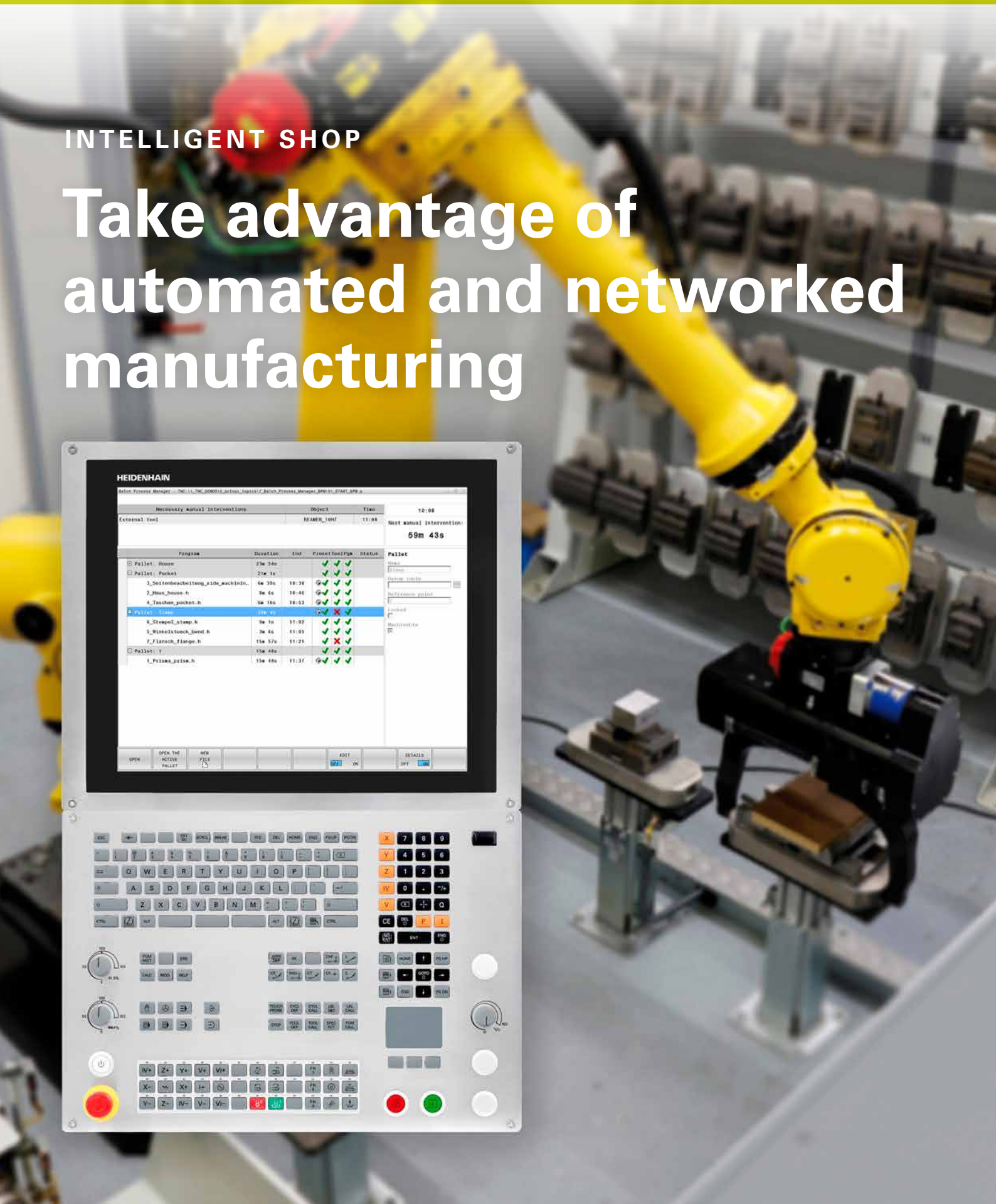
Klartext

HEIDENHAIN

INTELLIGENT SHOP

Take advantage of automated and networked manufacturing



Editorial

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

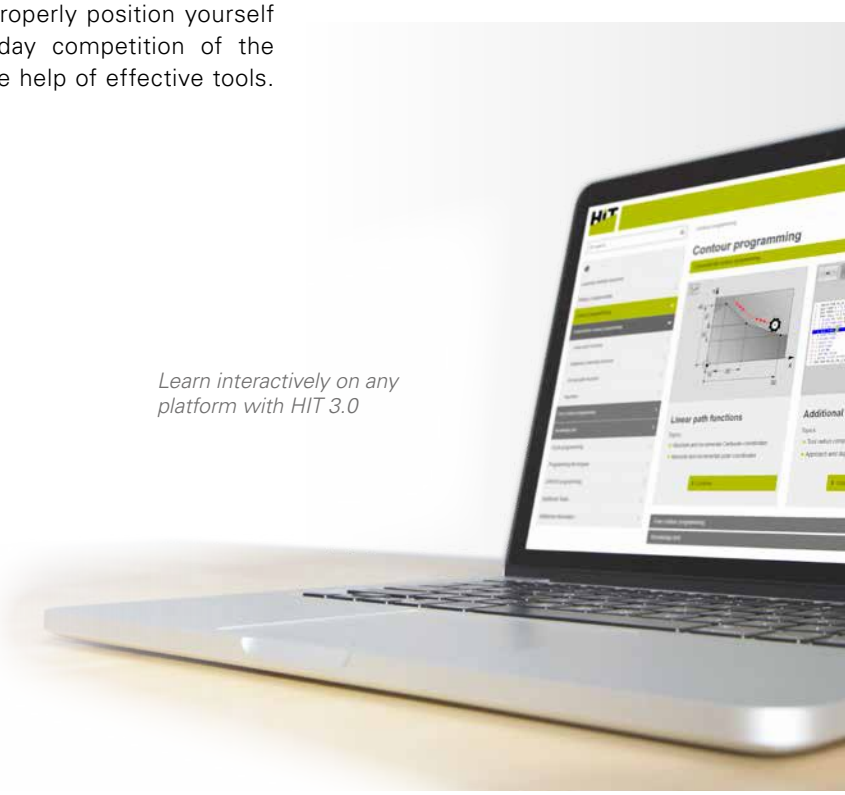
Dear Reader,

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, because perhaps you have already been riding this wave of the future for some time now, or because you 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!



