num information

JOURNAL FOR CNC–TOTAL SOLUTIONS

num®
CNC HighEnd Applications

Nr. 60 – September 2019

Editorial
Peter von Rüti, CEO NUM Group

Dear readers,

It gives me great pleasure to present our latest edition of NUMinformation. We can look back on a year that contained many new, exciting projects. In this issue of NUMinformation, we recap on some of them for you.

In September we will again be taking part in the **EMO** biennial in Hanover (Germany). You are cordially invited to visit us there in Hall 9, Booth E40. Among other things we will present a new type of **acceleration sensor** on a specially designed exhibit featuring a live demo. With the help of the encoder signals you can derive, evaluate and compensate for vibrations due to the kinematic chain. However, until now it has not been possible to measure or compensate for vibrations of the tool. With our new acceleration sensor, oscillations and vibrations can be measured where they occur. The vibration signals are processed directly in the drive amplifier, which allows very fast compensation. Combined with the DEMX function in the drives, this opens up undreamt-of possibilities for optimizing the behavior of the machine. For example, you can now compensate for vibrations in the spindle or at the tool head, and the acceleration information can also be used to optimize machining processes in general.

In this issue of NUMinformation you will again find interesting technical innovations, such as the **Earlier Block Change (EBC)**, which enables faster machining cycles. We introduce **NUMgrind**, our innovative total solution for precision grinding applications, which enables machine tool manufacturers and retrofitters to offer their customers easy to use workpiece programming. **NUMmonitor**, a completely new application with Flexium+, allows the monitoring of various machining parameters such as motor load. An important advantage of NUMmonitor is the fact that you do not need any additional hardware – which saves costs. The Flexium+ system's front-end or box PC is used to process the data. NUMmonitor can also be used for **predictive maintenance** by creating a "fingerprint" of the machine and checking it against it at regular intervals.

"With our new acceleration sensor, vibrations can be measured where they occur and processed directly in the drive amplifier, allowing very fast compensation."

Peter von Rüti, CEO NUM Group

As a compact solution for local security applications, we now offer the **NUMSafe CTMP1960** controller. It combines 20 safe digital inputs, 24 safe digital outputs and four additional, single-channel relay outputs in a single, compact device. With **Flexium CAM** – a development environment for creating and executing technology HMIs for integrated, computer-aided manufacturing – Flexium+ HMI software can integrate pre-defined projects to automatically generate ISO machining programs. **Flexium Office** allows the use of Flexium CAM technology HMIs without having to be near the machine. This can greatly simplify internal processes. The usability and ease of use of our systems is and will remain a major design consideration for us, which is why we are continuously working on **HMI improvements**. You can find out what these are on pages 14 and 15 of this magazine.

"**One Step Ahead**", our service motto, has another project in the implementation phase: the opening of an additional NTC (NUM Technology Center) in the strong growth market of **India**. Further information will be published on our website in due course.

I hope you enjoy reading this NUMinformation and would be delighted to welcome you personally to EMO.

Peter von Rüti
CEO NUM Group

Imprint

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NUMinformation is published once a year in English, German, French, Italian and Chinese.

NUM on WeChat and Youku

WeChat is by far the number 1 social media channel in China. WeChat has over 1 billion active users every day, at least 100 million, of which, come from outside China (source statista.com). Originally a chat service for smartphones, the app has since been expanded to include numerous functions such as the mobile payment system WeChat Pay (comparable to Google/Apple Pay).

In China, far more WeChat profiles are created than Chinese websites are registered. For companies, WeChat plays a very central role in China as a communication channel. This was reason enough for NUM to create an official company profile on WeChat. We publish there (as well as our other company profiles on Facebook, LinkedIn, Xing, and Twitter) current press releases, exciting new products, impressions of international trade fairs and much more.

Youku is used in China as a counterpart to the video portal YouTube. Here, too, NUM has recently been represented with its own video channel, on which we provide product videos, the company portrait and other videos for streaming, just like on YouTube.

By scanning the QR code in the WeChat app you get direct access to our NUM WeChat page.

Events

NUM Event Calendar 2019/2020

EMO 2019
September 16–21, in Hanover, Germany
Hall 9, Booth E40

FMB 2019
November 6–8, in Bad Salzuflen, Germany

Fabtech 2019
November 11–14, in Chicago, USA
South Building, Booth A5150

SPS 2019
November 26–28, in Nuremberg, Germany
Hall 3, Booth 449

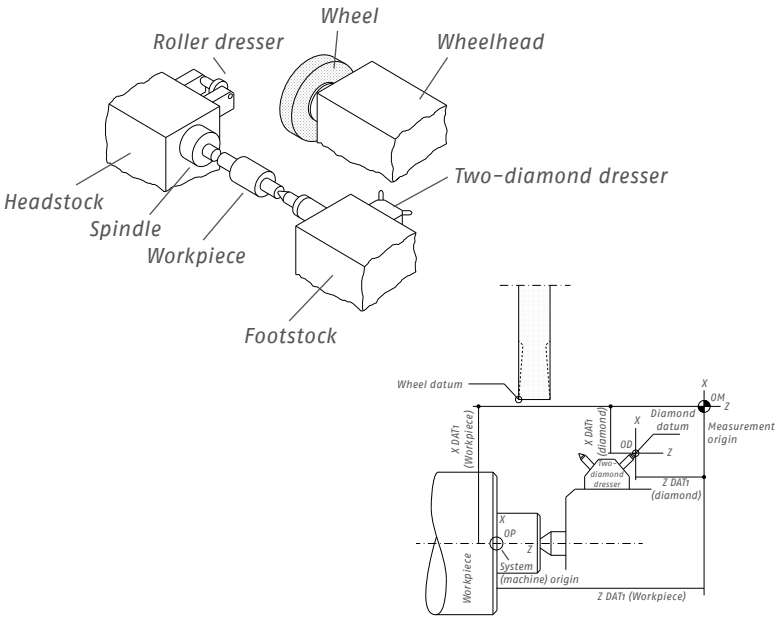
GrindTec 2020
March 18–21, in Augsburg, Germany
Hall 7, Booth 7100

NUMgrind GC – CNC Solution with 3D Simulation for Cylindrical Grinding Machines

Technology HMI NUMgrind

Innovative software from NUM enables CNC machine tool builders and retrofitters to provide their customers with exceptionally easy-to-use workpiece programming and machine control facilities for precision grinding applications. It also provides the necessary grinding simulation – which can either be performed in advance (offline) or simultaneously during part processing (online).

The NUMgrind package for cylindrical grinding is realized as a technology HMI and is based on an integrated Flexium CAM (computer aided manufacturing) application that is used for outer diameter (OD) and inner diameter (ID) grinding applications. The package includes OD/ID grinding cycles for 2-Axis (X/Z) horizontal or vertical grinding machines and also offers an inclined axis capability. The dressing station can be table-mounted or rear positioned to accommodate a wide range of machines. The basic kinematic for the machine would be X for the radial, Z for the axial and C axis for the part rotation. The extended kinematic also has a B axis in the wheel head.



Basic kinematic model for NUMgrind.

The end user requires no programming knowledge to configure the customized grinding process, because all OD/ID functions or cycles, as well as fixed and roller dresser cycles, are provided by the technology HMI.

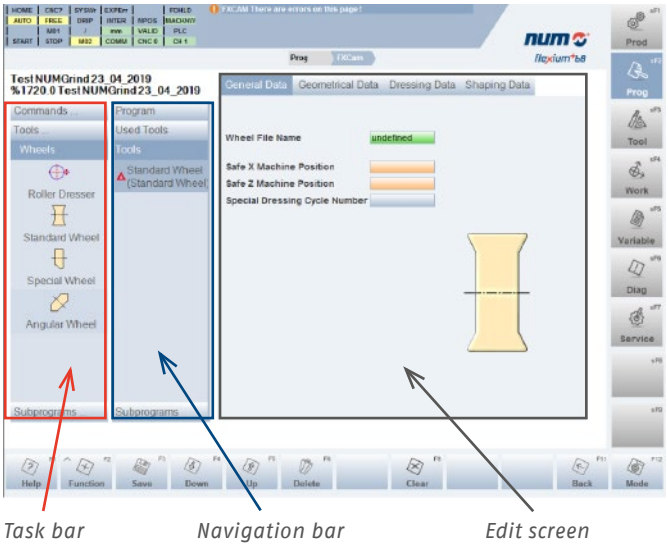
Supported G&M functions and cycles for cylindrical grinding:

Code	Description
G200	External plunge / multiplunge cycle
G201	Internal plunge / multiplunge cycle
G202	External plunge cycle with inclined axis
G203	Internal plunge cycle with inclined axis
G204	External oscillating plunge / multiplunge cycle
G205	Internal oscillating plunge / multiplunge cycle
G206	External cylindrical traverse cycle
G207	Internal cylindrical traverse cycle
G208	External profile grinding cycle
G209	Internal profile grinding cycle
G210	External conical traverse cycle
G211	Internal conical traverse cycle
G212	External oscillating shoulder cycle
G213	Internal oscillating shoulder cycle
G214	External shoulder traverse cycle
G215	Internal shoulder traverse cycle
G216	External shoulder cycle with fillet / chamfer
G217	Internal shoulder cycle with fillet / chamfer
G230	Wheel speed calculation
G231	Passive positioning (axial correction) cycle
G232	Intermediate measurement cycle
G240	Fixed or roller dresser wheel dressing cycle
G245	Fixed dresser wheel shaping cycle
M06	Selecting the wheel and setting up the working environment
M140	Dresser setup
M145	Part origin setting
M160	Periodic dressing test counter

A typical NUMgrind page is divided into three parts:

- **Task bar**
  with commands (left column: cycles, functions and tools)
- **Navigation bar**
  as program flow (middle column)
- **Edit screen**
  (right area: command dependent graphical input data area)

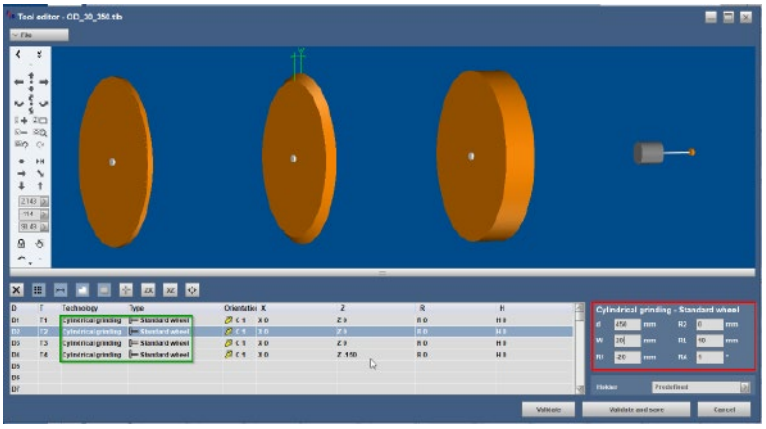
The general approach for OD/ID grinding applications is to create an ISO code program using prepared and highly intuitive graphically supported HMI pages for the wheel and dresser definitions, the canned and grinding cycles and the definition of the grinding process. The machine environment is adapted with the wheel and dresser setup, plus, the grinding project is generated automatically and sent to the CNC system for execution.



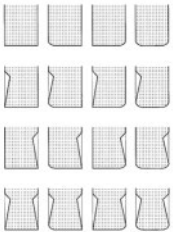
Simulation of Cylindrical Grinding Application

In conjunction with NUMgrind, Flexium 3D (NUM's graphical simulation software) provides the operator with another very useful tool to further enhance productivity. Once a part program is generated through NUMgrind technology, the operator can simulate the grinding program through Flexium 3D, based on the customized machine kinematic. The software can be configured in a variety of different ways to match many standard cylindrical grinding machines. It can be used directly at the machine or as a standalone program for grinding process verification. This software gives the operator more power to ensure that the generated programs match their desired outcome before the grinding process is executed on the machine.

To achieve a correct grinding simulation, the wheel types and data for a cylindrical grinding application (standard, angular and special; green color) can be imported from wheel files in Flexium 3D. A set of additional tool parameters describe the pattern of the wheel itself – such as its radius, peripheral face and side (red color). The picture shows a typical set of wheels to process OD/ID grinding.



With the tool types, the following wheel forms can be described:



A wheel form is defined with:
- Wheel Width (W)
- Radius (+) / Chamfer (–) Left (R1)
- Radius (+) / Chamfer (–) Right (R2)
- Relief Length (RL)
- Relief Angle (RA)

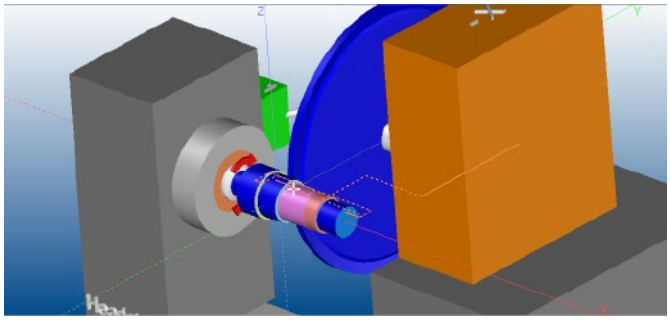
Abbreviations in brackets are referenced to the wheel table above.

Of course wheel changes are supported from NUMgrind in offline and online simulation mode.

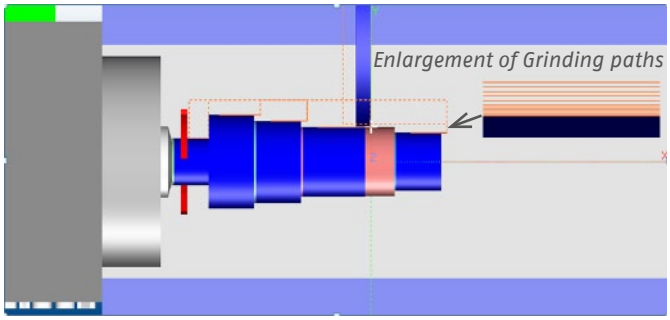
Offline Grinding Simulation

Offline grinding simulation can be used to verify and evaluate the grinding program either direct on the machine during part processing of another part, or as standalone in the production planning department. This pre-evaluation of the grinding project prevents downtime of the machine in the case of programming errors.

The following image shows the grinding process of running a wheel spindle part. The blue color highlights the already machined area of the shaft.

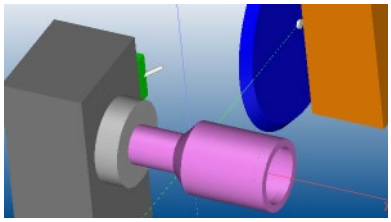


This view in Z-X plane enables detailed evaluation of the transitions on the shaft and the tracking of the grinding paths. Features for measuring diameters and shaft areas round off the simulation as an upstream process.

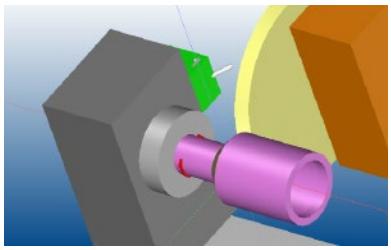


NUMgrind GC – CNC Solution and Simulation for Cylindrical Grinding Machines, 3D-WPC

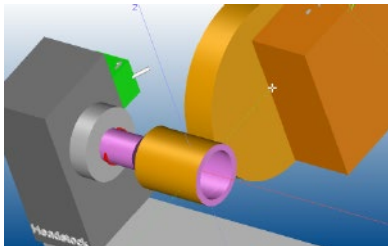
The following pictures show the inner and outer diameter processing of a more complex blank, with the use of three different wheels.



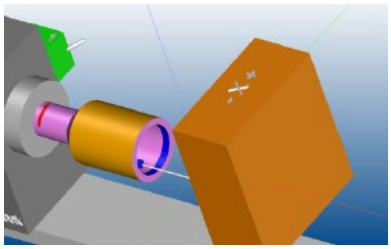
Blank formed as shaft and tube.



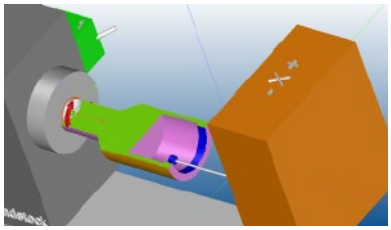
Processing start of OD conical traverse cycle G210 at inclined shaft part.



Wheel change and OD traverse cycle G206 at surface of the tube part.



Wheel change and ID traverse cycle G207 at inside of the tube part.

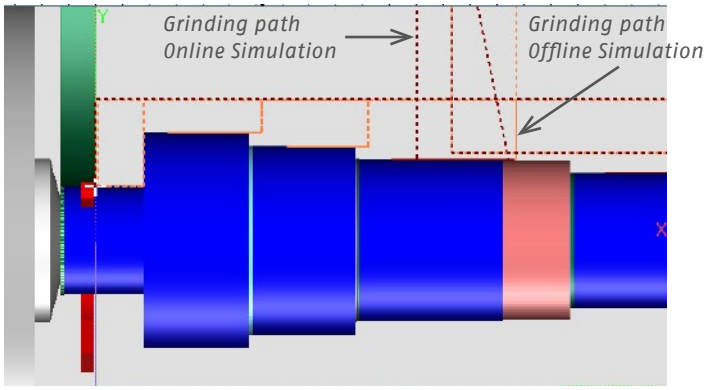


Visualization of ID traverse cycle G207 at inside of the tube part.

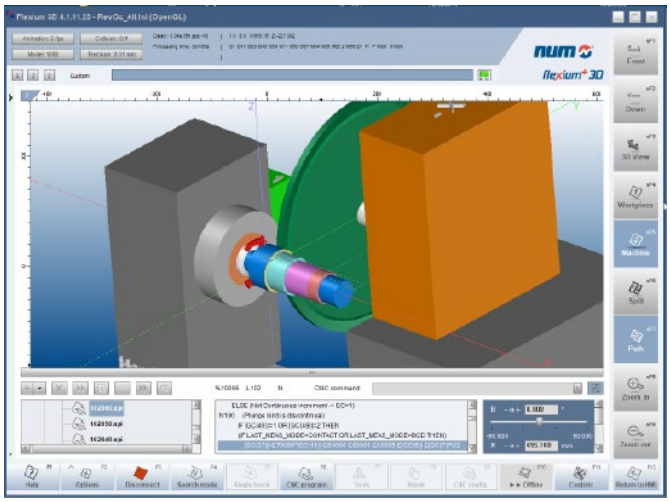
Section of the workpiece illustrates the real material removal during the grinding process.

