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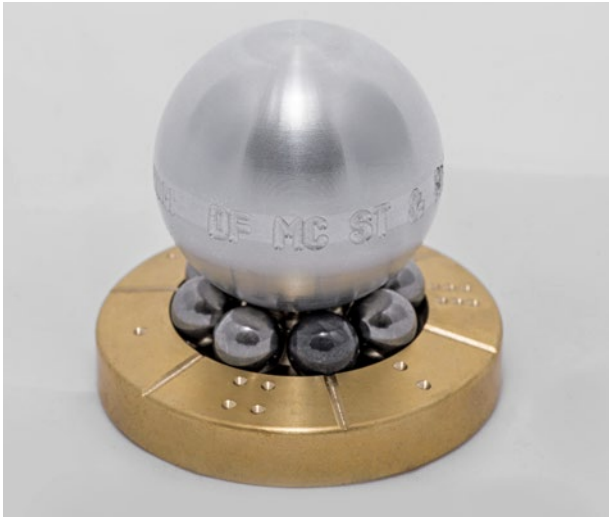
Digitalization

CNC knowledge



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The perfect practice workpiece: manufacturing dice with no corners or edges

On the shopfloor

Industry news

Education and training

News

Cover photo: Siemens AG/W. Geyer

IoT in CNC production

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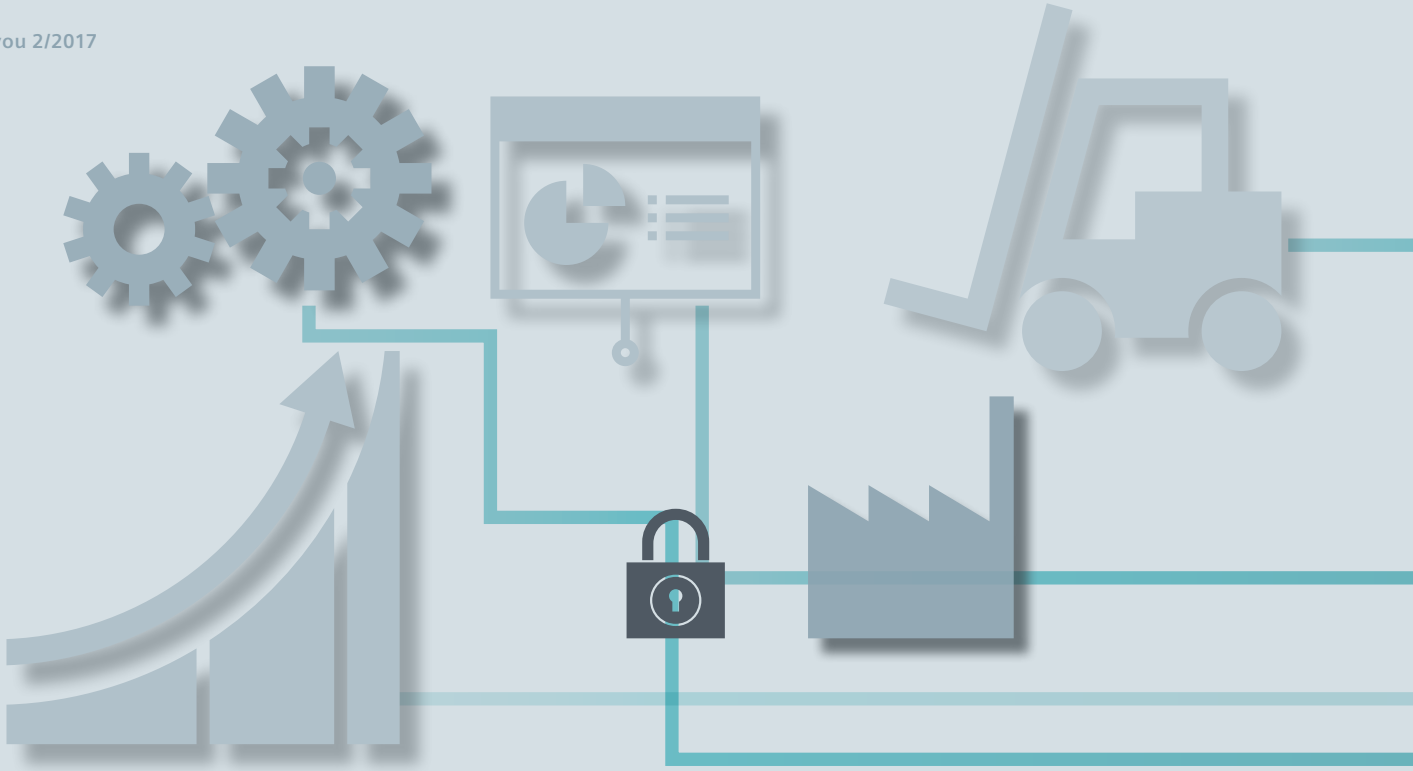
Digitalization

Use of the term Internet of Things (IoT) has become quite far reaching. If all definitions are reduced to one common denominator, IoT simply means: "The networking of objects which have the connectivity that enables them to communicate independently with one another via the Internet." The objects are connected to a cloud-based server on which the data is gathered, linked, and analyzed.

The picture initially conjured up by the term Internet of Things is most likely one of interconnected objects — such as household appliances or intelligent thermostats in homes — rather than production with machine tools. However, it is precisely in the latter that the IoT holds enormous potential for increasing the productivity of industrial processes.

Being the "brain" of the machine, CNC plays a key role in this: CNC provides important production data for optimizing production sequences, as well as machine status data for predictive maintenance of the machine.

The actual intelligence, however, lies in drawing the correct conclusions from the data provided. In other words, the IoT is not to be considered solely as a data transport medium. With MindSphere, the open IoT operating system from Siemens, we are providing an IT platform on which a multitude of software applications can contribute to sustainably optimizing productivity in industrial manufacturing. ■



Productivity in full view

Digitalization: MindSphere, Siemens' cloud-based, open IoT operating system, enables even small contract CNC manufacturing companies to generate "smart data" — and therefore contribute considerably toward increasing their manufacturing productivity using machine tools.

Overall equipment effectiveness (OEE) is an important indicator for manufacturers, and is closely monitored as a key variable by all CNC production managers. In the case of contract CNC manufacturing, this indicator usually boils down to the productivity of machining with CNC machine tools, as the machine is only productive when in operation.

From a mathematical point of view, OEE is the sum of the availability, performance, and quality of the production process. In order to assess the availability of the production process, scheduled downtime, such as breaks or planned maintenance, must be discounted. It is the unplanned downtime, caused by a sudden shortage of personnel or materials, or by waiting for maintenance, which leads to additional costs. "Performance" is defined as the number of workpieces per period of time, and "quality" — in simplified terms — the scrap rate.

A range of production data concerning the machines must be collected continuously to calculate the OEE. Even in small companies with just a few machines, the volume of data soon adds up. The data generated must be filtered logically to identify the production efficiency when using machine tools — essentially turning "big data" into "smart data".

Filters for "smart" data

The benefits of this process are illustrated by the following example: A contract CNC manufacturer was perplexed by the fact that, despite using the same number of occupied machines and employing the same number of personnel, the quantities manufactured during the early and late shifts differed significantly. An evaluation of the override switches and the CNC operating mode showed that the machining process was started much more cautiously