Learn interactively on any platform with HIT 3.0

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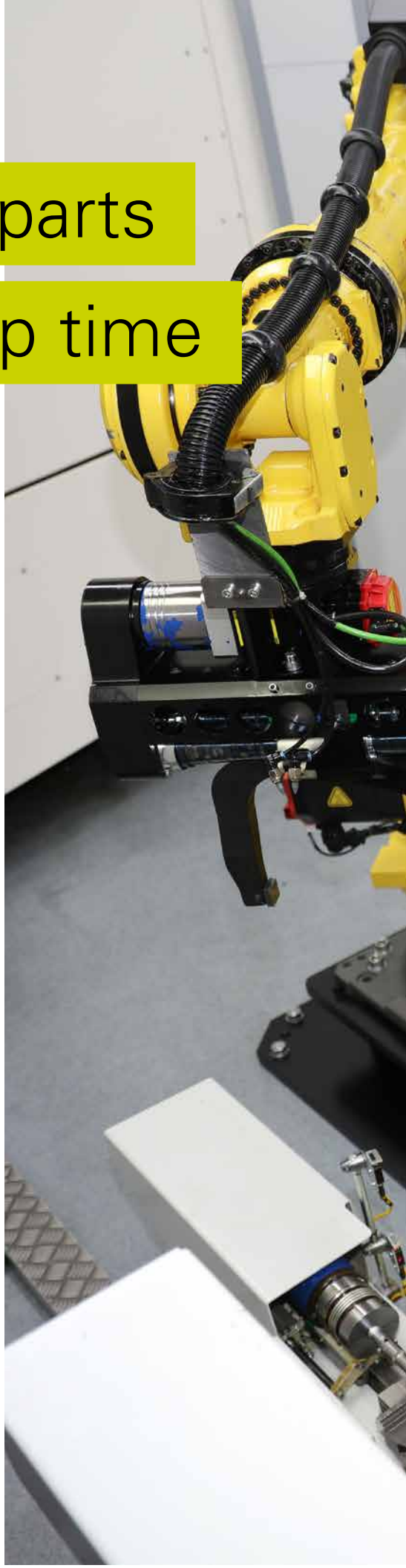
Content

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

USER REPORT

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, the 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 overnight; 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 other homework beforehand."

The homework that Trimatec primarily had to do 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, that you know your tools and have mastered the process of tool monitoring, that tool clamping functions perfectly, that you 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 the system, one mainly sees the enormous storage lift system that can accommodate 374 workpieces in 17 drawers. The drawers themselves are further subdivided into sections for workpieces ranging in size from

> “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.

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 are, besides the storage lift system, 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

"With this arrangement, particularly thanks to is 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, enumerating the system's facts and figures. "In a normal eight-hour day 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, adding that "subsequent to and partly even during all of this, each machine runs productively for at least 16 hours." Beja goes on: "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. This is because 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.

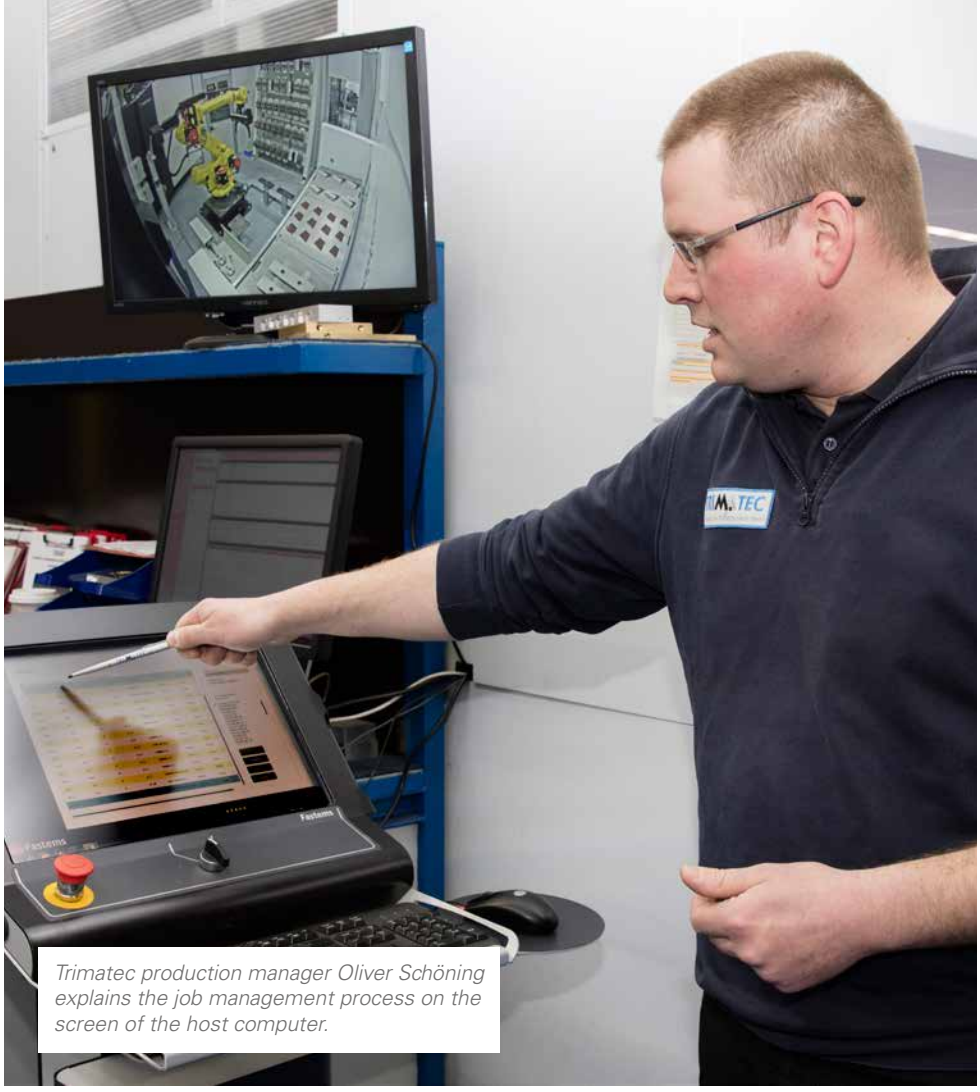
In addition to the machining program, a program header with data for the controls of the robot is also always included. This header contains a total of 27 parameters that enable the error-free

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 because the HEIDENHAIN controls are so widely used in demanding applications and because, as a result, a lot of people with a great deal of expertise are either trained on or have experience with these controls."