Online Grinding Simulation

It is also possible to directly visualize the axes' positions in real time in the online simulation window – which is displayed in realtime during the grinding process. A superposition of grinding tracks to the upstream evaluation process is also possible, as the grinding trajectories are displayed in different colors.



Complete view of online simulation with tracking NC block display, material removal and collision detection.



In short, the NUMgrind GC package can help save machine builders years of development time – and significantly reduce the learning curve for operators. The grinding simulation enables the operator to easily check whether the generated program meets his expectations.

3D-WPC: Work Piece Positioning Compensation with RTCP

NUM first implemented an RTCP (rotation tool center point) function for five-axis machining applications back in the mid-1980s. Today, little remains of that original function, except perhaps its name, its macro number and – more importantly – our ongoing commitment to providing customers with the best solutions for increasing their machines' capabilities.

We have already discussed the numerous improvements in performance and ergonomics, as well as the new features – like the G248 recalibration cycle – that were progressively added to the five-axis machining functions over time. Today we will focus on new programming opportunities.

In five-axis machining, a widely used programming method consists of directly programming the rotary axes' articular coordinates. Even though this makes the part program machine dependent, the method has several advantages: it is easier to anticipate machine behavior just by looking at the part program, and there is a total absence of singularity (multiple attitudes for a single tool orientation). This has been NUM's preferred option since the outset.

However, modern five-axis machining faces new challenges daily – one of which is part balancing. When a part is installed on a machine it might be very difficult to align it perfectly due to its weight, its structure, a previous machining operation or for some other reason. A shift parallel to the main axes is not a problem and merely requires an offset to adjust it. However, a tilt can become quite tricky because it implies compensation of the tool orientation. One common solution, after identifying the offsets and tilt angles, is to reprocess the program in order to take the misalignment into account, but this obviously takes some time.

Thanks to the powerful architecture of its Flexium+ CNC platform, NUM is now in a position to offer a new approach to part balancing – which also helps further increase machine productivity. Starting with Flexium+ version 4.1.20.00, we are introducing extended programming options for five-axis machining.

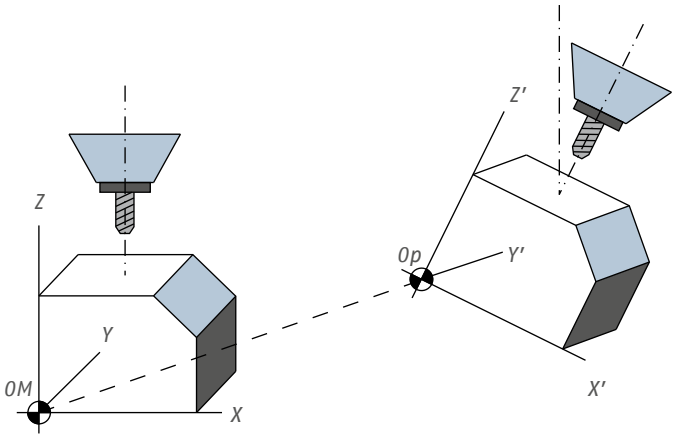
These rely on three new G codes, six E parameters and some variants. The G codes are the following:

- G30: This has been introduced for compatibility reasons and is the default mode. The part program is executed taking into account the actual axes' coordinates regardless of their linear or rotary status. In order to take the misalignment into account, the part program has to be edited.
- G32: In this case, the part program no longer defines the rotary axes' articular coordinates but now directly defines the tool orientation. This 'abstract' programming defines the orientation by the coordinates of the tool vector along the main axes. This orientation is then adjusted by the NCK according to the tilt values of the part and finally the articular coordinates of the rotary axes based on this adjusted orientation are recalculated. In order to handle these calculations, the NCK must obviously have knowledge of the machine's kinematic structure.
- G34: In this situation, the part program is still written based on the articular dimensions of the rotary axes. With the knowledge of the kinematic structure the NCK has the capability of 'rebuilding' the tool orientation vector, applying the compensation and finally driving the rotary axes by their adjusted articular coordinates. This also enables an inclined coordinate system to be added to the RTCP declaration. A variant (G34-) exists if the inclined coordinate system is already taken into account in the part program.

Six new parameters have been created to characterize the misalignment: three shifts (E60006, E61006 and E62006) and three orientations: pitch, roll and yaw (E66006, E67006 and E68006). These parameters are displayed in the work context of the HMI and can be entered either on this page or by programming – for example after a probing. It is also possible to display the tool orientation in any of the referentials (machine, part or corrected) and access it by E parameters.

Programming remains very close to its current form. In most cases, nothing more than entering the balancing parameters and the G code defining the situation will be required. For machine setup, the RTCP head configuration macro (generally %10151.9) will just require a recompilation with Flexium Tools to take these new possibilities into account. Two head configurations are already available and operational; other kinematics will soon be available.

Once again this demonstrates the power of the Flexium+ system as well as the philosophy of NUM, which is to bring you the largest range of options to help you secure a competitive advantage, while maintaining compatibility with existing developments. This brief presentation is, of course, not exhaustive and will subsequently be explained in detail; but in the meantime, please do not hesitate to contact our specialists. They will be happy to show you all the benefits you can get from your partnership with NUM.



EBC – Earlier Block Change, SWITCH CASE, Cyber Security for Machines

EBC – Earlier Block Change

NUM has introduced various new CNC functions and programming improvements with the latest 4.1.20.00 version of Flexium+.

One of these new functions is called **EBC (Earlier Block Change)**. EBC facilitates faster machining cycles, because the NCK (NC kernel) starts execution of the next block before the previous block has terminated.

EBC also provides a very fast signal exchange between the PLC and the part program, allowing the PLC to control and get information about program execution using 32 dedicated input bits and 32 dedicated output bits.

Block change can now occur under a variety of conditions:

1. Immediately – the two blocks are therefore executed simultaneously.
2. After a certain distance has been traversed.
3. When the residual distance is lower than a value.
4. When the PLC sets a certain signal.
5. When the block ends normally (standard way).

Furthermore, the NCK communicates to the PLC when certain conditions in the program execution have been reached, allowing the PLC to start auxiliary operations without the need to program M functions – and thus without stopping any axes.

All of these features are easily programmed with a single G function and a few parameters.

For example: Z100 G777 Q1 X40 P24 I25

The simple statement above moves the Z axis to the Z100 mm position. When 40 mm has been traversed, bit 24 will be set, and then as soon as input bit 25 is set, the execution of the next block will start. In the meantime, the Z axis will arrive at its final position.

SWITCH CASE

NUM also continuously improves its programming syntax by adding new functions. The IF clause allows the conditional execution of certain part-program sections. However, when structuring a part program, the choice is not always simply between two situations; it can very often involve multiple situations. In these instances the new **SWITCH CASE** programming statement provides a very easy and readable way of structuring your part program.

```
SWITCH Expression

    CASE constant expression 1
    ..... statements to execute until the next "break" keyword
    BREAK       //optional

    CASE constant expression 2
    ..... statements to execute until the next "break" keyword
    BREAK       //optional

    CASE constant expression 3
    ..... statements to execute until the next "break" keyword
    BREAK       //optional

    CASE constant expression i
    CASE constant expression j      \\ successive labels in cascade
    ..... statements to execute until the next "break" keyword

    BREAK       //optional

    DEFAULT     //optional
    ..... statements to execute until the "ENDS" ending the
    switch statement
    BREAK       //optional

ENDS
```

Cyber Security for Machines

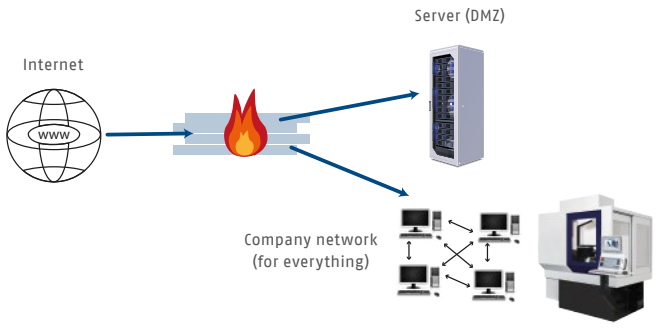
The benefits of digitalization are undoubtedly manifold. However, they also bring with them new problems and risks, the effects of which are best understood at all times. For example, hackers are increasingly targeting critical infrastructures and production sites. These attacks are made possible by the increasing digitalization and networking of systems and machines. As a result, there are completely new "entry gates", which are actively used.

In a so-called "Honeynet Experiment", TÜV SÜD simulated a small hydroelectric power station in a small town with real hardware and software, which was protected with the usual industrial protective measures. The aim of the experiment was to attract hackers in order to analyze access and attack actions, and to develop security precautions for the genuine threat scenarios that companies, in various industries, are exposed to. As soon as the infrastructure went live, the first interactions took place. After eight months, the balance sheet showed 60,000 accesses from servers in 150 countries, some with obfuscated IP addresses. Around 9,000 direct attacks were registered, mostly using standard IT protocols, but industrial protocols such as S7Comm or Modbus TCP were also often used. One result of this Honeynet experiment was that even small and unknown companies are discovered on the Internet through constant spying. These can become victims of attack waves, even if they are not specifically selected.

Another example is the "Mirai" malware. This exploits the fact that more and more everyday objects such as routers, CCTV surveillance systems, digital video recorders, televisions, etc. are connected to the Internet (keyword "IoT" – Internet of Things). The malware constantly scans the Internet, looking for devices with security vulnerabilities; if vulnerabilities are found, malicious code is applied to these devices. The original "Mirai" botnet compromised around 500,000 IoT devices worldwide in 2016. Over three million devices are now trapped in the botnet! In addition, it recently became known that hackers were offering a botnet with 50,000 infected devices for rent. With the help of this malware, shortly before the US presidential election in 2016, an attempt was made to bring highly frequented web services such as Twitter, Spotify and Amazon to a standstill.

It is therefore also possible to paralyze the production of a factory on the one hand, and to use machines to attack other systems or to spread malware on the other.

The networking of machines continues to progress (keyword "Industry 4.0"). The following network design is still frequently used:

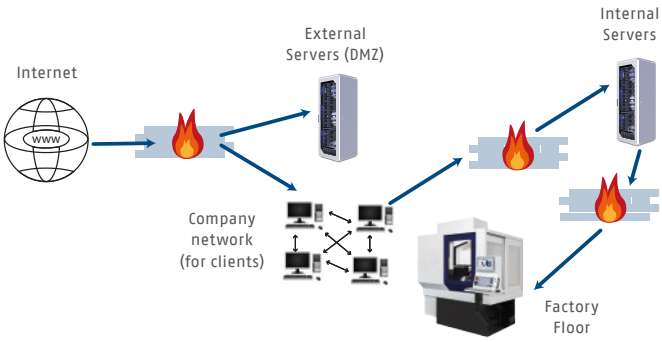


Shortcomings in this way of implementing networking are:

- Networking is universal and the same for all devices:
  - All devices have unprotected connections to the entire company network (intranet).
  - Automatic updates via the Internet, which can interfere with the operation of a machine.
  - Some connections are made via WLAN, which is not secure.
- Not all networked systems comply with security standards:
  - Old operating systems.
  - No (regular) security updates.

Many machine controllers use Windows or Linux operating systems. If real-time systems are also running on the same hardware, security updates are usually deliberately not carried out in order not to impair functionality. Also, such systems are not always equipped with anti-virus programs, as these can have a negative effect on functionality. For these and other reasons, a network with machines must be specially secured.

A possible solution is a network structure as shown in the following figure:



This network structure offers better protection of the industrial infrastructure with additional rules defined by the company's own IT group. These rules include:

- Subdivision of the production networks (factory floor) so that not everything is paralyzed in the event of an attack.
- Any updates should be applied manually and in a targeted manner. Automatic updates could take place at the wrong time and lead to the failure of a machine during production.
- For industrial systems, the IT group should create special rules for updates and access to the Internet.

In the infrastructure shown, the firewall to the production network should also be set so that only "permitted" data packets are forwarded. Access of machines to the Internet is (mostly) not necessary, so this can be prevented.

Of course, the Internet is not the only concern when dealing with machine security. Attacks can also be made without using electronic networks. Malware can just as easily be introduced via memory sticks, flash cards, etc.

Today, a comprehensive analysis of a company's information security is the order of the day and the first step towards more protection against cyber-attacks. Various standards (e.g. ISO/IEC 27001) and process models (e.g. ISIS12) also exist on this topic.

The product life cycle of a machine controller is considerably longer than that of a PC used in an office environment. It is therefore only a matter of time before the operating system used on a production machine becomes obsolete and there are no more updates (if any could ever be installed).

Continuously retrofitting a machine control system with the latest operating systems is usually too expensive or technically not feasible without undue effort. It therefore makes sense to use such systems in an IT-protected area.

We are happy to support you in integrating NUM systems into your IT infrastructure and finding suitable networking solutions.

NUMmonitor, CTMP 1960–2600

NUMmonitor: a brand new application of Flexium+ to reduce downtime

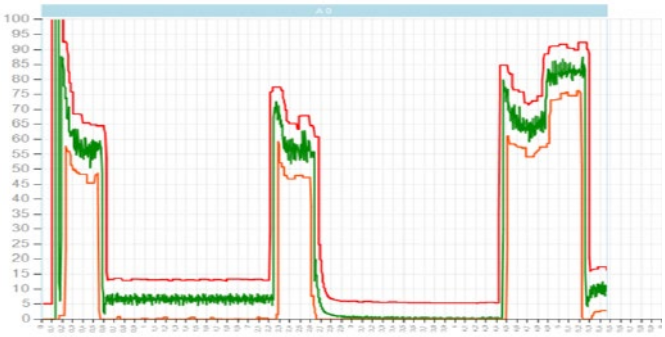
Thanks to its powerful hardware, sophisticated algorithms and flexibility, Flexium+ is perfectly capable of handling high-performance machines as well as one-of-a-kind applications. Some of its unique features, including the ability to control up to 32 spindles, make it equally suitable for high-production systems such as transfer machines.

In the field of high-production machines the smallest incident may lead to dramatic economic consequences; this is why it's important to monitor the machining parameters in order to prevent downtime due to a worn tool, lubrication fault, loss of performance or some other factor. Such monitoring devices are of course available – they generally require additional, and often expensive, hardware and software, significant setup time, and cannot always gain access to all desired parameters.

To bypass such constraints, NUM is introducing NUMmonitor. One of the key points of the specification was to avoid the need for any additional hardware. Flexium+ already provides a PC (front panel or box PC) to handle data from the drives' measurement points. Moreover, the PLC has direct access to machine parameters and the NCK Oscilloscope feature allows values to be read at the pace of the axis sample task, while RTE (real time Ethernet) and FXServer handle communications between all these elements. Another requirement is, of course, to be able to use NUMmonitor with any machine configurations – not just for transfer machines.

NUMmonitor: how does it work?

The first function is to record machining parameters under optimal conditions. The most significant of these measurement points is the motor load. NUMmonitor is capable of recording the load of up to eight motors. These parameters are recorded based on machining time in order to prevent variations due to different cutting conditions. Several recordings can be performed to calculate an average value. Based on these recordings an envelope with vertical and horizontal tolerances is then built and stored in a database representative of the part being machined. An example of this recording is shown here. The green curve displays the recorded load whereas the red curves define the acceptance area.



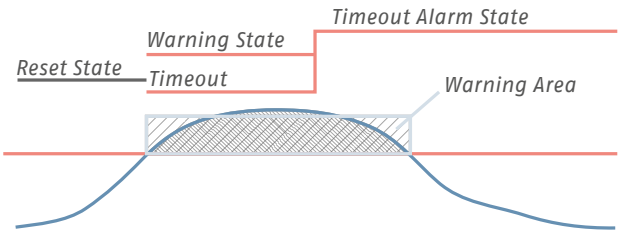
Once the 'teaching' phase has been completed it is possible to start production with the same part program that was used for creating the model.

First, an instruction in the program will identify the part, to enable loading of the corresponding data from the database. The active values are stored directly in the PC memory for fast access, to prevent any lag due, for example, to the reading on the PC hard drive. A second parameter in this program defines the exact moment when the comparison starts. Of course it is necessary to execute the program under the same conditions (override) to make sure the cutting characteristics remain the same. If a discrepancy on any of the monitored motors is detected then a signal is sent to the PLC, which will decide what action should be taken: from a simple warning message to an emergency disengagement. At the end of the measuring session the part program will send a request to close the recording.

According to the situation, several messages are issued:

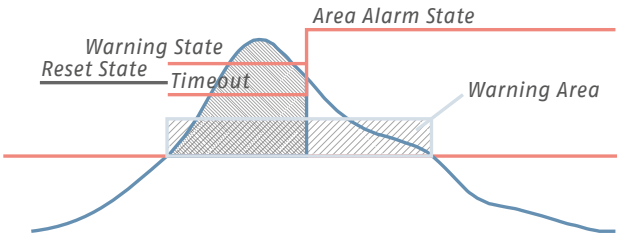
1. **The load exceeds the envelope for a certain duration (timeout alarm)**

   An alert state will be issued and if the load remains outside the tolerance after a predefined timeout then an alarm state will be activated. If the load returns to within the tolerance bandwidth before the timeout, then the system returns in standard condition (reset state). Of course it is possible to define a minimum time window for alert detection in order to prevent false alarms due to a short spike of load.



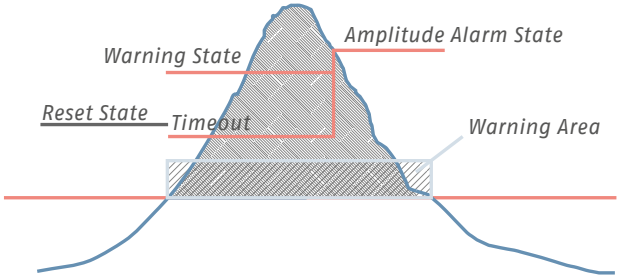
2. **The load integral exceeds the envelope area (area alarm)**

   In addition to the timeout detection, an area of overrun is also defined, in which case the alarm status occurs before the previously mentioned timeout should the load overflow be important in amplitude.



