num information

JOURNAL FOR CNC–TOTAL SOLUTIONS

num

CNC HighEnd Applications

Editorial
Massimiliano Menegotto and Peter von Rüti

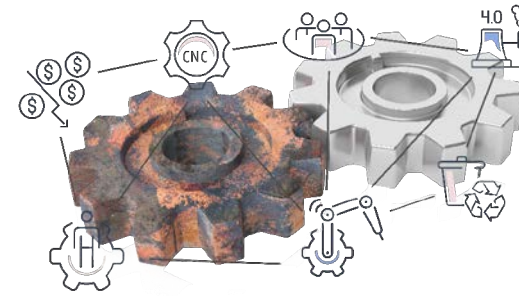## Complete Retrofit Packages in India

In many cases, when high quality machines are getting on in years, their continued use can be achieved through general refurbishment. The casting and mechanical parts of the machine are preserved or refurbished and all other components such as electrics, control technology, etc. are replaced by appropriate modern systems.

In India, there is a very large number of high quality machines that are over 20 years old and the market requires a total solution provider that combines both mechanical and CNC control expertise. In line with our corporate strategy of offering total solutions, NUM is expanding the site in Bangalore into a retrofit center where complete retrofit packages for the Indian market are offered and realized. This means that in addition to the CNC systems, software development and engineering, NUM in India also offers the mechanical retrofit of the machine. In order to be highly efficient, the NUM specialists are concentrating in an initial phase on high-quality gear and tool grinding machines.

Thus, NUM is able to transform a high-quality, outdated machine into a modern, high-performance machine at a comparably low price. Besides the positive financial aspect, compared to a new machine, these retrofits are also ecologically useful.

Opening ceremony production site NUM India April 22nd, 2023 on the day of Akshaya Tritiya festivities. This day is a symbol of luck and success in India

NUM India offers retrofit complete solutions

Dear readers

During the many years that I am employed at NUM, I have had the opportunity to take on many different roles, from application engineer, to CEO of the entire NUM group. Now the time has come, to pass on the CEO function, I am very pleased that as of July 1st, 2023, Mr. Massimiliano Menegotto has taken over this function. In my role as VP of the Board of NUM Group, and in my new support role as an employee, I will continue to support the NUM team and our partners. With Massimiliano Menegotto, we have a proven expert and manager at our helm who has been actively involved in shaping events as CTO and Managing Director of NUM Italy. The Board of Directors and the management of NUM are convinced that this approach will ensure a seamless transition to the new organization.

I would like to thank you very much for the good, cooperative partnership and look forward to meet you in person at the EMO.

With kind regards,

Peter von Rüti
VP Board of Directors NUM Group

Dear readers

With great pleasure and sense of responsibility, as of July 1st, 2023, I have taken over the new function as CEO of the NUM Group. My goal is to ensure continuity in the strategy, service and product quality and that you, as our partners and customers, will keep receiving the good support you are accustomed. The difficulties in today's environment are diverse and challenging. As we open this new chapter in the history of our company, we are very grateful to our former CEO, Peter von Rüti, for the work he has done. Under his leadership, we have achieved many important milestones and successes. Thanks to Peter, NUM has a unique company culture and it is therefore a great place to work and to collaborate. I am convinced that starting from this basis we can further develop our business relationships and look for new opportunities.

"With the succession plan that has been planned and prepared well in advance, we guarantee continuity and a smooth transition to the new NUM organization", says Massimiliano Menegotto, CEO NUM Group.

We are presenting at EMO Hanover, Germany, a new generation of CNC controls, the FlexiumPro. FlexiumPro's flexibility, scalability and configurability, as well as its high-energy efficiency, make it suitable for automating a wide range of machines. Your machine, if not yet driven by NUM, is ready to excel with FlexiumPro!

NUMROTO*plus* has already taken a leading role in the tool grinding industry in the past, delighting users with its advanced functions and user-friendly interface. With the presentation of NUMroto X, NUM is now setting new standards in this field.

You won't want to miss out on this. Visit us at our booth at the EMO show, where we can detail all the innovations we are introducing in the market.