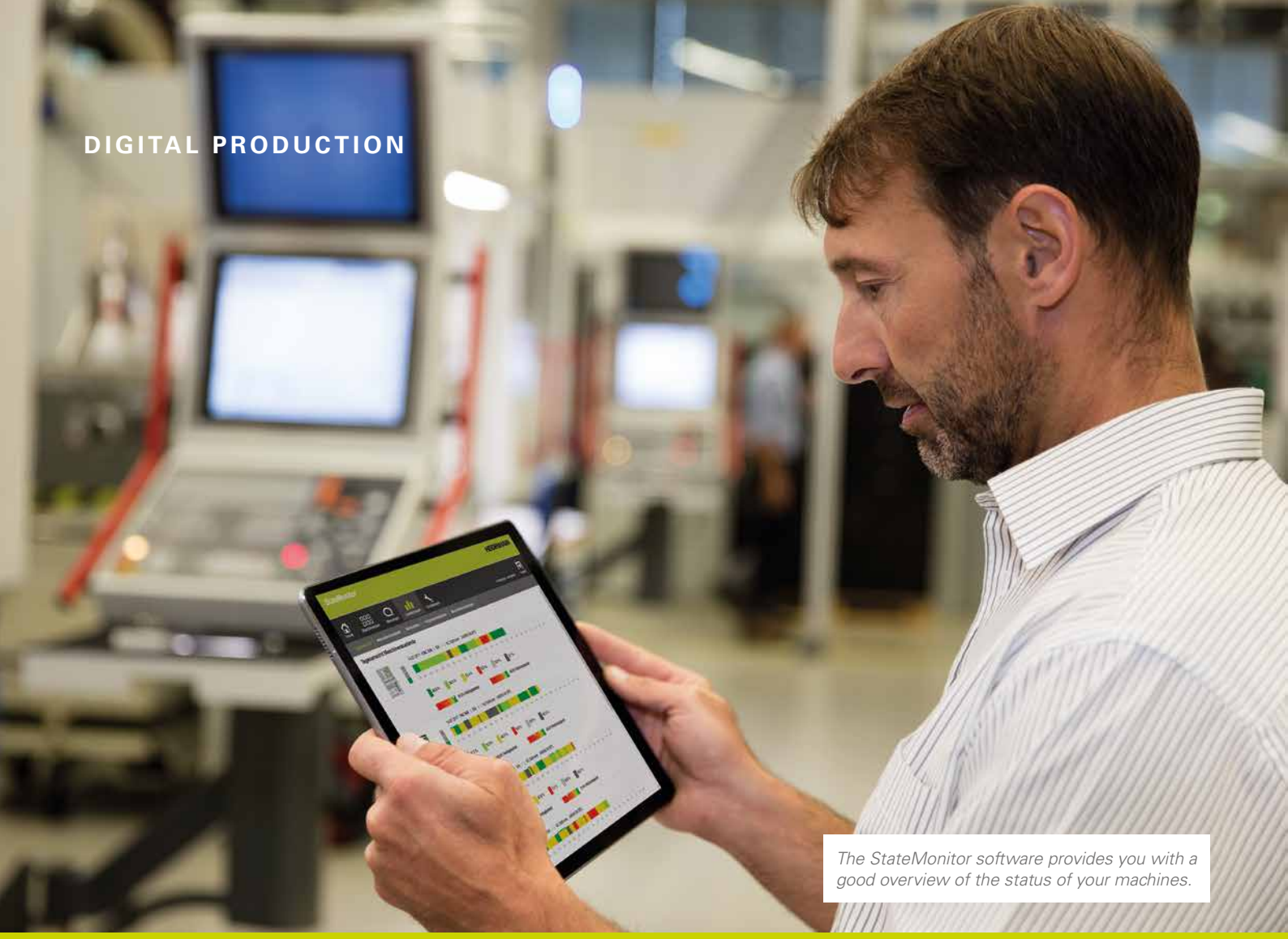


Trimatec production manager Oliver Schöning explains the job management process on the screen of the host computer.

> "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. So the Trimatec formula for success goes like this: 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.