3. **The load exceeds the amplitude limit (amplitude alarm)**

   If the load exceeds a certain level of overflow, an amplitude alarm state will be triggered immediately.



The three above conditions can be mixed using OR and AND operators to obtain the alarm condition, and of course, the monitoring can be limited to specific sections of the process.

Implementation

NUMmonitor has already been tested on several machines. The first results were very positive. One of the test configurations was a multi NCK system for a transfer machine which gave very satisfactory results. Among the noteworthy advantages over external solutions, the ease of commissioning was appreciated, as well as the absence of requirements for additional hardware or wiring. The parameters are meaningful and easy to define. During the tests, the quality of the signals from the drive was found to be good with very little noise – this allows for good sensitivity.

Generally, these kind of production machines are fitted with powerful motors to achieve high acceleration rates. As a consequence, the load during machining can be quite low – especially with a small tool – and requires a limited amplitude tolerance; for optimal results it is necessary to also monitor the spindle motors, which the NUMDrive X can handle easily even in V/F.

We will keep you posted about future developments of this solution, which is easy to implement and fully operational. NUMmonitor is another feature that will provide you with an additional competitive advantage.

NUMSafe CTMP1960-2600 Compact Controller

The NUM all-in-one solution for local safety applications is the NUMSafe CTMP1960-2600 Compact Controller. The NUMSafe Compact Controller is the complete safety solution for machines incorporating an EtherCAT gateway with 20 safe digital inputs, 24 safe digital outputs and four additional single channel relay outputs in a single unit. Due to its compact all-in-one design, the CTMP1960-2600 offers a significant cost saving over the equivalent individual components. As with all NUM EtherCAT couplers, the CTMP1960-2600 can be expanded with the use of additional standard and NUMSafe modules if required, depending on the mode of operation.

The functionality of the CTMP1960-2600 can be incorporated into the machine design in one of two ways:

- As a NUMSafe compact controller integrated into an EtherCAT network. The CTMP1960-2600 can be extended with standard and NUMSafe safety terminals on the E-bus connection and via the EtherCAT network.
- As a NUMSafe I/O module. The logic on the NUMSafe compact controller is not used. The coupler can be addressed by a NUMSafe logic terminal as an I/O module with 20 inputs, 24 outputs and four single channel relay outputs.

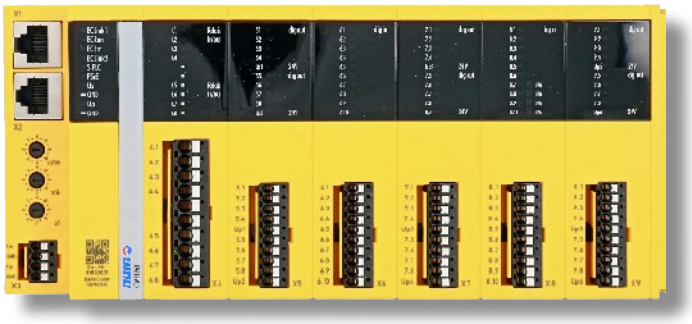
The NUMSafe Compact Controller is programmed via NUM Flexium Tools in the same way as other NUMSafe components. A NUMSafe project is created and loaded over EtherCAT into the CTMP1960-2600.

The Safety over EtherCAT safety protocol enables the integration of NUMSafe devices into the standard NUM fieldbus system. The safety I/os form the interface to the safety-relevant sensors and actuators. The ability to transmit safety-relevant signals over the standard bus system results in substantial advantages in terms of planning, installation, operation, maintenance, diagnostics and costs.

The NUMSafe Compact Controller CTMP1960-2600 is suitable for safety applications up to SIL 3 according to IEC 62061 and IEC 61508 and up to Cat. 4 PL e according to EN ISO 13849-1:2015. See following list for restrictions:

- The single-channel relay output is suitable up to Cat. 2 PL d.
- The two-channel relay output (use of two relay contacts in series) is suitable up to Cat. 3 PL d or Cat. 4 PL e, depending on the number of actuations.

Special proof tests are not necessary during the entire lifetime of the CTMP1960, on account of the high level of diagnostic coverage.



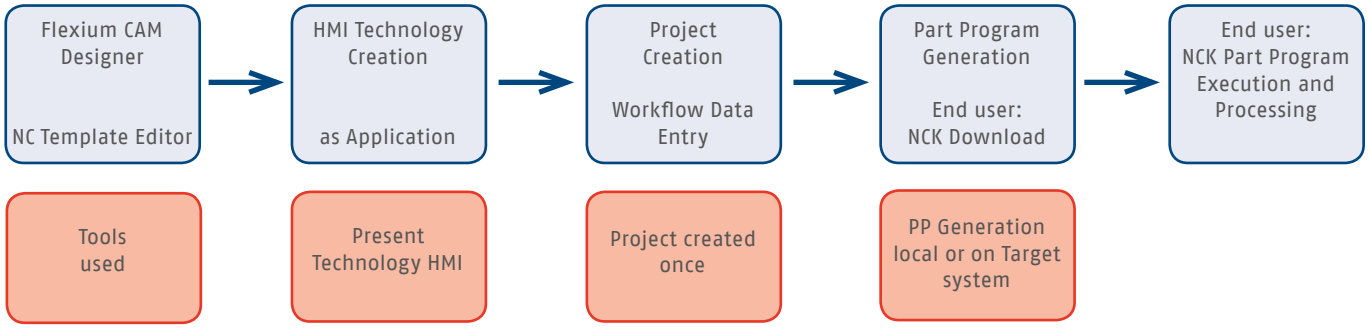
NUM's Technology HMIs and Flexium Office

The Flexium CAM Concept

Flexium CAM is a NUM development framework to create and run Technology HMIs for integrated computer aided manufacturing. Technology HMIs are a set of customized and application dependent UI-pages (User Interface) based on HTML and JavaScript created with Flexium CAM Designer. The Technology HMIs are packed and encoded to protect the application.

The Flexium CAM designer tool is a technical HMI creation tool which provides graphically supported, dynamic HMI pages, equipped with data and NC Template editor as well as a configuration setup to design the workflow with user friendly data entry capabilities. This enables the user of the Flexium CAM Designer tool to create application projects tailored to the respective needs.

These "ready to run" projects can be loaded in the Flexium+ HMI software (Flexium CAM run time environment) to automatically generate ISO part programs. With the integrated download functions the part program is sent to the NCK for execution.



Following five CAM Technology types are supported:

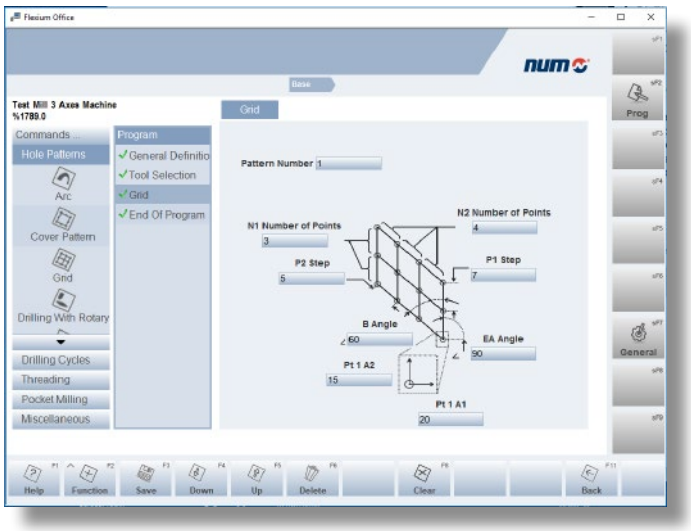
NUMgear HMI Hobbing	NUMgear Hobbing allows for up to five gears on a single shaft including automatic alignment and cutting processes from radial to diagonal to create spur and helical, tapered and crowned gears as well as splines.
NUMgear HMI Shaping	NUMgear Shaping can be used to cut internal ring gears or external disks. Simple and flexible cycles allow for interactive modification of the cutting parameters.
NUMgear HMI Threaded Wheel Grinding	NUMgear TWG uses data entry of gear, grinding wheel and dresser to provide cycles for threaded wheel grinding as well as for the dressing of the wheel. It sports automatic grinding pass calculation and can be used for external spur and helical gears.
NUMgrind HMI Cylindrical Grinding	This Technology HMI can be used for outer diameter and inner diameter grinding applications. The basic kinematic would be X axis for the wheel, Z and C axis for the part.
NUMmill HMI	This milling technology is used to provide an easy and user friendly method of creating part programs for a standard 3(-5) axes milling machine. Standard kinematic axes are X, Y and Z.

For end users it is important to know that they can get their customized HMI technology specified to their real application needs – either in cooperation with NUM or directly from the machine manufacturer. This concept is now extended with an offline framework tool called **Flexium Office**.

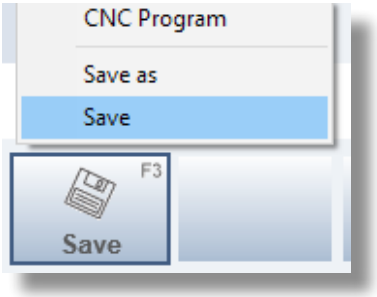
Working with Flexium Office

Flexium Office permits the use of NUM's Technology HMIs without being close to a machine – for example, in the office. Application dependent projects, and the corresponding ISO part programs, can be created, tested with NUM's Flexium 3D simulation software and transferred to the targeted machine.

The operator selects one of the provided Flexium CAM HMI technologies. With basic data definition, tools and workflow commands as well as language support for up to 14 languages, the project (xpj) for the concrete application is generated once.



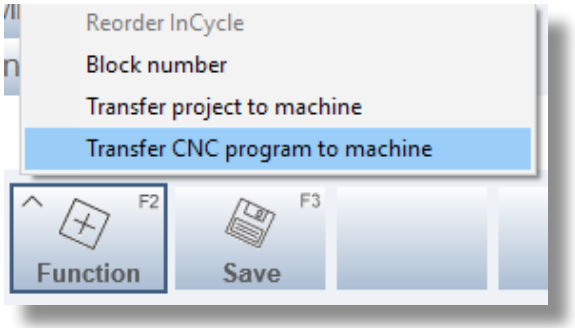
The file handling for projects on the local PC is divided into project "Save/Save as" or for evaluation purposes "CNC Program" to generate the CNC part program (xpi) direct locally on your PC.



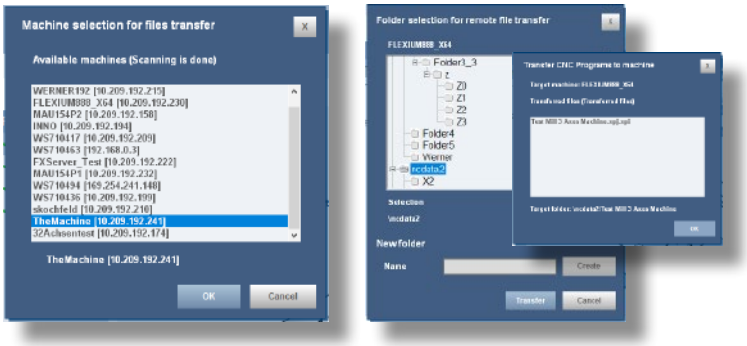
The most significant user benefit of Flexium Office is that the process and real workflow can be organized and tested in the office, in advance, if you generate the CNC part program locally for the simulation. The production machines are free only for real part processing; which clearly increases the machine efficiency.

Flexium Office communicates with the target system

To communicate with the target system, usually with NUM's industrial PCs, use the function button named Transfer project to machine" or "Transfer CNC program to machine". The project/CNC program can be transferred directly via network/TCPIP to the selected machine as the target system in the production plant. The advantage of transferring the project to the target machine is to have the capability to modify the work flow directly at the machine, if necessary.



Dialogs for selecting the target machine and storage location for project (xpj) and CNC files (xpi) are offered:



If a project is transferred to the machine / target system, the same Flexium CAM HMI technology has to be installed to load, recheck, and optimize the project before the generated part program is transferred to the NCK for part processing.

For transferring CNC part programs the standard Flexium HMI is sufficient to load generated CNC programs into the NCK for execution.

To summarize, Flexium Office, together with the mentioned technology HMIs, can help save machine builders years of development time and decrease the time for end users coming to the part. A big step forward as NUM sales and their OEMs have recognized.

HMI Improvements

HMI Improvements

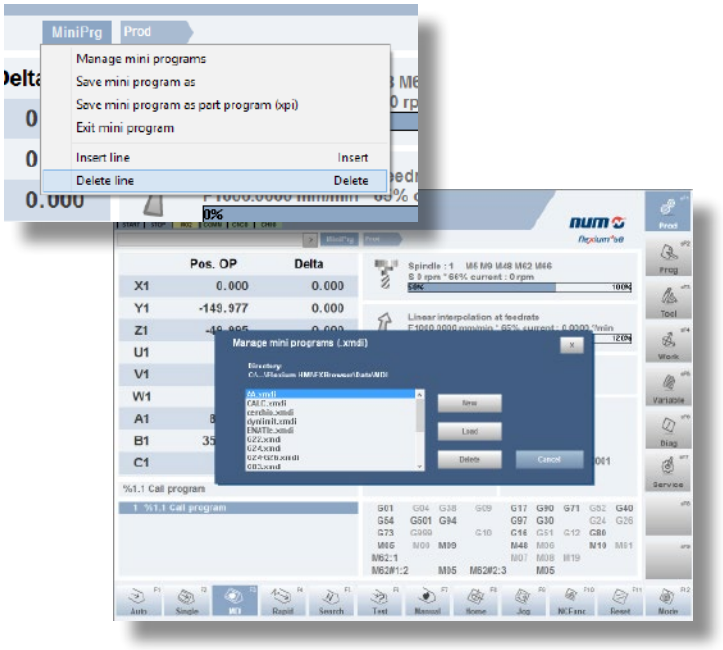
The usability and friendliness of NUM's Flexium+ system is now even further improved by the release of version 4.1.20.00 software. Some of these improvements are:

Multi line MDI (Manual Data Input)
The Flexium+ HMI (Human Machine Interface) now offers a new additional MDI operating mode called MiniPrg that extends the popular NUM MDI mode by allowing the use of several 'mini programs'.

In this way the user can save/load different predefined mini programs during MDI mode. For example, several sequences of NUM G-code commands can be stored, recalled and reworked whenever needed.

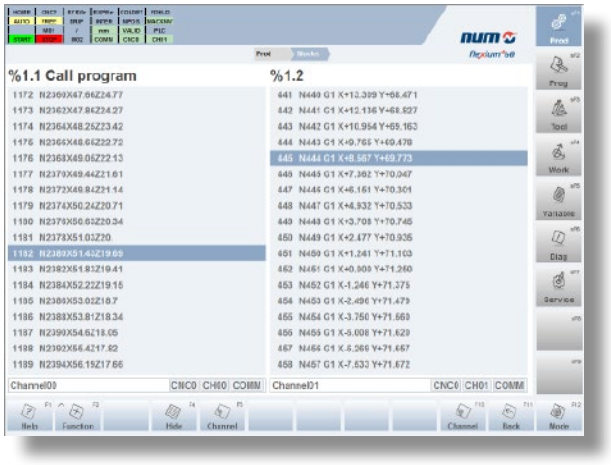
A new button has been added to the HMI to handle these mini programs so that it is now always possible to modify a line command or select a new line, simply by using the arrow keys or the mouse in a small editor which is located to the left side of the production button. The user can execute a specific selected line just by pressing NC start, or retype the command if it's not needed anymore.

Of course the MDI standard mode is always available and the user can choose the preferred way of working.



Block ISO viewer
One of the Flexium+ system's great strengths is its multi-channel capability. A machine driven by a NUM CNC can simultaneously run more than one part program (multi-channel); each channel is utilized by a dedicated part program and can be synchronized with other channels/part programs.

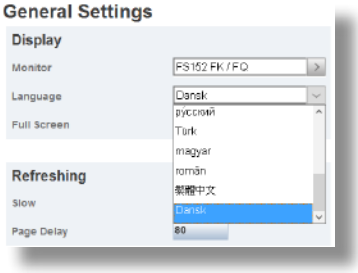
The new Block ISO view page can help the user to follow the part program's flow for more channels at the same time. The page can display two channels, selected by simple and intuitive horizontal soft key buttons.



Additional languages
The Flexium+ HMI is a multi-language human machine interface designed to offer a comfortable user experience. In the latest version 4.1.20.00 software, NUM has added Danish as a language option.

Users can select any of fifteen different languages:

1. FRENCH
2. ENGLISH
3. GERMAN
4. ITALIAN
5. CHINESE
6. PORTUGUESE
7. SPANISH
8. CZECH
9. POLISH
10. RUSSIAN
11. TURKISH
12. HUNGARIAN
13. ROMANIAN
14. MANDARIN CHINESE
15. DANISH



Oscilloscope
To improve diagnostic capabilities, in the latest Flexium+ software, version 4.1.20.00, three different oscilloscope types have been integrated in the Diagnosis context:

- **Online/offline NCK time domain oscilloscope**
  Up to nine traces can be recorded simultaneously for 289 different kind of E parameters. The E parameters are used by the part program to access information contained in the PLC or CNC memory – for example, it is possible to read out the axes' positions, the current block number, the result of the mathematic formulas and also the version of NCK software. The oscilloscope can help OEMs to understand unexpected machine behavior or a problem with workpiece surface quality, etc. The advantage of this diagnostic tool is that the values read are synchronized with NCK tasks, so the events are recorded and displayed graphically in a temporal sequence, making it easy for technicians to analyze.

  In the example below, position (green), speed (red) and lag error (blue) traces are displayed for the Y axis; with this type of graph, speed discontinuity can be analyzed graphically.