With kind regards,

Massimiliano Menegotto
CEO NUM Group

NUM Event Calendar 2023/2024

FABTECH 2023
September 11 – 14, in Chicago, USA
North Building Booth B11010

EMO 2023
September 18 – 23, in Hanover, Germany
Hall 9 Booth I42

DMP 2023
November 27 – 30, in Shenzhen, China
Hall 5 Booth 5B03

Global Industrie 2024
March 25 – 28, in Paris, France

Grinding Hub 2024
May 14 – 17, in Stuttgart, Germany

IMTS 2024
September 9– 14, in Chicago, USA

Innovations in NUMgrind

Innovations in NUMgrind

In the past few years, NUMgrind has developed into a well known and respected supplier in the cylindrical grinding sector. Through various successful projects in Asia and Europe, NUM has carefully listened to customer requirements and incorporated many new features into the development of NUMgrind.

The latest enhancements to NUMgrind increase performance, reliability and usability. In addition, new features have been added to further enhance the software's performance and functionality. Machine builders and end-users can benefit from these developments by integrating the latest version of NUMgrind into their process and products workflows. This allows machine shops to increase productivity, reduce costs, and shorten time-to-market. The following sections focus on a few of the numerous new innovations.

Short stroke
A new key on the machine operation panel can be used to interrupt the oscillating movement for the following cycles:

- Cylindrical Traverse (G206 / G207)
- Conical Traverse (G210 / G211)
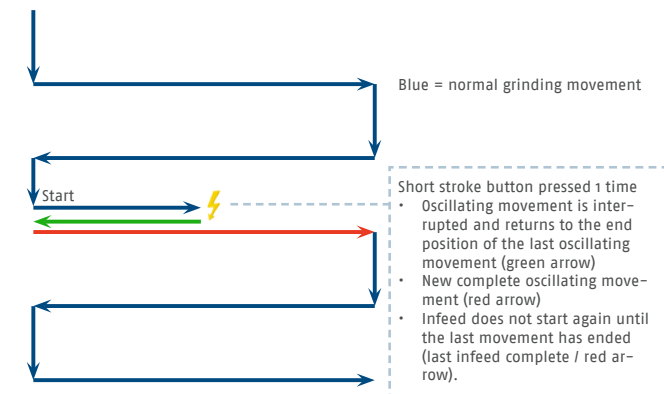- Shoulder Traverse (G214 / G215)

Figure 1: Interruption of oscillating movement by briefly pressing the button

A single press of this "Short Stroke" button will interrupt the machine's current movement and return it back to the origin of the stroke. If the button on the machine panel is held down, a short stroke is executed and the machine will continue to short stroke at the start position without infeed into the part any further. The short stroke distance can be set by the user.
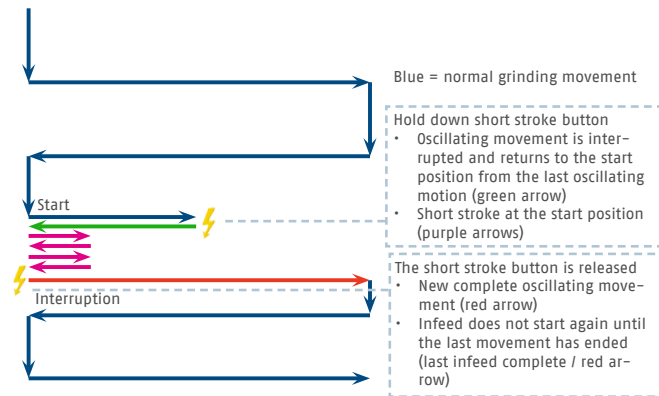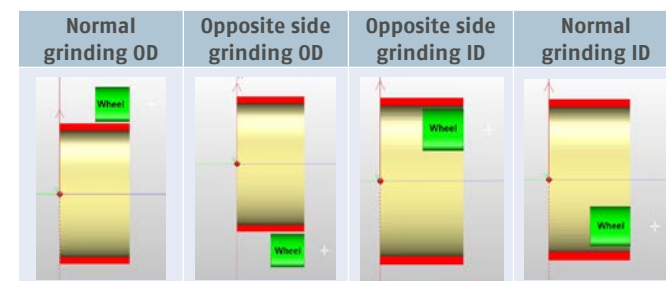

Figure 2: Short stroke at end position

The short-stroke function can be used to grind over certain points on the workpiece several times without an infeed taking place. In the case of slightly slanted or warped workpieces, it is possible to individually intervene in the grinding process for each workpiece without having to adjust the actual grinding program.

