so it isn't something on which we can minimize run time. This process is one that our customers continually request be done quicker, and we are happy to now be able to do it."

TNC Role in Krones Inc. Connected Machining

Krones Inc. has been utilizing the HEIDENHAIN TNCs in their mold-making departments for some time, with change-outs to updated machines approximately every five years. "I'm a huge fan of the HEIDENHAIN controls, explained Vincent. "Particularly in the mold-making industry, these controls definitely have a leg up on the competition as far as being able to achieve excellent and accurate surface quality at high speeds."

"There are many useful features that I particularly like, such as the manual probing routine on the machine via soft keys right on the control. You don't find that on other controls and it's a well-used feature for in-process inspection."

As new employees, Krones Inc. machinists receive training on the controls, though Vincent adds that once his employees learn the HEIDENHAIN control

they usually don't want to go back to another. The TNCs are conversational, and while Vincent admits that many new employees are hesitant to try something new, "after some training, they say they would never run anything but."

Vincent adds that he and his staff find many TNC control features easy to use, making special mention of the ability to do things on the fly and/or add checking programs by the operators, as well as the way the tool table systems work. "We use a tool data management software that incorporates well with the TNC. With this, we assign a number to every tool assembly in our plant. With the TNC, we can call out that number and it doesn't matter where it is in our machine tool magazine, the operator can pull it. It's easy since you don't always have to have tool number one in pocket number one. This is a real benefit to us and not something I see with other controls."

Here, Krones Inc. staff is utilizing the extended tool management feature. They can load and unload from the list of tools by simply dragging and dropping with the computer mouse. A tool usage list provides more details, and an import function allows for reading and exporting CSV files.

Another important TNC control feature used by Krones Inc. is the HEIDENHAIN DNC option, providing the ability to communicate with external Windows applications. In use as well is the Remote Desktop Manager which provides the user the opportunity to operate one or more Windows PCs directly from the TNC. "We comonly use TNC Remote to load programs into the machine's control from various locations," explained Vincent.

Vincent also describes another unique manufacturing system at Krones Inc. that utilizes an iTNC 530 in a different area in the plant. This one is incorporated on a machining center producing pallets for labelling machines that applies labels to bottles, such as beer bottles or BBQ sauce bottles. "In this system, we actually configured a waterjet into a 5-axis machining center. We were able to use the features in the TNC control to create multiple setup kinematics to handle using the normal milling spindle as well as the separate auxiliary waterjet feature. We are using a GF Mikron machine with a pallet changer (up to 21 parts). All the data is set up so that an operator can pull in the appropriate program so that the machine moves successfully between milling and water jetting as needed. It's working out great!

"This connected machining has really been going strong on a daily basis here at Krones over the last year, and we are now working to expand it to other departments," added Vincent.

Importance of Training and Support

To keep this large organization at the top of its game, Krones' culture includes daily employee support and training as needed.