- **Online/offline NCK 2D Map oscilloscope – profile and feed analyzer (XY domain)**
  The 2D Map oscilloscope is designed to read out and show as a graph the path and feed of two axes: when the user selects the axes that will be recorded, the system will save the nominal/theoretical positions and the real axes' positions. An efficient and quick analysis of the displacement between the real and nominal positions can be achieved by operators directly on the machine, in an easy manner. Additional information will be displayed such as the block number and, at the top of the graph, the path feed in mm/min. The user can check the dynamic response of the machine's axes, as well as the mechanical backlash and several other interesting performance aspects, to help speed problem solving.

  In the example below, using the NCK 2D Map oscilloscope it's possible to display the error between the theoretical (green) and the real (blue) path, the number of the part program block, the number of the part program line and the path feed (small chart over the top).

- **Offline drive test points time domain oscilloscope**
  The drive oscilloscope will upload two traces at time – the user can select, in a setting page, the interesting values that will be recorded, the trigger and the sample time. More than 180 different measure points can be traced in the oscilloscope. For example: mechanical motor speed, current reference, torque and reference enable and info from SAMX etc.

  The difference between NCK and drive oscilloscope is the minimum sampling rate. The drive oscilloscope can reach a sampling rate of 10 kHz.

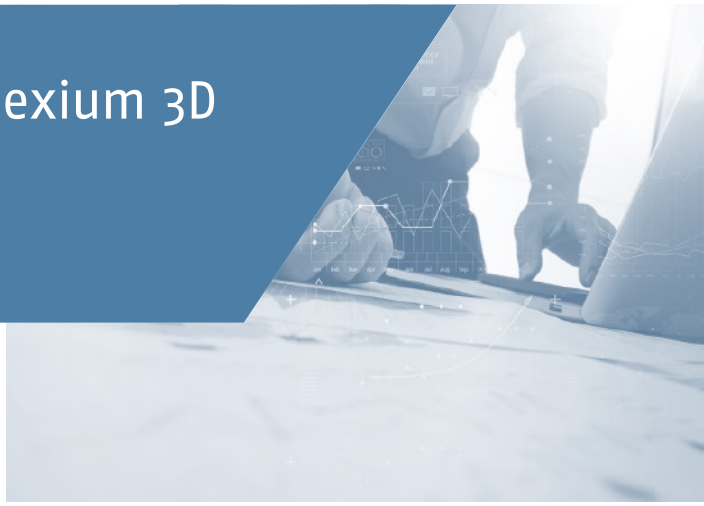
  In the example below, we can see the mechanical motor speed (green) and the motor current (blue).

For all oscilloscope types, functions such as zoom/pan/scale are available by means of mouse keys or horizontal buttons. Cursors can be activated to make the measurements even simpler.

Other powerful functions that help users to check the dynamic response of machines include:

- Save and load configurations and traces
- Save traces as image (png or vector svg)
- Compare traces

Online Collision Detection with Flexium 3D



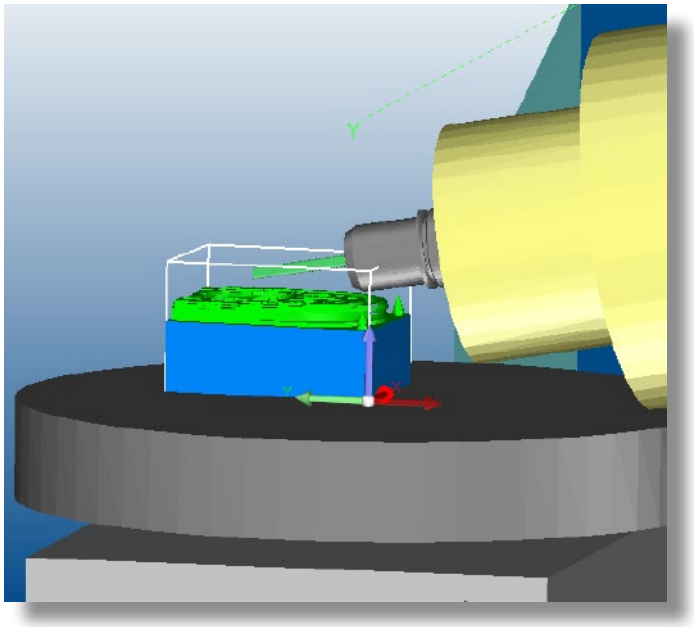
Offline collision detection behavior

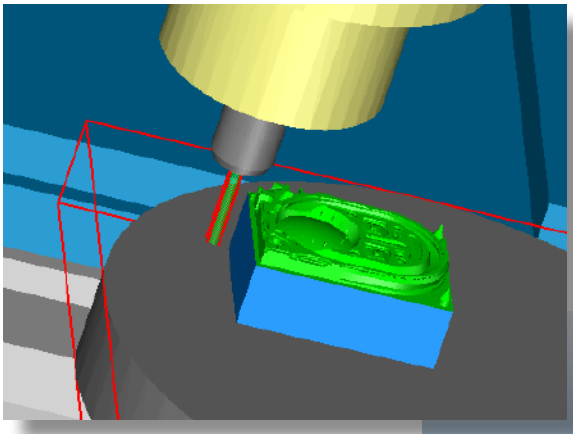
Ever since Flexium 3D was launched, more than 10 years ago, offline collision detection has formed an integral part of NUM's simulation software. The collision check analysis, starting from the main program of the application, is done before the part programs are transferred to the NCK using the same tool list, offset table, kinematic description and transformation properties as the target machine. Only in the case of a collision-free analysis are the part programs transferred to the NCK.

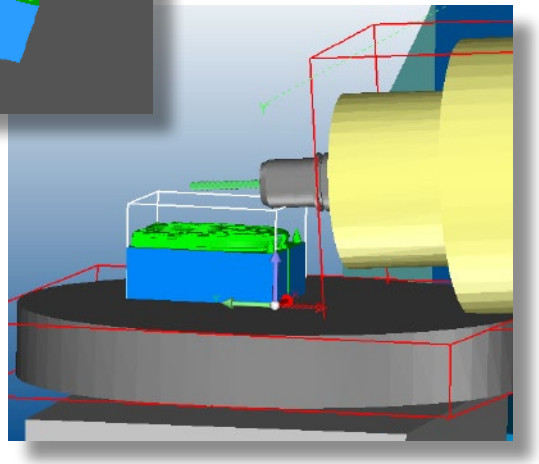
One big advantage of NUM's collision detection, and a valid competitive differentiator, is the consideration of the actual blank dimensions and the removed material during collision calculation. Flexium 3D considers far more than just the tool path. Rather, the tool dimensions and orientation, together with the holder and all other machine components, are considered simultaneously during collision calculation.

Visualization of collisions in Flexium 3D, in the form of red marked components, are shown in the examples below.

There will be no collision detected if the tool holder or other spindle/machine components are moving into the area of already removed material. The white box is the original blank size. The tool holder (grey cylinder) is located inside the already removed material, but there is no collision.







Enhancement to online collision detection using Flexium 3D

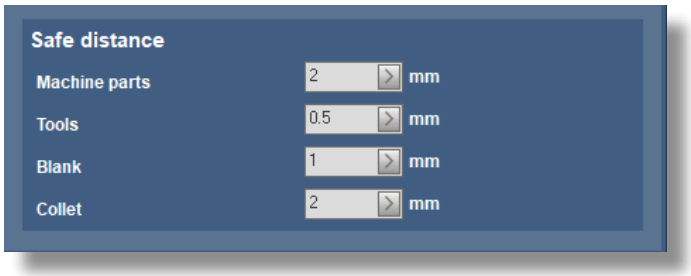
Why is there a need for online collision detection in manual mode?

As machining processes become more and more sophisticated, the risk of collisions between the tool, workpiece and machine components increases. Collisions mean costly downtime and cause expensive damage to the workpiece, spindles and sometimes even the whole machine.

Flexium 3D features, together with NCK extensions, form new functions which allow monitoring and prevention of collisions during manual/jog movements, moving axes with handwheel or in search-mode (part program resume) and in commissioning phase. In the case of 5-axis machining with complex blanks shape, manual movements can be very critical, but online collision detection makes it simpler and safer!

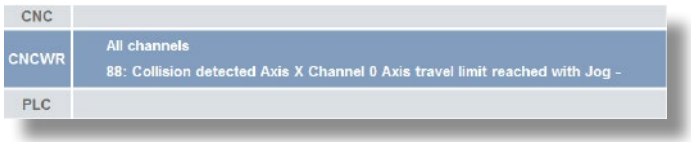
NUM's Flexium+ system is a powerful CNC control for all kinds of applications such as milling, turning, grinding, waterjet cutting and gear manufacturing. In conjunction with online collision avoidance software enhancements, it enables real-time verification and collision detection in critical manual modes. For AUTO mode, only collision-free tested part programs should be executed. It is clear that a mandatory pre-condition is that the kinematic description contains all relevant machine components which are critical for the collision check.

Safe distances for different machine components can be configured in Flexium 3D configuration.



If Flexium 3D is in online mode, which means connected to the NCK, and 'Collision Detection' is activated, Flexium 3D takes the real axis positions in the machine frame, together with detailed machine kinematic data, and implicitly calculates the physical presence of the servo axes, using the permitted ranges for single and multi-axis moves (also in the case of RTCP and/or inclined plane transformation). These permitted ranges also contain the consideration of workpiece position with material removal and the tool dimensions, as well as machine components such as jaws, clamps and fixtures.

The NCK works with these permitted ranges during manual axes moves and controls their look-ahead and ramp algorithm in such a way that limits are never exceeded. If an axis is at a collision limit and the next move would create a collision, the axis move or machining process is blocked and a dedicated operator warning is displayed.



Established in the market with passion, professionalism and innovative spirit

Developing and manufacturing special tools according to specific customer requirements is the specialty of WAWO, a company based in Oberriet (Switzerland). Founded in 1987 purely as a resharpening company, from the turn of the millennium the focus was on the manufacture of special solid carbide tools and resharpening was concentrated on the company's own products. The great potential and increasing complexity of these tools were quickly recognized; with NUM and the NUMROTO software, a reliable partner was found to turn even the most demanding tools into reality. The fact that both companies are only half an hour away from each other is further supported by a WAWO company motto: "short, clear communication" is the trump card.

The collaboration between WAWO and NUM began just over a decade ago. Today, WAWO uses NUMROTO software exclusively on several machines from various well-known manufacturers to manufacture tools of all kinds. The focus is clearly on the special solid carbide tools mentioned at the beginning, which are typically manufactured in small batches and used for milling, drilling, turning, reaming, thread cutting, etc. For individual customers, however, large batch orders are also fulfilled, in a 24/7 operation.

WAWO is therefore divided into two divisions. The customers of WAWO Werkzeuge GmbH, where the special solid carbide tools are manufactured, mainly come from the tool and machine construction sectors, the automotive industry, and the medical and vacuum technology sectors. However, special tools from Oberriet are also used in the watch industry. In the European automotive sector, many parts for steering, belt tensioning (as well as other safety components), powertrain and brakes are machined with tools from WAWO. One especially prestigious product line is impact tools, which WAWO grinds for producing gearboxes used in motor racing. In medicine, the tools are used in the manufacture of screws and plates as well as implants for joint replacement.

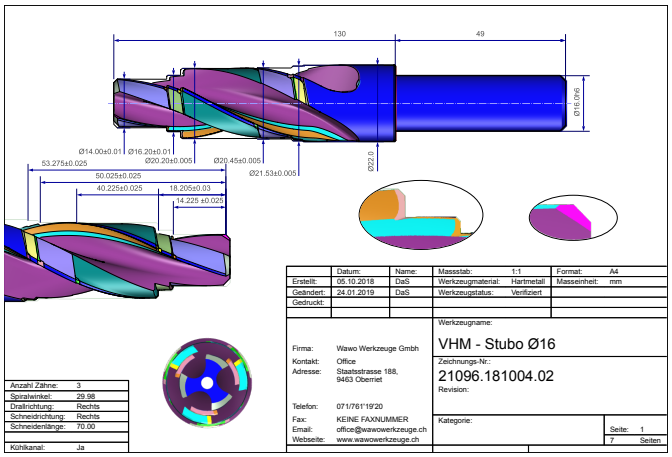
WAWO Produktion GmbH supplies customers who require medium to large batches of special tools and use them, for example, in the production of high-end furniture, car interiors and fashion articles. These are also manufactured exclusively on machines with NUM controls and NUMROTO software.

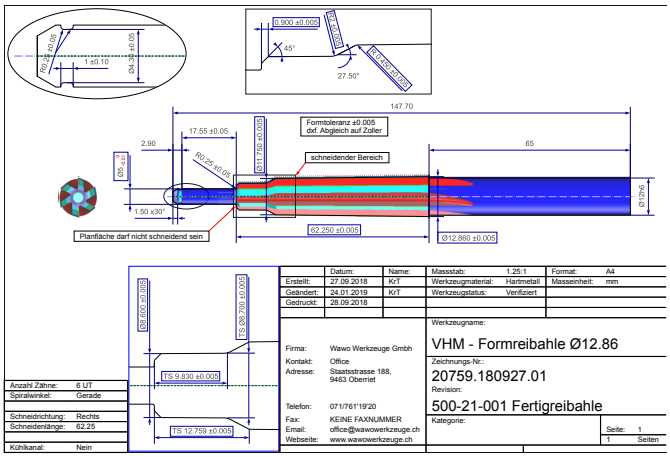
The extraordinary high order rate for proposals created by WAWO is very impressive. A major reason for this high value is the way in which NUMROTO has been fully integrated into the quotation system. According to Adrian Thurnherr, Managing Director of WAWO Werkzeuge GmbH, the deadlines for quotations and implementation are becoming ever shorter. In order to accommodate this trend, WAWO creates a finished NUMROTO program and a complete tool drawing with NUMROTO Draw during the quotation phase. After an inquiry, a customer receives a fully documented quotation with an exact calculation of the price. What initially sounds like additional work saves a lot of time in subsequent production. When the customer gives their "OK", WAWO can start production immediately. Adrian Thurnherr elaborates on exactly how this is done: "Efficiency can be increased optimally for both sides through clear communication in advance. NUMROTO Draw helps us to check feasibility right from the quotation phase and to identify potential problems at an early stage. This ensures that there are no unpleasant surprises later and the customer gets exactly what they need – including adherence to delivery dates."

But WAWO offers even more: the small, committed team in the St. Gallen Rhine Valley has a lot of know-how and also dares to tackle very challenging projects. Often the customer only specifies one end product. WAWO analyses this in terms of geometry, material and machining technology, among other things. The required tool is then designed and precisely documented with a keen eye for geometry details such as chip grooves or protective chamfers. The development and production of special tools is thus carried out completely in-house as a service for the end customer.

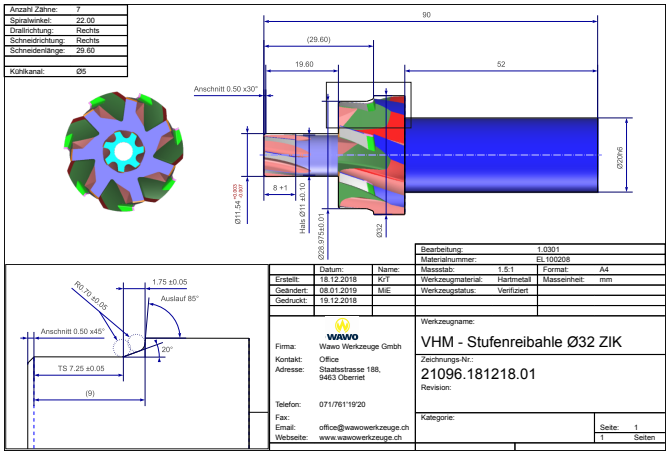
According to Adrian Thurnherr, the reasons for the exclusive use of NUMROTO are the flexibility of the system and the extensive functions. "NUMROTO offers companies a broad basis for letting their own creativity run wild. We are faced with new tasks every day; NUMROTO is an optimal tool for this and has never confronted us with unsolvable problems within the geometric possibilities." Daniel Schilling, Application Engineer at WAWO Werkzeuge GmbH,

Typical special solid carbide tools from WAWO.





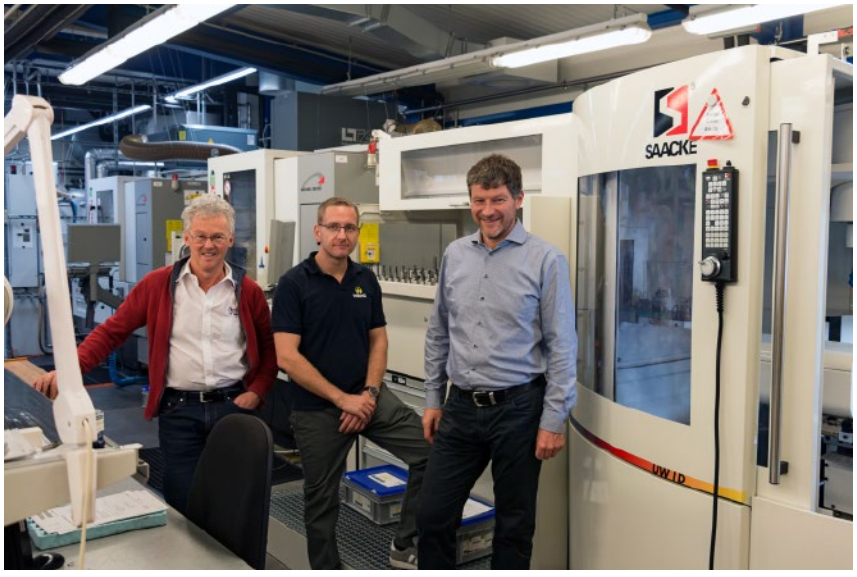
Comprehensive tool documentation with NUMROTO Draw, as already created in the quotation phase.



adds: "I like the logical, comprehensible structure. NUMROTO is a reliable tool that makes everything possible. When someone is properly trained on NUMROTO, they can make any tool. Once you know and appreciate NUMROTO, you'll want to stay with it."

WAWO goes into every detail with NUMROTO. For example, while chip grooves on sintered inserts are well known, WAWO went one step further in 2018 and developed, among other things, ground chip grooves on form inserts – thus turning steel and steps drills; which until then were not well-known. This is another example of WAWO's innovation and creativity, supported by NUMROTO.