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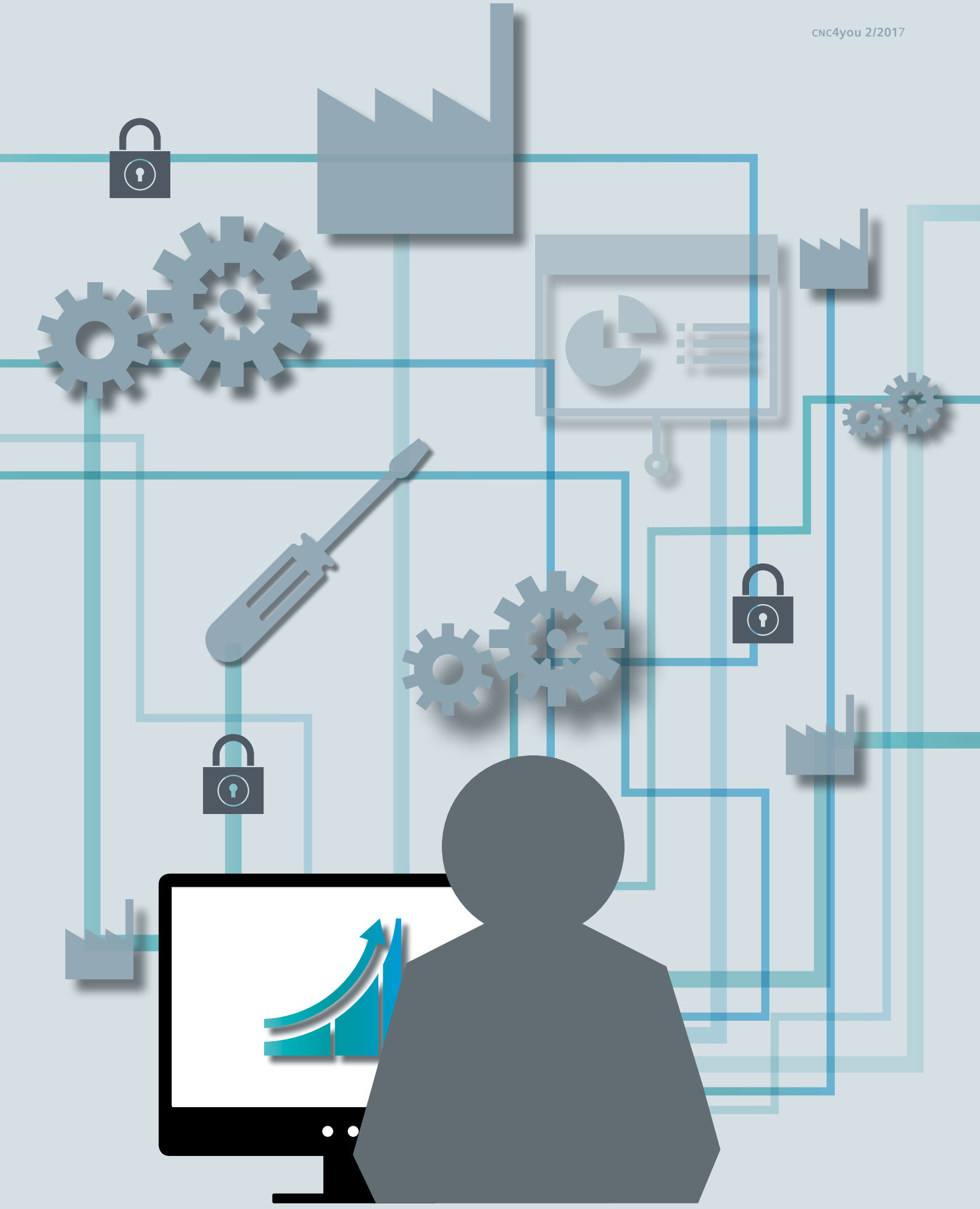
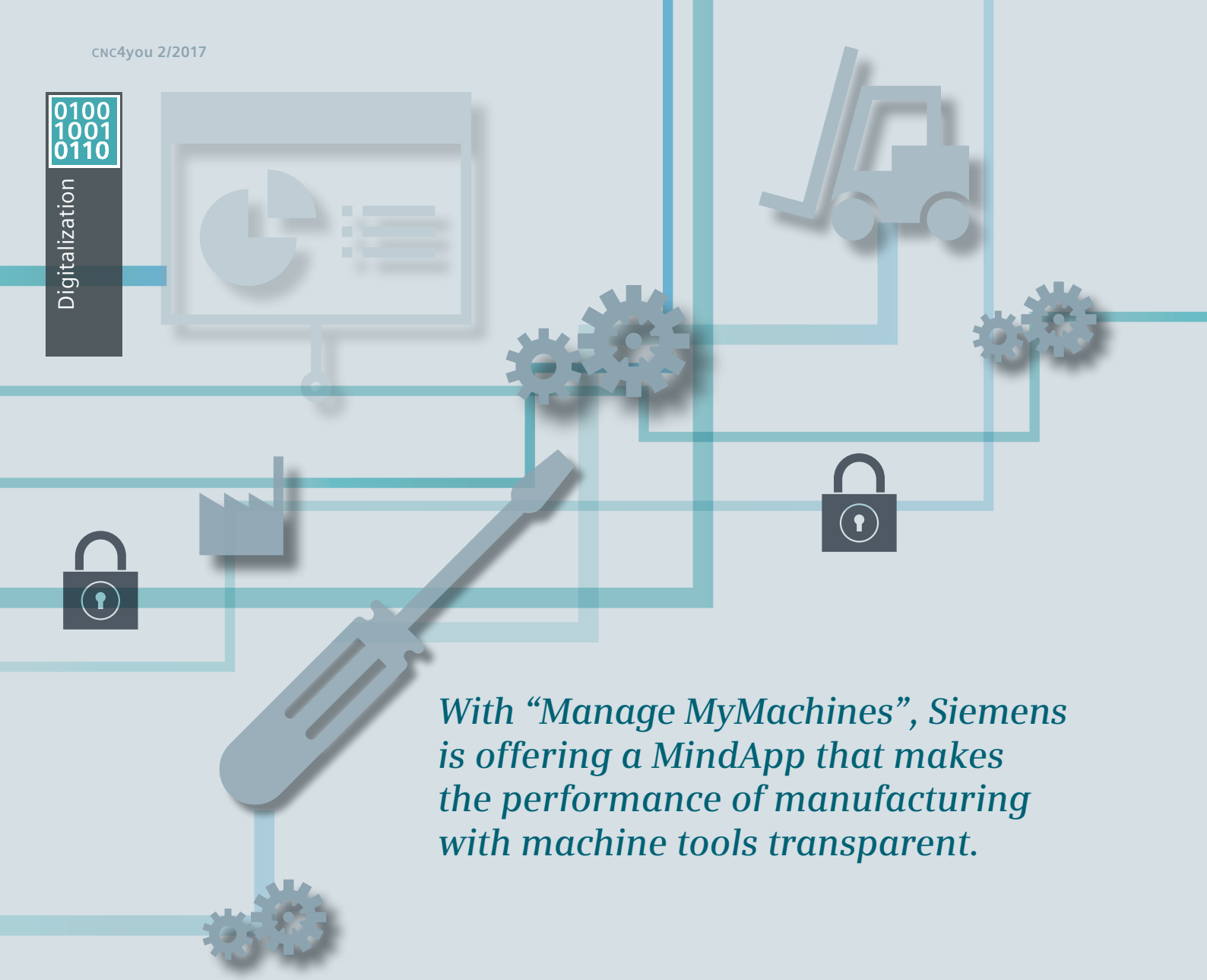


Transparent presentation of machine data with Manage MyMachines helps to reduce maintenance costs



With "Manage MyMachines", Siemens is offering a MindApp that makes the performance of manufacturing with machine tools transparent.

during one shift, with workpiece changes taking longer. Clearly, achieving transparency in a small area of smart data — that is, a subset of the OEE indicator — is enough to improve overall equipment effectiveness.

Securely connected to the cloud

MindSphere, Siemens' cloud-based, open operating system for the Internet of Things, securely connects Sinumerik CNCs — and other CNC systems — to the industry cloud with relatively little effort. As an industrial firm itself, Siemens understands the concerns of contract manufacturers regarding sensitive production data. This is why MindSphere only uses the latest security and encryption technology for recording, transmitting, storing, and processing data.

Furthermore, the cloud solution does not require specific IT knowledge, which is particularly beneficial for smaller companies. Just a few settings are needed to enable the machines' Internet access, after which all that remains to do is to create an "asset" — a virtual image of the machine in MindSphere. Again, this can be done with just a few clicks. Machine tool operators with IT expertise can easily connect to MindSphere and manage the machines in the cloud themselves, without the need to hire expensive IT personnel.

App provides transparency

However, MindSphere is more than just a storage space — it provides valuable assistance in the generation of smart data. Cloud-based applications, known as "MindApps", facilitate selecting and preparing the relevant production data. With "Manage MyMachines", Siemens offers a MindApp that makes the performance of manufacturing with machine tools transparent.

Aspects play a key role in MindSphere. These involve machine data that are collected based upon specific

criteria, or under certain conditions. As such, aspects represent a targeted, consistent filtering of big data from CNCs, the machine's data providers.

Already in the basic configuration, Manage MyMachines provides a substantial collection of important aspects, such as the values of the feed and spindle overrides, the NC program status, the operating mode, and the name of the active CNC program. These aspects allow important conclusions regarding the OEE of the machining with CNC machine tools to be drawn.

Machine operators or suppliers with the corresponding CNC and drive expertise can define customized company- or machine-specific aspects in Manage MyMachines. Based upon these data, it is possible to introduce preventive maintenance measures, or further enhance the performance of the machining process, for instance.

Visualizing smart data

Once the relevant production data are in the cloud, they can be visualized in different ways and with different levels of detail. Similar to the dashboard of a car, the dashboard of Manage MyMachines shows the aspects supplied in the basic configuration — and thus the status of the respective machine — clearly on one screen. This gives the production manager an immediate overview of the most important production data.

Each aspect can then be analyzed in greater detail. A line graph enables the progression of the parameters over time to be viewed, and bar graphs or pie charts show the relationship between different parameters. These targeted analyses allow the user to interpret even complex aspects of the machines in a reliable manner. Operators of large production facilities can bring up the location of each machine on a world map or production site map at the touch of a button in MindSphere.

It is a major advantage for the user that MindSphere can be operated and the aspects visualized in the MindApps using a simple web browser. As such, MindSphere is accessible not only on office PCs and notebooks, but also on tablets and mobile devices, as data access is possible anywhere and at any time.

Making big data manageable

With MindSphere, Siemens' cloud-based, open IoT operating system, and the Manage MyMachines MindApp, Siemens is supporting contract CNC manufacturers in their efforts to generate more overall equipment effectiveness — and thus more profit — from production data. In addition, MindSphere makes machine tools' big data manageable and usable, for both small contract CNC manufacturing firms as well as large international companies. ■

Benefits of MindSphere and Manage MyMachines at a glance

- Easy connection of machine tools to an industry cloud with the latest security and encryption technologies
- Targeted and consistent reduction of "big data" from CNCs down to manageable, meaningful "smart data" — known as "aspects"
- Clear presentation of relevant production performance aspects on one screen
- Further increase in the performance of the machining process through a customized definition of company- and machine-specific aspects
- Visualization of aspects via a web browser, even on mobile devices