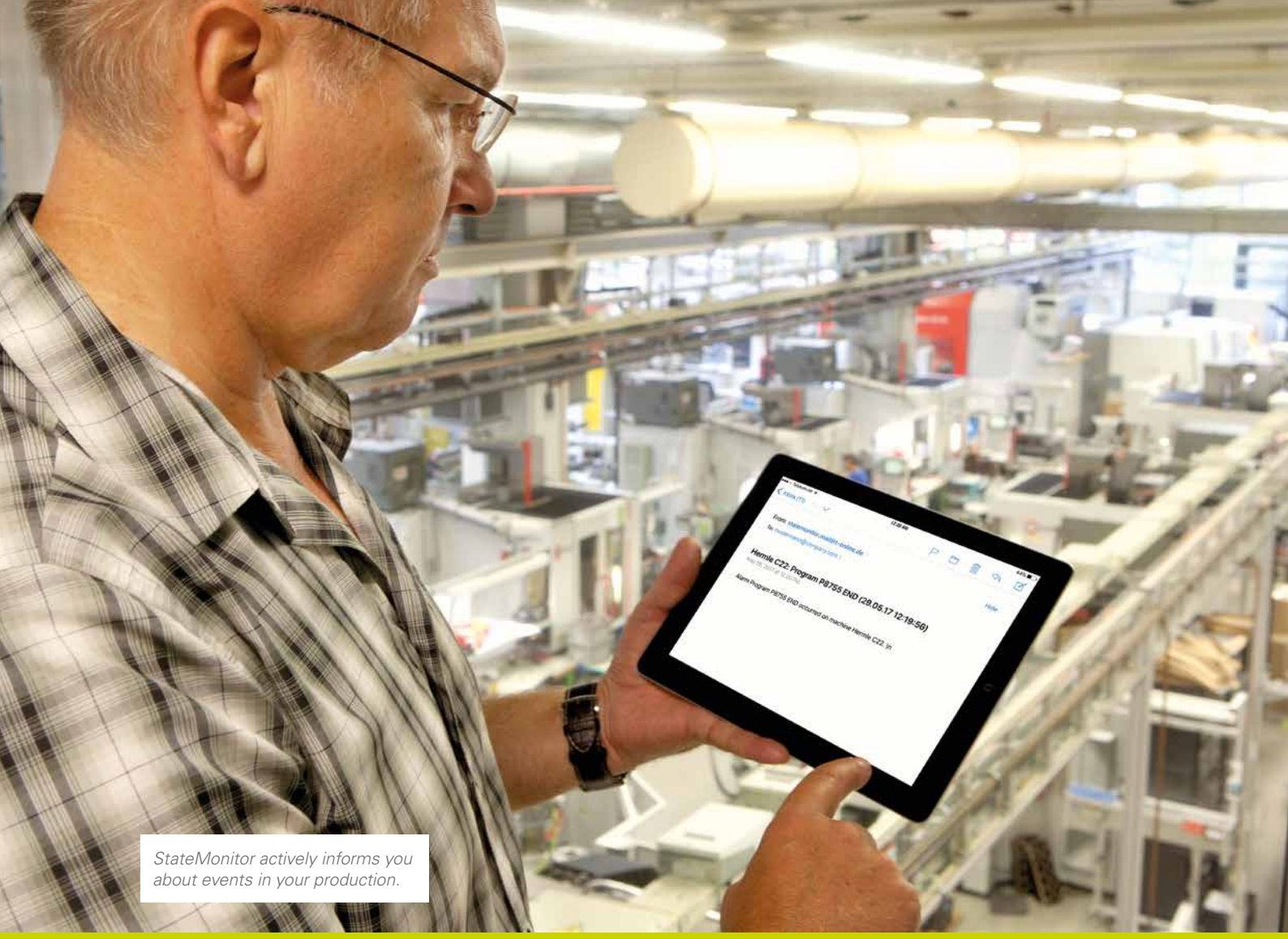
Window into the workshop

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

The times are changing—window shopping used to be the best option in private life for becoming informed about new developments and trends. Nowadays, though, we gain this information online on the screen of our PC, tablet, or smartphone. This also provides us with possibilities for evaluating and comparing in order to decide which offer 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 here you keep up-to-date with 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.

In fact, though, much of this is superfluous for you, because all this information could come directly to you in a thoroughly digitalized production environment. In addition to integration of the machines into the company network, e.g. via Connected Machining, you also require an intelligent software that collects the requisite data, displays this graphically for you, and thus also provides you with a window into your workshop: StateMonitor.



StateMonitor actively informs you about events in your production.

HEIDENHAIN
StateMonitor

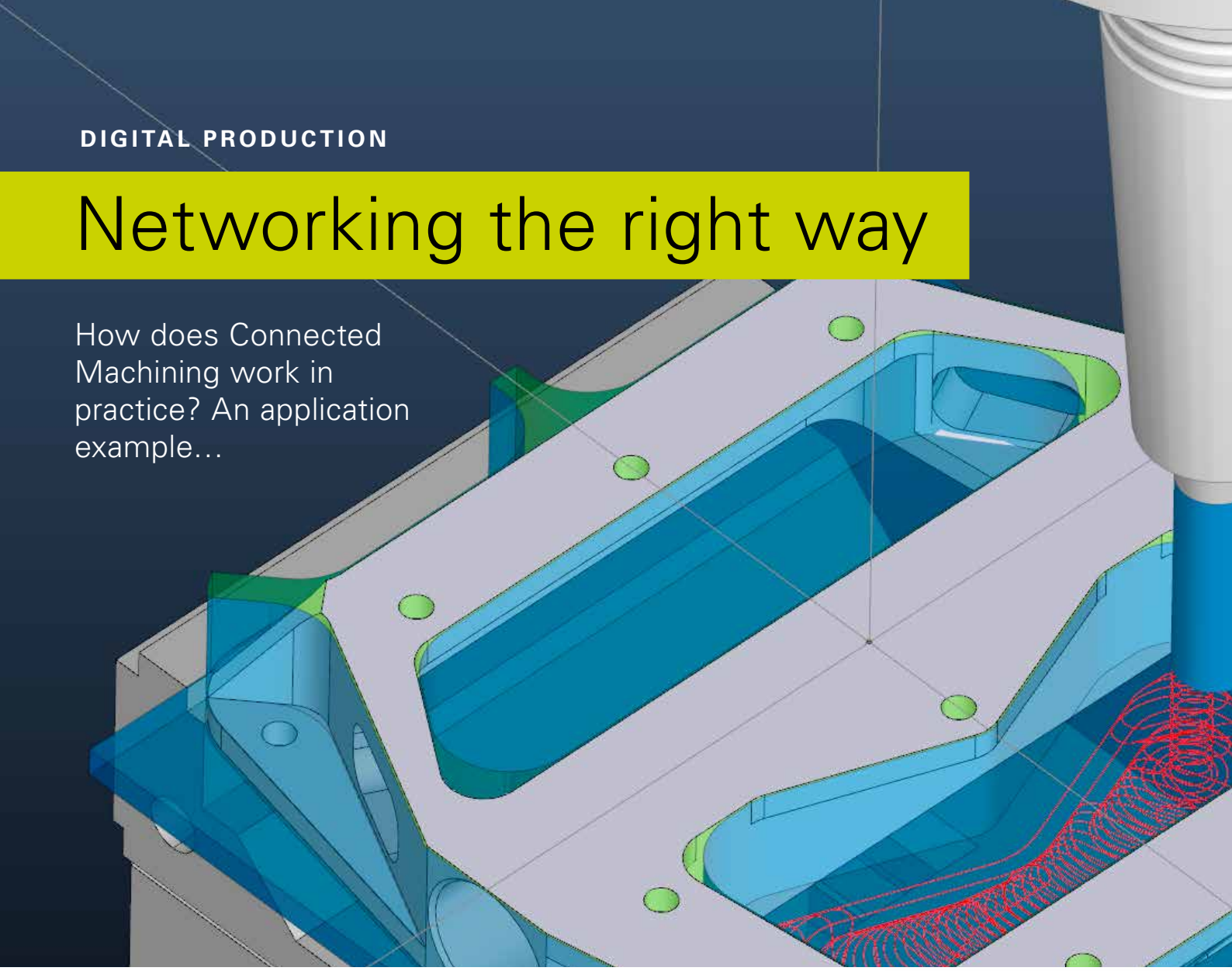
+ For your direct connection to StateMonitor, see www.klartext-portal.com/statemonitor

StateMonitor gives you a real-time view of each machine's status. But that doesn't apply only to machines with HEIDENHAIN controls. You can connect any machines if they have one of 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 these data with StateMonitor for improving yours levels of efficiency and productivity. The capture and feedback of job data also enables the order-related analysis of the machine data. An important factor in this regard is that you are and remain the master of your data, because you configure the StateMonitor software completely individually 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 think fit. And you also provide the data for the MES and ERP systems. StateMonitor adapts to your requirements—and not the other way around.