The development of a special logistics box for the transport and storage of tools also shows that WAWO goes to work with a lot of passion. These are thus not only protected from damage, but can also be optimally stored. "Tools are a high-quality commodity", Adrian Thurnherr adds. A further, creative solution was found for the use and handling of the products, leading to detail and process optimization, which is important in everyday life.



From right to left: Mr. Adrian Thurnherr, Managing Director of WAWO Werkzeuge GmbH, Mr. Daniel Schilling, Application Technician at WAWO Werkzeuge GmbH, Mr. Jörg Federer, Head of NUMROTO Application Technology at NUM AG.

Cost effective thermoformed parts reworked with high precision CNC milling

singleplast

The beginnings of Singleplast Wilfred Single GmbH, based in Herford (North Rhine-Westphalia, Germany), date back to the 1920s. The grandfather of the two present-day Managing Directors founded a wholesale business for the furniture industry at that time, which was very strongly represented by many companies in and around Herford. His son Wilfred Single joined the company at the end of the 1940s. In 1961, the company began processing plastics, for which it is now internationally renowned. With the classical deep drawing ("thermoforming"), Singleplast's proven strength, small to medium quantities were and are manufactured on a contract basis. Since 1994, injection molding has also been offered in order to meet the demand for large quantities of parts in the plastics sector.

Put simply: in the thermoforming process, standard thermoplastics such as PS, ABS, PP and PE, but also technical thermoplastics such as PC, POM and PA, are thermoformed – here in sheet form – under the effect of heat from above and below and with the aid of compressed air or a vacuum. In principle, all thermoplastics can be used, with the exception of PVC – this would release toxic hydrochloric acid during deep drawing.

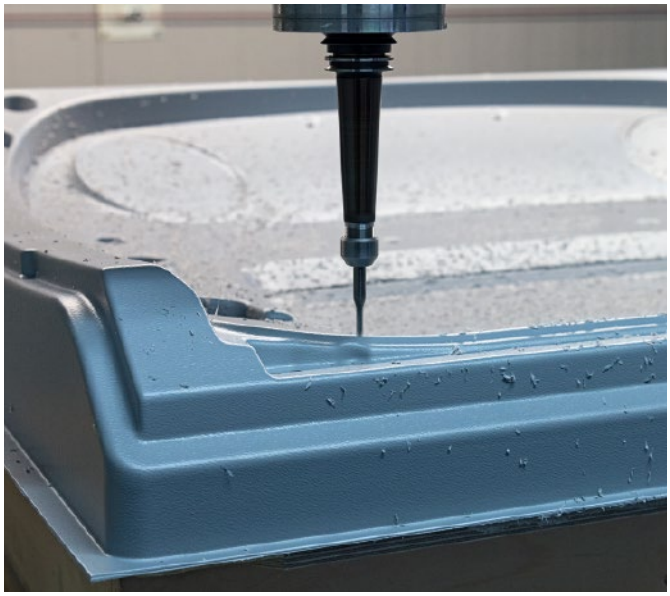
The plastic products resulting from deep drawing are then processed at the CNC machining centers and the final contour is milled. The mostly sharp-edged parts are then usually de-burred manually. Most processes – from thermoforming to milling – naturally take place automatically. But: "However, due to the occasional complex geometries and the high associated programming effort, manual de-burring is much more profitable", says Mr. Andreas Single, one of the two Managing Directors of Singleplast. "Of course, we also follow all topics relating to automation and 'Industry 4.0' with great interest, and we continuously invest in our machinery. In the end, however, an investment must also be profitable", Mr. Single continues.

For CNC machining, Singleplast almost exclusively uses machines in portal or rotary table design from HG GRIMME SysTech GmbH (Wiedergeltingen, Germany), equipped exclusively with drives and controls from NUM. The size of the machine park has increased considerably in recent years. In 2018 alone, four new machines were purchased or replaced by newer, more powerful models, bringing the total number of HG GRIMME CNC milling machines in operation to over 20. Another machining center followed in spring 2019. This ensures that the increasing number of production orders will continue to be executed on time and delivered to the customer in the future. NUM products have been used at Singleplast since the early 1990s.

CNC portal milling machine HG Grimme PSF.

View of the company premises of Singleplast in Herford.

Remote control panel FS122 with machine control panel MP04 of the NUM Flexium+ system.



Detailed view: a milling cutter machines a plastic product for an excavator.

In addition to current Flexium+ control systems with quad-core industrial PCs, windows 10 operating system and remote control panel, older CNC controls from NUM, such as analog controls from the 1000 series, are also in daily use. Mr. Single adds: "We have been coping with the controls without any problems since the beginning."

Today, Singleplast employs around 150 people at its headquarters in Herford and supplies various branches of industry, including cabin construction for industrial trucks, workpiece carriers and internal transport systems, the vending machine industry, the heating and sanitary industry, as well as manufacturers of healthcare beds and lying areas in hospitals. Singleplast has over 4,500 different workpiece holders available for processing the wide range of parts. Finished parts can also be stored temporarily for the customer in the company's own high-bay warehouse before delivery. In order to meet the quality requirements of its customers, Singleplast has also obtained ISO 9001n certification.

In addition, Singleplast places great emphasis on sustainability, recycling and the resource-saving use of materials. In order to cover its own electricity requirements and reduce CO_2 emissions, Singleplast uses its own large photovoltaic system with 1,270 modules. Excess energy is fed into the grid. NUM also practices this at its headquarters in Teufen and its production plant in Italy.

The successful cooperation between machine manufacturers, in this case HG GRIMME SysTech GmbH, and NUM as a specialized supplier, is reflected in the example of the end user Singleplast: as a satisfied customer, the machines have been in use for decades and prove their performance day after day.

From left to right: Mr. Andreas Single, Managing Director of Singleplast Wilfred Single GmbH, Mr. Bernhard Simon, Sales Engineer of NUM Germany.

Partnership for Target to Cost Design

MICHELIN
UNE MEILLEURE FAÇON D'AVANCER

RGIFRANCE
Créateur de machines-outils

The Michelin Man is one of the most recognized icons in the world. Anyplace, where tires are found, the majority of people will know how to associate Michelin and the quality of its products with 'Bibendum'. On the other hand, the fact that Michelin has trusted NUM for several decades is much less well known.

Quality is reflected in the details and Michelins knows this – by displaying the same care for quality in the rubber and structure to the extensive details on the sidewall of the tires. This goes so far as to make it feel like a 'velvet touch' on some tires.

The tires are baked inside a mold. This one is made of several adjacent elements for the tread and two toric-looking flanks for the sidewalls. It is the engraving of these two pieces that interests us today.

Even though the tools are only a few millimeters in diameter, the quality of the engraving and the machined material require rigorous design, high rigidity and efficient control. The initial machine, of purely Michelin design, was already controlled by a NUM 1060 control system. Over the years, various improvements have been made. For the current version (CN5S) Michelin has reviewed the design in partnership with the company RGI France located in St Cere in the Mecanic Valley. This 100% French-owned company produces both standard machines and machines adapted to the specific needs of its customers. RGI France succeeds RGI, which had already established a long and fruitful cooperation with Michelin for retrofits or supplies of machines used to produce electrodes or inserts for snow tires. The study was carried out with a view to Design to Cost, which made it possible to optimize cost while further improving performance. NUM was of course involved in this process and the system quickly proved to be the right solution to manage the whole process. This study also included a comparative section with a standard machine and it quickly turned out that the solution chosen was the most efficient.

The five axes of the machine, capable of acceleration up to 5 m/s², are driven by four conventional motors plus one torque motor, all controlled by NUMDrive X drives equipped with SAMX safety modules; a 40,000 rpm electro spindle completes the assembly. In addition to the security they provide, these SAMX modules combined with the NUMSafe functionality will further improve production performance since it will be possible, for example, to perform operations with the protection enclosure being open, without having to switch off the power. The PLC is managed by a Box PC system and a second PC on the machine manages Michelin's own machining management and supervision operations. A 22" portrait screen simultaneously displays this Michelin HMI and the NUM HMI with pages specific to RGI France.

The choice to have NUM be the supplier of the automation for this machine was a simple one. It should be noted that more than twenty identical machines exist from the USA to Thailand. The reliability of the systems and the quality of the support have never been lacking; moreover, as Mr. Boët, Prototypes Project Manager at Michelin, pointed out, "ease of use is appreciated as well as the compatibility of the part programs between successive versions".

This is of course not the only reason for this partnership with NUM. Both RGI France and Michelin appreciate the proximity and quality of the relationships that make it possible to make the best use of Flexium+'s own functions. Mr. Lachat, Director of RGI France, said on this occasion that he had never encountered a challenge that the various NUM equipment failed to solve. "This latest evolution of the Flexium+ system has made it possible to implement an advanced lubrication function that will reduce environmental pollu-

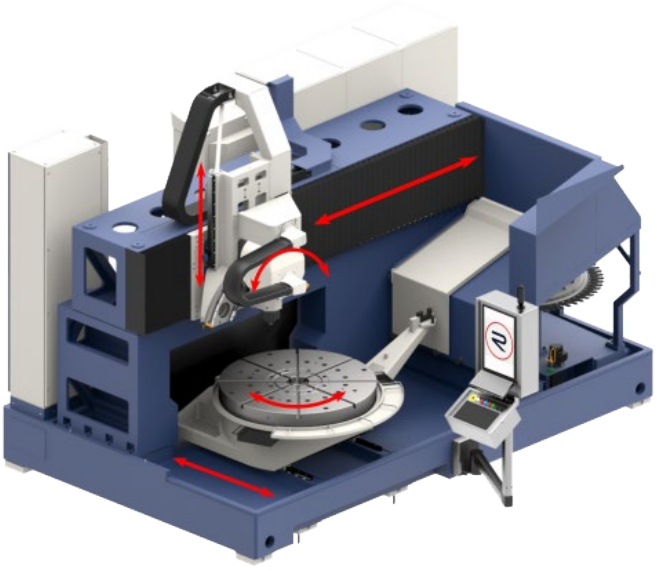
Velvet effect on a tire.

From left to right: Jérome Ricordeau, Business Engineer at RGI France ; Krzysztof Fokow, Maintenance Technician at Michelin; Nicolas Boët, Project Manager at Michelin; Gilles Gouraud, Sales Engineer at NUM France.

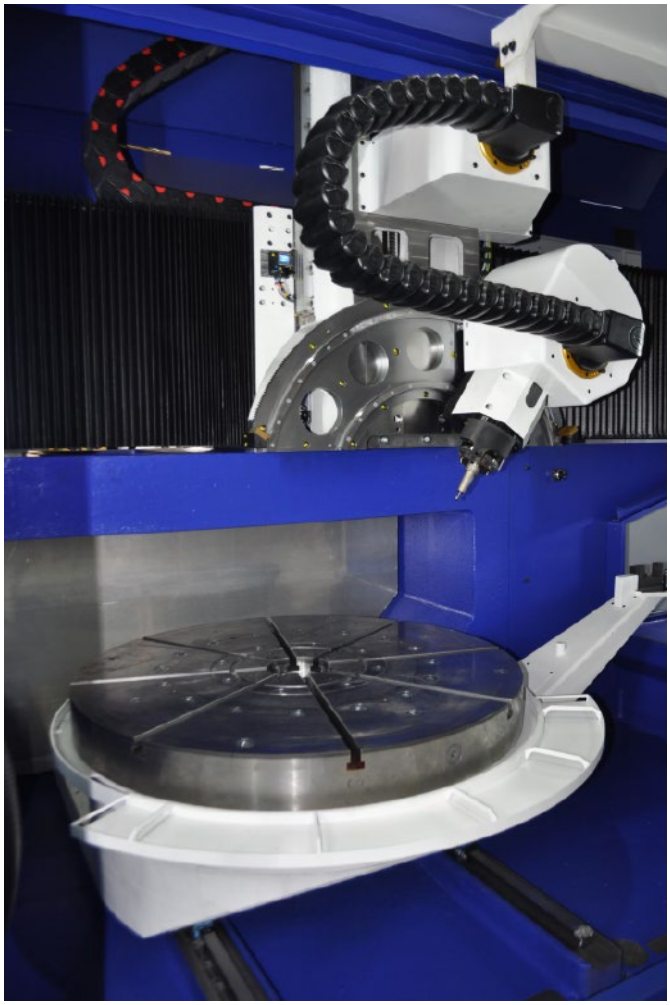
Machine panel with two simultaneous application displays.

tion while improving the service life of guides and bearings. We also note the quality of the drives and an excellent support from NUM for optimizing performance and eliminating parasitic resonances, which is another point for achieving a higher productivity." Finally, in order to maintain this performance throughout the life of the machine, a performance monitoring function during this life cycle, described elsewhere in this issue of NUMinformation, will be implemented to detect potential mechanical problems before they have any adverse impact.

This example of partnership between the customer, the manufacturer and NUM is not unique. It corresponds well to the company's philosophy of providing everyone with the necessary tools to make the best of their specific advantages. Do not hesitate to talk to your correspondents, they will be very happy to assist you in this way.



Machine axis overview.



Close up view of the engraving head.

Seventy tons overhead

We do not always consider the wear and tear that wheels and axles of rolling stock, used on trains or trams, are exposed to. Sliding on the leaves in autumn, emergency braking, shocks – all these remain in memory in the metal of the axles. And yet this is the first safety component, which is why these elements are subject to very careful attention and maintenance.

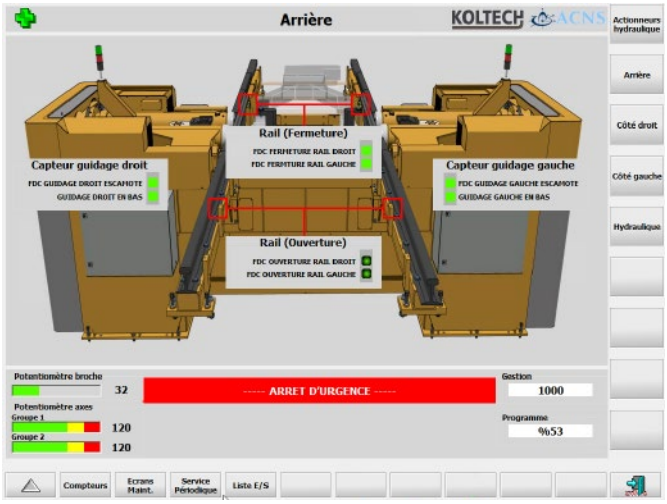
To ensure this maintenance, the SNCF technicentre in Noisy le Sec, northeast of Paris, has just equipped itself with a new Koltech underfloor wheelset lathe, the special feature of which is that it can process tram-trains. Indeed, with the extension of cities, tramways are required to use not only the urban network but also the nearby rail network and there are now vehicles capable of running on both types of track. They are commonly referred to as tram-trains and the new T4 tramway to the north-east of Paris is one of them.

An underfloor wheelset lathe is always an impressive machine. Imagine being in a deep niche and the seventy tons of a tramway, or the four hundred tons of a TGV (High Speed Train), slowly pass over you, and stop just a little forward to position an axle above four rollers; then a little more than one meter of rails disappear, this part of the train being held only by the rollers that will drive the axle in rotation to bring it back into condition.

A machining sequence begins with the identification of the axle and wheel profile, after which the cycle will measure the diameter of each wheel and their spacing. The operator can then access certain parameters to optimize them and will define the machining sequence to bring the profile back within the desired tolerance. The production of the profile requires a high degree of precision. The rolling stock wheels have a slightly conical profile and a flange on one side to keep them on the track. There is also a small amount of axial play. When the rolling stock is travelling around a bend in the track, the slope of the profile means that the two wheels on an axle present slightly different diameters to the track surface, and are therefore able to accommodate the required speed difference. This feature also allows a slight tolerance on the difference in diameters and therefore the optimization of material removal. A machining operation consists of several phases, the operator can choose the execution order, but the application ensures that all phases have been successfully executed before the operation can be considered complete.

SNCF has long trusted NUM for its equipment. During the retrofits it carried out, the SNCF expertise center defined an operating mode and ergonomics perfectly adapted to this type of machining. This operating mode, originally developed on NUM's 1060 CNC system, is found on several dozen machines distributed in the maintenance workshops. It has, of course, evolved to take into account the increased performance of control systems, but the philosophy remains unchanged.

View of the operator's spot just after tramway positioning.



Operation: Main sensors locations and status.

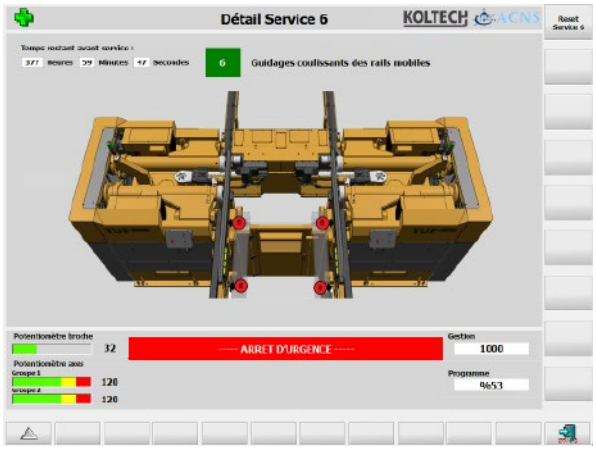
The machine we are interested in today is the result of cooperation between SNCF, the Polish manufacturer KOLTECH and the engineering and manufacturing company ACNS, which has been supporting KOLTECH on the French market since 2014. To this end, ACNS, which has been a long-standing NUM partner, has chosen a Flexium+ 68 together with SNCF. Mr. Hendriksen, its Director, explains why: "One of the advantages of NUM products is their adaptability and ease of integration, our engineers can quickly master the different aspects and NUM support is always available; moreover, the compatibility of the part programs with previous systems is a major asset for our customers."

The equipment includes four BPH155 motors for right and left machining carriages, four AMS132 10kW spindle motors driven by MDLUX 130A drives with STOX (Safe Torque Off) function, all connected to a regenerative power supply and completed by four measurement inputs on EtherCAT for determining the diameter and center distance of the wheels. The NUMSafe safety PLC monitors the whole system. The man-machine interface is provided by an MP04 machine console and a 15" FS152 screen console which presents the pages of the operating mode defined by the SNCF. This ergonomic user interface has been developed in C and communicates with the CNC and PLC via FXServer, the standard NUM interface is not displayed in this case.