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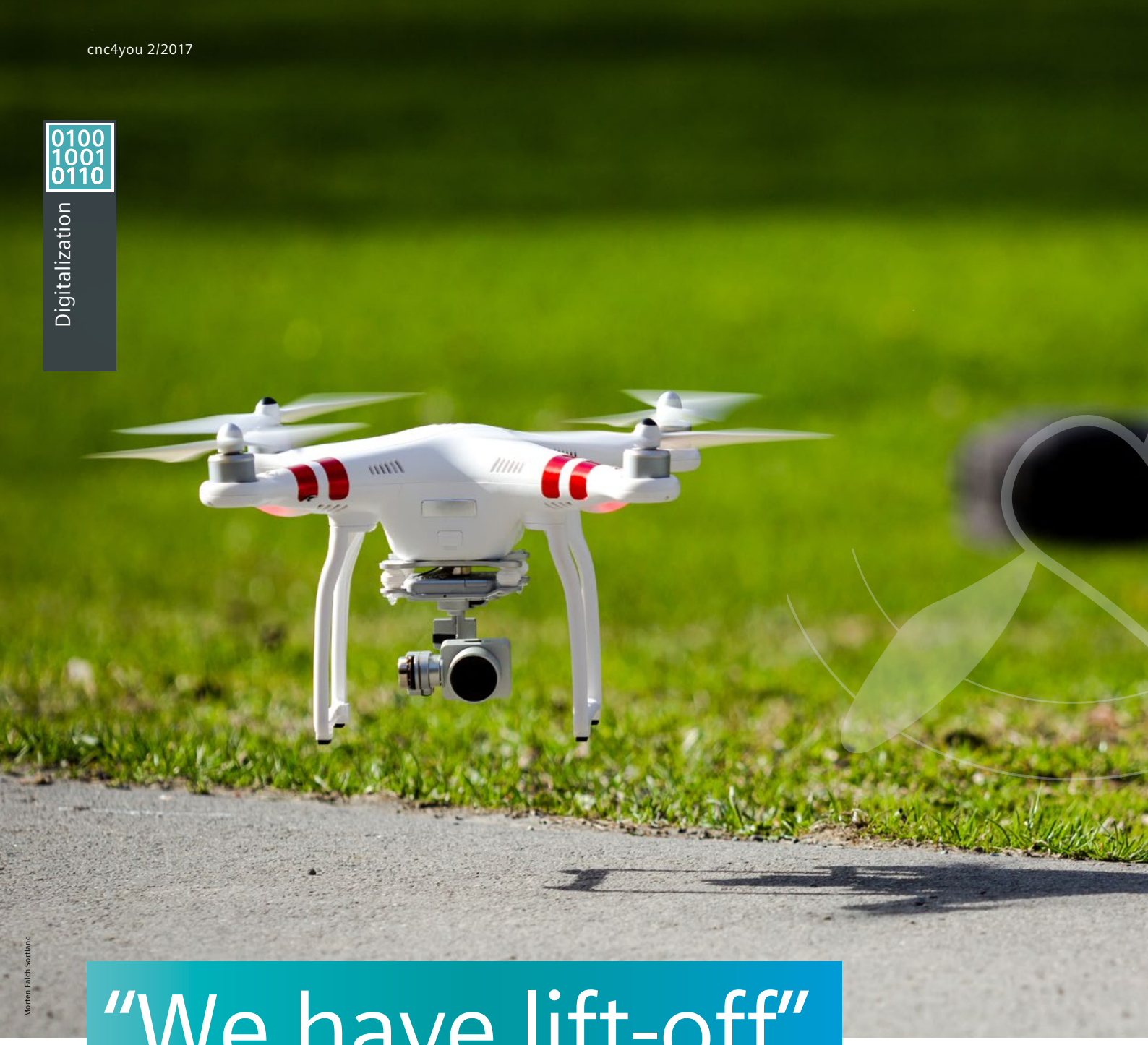

Morten Falch Sortland

“We have lift-off”

Production is changing — and not slowly, but at an incredible pace. This transformation is being driven by digitalization, and is not just the concern of large companies: small and medium-sized manufacturers can also take advantage of new digital tools and processes. But how and where do manufacturers begin? Using the example of quadcopter production, Siemens shows how digital processes can be introduced one step at a time.

With its Digital Enterprise Software Suite, Siemens is placing its focus on the topic of digitalization. Siemens is the first manufacturer to succeed in mapping the production process in a fully integrated manner — from the first design draft, to programming and control of machine tools, right through to the finished product. It has gone even further than this, in that real production data can now be used in a closed control loop to continually improve the information that underpins planning, while sensor data makes it possible to maintain machines more flexibly on an as-needed basis, depending on use (predictive maintenance).

For companies with internationally linked sites and processes spanning from design to finished product, it is recommended that the entire Digital Enterprise Software Suite be used — ideally alongside the cloud-based IoT operating system MindSphere. The advantage of digitalization is that companies will become more competitive as a result of increased flexibility, efficiency, and quality — along with decreased throughput time. This equally applies to medium-sized businesses and smaller contract manufacturers. Modular software can be used to digitalize processes in a targeted manner and with a manageable level of effort, as the below example of quadcopter production demonstrates.

The digital process chain begins with the design

Even for many small contract manufacturers, shopfloor programming on the machine is increasingly being done offline using CAD/CAM programs. The advantages are obvious: the machine remains productive during offline programming; complex components can be programmed more reliably; and full use can be made of the benefits of modern five-axis machines. Siemens offers a powerful CAD/CAM solution for this phase in the form of NX. Here, users will not find the typical design tools. With DFMPro for NX, it is now possible to test whether a product will be able to be produced as early as the design phase. Another advantage is in the case of molded parts, clearly illustrated by the quadcopter project. The same program can be used for the design and engineering of the component and mold.

Contract manufacturers will see new opportunities and options arise through additive production processes such as 3D printing. This allows workpiece prototypes and molds to be presented to the customer very quickly and cost-effectively. The components do not have to be converted in NX, instead the 3D print order can be launched directly from NX for initial sample parts. This means that production firms can directly integrate additive procedures in their normal software environment.

Digital process planning

Many of the advantages of digitalization are not particularly spectacular in technical terms, but in practice offer manufacturing companies enormous benefits, such as digital workflow planning. The simplest functions allow tasks to be visualized, and resources and information allocated, on the computer. This information is then stored centrally by Siemens' NX software, including computer-aided manufacturing (CAM) data, clamping fixtures, work instructions, etc. All changes are recorded through an integrated revision check, and are therefore transparent. At the touch of a button you can pool together and send programs, work instructions and additional information to the machines without any paperwork. Users can bring up all of the necessary information for an order on the machine without wasting time searching. Particularly in the case of the highly flexible production of smaller companies — or when products are changed often — this ensures considerably improved oversight, efficiency, and reliability.

Program simulation on the digital twin

A digital twin of the quadcopter and corresponding molds were created during the design and engineering phase. Within the digital process chain, it should now be possible to not only generate the NC program but also test its feasibility on the respective machine tool. However, in order to achieve this, there must be a digital twin of the machine tool. In NX, Sinumerik's virtual kernel (VNCK) can be used to precisely map the behavior of the control system and the machine. At EMO 2017, this will be demonstrated using the example of a Hedelius five-axis machining center that creates complex free-form surfaces. Realistic machining simulation on the digital twin makes it possible to reliably identify errors, unnecessary travel — or even head collisions — and optimize the program offline. The benefits for production: the programs reach the machine in a run-ready state; time-consuming tests and programming are not required; and the machine's productivity is increased.

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Digital Machine Shop blog and video series

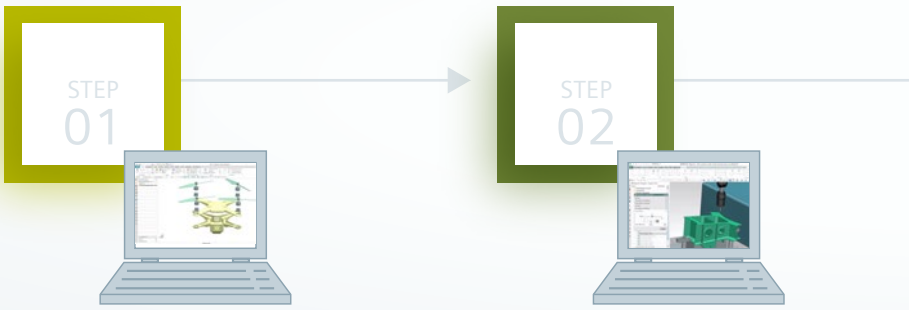
Want to learn about digitalization, and find tips and tricks for implementing modern processes in NC-supported production in a compact, convenient, and entertaining way? Just click on the tutorials and videos about digitalization in the Siemens blog.

You can view the first video in English at http://sie.ag/2wiiPTP

The process chain in a digital mechanical engineering firm: from design to production

Product design:
Design and engineering of the component and mold using the NX CAD/CAM program

Production planning:
Visualization of work processes, allocation of information, and storage in NX



The smaller the batch sizes, the greater the competitive advantage for the production company.

Alternatively, offline program creation can take place on a cyclical basis in Sinutrain. This option is especially helpful for shopfloor-based contract manufacturers that are unable to invest in major IT infrastructure or CAD/CAM workstations. With Sinutrain, Siemens offers such companies an efficient route to the digital process chain. In the new versions, users have the latest Sinumerik software and Operate interfaces at their disposal from the outset.

New tools for production planning and manufacture

A machine tool is only productive when it is machining. Uncertainty over the correct program version or searching for tools increases setup time and downtime, and therefore reduces productivity. Software for managing programs and tools creates transparency and reduces setup time. Siemens offers the ideal products for this with the Manage MyPrograms NC program management and Manage MyResources tool management suite. If the programs, tools, and other resources are digitally prepared, things can get moving along much more quickly in the real world: on the shopfloor, on the machine. However, even with digital processes it is only possible to map what the machine and control system can actually do. In addition to offering digital tools, controllers, and automation technologies from a single source, Siemens has upgraded the latest Sinumerik CNCs with a range of new functionalities. One example is Sinumerik MDynamics with Top Surface, which optimizes the machining of free-form surfaces by improving look-ahead. Another new feature of Sinumerik 840D sl is a three-stage collision avoidance system, which increases machine and workpiece safety.

Tempting helpers: robots

Thanks to their high degree of latitude, robots can support machine tools with key work steps, for example by deburring or machining workpieces that are difficult to reach. The disadvantage is that until now, robots have not had their own controllers and required special expertise. With Sinumerik 840D sl, Siemens is now providing a CNC that integrates robots into the shopfloor. RunMyRobot makes it possible to move the robot axes and implement the programming, teaching and monitoring processes via Sinumerik Operate. For several applications this makes working with robots extremely attractive, even for small contract manufacturers, especially as robots are becoming much less expensive.