Grinding on the opposite side
NUMgrind allows the grinding side (wheel in relation to the part) to be freely selected both for part setup and also for each cylindrical grinding cycle. The operator has two options for internal grinding (grind on the near side or the far side) as well as two for external grinding cycles.

This also allows machines with limited travel along the X-axis to grind inside and outside diameters in a user-friendly manner without having to reprogram the grinding cycles. Additionally, the ability to change the grinding side during internal grind cycles offers greater flexibility for especially complex workpieces.

Normal grinding OD	Opposite side grinding OD	Opposite side grinding ID	Normal grinding ID

Dynamic corrections
During the execution of a grinding cycle, it is possible to make dynamic corrections along the X and Z axes. These inputs are taken into account in real time and have an immediate impact on the grinding process.
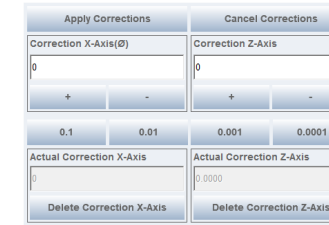

Figure 3: Dynamic corrections on sF1 side

Corrections to each cycle
The entire grinding program has a global datum offset (DAT1) that can offset the machine's program position. In addition to this global offset, each grinding cycle offers another, local offset, which can be applied to only this cycle and works in parallel to the global correction from DAT1.
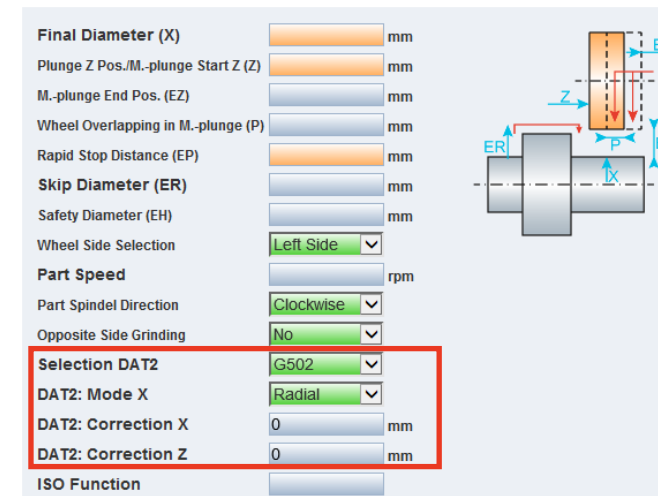

Figure 4: Workpiece datum correction DAT2

Workpiece spindle
The spindle speed can be set both in the Pre-Cycle (Pre-Cycle data are the basic data of the cycle about "where" to grind such as end diameter, Z position or rapid stop distance) and in each In-Cycle (In-Cycles are the individual grinding steps telling the machine "how" to grind, such as roughing, finishing, fine finishing, each with specific grinding parameters such as the feed rate or whether dressing is to be performed). If no value is set, the spindle will remain at its current speed.

With this option in the In-Cycle, the speed can be adapted even more specifically to the desired surface quality in the respective grinding steps, such as roughing and finishing. In addition, the direction of workpiece rotation can be set in the Pre-Cycle easily by the user.

Gap cycle
The grinding cycles can also include a gap elimination function which can be used to speed up cycle time and optimize the machine's speed and motion during the cycle. However, since the grinding of shoulders is often accompanied by an incremental amount of grinding, a new grinding cycle was created
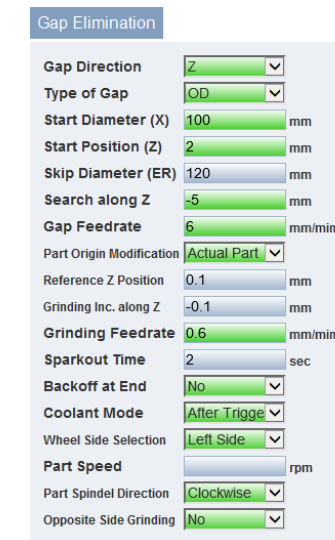

Figure 5: Gap elimination data input mask in the NUMgrind HMI

especially for this relevant grinding operation. This new gap elimination cycle can be used in X, Z or along both axes simultaneously.

The input fields of the Gap Elimination page make it easier for the user to program the grinding operation and make the process more straight-forward.