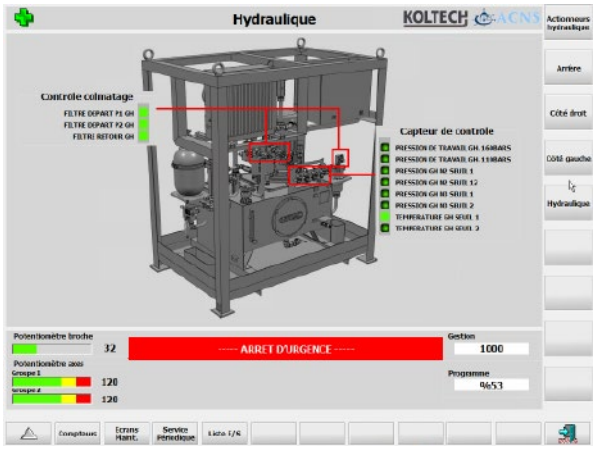
One of the difficulties that can be encountered with these kinds of lathes concerns the rotation of the axle that will be machined. As it remains in place on the train it cannot be clamped and is only frictionally driven by four rollers. It is therefore necessary to perfectly synchronize the speeds of the two rollers of the same wheel and to take into account the difference in diameter for the synchronization between the right and left wheels. Thanks to the precision of the MDLUX digital drives, it was not necessary to perform torque synchronization which could generate slippages. The drives of the right side receive the same speed setpoint and those on the left side receive a value proportional to the diameter ratio. This solution is perfectly satisfactory.

Mr. Kleiber, the SNCF expert in wheelset lathes who carried out the first retrofits and defined the ergonomics and operating procedures of these machines, tells us: "I also appreciate the ease of integration of NUM products and then we always have a contact person for after-sales service or development. We are very satisfied with this cooperation and the performance of the products, the integration of new functionalities is planned."

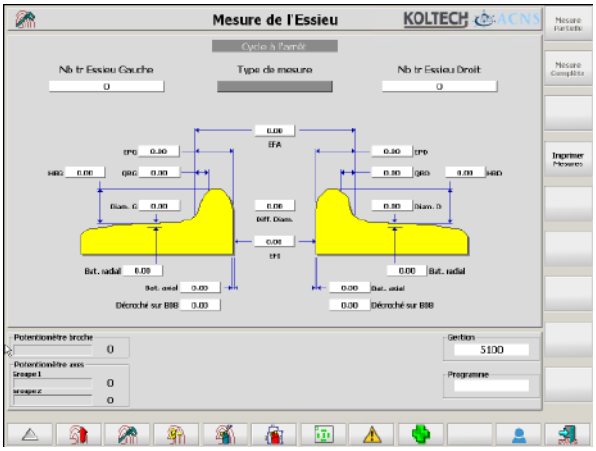
Simplicity, performance, proximity, these qualifiers are often mentioned as part of NUM's assets. Thanks to them, partnerships are established that will allow you to highlight your competitive advantages. Do not hesitate to discuss with your correspondents so that you too can benefit.



Maintenance: Lubrication points.



Diagnostic HMI Hydraulic maintenance.



An example of a page from the Man-Machine interface Axle measurement.

Under the machine, from left to right: Mr. Hendriksen and Mr. Duchamp (ACNS), Mr. Kleiber (SNCF Expert), Mr. Barsanti (NUM). In the back: Mr. Schaller (SNCF).

Conquering new markets with modern 5-axis rod machining center

elumatec

elumatec AG is the world market leader in the manufacture of machines for machining aluminum, plastic and steel profiles. With an extensive product range, the company covers the entire user spectrum from small craftsmen to industrial profile processors. Tailor-made and modular machine concepts enable flexible and individual industry solutions for all customer groups at all times. The company, headquartered in Mühlacker, Swabia (between Karlsruhe and Stuttgart, Germany), was founded in 1928, has subsidiaries and dealers in more than 50 countries and, with more than 700 employees worldwide, generated consolidated sales of over 130 million euros in 2018.

elumatec has made a name for itself with a wide variety of machines for SME trading companies, such as smaller rod machining centers, double miter saws, corner jointing presses, milling machines and 4-axis machining centers. The cornerstone of the company's success was laid in the 1960s, when the company began to devote itself consistently to profile machining of a wide variety of materials.

In 2006 elumatec launched the SBZ 151 rod machining center for the flexible and efficient machining of aluminum and thin-walled steel profiles. With it, the company also ventured into the field of machines for industrial companies for the first time – and promptly landed a huge success! Today the machining centers are used in the construction of windows, facades, trains, mountain railways, car bodies, ship masts, truck superstructures, motorcycles, lights, football goalposts, office furniture, etc. They are also used in the manufacture of materials for such iconic buildings as the Louvre in Abu Dhabi and the highest building in South Korea, the Lotte World Tower (with a height of 555 meters this is currently ranked fifth in the world ranking of the highest buildings). Both of these buildings incorporate material produced on SBZ 151 machines utilizing Flexium+ control from NUM.

The collaboration between elumatec and NUM started in 2002 when a prototype machine was developed. Components from different manufacturers were compared and analyzed over a period of approximately one year. In the end "no other controller achieved a better performance than the Axium controller from NUM", says Oliver Guigas, software developer at elumatec AG. The requirement for such a machine type came from customers in the market – who desired an internationally known control system.

In the meantime, the rod machining center has been further developed and upgraded both mechanically and in terms of control technology. The Flexium+ 68 replaced an Axium system in 2015 and is now the exclusive controller for this type of machine. According to Stefan Schweikert, head of electrical design at elumatec AG, "Flexium+ and the integrated safety system offer us something like a 'unique selling point' – we can effectively use many of the features offered by the control system."

Safe CAM (safe cams), for example, is a safety function within the control system. This eliminates the need for external sensors and allows safe working areas to be defined. In the SBZ151, in combination with SLS (safe, reduced speed), a clear increase in

The SBZ 151 Edition 90 rod machining center from elumatec.

FS154i P2 control panel (with SSD and Quad-core processor) and MP06 machine control panel from NUM.

efficiency can be achieved by simultaneous machining and loading. Thanks to the openness of the NUM control system, customer-specific requirements can also be implemented very quickly. By relocating functions previously implemented with hardware to the software, a very high degree of flexibility can be achieved by means of modular programming.

"Thanks to the 'Single Cable' motors, the wiring costs are much lower than in the past. This was a 'quantum leap' and ultimately saves time and money", adds Werner Münsinger, electrical designer at elumatec AG. The 'Single Cable' motors also made it possible to reduce the susceptibility to faults compared to earlier versions. "Regular technical meetings also ensure the synchronization of elumatec and NUM. The topics are always very well prepared, which results in a very high quality and competent solution finding for elumatec", adds Mr. Felix Schlachter, head of software development at elumatec AG.

SBZ 151 Edition 90

The 5-axis SBZ 151 rod machining center was reworked to mark the 90th anniversary of elumatec and is now available as 'Edition 90'. This machine is characterized by revised clamps, new computer generation, optimized control and regulator technology as well as certified, drive-integrated safety functions and is controlled by a Flexium+ 68 CNC system from NUM.

The SBZ 151 Edition 90 can be ordered as standard with the following machining lengths:

- 6.0m
- 7.3m
- 9.0m
- 10.3m
- 12.0m
- 13.3m
- 15.0m
- 16.3m

Longer versions are possible on request thanks to the modular concept.

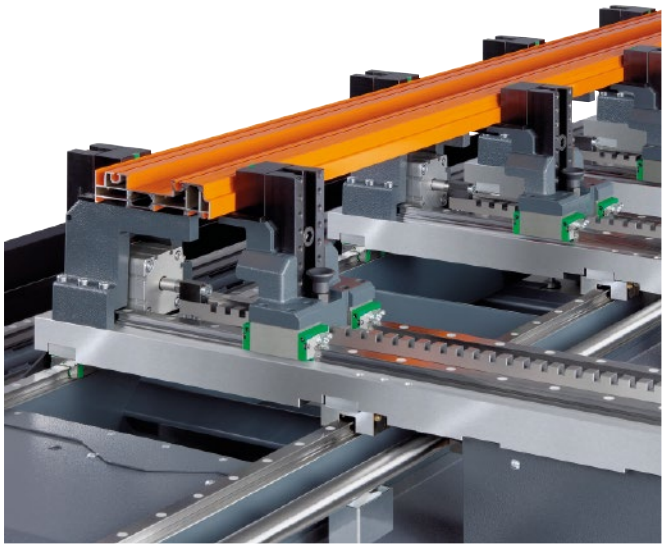
- The machining lengths mentioned above correspond to the respective travel path of the X axis, at a maximum travel speed of 66 m/min.
- The positioning accuracy of the X, Y and Z axes is +/- 0.1 mm/m, that of the A and C axes +/- 0.1°.
- Maximum spindle speed: 24,000 1/min
- Spindle power: 20 kW S1
- Tool changer right: 20 tool places (13 standard and 7 special tools)
- Tool changer left: one saw blade with diameter 500 mm (400 mm optional).
- Maximum cutter diameter: 100 mm
- Autonomous clamp positioning with absolute measuring system.
- Two separate machining zones allow machining in pendulum mode. Access protection with safety fences and light barriers.
- Certified, drive-integrated safety functions
  - STO = Safe Torque Off
  - SS2 = Safe Stop 2
  - SLS = Safely Limited Speed
  - SCA = Safe CAMs

Detailed view of control cabinet: Flexium+ 68 CNC system with NUMDrive X with integrated safety solution.

Article continues on the following double page →

Conquering new markets with modern 5-axis rod machining center

elumatec



Detailed views of the SBZ 151 Edition 90.

From right to left: Mr. Stefan Schweikert, head of electrical design at elumatec AG, Mr. Oliver Guigas, software developer and Mr. Werner Münsinger, electrical designer at elumatec AG, Mr. Felix Schlachter, Head of Software Development at elumatec AG and Mr. Christian Unger, Managing Director NUM GmbH.

eluCloud Industry 4.0 Application

With eluCloud, elumatec offers an industry 4.0 solution that provides the user with a wealth of machine and production data in real time. "Especially on our SBZ 151, which fully supports eluCloud, the solution is in high demand and at the pulse of time", says Felix Schlachter. The advantages are obvious; at any time and theoretically from anywhere, it is possible to see what is currently happening in production or what has happened in production – for example in a certain shift – thanks to individually personalizable reports. Shift supervisors like to use the application frequently. Mr. Schlachter adds: "We are increasingly receiving requests from industry for machine data acquisition, including features such as spindle running times, capacity utilization monitoring, and machine uptime and downtime."

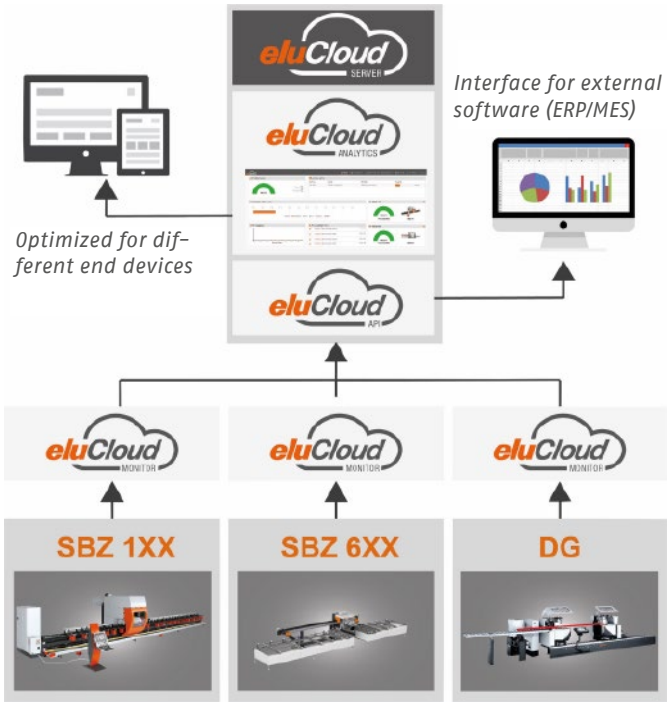
The GUI (graphical user interface) looks very modern, is modular and can be operated intuitively. Reports can be compiled according to individual requirements using simple drag & drop actions. Predefined Excel templates can be imported into the reporting tool via an import function. A filter can be used to limit the data collection, e.g. to a specific shift, machine or weekday.

eluCloud is the joint solution of elumatec and elusoft (a subsidiary company that is based in Dettenhausen, Baden-Württemberg) for machine data acquisition and analysis of this data.

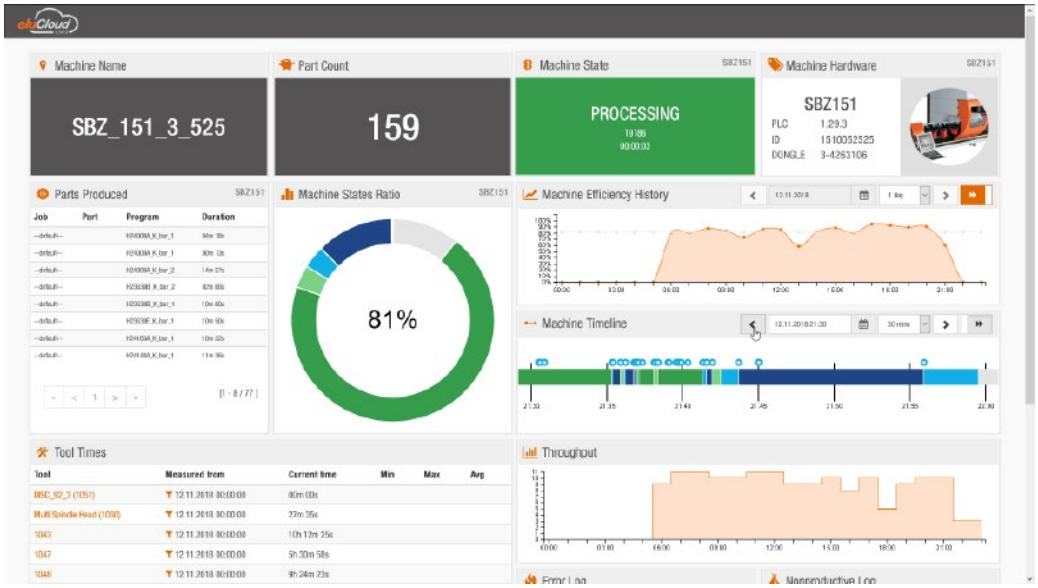
The software consists of four modules:

- eluCloud-Monitor
  Acquisition of machine data
- eluCloud-Server
  Storage and preparation of data for evaluation
- eluCloud-Analytics
  Analysis of the data and detailed evaluation
- eluCloud-API
  Interface to the machine data pool and already created analyses

"The switch to Flexium+ came at just the right time. Thanks to the FXServer provided by Flexium+, connecting the SBZ 151 to the eluCloud was relatively simple. Our cloud solution generates added value for the customer in which productivity increases and process optimizations can be achieved", concludes Mr. Felix Schlachter.



eluCloud: Machine data acquisition for versatile, personalizable data analysis.



Screenshot of the eluCloud application: Machine statistics of an SBZ 151.

NUM assists development of innovative abrasive waterjet cutting system

With the help of NUM, a start-up company of Chemnitz Technical University is bringing abrasive waterjet cutting with suspension technology to the CNC machine tool market. Offering higher efficiency and quality than conventional waterjet cutters, the technology looks set to position itself as a cold cutting process between laser and injector waterjet cutting. A flexible and open control system from NUM provides the optimum conditions for abrasive beam generation – a cutting technology that until now has not been seen in industrial manufacturing applications.

"Our goal was to build a compact abrasive waterjet cutting system based on suspension technology that is significantly more powerful and at the same time more efficient than a conventional waterjet cutting machine with injector technology. We have succeeded", says Markus Dittrich, co-founder and managing director of the NOVAJET start-up and currently still a research associate at the Institute for Machine Tools and Production Processes (IWP) at Chemnitz Technical University. The aim is to develop a fine blasting system that focuses on beam diameters smaller than 0.4 mm and is optimized for the production of small precision components from difficult-to-machine materials such as ceramics or tungsten carbide. With this development, the founders have broken new ground in technology – a machine tool of this kind does not yet exist and the control system is currently still being developed. Due to the fact that optimizations and hardware changes are quite common during the course of setting up any prototype system, the founders opted for a flexible and open NUM control system.

From injector to suspension technology

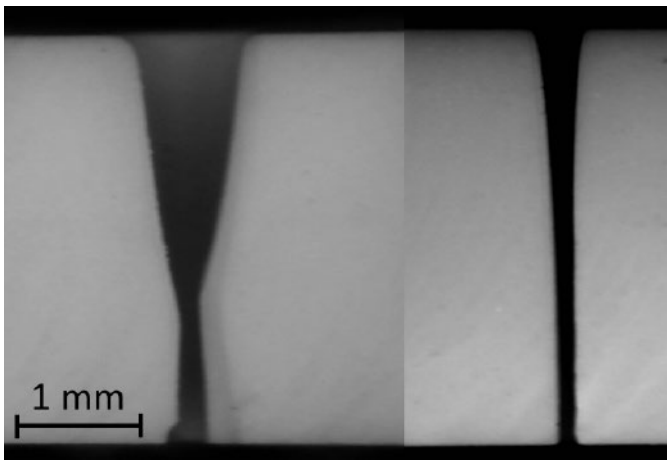
It began with a research project on 3D abrasive waterjet cutting with jet diameters of about 0.3 mm. "We have found that the cutting power of the jet with conventional injector technology decreases exponentially the smaller we make the jet diameter. In the end, we could only cut thin sheet metal", explains Markus Dittrich and provides the technical explanation at the same time: In conventional abrasive water jet systems, the water is brought to a pressure of between 3,000 and 6,000 bar and fed through a water nozzle into a mixing chamber. This creates a vacuum that sucks dry abrasive from a storage container and carries it along with the water jet. "Accelerating the abrasive alone consumes around 30 percent of the energy originally introduced into the water", says Dittrich. In addition, this type of mixing process introduces a lot of air into the jet and mainly distributes the abrasive around the circumference of the jet. Both reduce the removal rate.