Plenty of support through training and services

Digitalization calls for new skills — both within an organization and on the shopfloor. This is another area in which Siemens provides its customers with support. Together with its training partners, Siemens offers a wide range of training sessions that are constantly being expanded to include more information on digital workflows, complemented by consulting and services. For example, companies can prepare for their foray into digital workflows through the Digitalization Check and Digitalization Preparation services. The quadcopter project at EMO 2017 not only demonstrates that Siemens can provide powerful tools for integrated digital process chains, it also illustrates that companies can choose the route they want to take through the world of digitalization. ■

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Production engineering:
Programming, simulation, and verification of NC programs using a digital twin of the machine tool in NX

Production execution:
Digitalization support with new functions for current Sinumerik CNCs, and use of robots

Services:
Consulting and services, as well as training in digital workflows

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Digitalization — in concrete terms

"We at Siemens challenged ourselves: could we use our software, hardware, and service solutions to guide the way from design through to the finished product in an integrated digitalized process? It was in answering this question that the quadcopter project came about," explains Matthias Leinberger, marketing manager at Siemens.

Siemens will be presenting its results live at trade fairs such as EMO 2017, as well as in a video on the Internet and in print. These results will show that integrated digital workflows are possible, and Siemens offers the solutions needed to be able to do so from a single source. "Why does digitalization allow me to manufacture more quickly, efficiently, flexibly, and with a higher level of quality? This is a question that we can now answer concretely and clearly for our customers using the example of quadcopter manufacture — for each individual step of the process," continues Leinberger. Where the greatest benefits arise will vary by company and application. Leinberger dispels a preconceived notion straight away: "Many managers and NC experts in small and medium-sized enterprises are overwhelmed by terms such as 'cloud computing' and 'big data'. However, one thing is for sure: it is not just big companies with machine parks in various locations and a value chain ranging from design to finished product that can profit from digital processes. Contract manufacturers with just a few machines can also benefit. Neither clouds nor big data are required in the beginning. With Siemens, digital processes can be implemented on the local level. The benefits begin with modernized program creation and management, with digital simulations that replace expensive test runs on the machine, or with maintenance processes that provide better protection against unpleasant surprises."

His top tip?
"Small companies, in particular, should simply look to get started in a place where they can see weaknesses in their own processes. Does it take too long for an NC program to be truly fault-free and ready to run? Are my runtime plans often unrealistic? Do I lack transparency about tools, causing me to lose time? Here and elsewhere, companies can get started with digitalization using their own tools and individual process steps — in a concrete manner that will be demonstrably beneficial straight away."

CNC knowledge

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Sinumerik 808D, 828D, and 840D sl controls are equipped with milling functions to suit the areas of application and capabilities of the machines they are used on

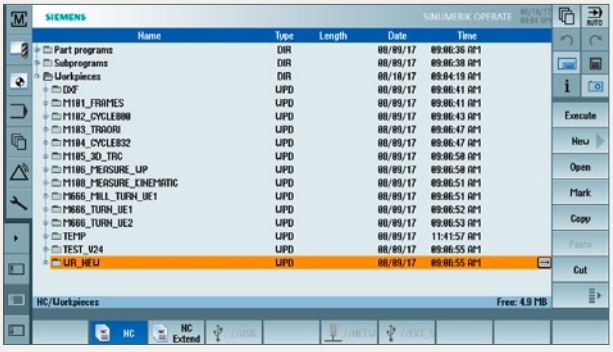
Better milling with new functions

The ways in which Sinumerik controls can be used in milling processes are increasing as a result of several new functions. Alongside improvements in workpiece machining, additional functionality has been integrated that makes it easier for companies to organize work processes on the shopfloor.

As a result of continued development, Sinumerik controls in milling processes are pioneering the way for greater functionality in terms of workpiece surface, accuracy, operability, and efficiency. However, in addition to the actual machining functions of Sinumerik CNC, there is also an increasing need for applications that optimize tasks "alongside" the machine.

Editing programs from external storage

In the past, programs always had to be stored locally on the machine before being launched because the involved components were not linked. Today, however, all machines can be integrated into efficient networks without issue. As a result of Execution from External Storage (EES) functionality, Siemens makes it possible to execute or edit programs directly from data storage locations outside the machine itself. This may be from another server or hard drive on the network — or a storage device connected via USB. It is, of course, also possible to execute or edit from the integrated storage, such as on the internal CF card or internal drive. Nowadays, this is made very easy and is possible without restriction in terms of the size of the program, or the number of programs and subdirectories. The advantages of EES are obvious: direct execution without copying makes it possible to save considerable production planning time, while minimizing machine downtime.



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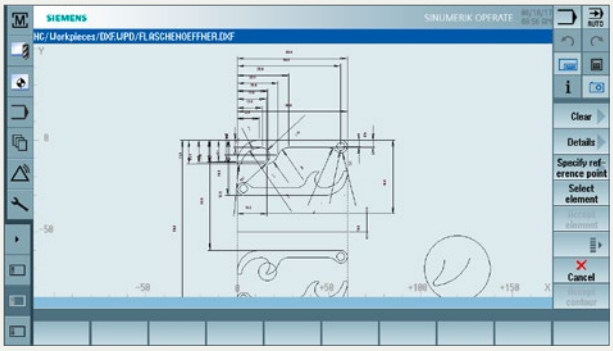
With EES, users have no restrictions in terms of programs or subprograms

A quicker route to the workpiece

Due to optimization, Sinumerik 828D and 840D sl controls now have an integrated DXF reader for Sinumerik Operate, which facilitates graphical work step programming in ShopMill and DIN/ISO programming in programGuide. This makes it possible to deliver corresponding geometries straight to the control system, where they can be further processed without having to pass through CAD/CAM systems — consequently saving companies valuable time.

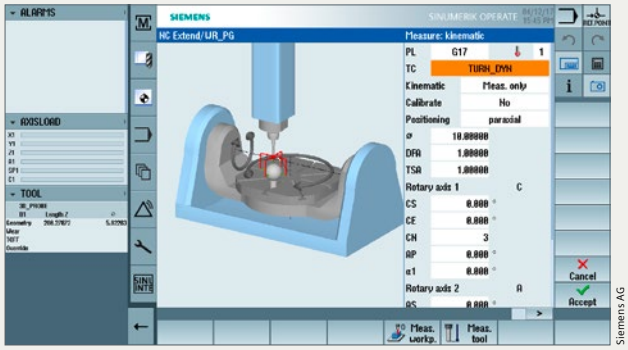


DXF makes it possible to carry geometries, e.g. of a bottle opener, directly from the CAD/CAM system to the CNC

In the past, it was only possible to display a few selected file formats on the control system operating panel, but now a new data reader makes it possible to access a wide variety of file types. Alongside DXF, this includes general PC formats such as .pdf, .txt, and .jpg. This means that manufacturers no longer need to print out additional files — including aspects such as the clamping, tool information, or maintenance notes — or transfer them to the machine separately from the program. This data can now be stored in a central location and, if required, fed into the respective workpiece program. As a result, lost or outdated paper notes and errors made due to incorrect information are now things of the past.

Optimizing machines and production

Alongside these improvements in programming and machining, new Sinumerik versions also offer functions designed to optimize machines. For example, machine properties can be verified with the help of expanded measurement cycle functions, such as automatic logging



With functions such as measurement of machine kinematics, Cycle9960 facilitates machine optimization

of measurement results as .txt or .csv files, or measurement of machine kinematics with Cycle996/Cycle9960. New functionality such as nodding and friction compensation can offset the mechanical imprecision caused by the design features of the machine, and therefore improve accuracy on the component and workpiece surface quality.

Offline programming in Sinutrain

For small-scale operations, offline programming using Sinutrain is a great alternative or supplement to programming using CAD/CAM systems. The new versions of Sinutrain are also based upon the Sinumerik Operate interfaces of the latest Sinumerik 828D/840D sl software — or 808D on PC — using identical control systems. Even machine manufacturer-specific adaptations can be mapped 1:1 in Sinutrain. This generates a more accurate picture of the machine, and the NC program can be edited and tested on the PC in exactly the same way as on the real machine.

Three trends in controls

There are three generally identifiable trends in the field of controls. First, machine tools are morphing into multi-function machining centers that combine milling, turning, and other machining processes all in one — and the Sinumerik 840D sl is an especially powerful CNC which handles this challenge with ease. Second, the topic of robotics is playing an increasingly significant role within manufacturing companies: with RunMyRobot, Siemens makes it possible to control robots using the company's normal NC, instead of having to develop additional expertise in robotics programming. The third trend is that of additive manufacturing: 3D printing offers enormous potential, for example, in terms of the rapid creation of prototypes in mold-making. However, this requires a reliable control system. ■

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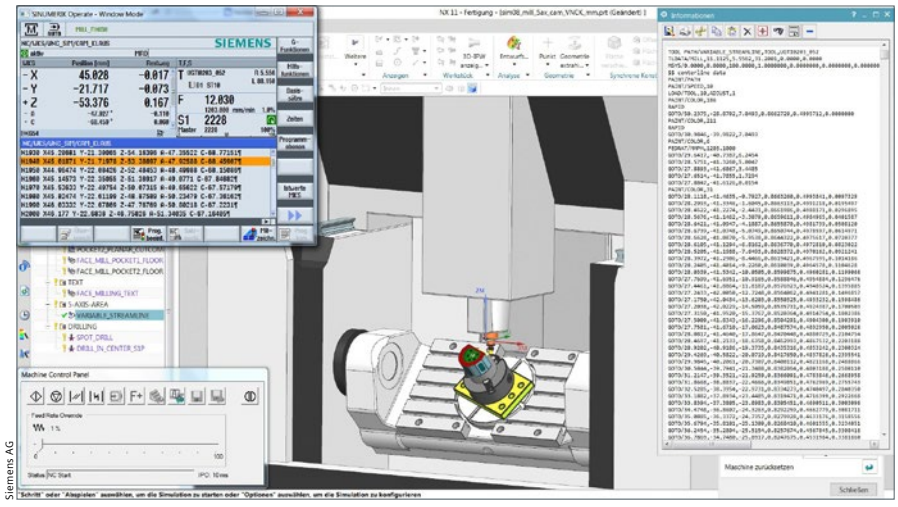
CNC knowlegde

Valuable translation work

Detached from the real world, a CAM system maps workpieces, machining steps, tools, and tool paths — in the virtual sphere. Transition into the real world involving machine-specific control systems, kinematics, and customer requirements is handled by the postprocessor.