Networking the right way

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



Digitalization, networked production, and intelligent factories—these and several other buzz phrases demonstrate which topics the manufacturing industries are currently hotly discussing. 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

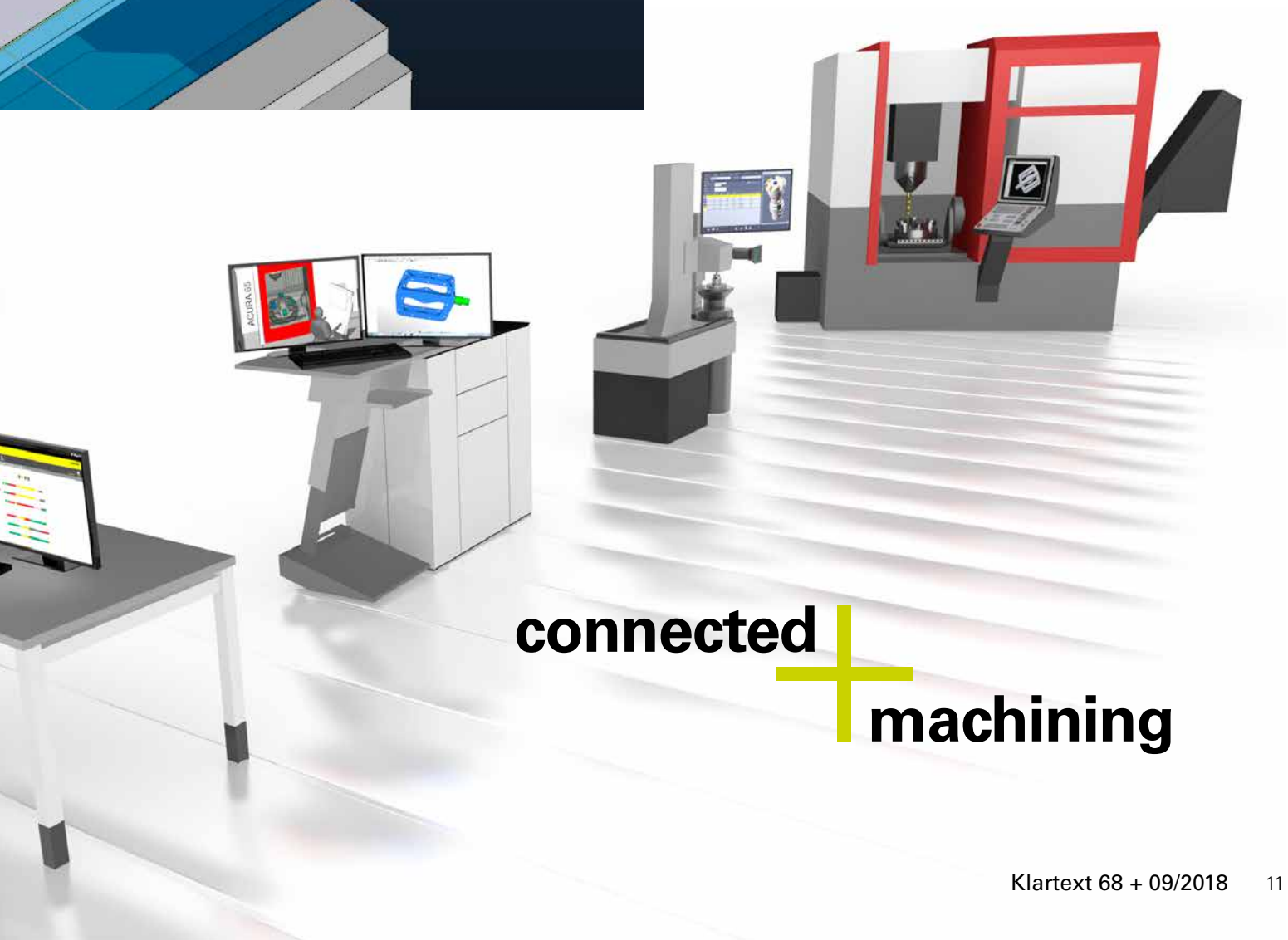
Digitally networked throughout with Connected Machining: The complete process from design and simulation to production

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. Because only in very few cases are these sorted in the folders so that you gain a quick insight into the production-relevant data.

However, you no longer need this folder in production environments networked digitally 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 data relevant to production, which in turn is also networked.



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 execution of the production job on the machine. NC programs and the position of the workpiece fixture on the pallet are linked according to the specific job. The Batch Process Manager also provides you with information about the machining duration. This 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 are used together with data from the tool management to order new tools. The tool preparation station then immediately receives orders for any additionally required tools. Based on the data stored in the tool management, the tool preparation station can then promptly prepare new tools in the tool presetter for calibration.

In this case as well the data of the exact tool settings are sent to the tool management. The pre-set tools are given their own code on the tool holder for unambiguous identification. The CAM program and the virtual machine then also have access to precisely 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 around ten years now, you as the operator have been able to open DXF drawing files directly on your TNC control and transfer the 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. But just as 3-D movies have now become the measure of all things in cinemas, you also now mainly design 3-D models. After all, 3-D significantly facilitates the ability to envisage complex workpieces. As a result it is only logical that HEIDENHAIN makes its TNC control fit for CAD data of the third dimension.

TNC controls provide you with the 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. In the event of uncertainties 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 enables 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 any 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 in particular its CAD import extension are highly effective tools for workshop-oriented programming. Programming is not only faster but also significantly more reliable thanks to this transfer of CAD data. Simultaneously, with 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, for example this mountain bike handlebar mount, can be directly loaded 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 though. You can simply and economically machine spur or helical gearing systems completely in one set-up with skiving or hobbing. The software allows both forms of machining in both milling and turning mode.

Concealed internal and external gearings exist millionfold, for example in all automotive vehicles. From bicycles to construction machines and from electromotively supported pedal drives to hydraulic heavy machinery drives, progress is made only if the gear systems of hubs and drives cleanly intermesh. Gearing manufacture often still takes place on special machine tools so that workpieces need to be laboriously re-chucked. Traditional sequences for machining gears are also themselves frequently 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 efficiency and levels of productivity compared to traditional heading. New tool technol-

ogies 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

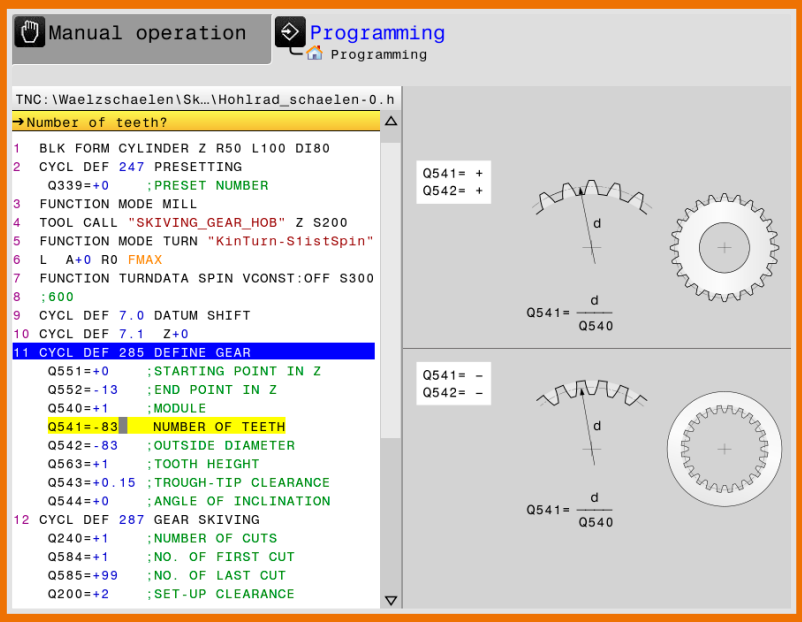
In the same simple way as skiving, i.e. with program generation based on the gear geometry and tool definition, the TNC 640 also makes life easier for you with Cycle 286, “Gear hobbing”. Hobbing is mainly suitable for external gearing systems. Its advantages are found in the high levels of productivity 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

As well as simple programming, a further 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 little 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: amb.heidenhain.de

It's the HIT!