An alternative is suspension technology, an abrasive water jet cutting technology that has so far been used more for coarse applications, for example in power plant dismantling. In principle, water and abrasive are mixed to form a suspension when at rest, pressurized in a high-pressure container, fed to the cutting nozzle and formed into a high-speed cutting jet. That this technology has the potential to be used on a machine tool has already been proven in a follow-up project at Chemnitz Technical University with industrial project partners ANT AG and ATECH GmbH. "Performance increases of up to 340 percent compared to the injector process are possible", Dittrich summarizes the result. In practical terms: with a pressure of 1,400 bar and otherwise the same conditions, the tests showed that cutting was more than three times faster and more precise than with the injector technology at 3,000 bar. And also in ceramics. This is also due to the jet quality, because the jet is air-free and the abrasive is distributed in the jet core. Even the typical water jet angle error is significantly smaller during suspension cutting and jet diameters of 0.2 mm have already been achieved in tests.

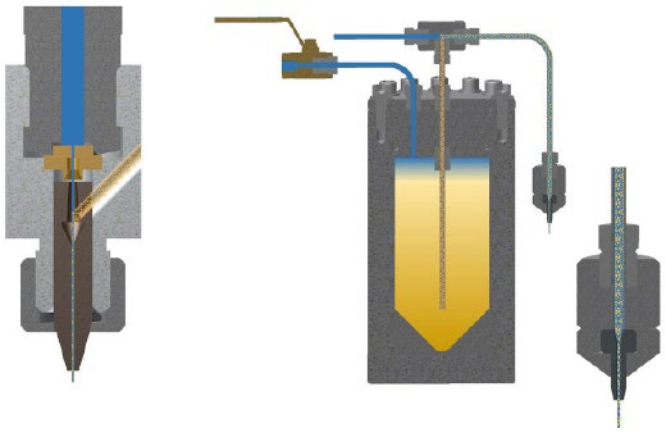
Machine for industry

The system is about to be further optimized. The plant is very compact in design and after the first expansion stages all components – from the high-pressure pump to the high-pressure tank to the worktable and cutting system – are housed in a single frame behind a common cladding. The machine operates at 1,500 bar water pressure, and a 350 mm x 510 mm worktable is sufficient for precision manufacturing of small parts. The high-pressure tank is designed in such a way that with a single filling and a jet diameter of 0.4 mm, around 20 minutes of pure cutting time can be achieved. Then, in the final development stage, the container will be automatically unloaded, refilled and pressurized again. In the high-pressure range, however, the system is more complicated than the principle of suspension technology would suggest. For example, a main flow path with pure water from the high-pressure pump is coupled with a secondary flow path for the suspension from the high-pressure tank. However, the homogeneous composition of the jet requires more complex control

Working area of the NOVAJET waterjet cutting system.



Comparison of the joints cut with the same pump performance in injector technology (left) and suspension technology (right) in aluminium oxide.



In injector technology, water is fed under pressure through a nozzle into a mixing chamber where it generates a vacuum that sucks in and accelerates abrasive. In suspension technology, water and abrasive are mixed and then pressurized together.

technology. "We have far more than a handful of valves that have to be matched to each other. There is also an integrated high-pressure pump. And we have process monitoring systems that monitor both the jet and the abrasive mixture itself as well as the high-pressure tank", says Markus Dittrich. These monitoring systems do not exist in injector technology and consequently there is no ready-made control system that converts the signals from the monitoring systems into regulating inputs for the entire system.

"For the selection of the control system, it was very important to us that everything from the low-pressure water at the beginning to the axis control and the automatic filling up to the cutting head at the end runs via a control system. In the worst case, the cutting head monitoring provides a signal that requires readjustment at the high-pressure pump. Establishing these links in the background is very relevant for our technology", says Markus Dittrich.

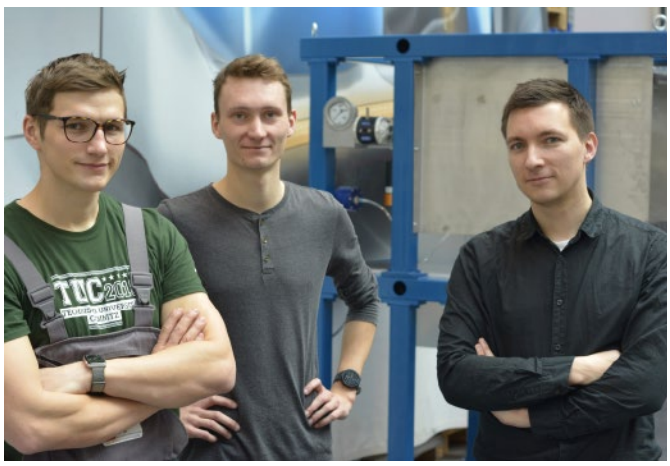
NOVAJET elected to use NUM's CNC platform for several reasons. Firstly, NUM controls are standard in the grinding machines in the targeted market of the high-performance materials industry; secondly, there are already waterjet cutting systems with NUM controls on the market, which means that appropriately configured components are available for waterjet cutting; and thirdly, NUM supplies a complete package from the PC to the panel and the CNC control to the drives and motors. Not forgetting the support of engineering services.

Positive experience with commissioning

The decision to choose NUM proved to be the right one, even during the start-up phase. A NUM employee spent two days in Chemnitz to commission the motors, so that the drives were quickly installed. With the knowledge gained from a one-week training course, the founders were able to complete the remaining commissioning within 14 days on their own. "However, we always had the option of telephone support. The colleagues then logged on to the system using TeamViewer. We were able to eliminate all difficulties relatively easily", says Stefan Seidel, the co-founder responsible for the technical part. And during the construction phase of the plant, the programming of the reaction cycles also proved to be uncomplicated. However, the focus is on the option of direct access to the NC of the control system.

"During commissioning, we kept noticing details that we needed to change or adapt", says Dittrich. "Then, of course, we also had to adapt the control. If we had been forced to rely on a controller manufacturer who charged for every change or who required large iteration loops, then the project would have been up a creek without a paddle", sums up Markus Dittrich.

Design draft of the abrasive water jet cutting system with suspension technology.



The start-up team, from right to left: Markus Dittrich, Stefan Seidel and Stephan Richter.

Smart software for the combination of computer science and production

innovative computer aided manufacturing ag/sa

Much of what is today understood by "Industry 4.0" has, on the whole, been lived, developed and distributed at Innovative CAM AG for decades, with the exception of cloud and similar online services, which of course did not exist at the time. The name of the company is also very much part of the program: "CAM" stands for "Computer Aided Manufacturing" and this is exactly what the company in Nidau in the canton of Bern (Switzerland) has always been dedicated to. The focus is on the combination of information technology and production. Today, its business activities are based on three pillars: SpaceClaim, Esprit and iCAMNet.

SpaceClaim from ANSYS is a versatile 3D modeling tool that can be used to create and edit exact 3D data across departments. A major advantage of this software is its simplicity of use, so that even non-experts can create 3D models with little effort. **Esprit** by DP Technology is widely used and well established in the industry as CAM software that allows programming of any machine tool, including 2 to 5 axis milling and drilling, 2 to 22 axis turning, 2 to 5 axis wire EDM and multitasking mill-turn machines with and without a B axis.

Combined, these two pillars account for around 50% of Innovative CAM AG's sales. The company acts as a reseller and offers support and training. With knowledge built up over many years, it comes as no surprise that the Esprit program has achieved the highest sales figures in the world seven times in around 20 years – and this in the rather small Swiss market!

The other half of the company's turnover is generated by the third main pillar: **iCAMNet**. This software was launched on the market in 2010; it was developed by Innovative CAM AG itself and brings all the services that arise in a production environment to a common denominator. iCAMNet includes DNCNet, which on the one hand automatically checks NC programs for changes, and on the other hand manages and secures all part-relevant documents. The consequences are a simplification of the work, as well as a reduction of rejects. All transactions and changes are logged, ensuring complete traceability. iCAMNet is thus a holistic instrument for recording the overall effectiveness of the manufacturing system, which can also be used across several generations of CNC machines (with and without PCs) from different manufacturers.

Terminal on an analog CNC machine to connect it to iCAMNet.

The beginnings of this workshop monitoring can thus be described as an "early version of industry 4.0". Today, cloud solutions are of course also available. Daniel Vez, Managing Director of Innovative CAM AG, comments: "The industry has long been calling for an Internet connection. However, we are currently seeing an about-face: many of our customers explicitly do not want to connect their machines to the Internet for security reasons." The machines are therefore not directly connected to the Internet, but communicate with a dedicated server. The server itself may or may not be connected to the internet, depending on the configuration and customer requirements.

In the workshop, all machine data and conditions that are important for the respective customer are monitored and recorded. It is thus possible to see live – or later in report form – how the individual machines perform. The following are just a few examples of evaluation – the list could of course be extended extensively:

- Which machine produces which workpiece?
- Which tool will soon be blunt and will have to be replaced or reground?
- Which machine is stationary – and why (error, maintenance, no material, doors open, ...)?
- Which batch is being processed (traceability, e.g. for the medical industry)?
- How long did machine XYZ stand still compared to the other machines?
- How do the individual shifts perform, e.g. are there differences day/night?
- ...

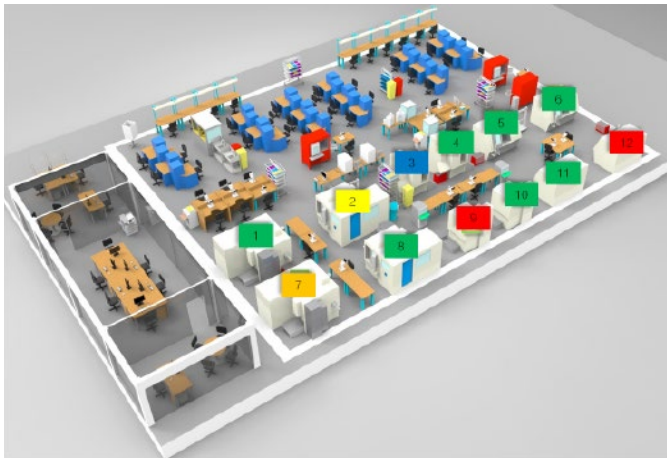
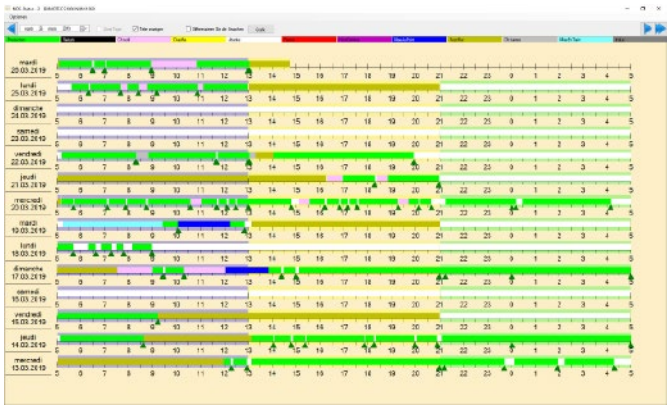
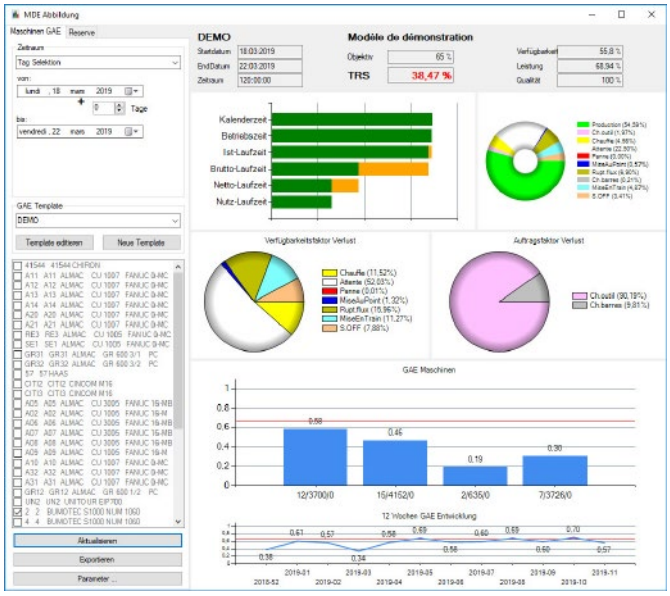


Illustration of the production overview / control station of the production machines (live).

Machine No.	Condition
1	Production
2	Maintenance
3	Setup
4	Production
5	Production
6	Production

Machine No.	Condition
7	Turned off
8	Production
9	Not running
10	Production
11	Production
12	Not running





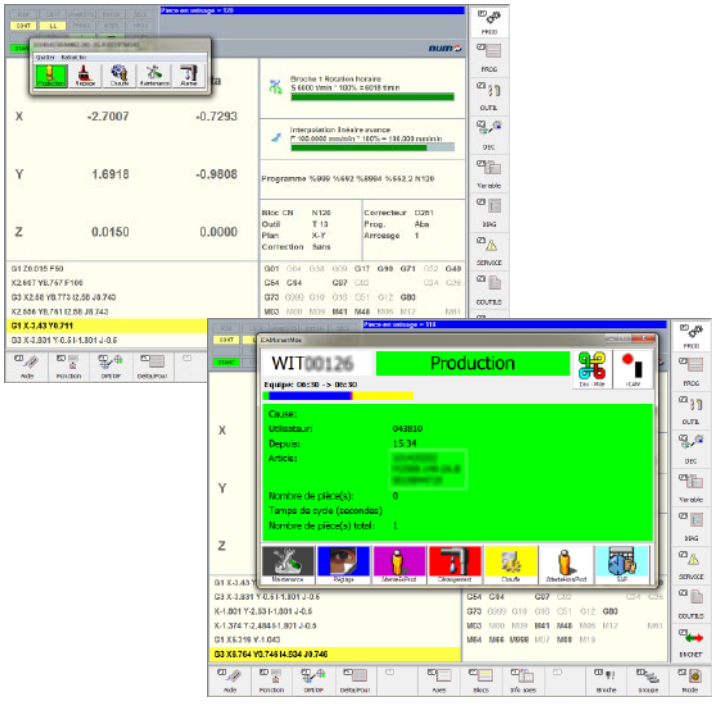
Examples of production evaluations.

In the following cases iCAMNet offers manufacturer- and generation-spanning advantages:

- *A machine park consists of digital and analog-controlled CNC machines.* A specially developed terminal also allows analog machines to be integrated into iCAMNet and evaluated together with the newer machines in a workshop monitoring system.
- *A machine park consists of machines from various manufacturers.* As a platform-independent supplier, the machines can be connected to iCAMNet via predefined interfaces, which enables homogeneous monitoring.

The goal is clear: the optimization of all workshop processes. Interfaces to ERP systems, such as SAP, as well as alarm options (SMS, e-mail, etc.) are also available for this purpose.

The first cooperation between Innovative CAM AG and NUM AG dates back about 20 years and involved a transfer machine. Mr. Vez remembers: "The cooperation was very pleasant even back then. For example, if you had a problem or a question about the NUM 760 controller, you could get help quickly and easily from the NUM service." For a Swiss customer, the two companies were able to work together to develop a tailor-made solution on which iCAMNet was integrated into Flexium$^+$'s HMI, a prime example of the benefits of an adaptable, open system such as NUM offers.



Integration of iCAMNet in NUM HMI in 2 variants.

Innovative CAM AG was founded in April 1991 as a spin-off from the Biel-based machine manufacturer Mikron, which gave up the "Software Engineering" division (Mikron later became Georg Fischer AG). Today, the team around Managing Director Daniel Vez consists of 15 employees at three locations. The headquarters are located in Nidau near Biel. The latter, along with Le Locle, Grenchen and La Chaux-de-Fonds, is one of the most important locations in the Swiss watch industry. Innovative CAM AG generates around 40 percent of its turnover with this industry. In addition, the international customer base includes various well-known companies in the machine industry and medical technology sectors.

Innovative CAM AG and Swissmechanic Training AG started a cooperation in 2017 under the motto "Mechanical showcase workshop, from basic training to application of industry 4.0". The goals are the focused training and further education of employees and specialists as well as the strengthening of the competitiveness of the industry under given, currency-related difficult conditions.

Industry 4.0 – TechniControl and NUM implement link between ERP system and production

Industry 4.0 is not new territory for TechniControl and NUM. TechniControl stands for top technology in process automation and production control, NUM represents CNC high-end applications. With these qualified prerequisites, a connection to an ERP system with fully automatic data generation of the ISO code and subsequent transmission (NUM IsoTrans) to the CNC machine could be realized. At the same time, the processing sequence is optimized, production speed is increased and waiting times are noticeably reduced.

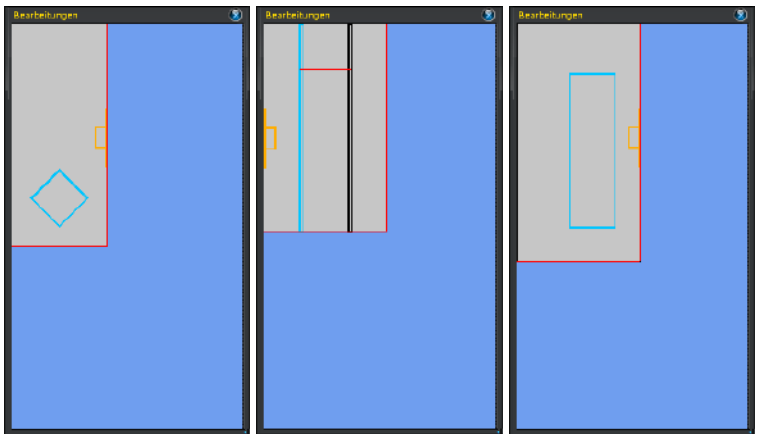
TechniControl Informatik GmbH offers complete systems as well as individual solutions and services for the manufacturing industry. For almost 20 years, TechniControl and its employees have been controlling, optimizing and visualizing industrial processes at SCADA level. The company is based in Schmalenberg, south of Kaiserslautern (Germany). Many years of experience and the use of sophisticated software modules enable the developers to implement even complex special solutions in the shortest possible time. The aim of the company is to offer an efficient and powerful software structure for the realization of integrated production processes, fully automatically down to batch sizes of one.