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From the Siemens NX CAD/CAM system: on the right the output in CAM format (CL data), on the left the output in the postprocessor format of the Sinumerik control

The growing importance of CAD/CAM systems and digital workflows also means an increase in the importance of postprocessors. Essentially, the postprocessor is a piece of software that translates an unspecific CAM program — containing tool paths and any additional information (e.g. in regards to tools) — into the language of the machine-specific control system while also taking into account the relevant options, axis descriptions, and kinematics.

A worthwhile investment

Less capable postprocessors do not utilize the options available in the control system, and therefore increase machining times. As such, scrimping on a postprocessor represents a false economy. If you invest less money in the postprocessor, you will pay for it in extended runtime or reduced machining quality.

There are many CAM manufacturers that offer postprocessors for machines and control systems. However, if the manufacturing company is to make use of this offering it will be based upon CAM software, because the postprocessor supports data from the respective CAM manufacturer. Alternatively, postprocessors can be created using special postprocessor tools. These are machine-specific but can implement input from various CAM programs on the machine.

The route taken depends on the user's manufacturing philosophy. Manufacturers have different requirements for their programs, which depend on the machine operator's experience and the company's production processes and equipment. Accordingly, the postprocessor must meet these requirements.

Sinumerik makes things easy for postprocessors

Postprocessors for control systems and machines with five-axis simultaneous machining are extremely complex. The Sinumerik helps to simplify programming of tool orientation: swivel axes can be described in the postprocessor through vectors, and the Sinumerik control takes care of conversion for the specific machine. The benefit is obvious: the Sinumerik control knows the machine's abilities and kinematics.

The user benefits from programming with direction vectors because the CAM program can run on different machines with Sinumerik controls. However, describing tool paths with vectors is very complex, and the entire program creation must take place in a closed CAD/CAM-CNC workflow. Making changes to the NC program on the shopfloor demands extensive operator experience. ■

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Programming islands and pockets

CNC knowledge

The Sinumerik Operate DIN/ISO contour editor allows operators to describe geometric contours. The order of contours decides whether they are processed as an island or a pocket.

The Sinumerik Operate contour editor offers special functions that use programming to quickly and easily create contours in the form of islands or pockets. You just need to ensure you pay close attention to the order of the contour definitions when programming.

In the DIN/ISO program, contours are defined with CYCLE62. The example below shows the milling of a front contour and illustrates the general principle. The contour is made up of a square and an octagon. The octagon is first milled as an island.

Interpreting contours as a pocket or an island

Whether consecutive contours are milled to form an island or a pocket depends on the order of the contour definition. When using different contours consecutively in the NC program, the Sinumerik CNC automatically identifies if they are related to each other, and then interprets them as either a pocket or an island. ■

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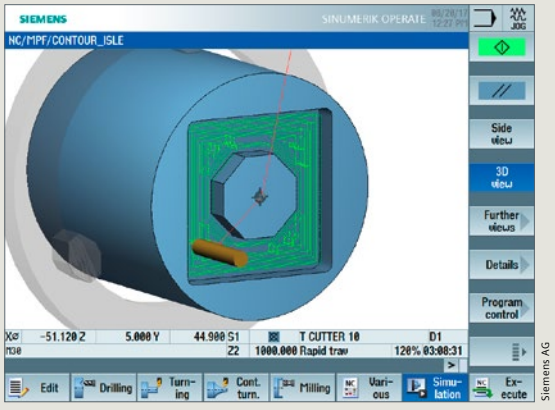
Octagon as an island

Use CYCLE62 in the NC program to define the square contour, followed by the octagon contour.

```
...
CYCLE62("RECTANGLE",1,,)
CYCLE62("OCTAGON",1,,)
...
```

The control system automatically generates an island in the octagon form you programmed second. The square is the boundary.

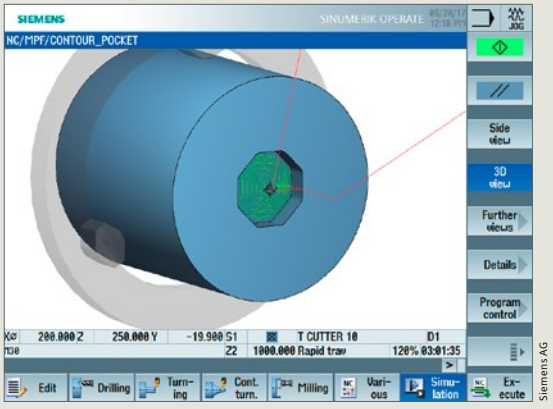


Octagon as an island with square as the boundary

Octagon as a pocket

If you change the sequence in the program so that the contour definition of the square is only programmed after the octagon, then the octagon is milled as a pocket.

```
...
CYCLE62("OCTAGON",1,,)
CYCLE62("RECTANGLE",1,,)
...
```

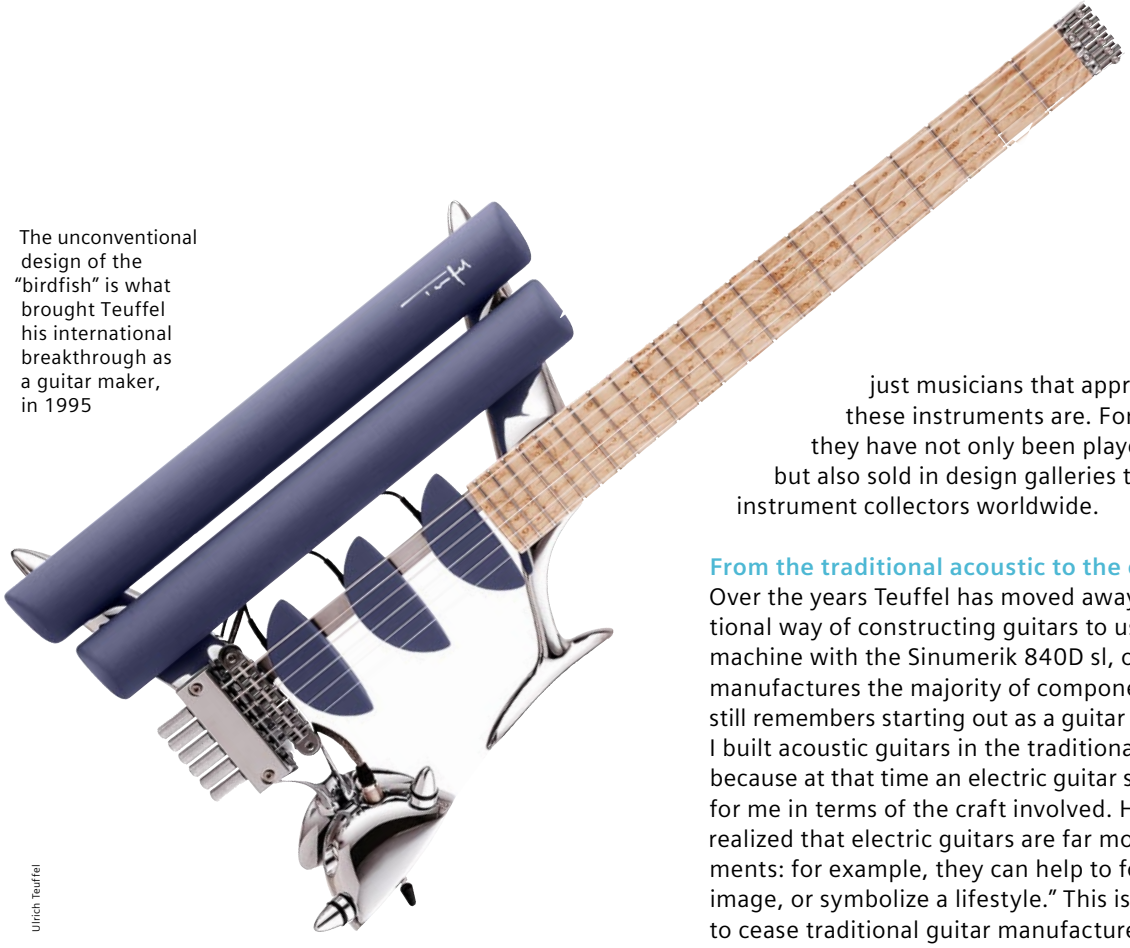


Octagon as a pocket

On the shopfloor

Free rein on design

Ulrich Teuffel's striking guitars are in demand all over the world, as both musical instruments and beautiful works of art. The guitar designer makes virtually all parts using a CNC milling machine and the Sinumerik 840D sl.



Ulrich Teuffel

The unconventional design of the "birdfish" is what brought Teuffel his international breakthrough as a guitar maker, in 1995

Just a brief glance into Teuffel's tranquil timber-built workshop is enough to see that this is a place where extraordinary guitars are made with a great deal of creativity and craftsmanship. The guitar maker's work is not designed for mass production and yearly he can make up to 20 different — and normally very unusual — instruments. His "birdfish" is especially extravagant, and its unconventional design is what brought about Teuffel's international breakthrough as a guitar maker, in 1995. Today, Teuffel's guitars are played by world-renowned musicians such as Billy Gibbons of ZZ Top and Kirk Hammett of Metallica. However, it is not just musicians that appreciate how special these instruments are. For many years now, they have not only been played on the big stage but also sold in design galleries to art lovers and instrument collectors worldwide.