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

HIT is the 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 that time more than 20,000 users have benefited from the interactive training program to become 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. This learning platform is based on the Moodle learning platform used by many schools and universities and, especially for teachers, offers various highly useful functions. 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

TRAINING AND FOLLOW-UP COURSES

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 oriented to the user: this describes not only the programming courses but also the service courses at HEIDENHAIN. This is keenly 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 do what is expected of it. 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. The participants see this differently though. "The trainers asked about the preconditions and expectations of all the participants at the start of the course and took that into consideration," revealed Kenny Magasiner, trainer for servicing 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. He therefore 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 in 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 is not 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. In this way the (at first glance) highly theoretical service training 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.”

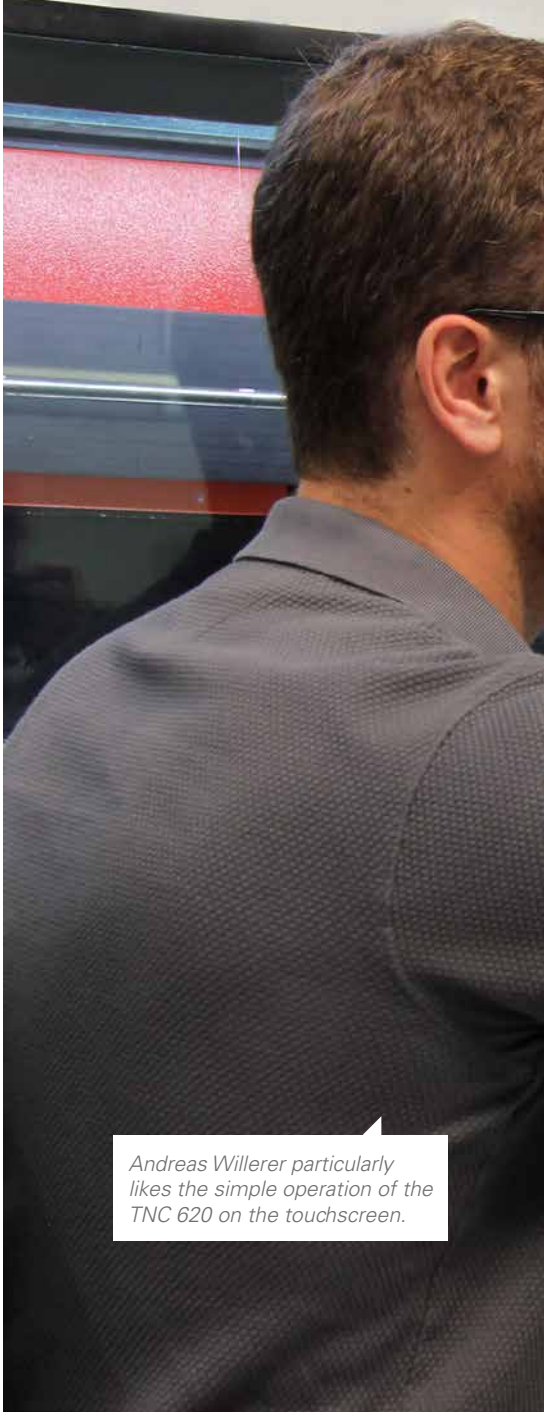
Christoph Etzelsdorfer, Servicing Division, ifw mould tec GmbH

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

SERVICE

Off-the-wall thinkers

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



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

The resolver winders at LTN Servotechnik in Otterfing, near Munich, Germany, have been unremittingly doing their job for over 20 years. This is a long time that has left its marks—mechanical wear 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 now be seen.

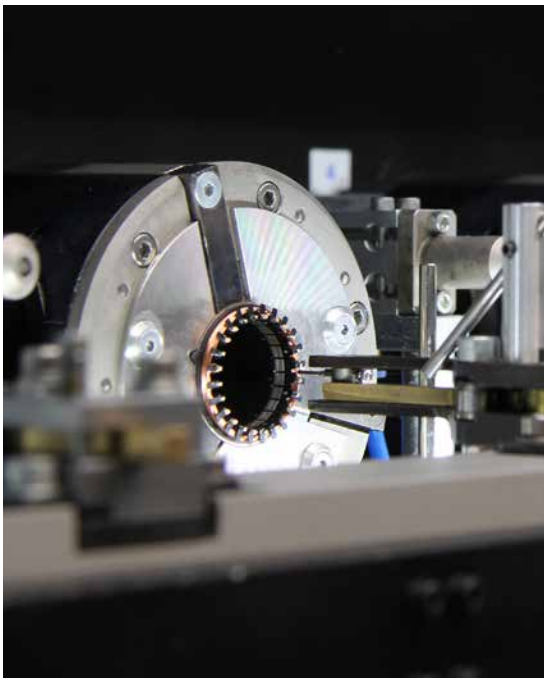
At first glance a look into resolver production at LTN is more reminiscent of a textile company than high-tech electronics. Machines stand in orderly rows, where feed units with coils running above on the machine canopies mainly catch the eye. Coils on which the strands are wound are located in the working 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 are also not 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.