This is especially useful for shoulder grinding with an internal grinding wheel. The coolant can only be activated after the AE sensor (AE sensor: Acoustic Emission Sensor) has been triggered. This allows the AE sensor to more accurate and less susceptible to audible interference from the sound that the coolant makes.

Semi-automatic mode
The semi-automatic mode allows the operator to easily achieve perfect roundness on the workpiece, or to over grind a workpiece.

This operating mode is started by an M command or a button on the machine panel, then the user is guided through the entire process by questions and prompts on the screen.

The user can choose to oscillate along the X-axis as well as along the Z-axis. After the user enters the necessary fields and they have been validated, the manual infeed is activated. The user can now feed the machine in manually from the hand wheel (also known as Pulse Generator) during the grinding process. For measuring the workpiece, or for other interventions, the process can be interrupted any number of times, adjusted, and continued again.

Configuration file of the HMI
In order to better adapt the HMI to the respective requirements, the OEM or user has the option in the configuration file to show or hide certain input fields. The input fields that are not needed by a machine or operation are then hidden in the NUMgrind HMI. This simplifies the user interface and streamlines the programming of grind cycles. Additionally, the default values for fields can be stored and customized for any input fields on the page. These default values are then loaded automatically in the respective cycles once they are added to a program.

Block Skip and Program Re-Entry
If a workpiece needs to be reground, but the entire program is not required for this process, the cycle blocks that are not required to run can simply be skipped in Flexium CAM program.

In this example, only the first and last Cylindrical Traverse cycles will be executed by the program. The user opted to skip the other three grinding cycles would be skipped, which we can tell because they are crossed-out in the program tree. In order to re-enter a grinding program, the user just needs to highlight the cycle block in the program then select the "Re-Entry" menu item seen during the program download.
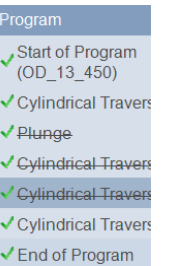

Figure 6: Example Block Skip

In this example, the last Cylindrical Traverse cycle is selected and then the user chooses "Program Re-Entry" when generating the program to send into the CNC.

Figure 7: Example Program Re-Entry

NUM IIoTgateway Supports the umati Interface

Flexium 3D Enhancements

Simulation of Non-Circular Grinding Functions

The 3D simulation of a machining process before it is executed on the real machine helps to prevent collisions, detect errors and verify the grinding results (with virtual measurements). The 3D simulation software of the NUM Flexium$^+$ CNC control (Flexium 3D) is now able to simulate functions used in the non-circular grinding cycles also in offline mode (see Fig 1). In order to enable this in offline mode, Flexium 3D had to be enhanced with several new features. The interesting part is that these new functions can also be used in other G-functions created by the machine builder or the end user, and these G-functions will then be automatically displayed correctly in Flexium 3D. Let's take a look at the individual functions used in non-circular grinding.

As already mentioned, the user does not have to program all these steps for non-circular grinding. He has a complete grinding cycle at his disposal, but you can of course use these functions in your own G-functions.

If the user has a polygon / contour as a reference, then the Cartesian/Polar coordinates transformation is used. With the Cartesian / Polar coordinate transformation (G21), programming takes place in a virtual Cartesian coordinate system XY, which is perpendicular to the spindle axis. During the execution of the G21, the CNC system performs a Cartesian-polar coordinate transformation (conversion from X-Y to X-C). The G21 function allows to program the contour, here the hexagon (see Fig. 3 blue), in a local coordinate system, here with zero point in the center of the hexagon (see Fig. 3 red) instead of the coordinate system in the center of the spindle (see Fig. 3 orange). The grinding wheel position is automatically calculated accordingly.

As the name implies, non-circular grinding is about grinding a non-circular shape. A characteristic of these shapes is that they are defined with closed contours. The definition of the closed contour in polar coordinates is done with the function C.INIT. With the function C.OFF you can easily define a "Contour Offset" to a closed curve. When such a shape is ground, the shape is ground with an offset that becomes smaller and smaller until the offset is finally zero and the shape is thus completely ground.

The coupling of the C axis (work piece spindle) with the X axis (infeed axis) is of central importance in non-circular grinding. Here, the CNC offers two basic options. Either the use of the Cartesian / Polar Coordinate Transformation (G21) or the use of the Multi Level Electronic Gear Box (MLEGB). Originally developed for gear manufacturing, the latter presents itself as a strong alternative to the G21 in non-circular grinding.