From the traditional acoustic to the electric guitar

Over the years Teuffel has moved away from the traditional way of constructing guitars to using a CNC milling machine with the Sinumerik 840D sl, on which he now manufactures the majority of components himself. He still remembers starting out as a guitar maker: "Initially I built acoustic guitars in the traditional way, partly because at that time an electric guitar seemed too simple for me in terms of the craft involved. However, I then realized that electric guitars are far more than just instruments: for example, they can help to form a musician's image, or symbolize a lifestyle." This is why Teuffel chose to cease traditional guitar manufacture and study industrial design at the age of 27. The founders and managers of the legendary guitar brand, Fender, became aware of his work and commissioned him to create an extensive design study. The guitar model he developed has never gone into production at Fender.

Contemporary machining methods

This was also the time when Teuffel developed his own special way of working. "One of my weaknesses is that, for a designer, I am no good at drawing by hand. Making a virtue out of necessity, I quickly moved from my initial scribbles and sketches to designs in CAD programs. I see electric guitars as an expression of our era of modern

Ulrich Teuffel

»Five-axis machining gives me entirely new freedoms in terms of design, because I can manufacture with extreme precision.«

Ulrich Teuffel, Managing Director, teuffelguitars

industrial production, so for me transitioning to CAM and manufacturing using CNC machines was only logical," says the guitar designer.

This way of working opened new doors for Teuffel: "For me, machining using CNC machines is not about productivity. Designing a new model takes months, or even years, meaning that I only make around 20 different guitars a year. Here, precision work is key. With the traditional methods using templates, it was extremely difficult to insert drill holes for the electronic components exactly perpendicular to the surface on the curved body of the guitar, or to place the screws in the neck and the body without any play. Five-axis machining gives me entirely new freedoms in terms of design, because I can manufacture with extreme precision." Teuffel has now perfected his working method: he designs in the CAD program; transfers the design into the CAM software, HyperMill; and then transfers it directly to the machine via the Sinumerik.

All functional parts can be switched out

The extent to which the manufacturing possibilities influence the design of Teuffel's guitar models is illustrated by the layout and structure of the birdfish. Its design embodies the idea of industrial manufacturing: modularity, separation, flexibility, and variety in materials. On the birdfish, a musician can change or move the pickups, tonewoods, and other functional elements. This would be impossible without the dimensional accuracy provided by a precise CNC machine. Customers get several part sets for their instruments, with each configuration having its own character in terms of sound.

Teuffel's newer guitar designs — such as the niva, tesla, and antonio — also show how much of a perfectionist he is. Where other guitar makers' fret slots are sawed into the neck of the guitar, he uses end mills in his Reichenbacher milling machine with the Sinumerik 840D sl. The reason is clear, as Teuffel explains: "This means that the edge of the fret slot is kept and the neck of the guitar is intact and smooth at the side — which makes the guitar considerably nicer to play." However, getting there took a long time, remembers the guitar maker: "Wood is a special material, and every type has its own characteristics. Even rounding edges requires very differentiated machining strategies and precise control, otherwise the wood can start to splinter. In the beginning I had the milling done by other model makers, but the results always fell short of my expectations. Today, other than a few screws, electronic elements, and the strings, I make everything myself — including the lacquer and parts of the pickups."

Investing in new technology

Teuffel now works toward almost 100% vertical integration and is constantly improving his artistic and technical skills. "My milling machine is getting on, and is actually really too large-scale for guitar making. I am currently working on designing a CNC machine that is tailored exactly to my special requirements as a guitar manufacturer." ■

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Carbon machining specialists

Lightweight, flexible and extremely strong: these are the key properties of carbon-fiber-reinforced plastics, also known as CFRPs — or simply as "carbon." The CFRP specialists at CrossLink use CNC machines equipped with the Sinumerik 840D sl for complex machining tasks involving this material.

The properties of machining materials such as metals have the same values when measured in different directions; this state is referred to as "isotropic." A special characteristic of CFRP materials is that their properties can be modified to achieve specific results, due to the composition of the materials and the alignment of the fibers. This also increases the complexity of the design and the machining, making quality assurance a primary issue — an area in which CrossLink's expertise lies. Their team of around 50 employees, based in Cadolzburg, Germany, specializes in the design and production of high-quality CFRP products.

CrossLink's customers have special requirements for the materials used in their products, which cannot be met by metals or simple plastics. For instance, customers from the aircraft and motorsports industries — as well as manufacturers of sports cars and electric vehicles — require components that are remarkably lightweight, yet extremely rigid. Medical technology also requires the special properties of CFRP workpieces for equipment and materials exposed to light or radiation. Additionally, luxury consumer brands place great value in the high-quality surface appearance of carbon.

Besides appearance and weight, other functional requirements often have to be taken into account such as high load capacity in certain directions, or embedded features such as supports or drill holes. These requirements can be satisfied with the right design. To this end, specially cut fiber mats ("sheets") are aligned in molds in several layers before being joined and hardened in an oven, along with thermosets or thermoplastics to form a matrix material.

Undercut freeform surfaces call for five-axis machining
This process uses machine tools designed for demanding mold-making tasks and surface machining, such as when deburring edges, for example.

Siemens AG/F. Kronfeld

»Five-axis machining is absolutely essential for undercut freeform surfaces and 3D geometries, which means the CAD/CAM process often becomes a bottleneck. That's why it's a good thing we use the Sinumerik 840D sl on all our NC machines.«

Wolfgang Ludwig, Team Leader for CNC Milling at CrossLink

CrossLink

The CFRP workpieces are generated from precisely cut sheets before being hardened with thermosets or thermoplastics to form a matrix material

The material is flexible and it also expands, which means material-specific expertise is required for the CAD process and NC programming of the molds, and that production work must be adequately precise. In order to ensure this is the case, the programs generated and simulated on the CAD/CAM workstations are transferred to the CNC machines in the production department via a network.

Wolfgang Ludwig, team leader for CNC milling at CrossLink, explains: "Many of our customers request prototypes on very short notice. Especially when we receive requests for complex prototypes, we can put our expertise to good use and take all the client's wishes into account, usually supplying within a week. Five-axis machining is absolutely essential for undercut freeform surfaces and 3D geometries, which means the CAD/CAM process often becomes a bottleneck. That's why it's a good thing we use the Sinumerik 840D sl on all our NC machines. Smaller adjustments or processes for cutting out workpieces can be programmed directly on the shopfloor and on an integrated interface for all machines."

Easy operability and perfect results

CrossLink uses a five-axis machining center to mill extra-large molds, such as body parts or medical technology components measuring over six feet in height. Machines including the C40U from Hermle are used for smaller components. All machines are equipped with Sinumerik 840D sl CNCs. The high degree of precision and excellent operability of the control system were key factors in CrossLink's decision to purchase the Sinumerik 840D sl, as was the perfect surface finish it can achieve on workpieces. The CNC also scores points with its simple solution for measuring accuracy in the five-axis range. The kinematics measuring cycle, Cycle996, is used in combination with a calibration ball and measuring probe for this purpose. This allows for reliable, high process quality to be achieved within required workpiece accuracy values. This is a particularly important point when dealing with CFRP workpieces, as the material is relatively expensive. Machining errors due to inaccuracies immediately make their presence felt here.

The same also applies to trimming — an important step in the process required for machining and smoothing the edges of molded parts. CFRP is a fibrous material, therefore the trimming process for products with complex curves — such as body parts — requires constant positioning of the tools. When it comes to large molded components, the Eima demonstrates additional strengths here in conjunction with the Sinumerik. Its high precision and performance during rapid traverse milling allows even large, complex molded parts to be trimmed very efficiently. ■

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gettyimages/DSGpro

Lifelong teaching

Walter Linsenmaier worked as a metalworking and CNC technology instructor for most of his career. However, it seems this was more of a passion than a job: even after retirement he traveled to Indonesia to spend four weeks as an assistant at a vocational school in Adiwerna.

Linsenmaier has a wealth of experience providing training in the field of metalworking. He began his own training at Mercedes-Benz, in 1967, and by the end of the 1970s he was working on the first CNC machines and Siemens controllers implemented by the automobile manufacturer. He then drew upon his 42 years of in-house training experience. Starting in 1995, he spent four years training employees at the Mercedes factory located in Tuscaloosa, Alabama.

By the end of 2016 — at which time the machine tool expert and German native from Swabia had already retired — the organization, Senior Experten Service (SES), based in Bonn, Germany, introduced Linsenmaier to an Indonesian vocational school that was seeking assistance. "A doctor friend of mine told me about the charitable foundation SES. SES sends experts that are retired or taking a leave of absence to take part in international development projects in a wide variety of industries. Alongside a small allowance, the volunteer specialists receive reimbursement for their travel expenses. I thought to myself, if my experience in NC technology and metalworking can be of use, why not travel to foreign countries and have new experiences?" says Linsenmaier, enthusiastically.

»I was struck by how friendly and disciplined the students were.«

Walter Linsenmaier, Volunteer
with the Senior Experten Service (SES), Bonn

Indonesian vocational school makes an appeal for help

The vocational school in Adiwerna has a milling machine and a turning machine, both of which were experiencing technical problems. The school approached Linsenmaier and requested that he inspect the machines on-site, organize the repairs, and also share some of his experience with the teachers and students. "I tried to get an idea of the situation while I was still in Germany," continues Linsenmaier, "but it was no use. The language barrier was a considerable hurdle, so I just had to jump in at the deep end." When he landed in Jakarta, on March 6, 2017, he was met and brought to the facility by four representatives from the school.