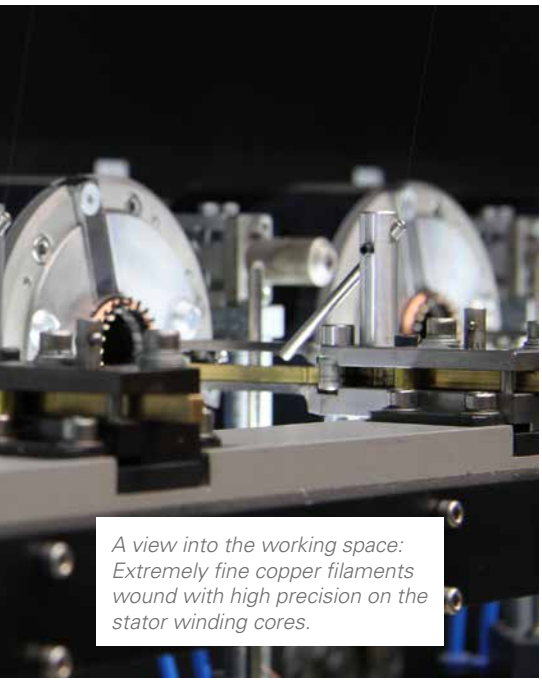
For manufacturing equipment designer Andreas Willerer, who managed the conversion project at LTN, it was clear from the beginning that the retrofit could only be rewarding and successful if the old resolver winding machines were upgraded in their entirety. “We didn't want just superficial results, but rather future-capable machinery after the retrofitting.” For this reason the technicians implemented a complete tidy-up on the first machine to be converted—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 further 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 giant spectrum of controls for every conceivable automation solution that can also be adapted to this application. To specify 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



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 material 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

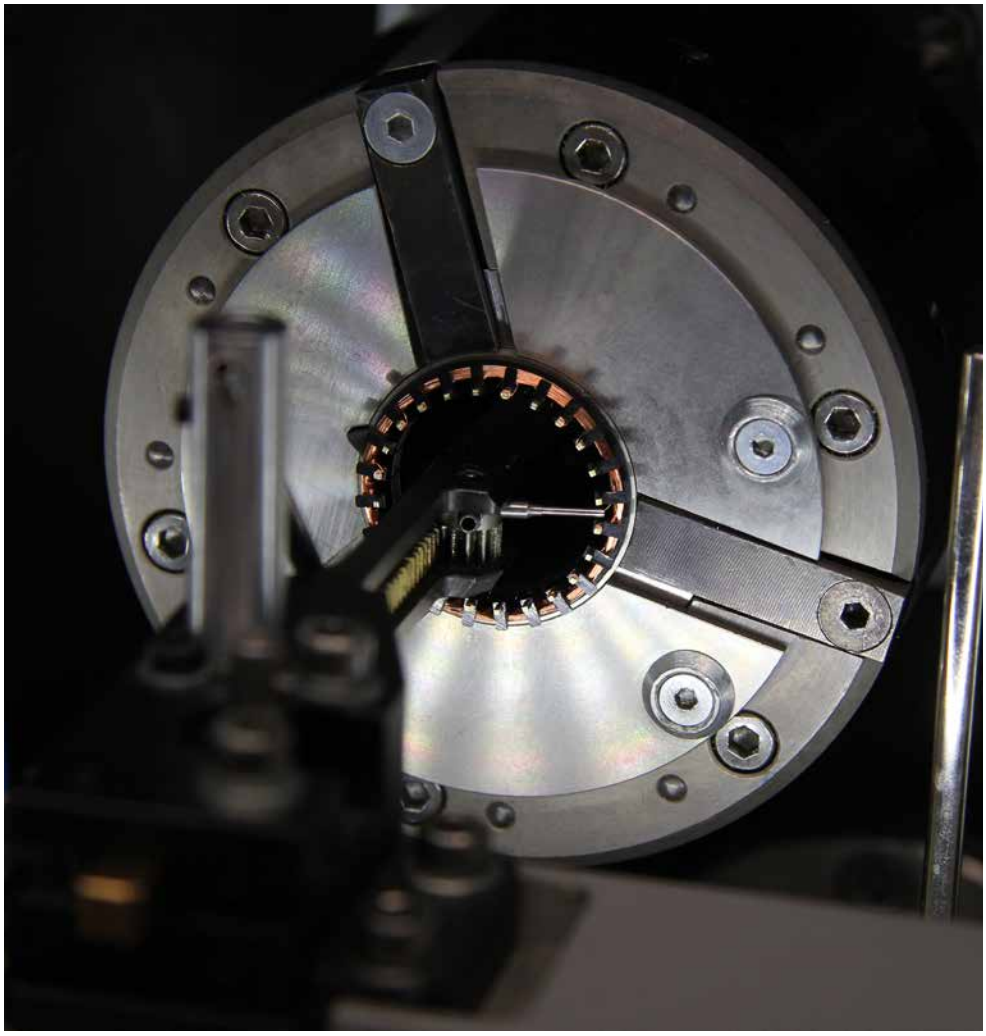
The upgraded resolver winding machine with TNC 620 control is located at the head end, with three of the six systems to be retrofitted by the end of 2019 on the left.

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 the 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 from 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, and in the meantime 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. Runtimes 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 also superfluous.
- Running winding sequences can be stopped and continued at any time, also 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 be at the vanguard in terms of 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 still receive very little attention in this arrangement, which is also completely unjustified, as we wish to show.

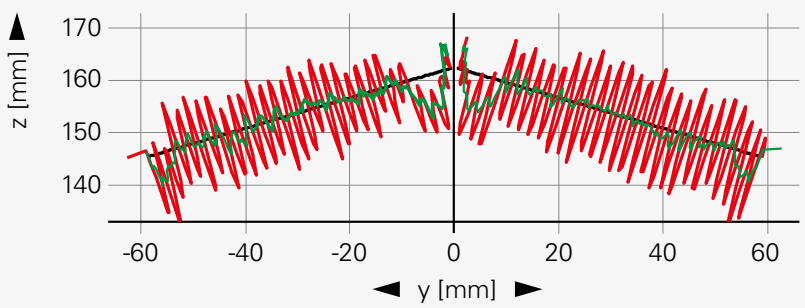
Outstanding results in the machining industry come from the ideal interplay of all components on the machine tool. This also includes the axis motors. Axis motors designed specifically for the machine tool feature not only balanced rigidity and good acceleration capability but also low torque ripple. 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 introduce fewer disturbances into the entire system 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.