TechniControl and NUM have implemented the link between ERP system and CNC machine. The automatic processing of the data records takes place in the background while the machine is running. The individual machining operations on the current workpiece are graphically displayed to the operator by the control system software. The detailed sequence takes place as follows: From the data record for a production order, TechniControl generates a job file for each individual part directly from the order pool of the ERP system and transfers it just-in-time to the IPC (industrial PC) of the machine. This job file is used to generate the ISO code for the NUM Flexium+ machine control system. The job file of the control system is analyzed fully automatically. In addition, an optimized processing sequence is calculated from which the path-optimized ISO program code is generated. All processing steps can be flexibly combined by four defined basic geometries. The ISO code for the CNC machine is generated using NUM's newly developed IsoTrans program and transferred from the postprocessor to the machine control via FXServer. One area where this approach comes into play is, for example, a waterjet cutting machine from STM Stein-Moser GmbH in Austria, which cuts insulation materials precisely and fully automatically. This is a 5-axis waterjet cutting machine with a NUM Flexium+ 68 CNC control and NUM industrial PC.

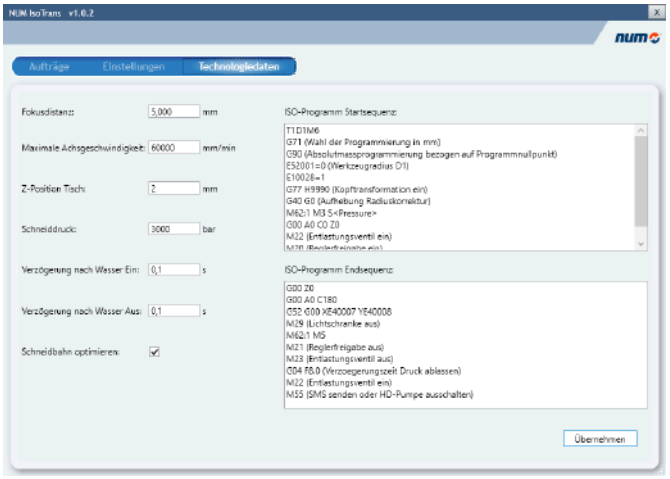
In the further processing process, the cut insulating and insulating materials are further processed together with other individual parts, some of which are manufactured in different production plants and different machines. Therefore, the accuracy of the machined workpieces and a fully automatic process for further processing are of utmost importance. On the basis of the order from the ERP system, TechniControl generates a unique ID number for quality assurance reasons and to ensure complete traceability of the product and applies it as a label to the individual parts.

Waterjet cutting machine from Stein-Moser.

The web optimization function has, among other things, a special function for avoiding double cuts and generates a continuous cutting path. Unnecessary cuts and superfluous repositioning of the cutting nozzle can thus be avoided, which guarantees an enormous reduction in processing time. Depending on the configuration and requirements, the optimum cutting path can be individually selected – down to a batch size of one – automatically using the NUM IsoTrans application. This modern communi-

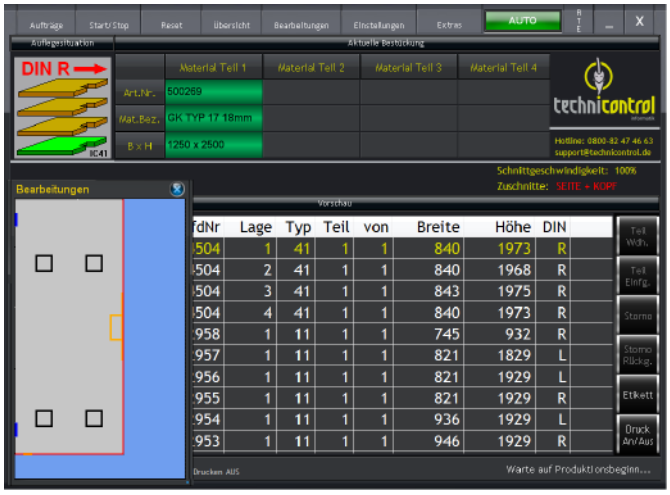


Different machining processes in the manufacturing process with different cutting paths.



Screenshot of the NUM IsoTrans technology data.

Status messages of the current process steps via Balloon Tips.



Screenshot of TechniControl data set from ERP system.

cation technology networks the entire production process. There are no waiting times for the machine operator and no loss of time in the entire production process.

NUM IsoTrans monitors each workpiece from start to finish and sends feedback on the status of the job to the PCS (Process Control System). In the event of an error during machining, all messages that have occurred on the machine are sent to the PCS. The PCS uses this information to inform the operator of production progress and to enable an uninterrupted workflow. No user interface is visible in the production mode of NUM IsoTrans. The connection status is indicated by a tray symbol and the machine operator receives status messages of the current process steps via so-called "Balloon Tips". The user interface can be opened via the tray icon and displays information about the immediately processed order as well as the next order that has already been prepared and, if necessary, transformed. The message history provides an overview of the last processed orders and events. General settings such as required directories, CNC program number etc. can be defined via a settings page. Technology data such as focus distance, maximum axis speed, Z position, cutting pressure and other settings can be defined via an additional tab.

The starting point of the project was the requirement for individual production as well as the critical analysis and screening of the systems involved in the production process by TechniControl. Subsequently, possible solutions were discussed together with NUM and the project schedule was defined. Due to the open and professional communication, challenges could be overcome quickly and solved in a target-oriented way by both sides. "The performance efficiency of the machine could be significantly increased by optimizing machining", says Stefan Velten, one of the two Managing Directors of TechniControl. Mr. Viktor Horn, second Managing Director of TechniControl, adds praisingly: "One highlight was the commissioning. Instead of the planned three days, commissioning could be carried out within half a day. A true example of commissioning."

From right to left: Mr. Viktor Horn and Mr. Stefan Velten, Managing Directors of TechniControl with Daniel Uršič, Head of Application NUM Germany.

NUM helps Taiwanese machine tool company to automate production of involute and cycloidal gears for robotics

CHIEN WEI

NUM is helping the Taiwanese machine tool company Chien Wei Precise Technology to develop innovative CNC grinding machines for manufacturing specialist gears used in robotics applications. Based entirely on NUM's latest-generation Flexium+ 68 CNC platform, Chien Wei's new machines are designed to speed the production of both involute and cycloidal profile precision gears. They are believed to be the first gear grinding machines on the market that are capable of handling both types of gear profile. There are two versions of the grinding machine, one for internal gears, the other for external gears.

Founded in 1981, Chien Wei Precise Technology Co., Ltd is based in Fengshan District in southern Kaohsiung, Taiwan. The company initially specialised in precision machine tools such as vertical grinders, jig grinders and machining centres, together with co-ordinate measuring machines (CMMs). Over time, it also diversified into robotic automation systems.

Robotic systems typically use either planetary gearboxes equipped with involute gears, or cycloid drives based on a combination of a reduced epitrochoid rotor and a cycloid stator. While planetary gearboxes have been around for a long time and enjoy extensive use, cycloid drives have far fewer moving parts and offer a more efficient means of achieving extremely high reduction rates. A speed reducer with a ratio of 200:1 would typically need a chain of three planetary gear boxes with twelve moving involute gears. The same reduction ratio could be achieved with a cycloid drive using one stator and one rotor. However, cycloid gears are notoriously difficult and expensive to manufacture.

In 2015, Chien Wei decided to bring gear manufacturing in-house, by developing its own gear grinding machine. By producing its own gearboxes the company could control quality, shorten lead times and reduce costs. It would also enable it to sell gearboxes to machine builders – and possibly the machines themselves to gear manufacturers.

Chien Wei initially based its gear grinding machine on a Fanuc series oi-MF CNC system, which it uses for other machine tools, together with Mastercam CAD/CAM software and its own CMM. But it soon became apparent that the profile complexity of cycloidal gears meant that CMM data was inadequate for controlling the manufacturing process. Another major disadvantage was that customers wishing to purchase the machines would also need to invest in an expensive CAD/CAM system and extra personnel.

According to Chien Wei's President, Mr Lee, "We quickly decided that what we needed was a CNC system that fully supported gear grinding from the outset, so that our customers could simply input the parameters of the gear they wanted, with the CNC then controlling all aspects of the machine's dressing and grinding processes in real-time. NUM was an obvious choice, because of its proven expertise in CNC gear grinding applications. The company was also willing to collaborate in the joint development of the CNC system, which includes an application-specific HMI (human-machine interface) and various dedicated control functions."

The new generation of Chien Wei's gear grinders together with NUM's new profile grinding technology now provides the ability and flexibility to manufacture both cycloid and involute gears on the same machine.

Adrian Kiener, CSO Asia and Managing Director of NUM Taiwan, points out that this application highlights the importance of NUM's decentralised support strategy. "By providing direct access to the CNC experts and extensive development facilities we have here in Taiwan, as well as those in many other countries around the world, we are able to provide our customers with a very fast response service that helps them shorten their time-to-market significantly. In combination with the knowledge and experience

Chien Wei's new gear grinding machine is based entirely on NUM's latest-generation Flexium+ 68 CNC platform.

of our gear product group in Switzerland, this led to the complete package that NUM is providing. It includes the user interface, technology and calculations, as well as all the NC cycles."

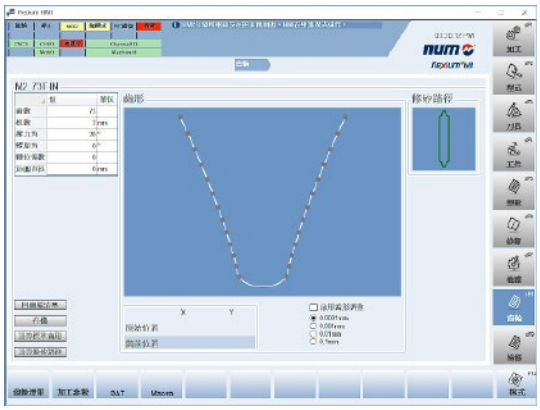
Chien Wei's internal gear grinder is a 9-axis machine. The work piece table is mounted on a linear axis that moves axially towards the grinding wheel, which is belt-driven (due to space constraints inside the gear) and mounted on a vertical axis driven by a linear motor. As the grinding wheel spins, it is driven up and down by the linear axis, while the work piece table moves in continuously. Both flanks of the gear are ground simultaneously. The machine also handles gear dressing. During the dressing cycle, the entire tool head is moved horizontally to the right, and a symmetrical dressing disk moves along the outer shape of the grinding wheel in three sections, right/left flank and tip. Cycloids as well as involute shapes can be dressed.

The external gear grinder is an 8-axis machine. Broadly similar to the internal gear grinder in operational terms, it features a direct drive grinding wheel. Again, like the internal gear grinder, it also handles dressing. However, in this case the shape of the tooth gap can be reduced epitrochoids or involutes.

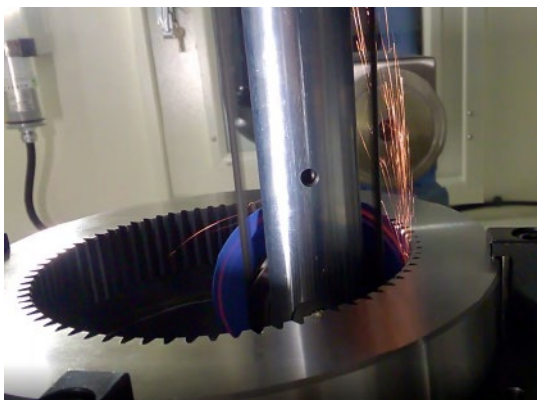
Manual correction of the gear tooth shapes is possible on either machine.

Both machines are controlled by NUM Flexium$^+$ 68 CNC systems, equipped with NUM FS153i touch-sensitive operating panels. The application-specific HMI that has been jointly developed by NUM Taiwan and Chien Wei controls both the grinding and dressing cycles, and allows users to fully specify the required gear profile simply by entering the appropriate parameters. Graphical DXF (Drawing Interchange Format) files can be imported from – and exported to – CAD systems, and the system features a comprehensive database for grinding wheels and work pieces. The NC programs are generated entirely automatically, without any need for operator involvement.

As Johnny Wu, Sales Manager for NUM Taiwan, points out, "NUM's open architecture CNC platforms, combined with the company's willingness to partner with machine builders in developing application-specific solutions, is a key differentiator when it comes to choosing a CNC supplier."



Jointly developed by NUM Taiwan and Chien Wei, the application-specific HMI allows users to fully specify the required gear profile simply by entering the appropriate parameters.



Grinding the involute profile of an internal gear on Chien Wei's new machine.

Reduction gearboxes for robotic applications

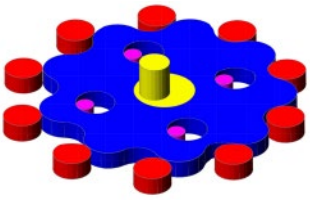
Most robotic systems demand smooth, precise and highly reliable low speed movement. Deriving that movement from a motor that runs optimally at, say, 1000 rpm necessarily involves some form of speed reduction gearbox. Designers typically have a choice of two types of reduction gearbox – planetary drives and cycloid drives.

Planetary drives (or gearboxes) use one sun gear in the middle and planet gears around it, all imbedded into a ring. All of the gears, including the ring, have involute profiles. These types of drives are ubiquitous – they are used in a broad diversity of applications, including cars and other road vehicles, and are produced by virtually every gear manufacturer in the world.

The other type of speed reduction gear drive is the cycloid gear box. It does not have sun and planet gears, so it is not a planetary gear drive. Instead, a cycloid gearbox has one or two external rotors in the middle, and one internal stator as the ring.

Gearboxes that use cycloid gears have very few moving parts and are some of the most efficient and reliable speed reducers available today. Single stator/rotor combinations can accommodate ratios as high as 300:1 and can provide efficiencies in excess of 93 percent.

Chien Wei's latest generation gear grinding machines, incorporating NUM's new profile grinding technology, now enable gear manufacturers to produce both cycloid and involute gears on the same machine. This significantly increases manufacturing flexibility – production can be switched from one type of gear to the other without changing over machines.



Typical cycloid gearbox.

Typical planetary gearbox.

An internal gear after profile grinding.

NUM Flexium+ CNC enables sheet metal laser cutting systems to achieve exceptional accuracy of +/– 10 microns

LEGEND LASER

In collaboration with NUM Taiwan, the Taiwanese machine manufacturer, Legend Laser, Inc., has developed a unique, multi-axis system for the precision cutting of thin sheet metal parts. Based on NUM's latest-generation Flexium+ CNC platform, the system combines high dynamic performance linear motors with a pulsed fibre laser, and is expressly designed for 24/7 operation in a standard production environment.

Founded in 1995, Legend Laser specializes in the design and manufacture of a diverse range of laser marking, micro-machining and micro-tube processing systems. Initially concentrating on the domestic and Chinese markets, the company nowadays serves a worldwide customer base. Its headquarters are located in Xinzhuang District, New Taipei City, in northern Taiwan.

Legend Laser's new SRC-610 precision sheet metal cutter is a 3-axis system with a working area of 1000 x 600 mm and an above-worktable clearance height of 150 mm. It is mounted on a high inertia platform, comprising a large mass solid granite base with a rigid metal frame. To ensure smooth, burr-free cutting and to prevent any heat-induced deformation of thin metal workpieces, the power output of the pulsed fibre laser is fully synchronised to the cutting operation. The laser has a peak output power of 1.5 kW and can cut sheet metal with a thickness of between 20 µm (0.02 mm) and 1000 µm (1 mm), at speeds ranging from a few millimetres per second to a hundred millimetres per second.

Legend Laser's new SRC-610 precision sheet metal laser cutting system is based entirely on NUM's Flexium+ CNC platform.

In addition to sheet metal, the SRC-610 is also suitable for cutting and drilling ceramic and sapphire plate. Thanks to the system's high dynamic performance and continuously variable laser power level, it is capable of exceptional cutting precision – to within just plus/minus 10 microns (10 µm or 0.01 mm).

The X and Y axes of the system – which control the lateral movement of the sheet metal workpiece and the laser cutting head respectively – are capable of very fast acceleration/deceleration and ultra-precise positioning. Both axes employ linear induction motors, driven by NUM's NUMDrive X servo amplifiers.

The gap between the laser cutting head and the workpiece is controlled very accurately, using a unique 'Dynamic Operator' function in NUM's Flexium software.

The Z axis, which controls the vertical height of the laser cutting head and thus the gap between it and the workpiece, uses a NUM BHX series AC brushless servomotor and a NUMDrive X servo amplifier. The gap between laser cutting head and workpiece is controlled very accurately during the entire cutting process, through use of a unique 'Dynamic Operator' (DO) function in NUM's Flexium software. This employs special fast calculation and communication facilities which enable event-driven machine cycles to be integrated into the real-time CNC kernel.

According to Sherman Kuo, President of Legend Laser, NUM is now our CNC provider of choice. Its open architecture CNC platforms simplify system integration; while its willingness to actively collaborate in joint machine development projects, such as this, helps to shorten time to market significantly."

Locally placed technical support is also an important factor, as Adrian Kiener, CSO Asia and Managing Director of NUM Taiwan, points out: "Legend Laser's HQ is only about 150 km from NUM's offices in Taichung City. By offering direct access to the CNC experts and development facilities we have here, as well as in Switzerland and other strategic locations around the world, we can provide a very fast and supportive service to companies in Taiwan and other countries in Asia."

NUM is supplying Legend Laser with a complete CNC solution for its SRC-610 precision sheet metal laser cutting system. In addition to the Flexium+ 8 CNC systems and NUMDrive X servo amplifiers, this includes a custom HMI (Human Machine Interface) that is dedicated to laser cutting, the PLC software, specially developed part program macros and the system commisioning.

Legend Laser's new SRC-610 system can cut complex sheet metal parts to +/- 10 microns accuracy.

From right to left: Mr. Sherman Kuo, President of Legend Laser, Mr. Adrian Kiener, CSO Asia and Managing Director of NUM Taiwan, standing in front of Legend Laser's new SRC-610 precision sheet metal cutting system.

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