W. Linsenmaier

Everyone was very grateful: they made up 15-foot banners to thank Linsenmaier

Discipline and warm hospitality

Although he did not arrive in Adiwerna until nighttime, after over 30 hours of travel, the expert's school day began at 8 o'clock the next morning. He found himself in a large vocational school with over 2,100 students and 200 teachers providing lessons in seven subjects including architecture, IT, mechanical engineering, and CNC technology. A large delegation from the school was there to greet him, and everyone wanted photos taken with him. The local press was there as well to report on the arrival of the expert from Germany.

In addition to the friendliness of the people, what struck Linsenmaier the most was their tremendous discipline: a kiss of the hand and a bow are signs of respect for teachers and superiors. "One of the difficulties that I had when teaching, however, was that the teachers always nodded when talking to me, indicating that they had understood everything, which was often not the case. So I always had to ask what they had learned," reports Linsenmaier.

Personal contact with Siemens, a great help with repairs

Linsenmaier discovered that the school's turning machine was an older, very simple model. "This machine did what it wanted, and not what was programmed," says the expert, in explaining the problem. Repair initially proved to be difficult, until he came up with the idea of checking backlash with a meter. Linsenmaier also had obstacles to overcome when feeding workpieces into the machine for programming training. "At the hotel at night, I sent out a request for support via the Siemens cnc4you website. I received help very promptly. With assistance from the Siemens hotline in Erlangen, Germany, we worked out that some parts of the machine were set back-to-front. I never would have solved the problem without this support."

Large banners as a sign of thanks

The agenda included training teachers as well as carrying out the repairs, and Linsenmaier also gave a presentation on his home country of Germany to the more than 1,000 students in attendance. Everyone was very grateful, and when he returned from a weekend excursion he found several 15-foot long banners on display in the CNC room — and at the school's entrances — with drawings of him along with messages of thanks. The German CNC expert would have preferred that the money spent on the banners was instead invested in tools — but he nonetheless appreciated this gesture of gratitude.

As a result of school-wide preliminary examinations, there were several days when the machines were not in use. Linsenmaier took this opportunity to give the CNC machines a thorough cleaning, and he addressed the concept of preventive maintenance during his courses with the teachers. By the end of the exams, all of the machines — including the conventional ones — were in top condition.

A role model — perhaps not just for the Indonesian students and teachers

After four weeks of fascinating experiences and new insights, Linsenmaier returned to Germany. One thing that remained with him was the impression that the students and faculty in Adiwerna were extremely grateful for his help. Perhaps other German retirees will see Linsenmaier as a role model, awakening a desire in them to pass on their expertise to thankful students — while at the same time experiencing something new themselves. ■

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Senior Experten Service (SES)

SES is a foundation within the German Industry for International Cooperation that sends volunteer specialists and managers who are retired — or taking a leave of absence from work — to developing and emerging nations. SES currently consists of approximately 12,000 experts and the organization has coordinated over 40,000 voluntary deployments to more than 160 countries, since 1983.

Linsenmaier taught in a large vocational school with over 2,100 students and 200 teachers who were all delighted to receive his support

W. Linsenmaier

Industry news

Fighting the skills shortage

Anwendung neuer Technologien
NC Gesellschaft e.V.

Founded in 1975, NC Gesellschaft (NCG) is one of Europe's pioneers in the use of CAD/CAM and NC technologies. Now it is restructuring, and in the future will focus solely on practical training in CAD/CAM and NC technologies — with the goal of combating the industry's shortage of skilled workers.

When NC Gesellschaft was founded, its objective was to promote the use of CAD/CAM and NC technologies within companies. Today they are an everyday reality for most firms. However, new challenges such as a lack of specialized workers and rapid technological development are demanding that companies acquire new skills.

Focus on the NCG examination board

The management and member companies of NCG are reacting to these new challenges by restructuring. In the future they will be concentrating on their successful and essential work regarding the NCG examination board, while also adapting their other activities accordingly. For years, this board has been playing a key role in ensuring that education and training has a practical orientation and is aligned with current technological developments. Courses and examinations that adhere to NCG guidelines allow skilled workers, master craftsmen, technicians, and engineers to train and receive certification in the fields of CAD, CAM, and NC.

A certificate with a practical application

In many companies, examinations based upon NCG guidelines carry more weight than other training courses and examinations — such as those offered by the Chambers of Commerce and Industry — when it comes to choosing specialists for CAD/CAM and CNC. An NCG certificate serves as evidence that the applicant has undergone training that has a practical approach. For example, during the CNC user examination the candidate must program a task (including establishing the cutting data), transfer data to the machine, measure and preset tools, determine tool tension, and cut the workpiece in the machine. They also have to demonstrate theoretical knowledge in a written examination.

Interest from Nachwuchsstiftung Maschinenbau

"The primary goal of NCG is to promote NC technologies. In order to achieve this goal, today the focus must be on practical and modern training, and on constant improvement and development of teaching and examination content. Only then will companies be able to acquire the specialists and skills that they need to implement digitalization and Industrie 4.0," says Friedrich Reiner, managing director of Eckert Schools and a member of the NCG management board. Nachwuchsstiftung Maschinenbau, a foundation that aims to support up-and-coming mechanical engineers, has shown an interest in the examination board's work, and is considering whether the NCG's previous activities can be integrated into the foundation and developed in line with its objectives. ■

Dr. Robert Eckert Schulen AG

NCG board meeting at Eckert Schools in Regenstauf, Germany

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Worldskills Germany/Jörg Wehrmann

"Rockin' the desert"

It is under this motto that Team Germany will be taking part in the WorldSkills competition in Abu Dhabi from October 15 through 18, 2017. Young people from 77 countries will put their skills to the test in 51 disciplines — and among them will be two German masters of CNC milling and turning.

Eva-Maria Wahl and Lukas Bosslet are waiting excitedly for October, when they will fly to the desert city of Abu Dhabi. The two 21-year-old cutting machine operators qualified as German masters in the categories of CNC milling and CNC turning, at WorldSkills Germany in Stuttgart, earning them a coveted ticket to the world championships of skilled professionals. Wahl, from the German state of Baden-Württemberg, completed her training with distinction at Chiron-Werke GmbH & Co. KG — an outstanding accomplishment. She is the first woman to win the title in this male-dominated field where the proportion of women in the profession is just five percent. "I really wanted to go to Abu Dhabi, and I'm delighted that I've managed to get there," says Wahl. Bosslet, a cutting machine operator for Festo at its site in St. Ingbert-Rohrbach, Germany, is also proud to be competing: "The excitement builds every day and my training workload is continuously increasing. Preparing for this type of competition is a lot of fun."

Preparation on state-of-the-art machines

Both cutting machine operators have been undergoing intensive preparation for the world championships. Exclusive training programs were developed for them, supervised by WorldSkills CNC milling expert, Herbert Mattes, of Chiron-Werke, and CNC turning specialist, Hanno Hapke, of DMG MORI Co., Ltd. Additionally, they have been taking part in special preparatory training sessions run by DMG MORI since May. This has given them the opportunity to completely familiarize themselves with the CNC and the CAD/CAM system. DMG MORI will be supplying 29 machines in total for use at WorldSkills in Abu Dhabi, including 12 CTX alpha 500 V4 turning machines and 17 DMU 50 3rd Generation milling machines. All the machines are equipped with the CELOS® user interface as well as the high-end Sinumerik CNC and the latest Sinumerik Operate V4.7.

Specialists in demand

At the German championships in Stuttgart, Wahl and Bosslet have already demonstrated a high level of competence and the ability to focus and perform accurately under pressure. Under conditions similar to those at the world championships, they had to accurately produce three different workpieces based upon a diagram and also write a corresponding executable CNC program; independently measure and select the right machining tools; and setup the machine. And it wasn't all about speed: the quality of the finished parts was also carefully examined by the panel of experts.

At the international competition in Abu Dhabi, the two German champions will have to withstand even greater pressure in competing against the best in the world. However, whether or not they earn a spot on the winner's podium, they will definitely benefit from taking part in the event. Hubert Romer, managing director of WorldSkills Germany, agrees: "The participants will have many doors open to them after the world championships. After all, passionate, highly trained and innovative specialists with international experience are in demand in all areas of industry." ■

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Education and training

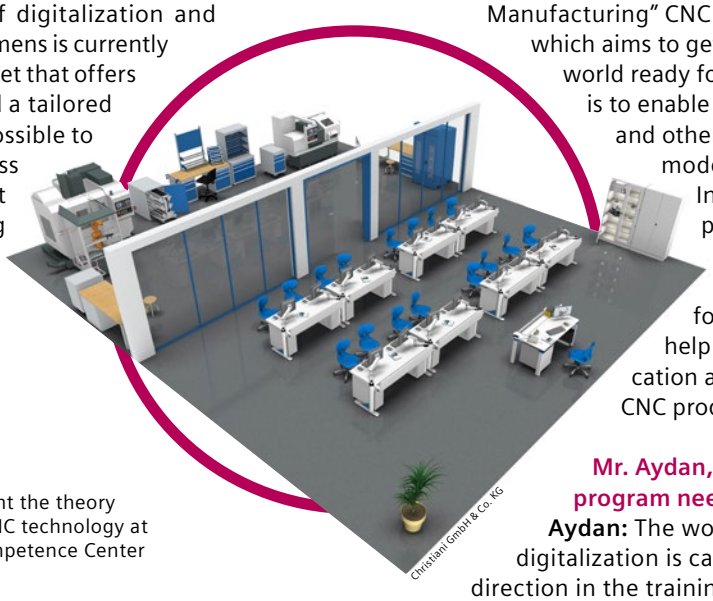
Promoting training together

Siemens has entered into close partnership with Dr.-Ing. Paul Christiani GmbH & Co. KG in order to develop modern, didactically prepared learning and teaching media for certification programs.