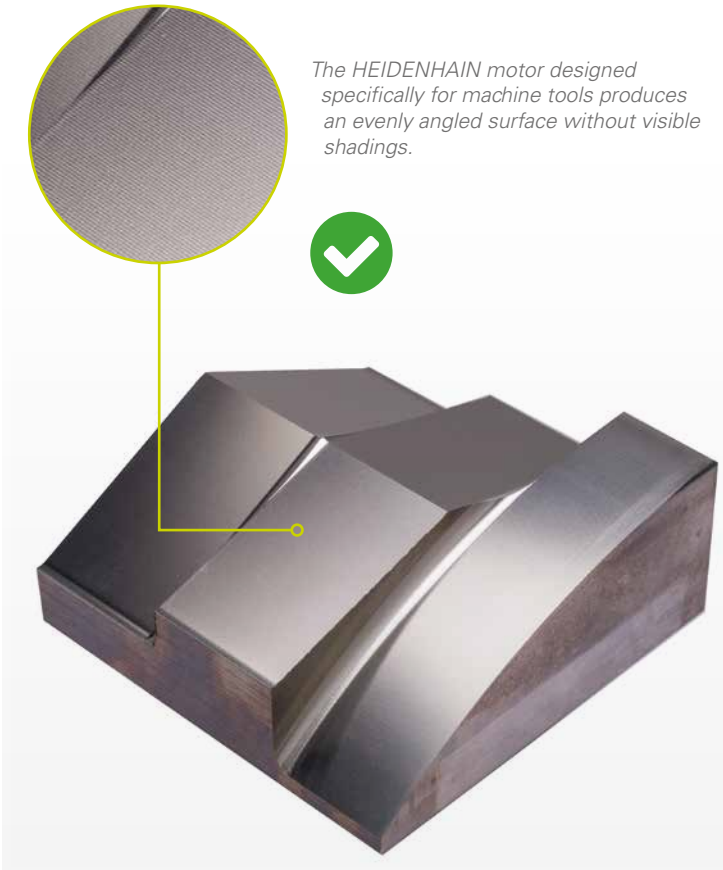
Contour errors measured for the machining samples:
HEIDENHAIN axis motor with low torque ripple (green line),
adapted motor with considerably higher deviations (red line)
Magnification factor of the contour errors: 1000

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

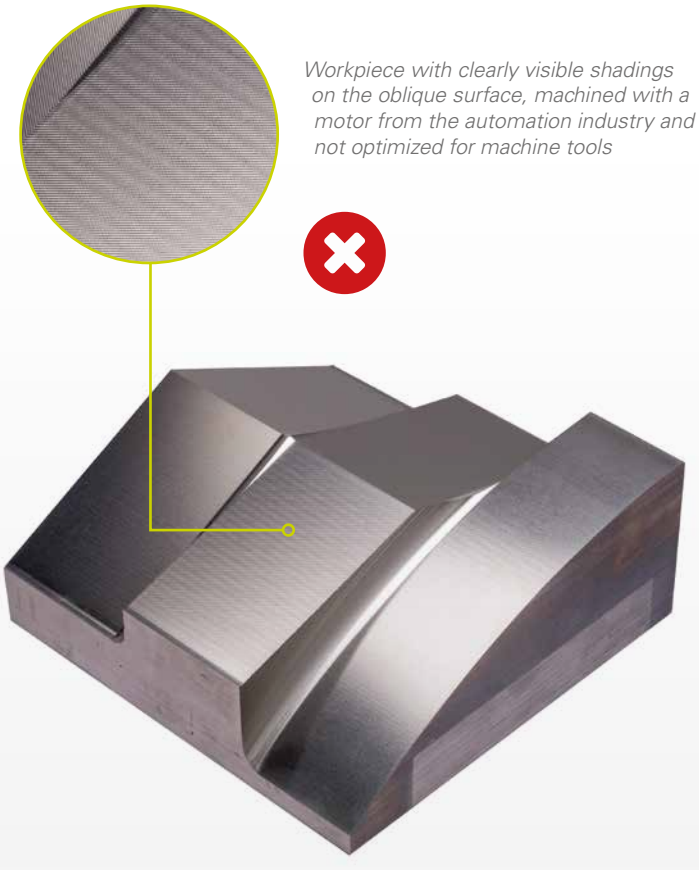
Motor speed stability

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.

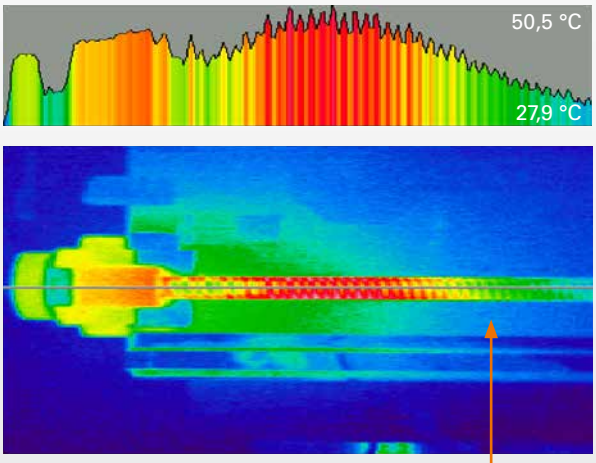
With such semi-closed loop control systems an essential cause of positioning error on machine tools comes into effect: thermally induced deviations influenced largely by the machining process itself. Analyses of the ball screw show that due to the combined rolling and sliding friction, the temperature 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, 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.

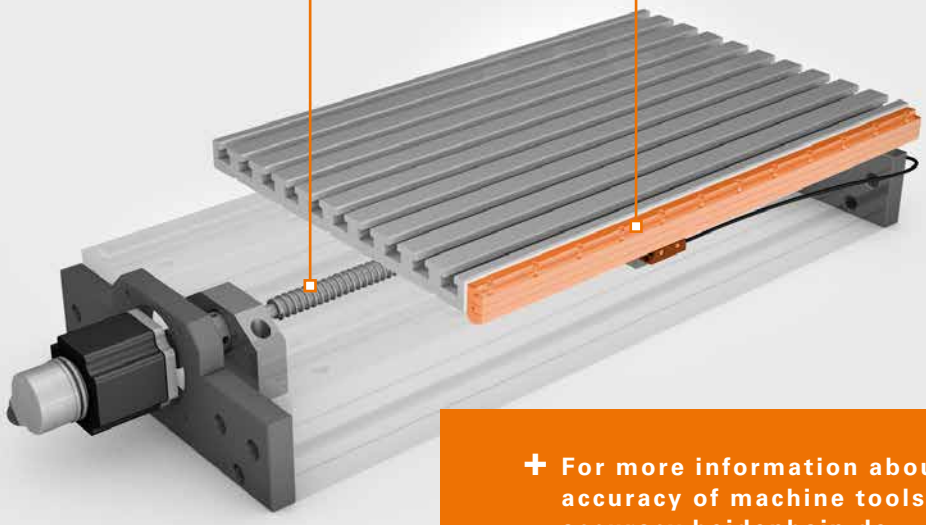
This naturally applies to rotary axes with mechanical gears as well. Here, too, position measurement via gear reduction ratio and a rotary encoder on the motor (semi-closed loop) can be replaced by highly accurate, thermally uninfluenced position measurement with the aid of an angular encoder on the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



+ For more information about the accuracy of machine tools see: accuracy.heidenhain.de

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