The above mentioned functions, which are fully integrated in Flexium 3D, are used in the NUMgrind grinding cycles, but are of course not visible as such to the user there. However, if a machine builder or end user wants to write his own cycles, he can use these functions and also simulate his cycles with Flexium 3D.

Example with excentric polygon

First, let's look at the MLEGB function. This function is used when the shape to be ground is available as a C-X table, in other words, each C-axis position is stored in a table with the corresponding X-axis position.

The properties of the MLEGB can be freely defined in the part program. Each axis can be defined as master or slave, as linear or rotary axis. The ratio between the master and slave axis can be controlled by a user-defined fixed parameter or a dynamic variable (curve table). Flexibility is further increased by the possibility to cascade several MLEBGs. For example, the slave axis in one dynamic gearbox can be used as the master axis in another MLEGB. Thereby, the axes do not necessarily have to be real, they can also be virtual axes in the system.

In non-circular grinding with the MLEGB, all these great possibilities are used. In the example (Fig. 2), for each position of the master (C axis) a corresponding position of a slave (X axis) is defined via a table. After activating the electronic gearbox, the two axes are synchronized and will also be displayed in Flexium 3D.

NUM IIoTgateway Supports the umati Interface

A key technological advantage of the 21st century is the ability to network CNC machine tools with IT and communication systems. By connecting the two together, companies are able to keep digital records, track trends, and identify problems or ways to be more efficient with the resources they have on hand. The umati interface (Universal Machine Tool Interface) is a solution that aims to enable seamless data exchange and integration between different machines, software, and systems in the manufacturing environment.

It can be very expensive to set up production systems with the integration of different machines into one supervisory control system. This is due to the inconsistent data offered by the different control systems among other things. Additionally the lack of a generally applicable standard with regard to the structure, content and presentation of the valuable information in the industrial environment makes matters worse.

umati is an open interface standard based on OPC UA, which connects machines, components and plants with customer- and user-specific IT systems. This interface standard is jointly supported by the VDW (German Machine Tool Builders' Association) and the VDMA (German Engineering Federation) and is open to participants from industry, research, organizations and networks from all over the world.

The interface enables an easy, secure, and seamless connection of a variety of machine tools with customer-specific IT infrastructures and thus allows the fast realization of projects with the goal of generating added value out of data.
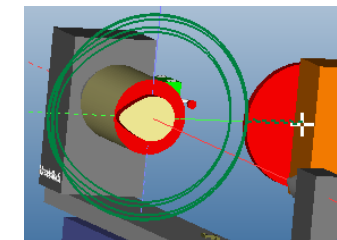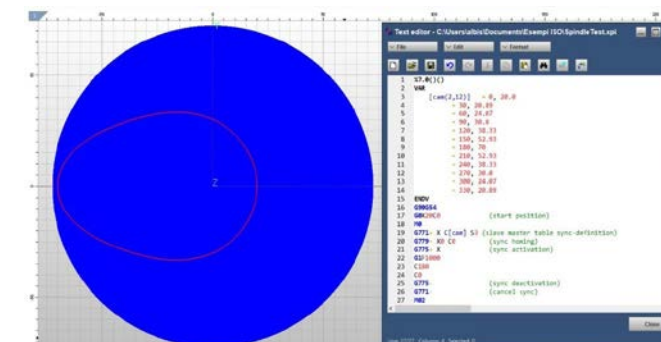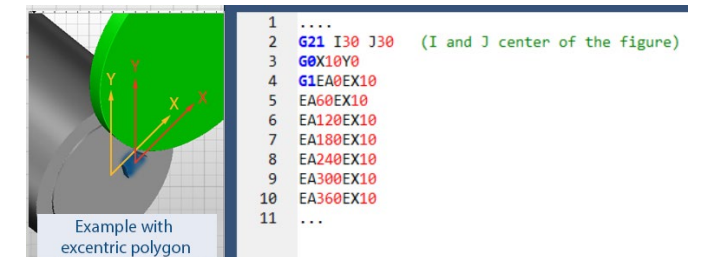
But, there is more in store for the future. Most previous standards only had the ability to read data. OPC UA also allows data to be written from external sources. If a machine sends data that signals it requires an intervention from a person or program, it could also be given instructions. At the moment the write function in the umati area is not yet in use.