Philippe Lardy, product manager in the metal technology training division at Christiani; Zeki Aydan, global education coordinator at Siemens Machine Tool Systems; and Karsten Schwarz, head of the Siemens Technology and Application Center (TAC) in Erlangen, Germany, explain the details of their collaboration in a joint interview.

Mr. Aydan, what makes Christiani so attractive for Siemens?

Zeki Aydan: Our collaboration lays the foundation for the continual expansion of services and new teaching materials for CNC training in light of digitalization and Industrie 4.0. In addition, Siemens is currently the only provider on the market that offers both a CAD/CAM system and a tailored CNC system. This makes it possible to map integrated digital process chains, which is important when it comes to developing systematic teaching concepts for the entire process chain.



Learners are taught the theory and practice of CNC technology at the Christiani Competence Center

Mr. Lardy, what does the Christiani learning institute bring to the collaboration?

Philippe Lardy: Our strength is developing and implementing teaching materials — from books, to digital media, to project work. We combine technical skills with didactic expertise, allowing us to create practical, up-to-date education services.

Are there any joint projects already under way?

Lardy: As part of an initial project, Siemens and Christiani have worked together to develop the "Mechanical & Manufacturing" CNC certification program, which aims to get trainers from all over the world ready for CNC training. The goal is to enable them to teach trainees and other learners according to the model of German standards. In the "Train the Trainer" program we teach small groups the theory and practice of CNC technology for two weeks, in order to help secure the quality of education and training in mechanical CNC production worldwide.

Mr. Aydan, why is this certification program needed?

Aydan: The worldwide trend toward digitalization is calling for a change of direction in the training of skilled workers. This is why our motto is "Digitalization Needs Education". Training programs that include aspects of Industrie 4.0 have appeared in some growth markets.

Stefan Koeppel & Siemens AG

»Utilizing digitalization in the manufacturing sector demands that operators have not only knowledge of new technologies, but also the ability to handle the associated processes.«

Zeki Aydan, Global Education Coordinator at Siemens Machine Tool Systems

»As part of an initial project, Siemens and Christiani have worked together to develop the 'Mechanical & Manufacturing' CNC certification program.«

Philippe Lardy, Product Manager
in the Metal Technology Training Division at Christiani

Christiani GmbH & Co. KG

Many take inspiration from the exemplary dual training system in Germany. Siemens has been active in the training sector for decades, and therefore it was a logical next step for us to work with a company with strong didactic expertise such as Christiani to develop a "Train the Trainer" program for CNC training.

Mr. Schwarz, what kind of content can the participants of this certification program expect?
Karsten Schwarz: Level 1 provides the basics of training as a CNC user. At the end of the teaching, the trainee should be able to operate a CNC machine and set it up in accordance with the stipulations provided by production planning. Reading a technical drawing and understanding all of the processes in and around the machine are also included in this level.

Level 2 covers the basics of training as a CNC specialist. This teaches CNC programming in detail, so that the trainee acquires a greater understanding of processes in the factory. Level 3 includes the basics of training as a CNC expert, and additionally teaches CAD/CAM knowledge and the ability to optimize processes.

Mr. Aydan, why is the concept of "understanding of processes" found again and again throughout the certification program?
Aydan: Utilizing digitalization in the manufacturing sector demands that operators have not only knowledge of new technologies, but also the ability to handle the associated processes. As such, the certification program is both process and system based. In concrete terms, this means that alongside CNC programming itself, it has to teach about the mechanical, production-related, and mechatronic requirements of the entire value chain.

Mr. Schwarz, can you illustrate that more precisely using examples?
Schwarz: On Level 1, for example, the trainee learns how to work with tool presetting devices and simple measuring methods to conduct quality checks on the workpiece, which gives him the beginnings of an understanding of processes. Things work in a similar way on Level 2: the CNC specialist should be able to choose clamping assemblies and tool sets to suit the tools and workpieces from the stock of different clamping devices.

Mr. Lardy, when will this certification program be launched, and who is it designed for?
Lardy: The newly developed certification program is split into the three modules described: for CNC users, CNC specialists, and CNC experts. The first module will start as early as the beginning of 2018. The training will take place on machining tools at the new Christiani Competence Center in Rheine, Germany, or at the Siemens TAC in Erlangen. Successful participants will receive a certificate.

Thank you for this informative interview. ■

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Stefan Koeppel & Siemens AG

»On Level 1, for example, the trainee learns how to work with tool presetting devices and simple measuring methods to conduct quality checks on the workpiece.«

Karsten Schwarz, Head of the Siemens Technology and Application Center (TAC) in Erlangen

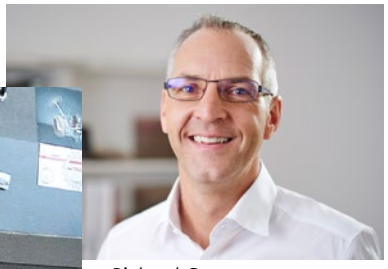
Education and training

New certified Sinumerik trainers

Siemens awards special Sinumerik-related certificates to freelance trainers. In order to obtain a certificate, it is necessary for trainers to demonstrate their Sinumerik-related knowledge in a multi-day course.

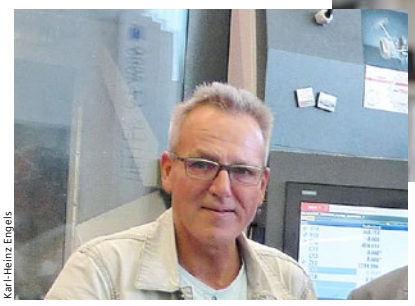
The ranks of certified Sinumerik trainers were recently joined by Frank Würzinger. A machine fitter by trade, he became self-employed in 2016 and offers training courses in CNC milling and turning. His focus is on operating and programming the Sinumerik 828D/840D sl using Sinumerik Operate and Sinutrain.

Another newly certified trainer is Richard Gauss, who formerly worked for Wolfgang Sixt as a consultant and sales representative for precision machines made by a variety of manufacturers. His wide-ranging experience in various areas of machining has provided him with a wealth of knowledge which he shares with students in tailored CNC and operating training courses — delivered through his own company, Zerspantech. You can find an overview of our certified trainers in the Education and Training section of the cnc4you portal.



JEAN-CLAUDE WINKLER

Richard Gauss



Karl-Heinz Engels

Frank Würzinger

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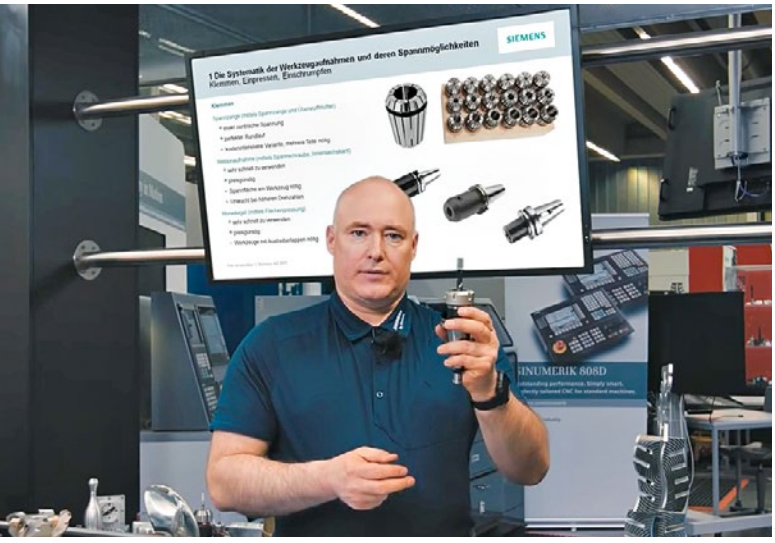
Sinumerik live: Video tutorial on tool management



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In the Sinumerik live video series, we present applications engineering to you in a way that is clear and easy to understand. It is intended to show you individual topics regarding the use of the Sinumerik based upon practical examples. For example, the tool management milling video tutorial shows you how to create and file tools within the tool management system. Get to know more about the tools and associated clamping — and find out why tool management is necessary and how it works with Sinumerik Operate. Click here for the video:
↗ **bit.ly/2x8XsWc**

You can also find the video among our tips and tricks on CNC machining at siemens.com/cnc4you:
↗ **sie.ag/2vVbsUG**

✉ **armin.baernklau@siemens.com**

Dice with no corners or edges

Anyone who thought dice couldn't be round will think differently after seeing this workpiece. Simply turn the large ball, and the small colored ball shows the roll of the die in the number field. The components that make up these rotatable dice are a ball and plate, which can be produced on a CNC turning machine. Combined with eight steel balls — one of which is colored — the die is ready to roll.

The Siemens Professional Education teaching facility in Nuremberg, Germany uses this component as a practice workpiece for apprentices of industrial mechanics, and it has proven to be a favorite among them each year.

The ball is produced using two clamping fixtures in a turning machine with a counter spindle. The outside contour is created in a contour turning cycle. In this case, the engraving cycle provides the opportunity to individually engrave each ball. The workpiece is then transferred to the counter spindle, where the remainder of the ball machining takes place.

The plate is produced solely in the main spindle using two clamping fixtures.

Siemens AG

The contour turning cycle is also used here for the external shape and plane groove.

All the CAD drawings and programs as well as the production description are available at:

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Events

cnclive4you with new events and topics. Take a look now under the Events section of the cnc4you portal. There you will also find an overview of additional trade fair dates and training courses.

EMO	**September 18 — 23, 2017**	Hannover, Germany
NORTEC	**January 23 — 26, 2018**	Hamburg, Germany
METAV	**February 20 — 24, 2018**	Düsseldorf, Germany

↗ **sie.ag/1TEVXG6**

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