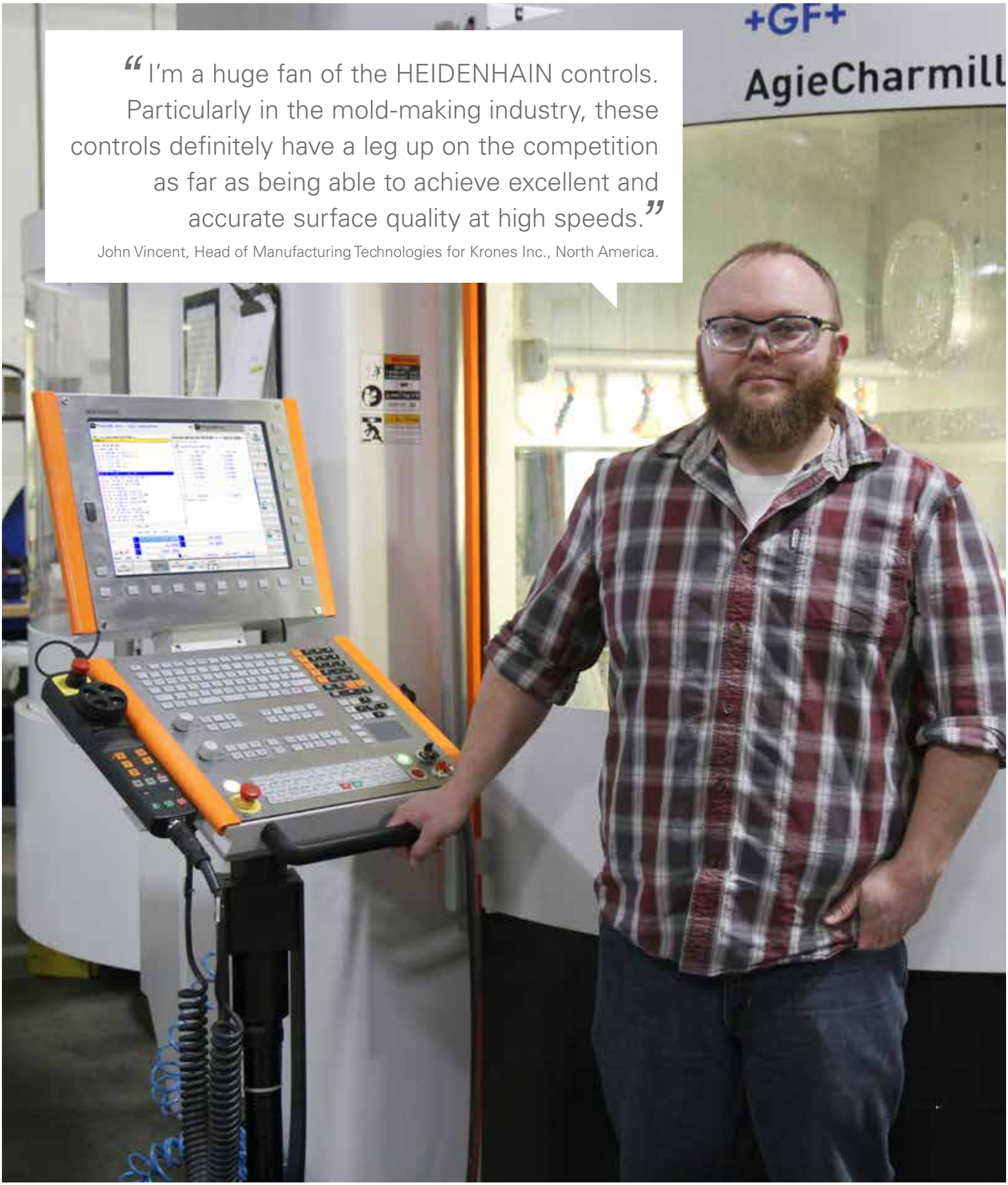
"As we look to the future of manufacturing and global connectivity, we know that it is important to know what today's advanced capabilities offer," said Vincent. "We understand that it's beneficial to have skilled staff that can and want to interact with our machines, to customize and optimize the end products. We applaud these efforts, and work to empower our people to do so."

Vincent explained that Continuous Improvement programs where employees meet weekly in groups are part of this process. He also adds that both in-house and external machine training is provided to Krones employees. Last year, for example, eight Krones Inc. employees were sent to HEIDENHAIN's North American headquarters in Schaumburg, IL, to participate in a four-day TNC control training. They were able to enhance their skills and learn tips to do even more. Since HEIDENHAIN keeps these classes small and customized, Krones was able to have a dedicated trainer to themselves the entire time.

"Training at HEIDENHAIN encourages full use of this conversational control in various ways and enables greater creativity for the operator to fully use its features," explained Vincent. "I'd say 95% of Krones programs come from a CAD system. But when using a HEIDENHAIN control, our operators can easily fine-tune them, right at the control as needed. This allows improvements otherwise not realized and allows our operators to take ownership of their work.

"After the training at HEIDENHAIN, I spoke to all eight of our employees who attended, and every one of them expressed that this was a positive experience. Some even requested to go back another time for more advanced classes since HEIDENHAIN had just introduced a much larger TNC training schedule in 2018."

Close-up of Krones' 5-axis milling machine modified with Waterjet head, cutting a plastic component.



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>
> John Vincent, Head of Manufacturing Technologies for Krones Inc., North America.

HEIDENHAIN

TNC 640 – High-End Control for Milling and Turning Operations

For the first time, milling and turning are combined in one TNC. With HEIDENHAIN's TNC 640, users can now switch as desired between milling and turning—within the same NC program. Switchover is independent of the machine kinematics. It automatically takes the respective operating mode into account and without any additional action. This new simplicity is complemented by dialog-guided plain language programming, the optimized user interface, powerful programming aids as well as comprehensive cycle packets taken from amply field-proven HEIDENHAIN controls into the TNC 640.

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