Digitalization and Industry 4.0 enable companies to have new business models and plans. With the IIoTgateway, NUM has already offered a ready-made solution with which the control system can transmit data to a higher-level system. As always, we are happy to support our customers in their implementation of IIoTgateway even if it means extending the core functionality.

The NUM IIoTgateway now proudly supports the umati interface in addition to OPC UA, MQTT and MTConnect. The NUM IIoTgateway is not only available for the FlexiumPro and Flexium$^+$ CNC systems , but can also be installed on the Flexium, Axium Power and Num Power controls as well. To enable this functionality we only need to install the software along with the corresponding license.

Inclined Plane (iPlane)

Inclined Plane (iPlane): New Functions ANGLES, ROTATE, PLACE

The Inclined Plane machining function (G150) is designed to aide programming when machining in a coordinate system that is not aligned with the physical axes of the machine. So an NC program designed in the standard (not inclined) frame can be used without modification to machine the same shape in an inclined face. This task requires not only that the function iPlane is programmed with the correct angles, but also that the tool is perpendicular to that plane.

An easy example of the last statement is depicted in Fig. 1 where an NC program is written to machine a square pocket in the XY plane (on the blue face) and then used to machine the same pocket on the red face that is inclined around Y at 43 degrees. As you can see, moving from the blue face and red face, the tool has to be reoriented to perform the task correctly.

The orthogonality between the tool and the inclined face is fundamental to obtain the right result: if this step is overlooked, then not only is the result wrong, but it can also be dangerous and result in damage of the tool and/or the part.

While the orthogonality condition is straightforward if we work with a double twist head (see figure 1a), the reorientation of the tool to satisfy this condition is more challenging while working on a tilting turntable machine. In the tilting turntable case, the machine has a simple head in-line with the linear axes, while rotative axes are attached to the table. In this case it is the table that has to rotate to ensure that the tool is perpendicular to the inclined plane.

Furthermore if the inclined plane requires a twist around an axis that isn't in the set of machine axes, the other two axes have to work together to compensate also for the twist. For instance we are supposed to work on a machine that has A and C rotative axes
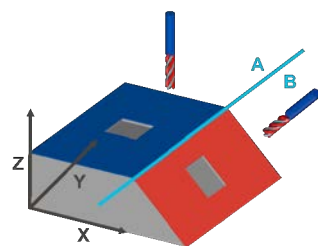
Figure 1: (Section A) Square pocket in grey on the blue face. It's supposed to have the part program that machines the pocket in the XY plane. (Section B) The same pocket is machined on the red face, inclined around Y at for example 43 degrees, using the same part program and the iPlane function. As it can be seen, the tool has to be reoriented to be perpendicular to the inclined plane

and the inclined plane requires a twist around B.

New functionalities
Simplifying the declaration of the tool orientation for the user, new functions called ANGLES, ROTATE and PLACE, were developed for tilting turntable kinematics of the inclined Plane macro. The referenced kinematics are type 17 and 18 (see Fig. 2 and Fig. 3).
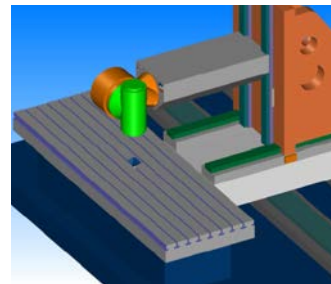
To activate and select one of these new functions, the new parameter EM is added to the current iPlane macro (G150) so that:

- EM0 corresponds to ANGLES,
- EM1 corresponds to ROTATE,
- EM2 corresponds to PLACE.

Let's briefly see how these three new functions work and the difference between them.
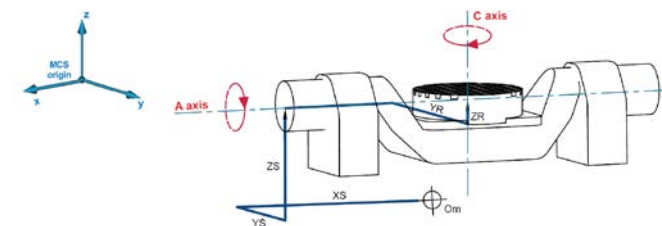
Figure 1a

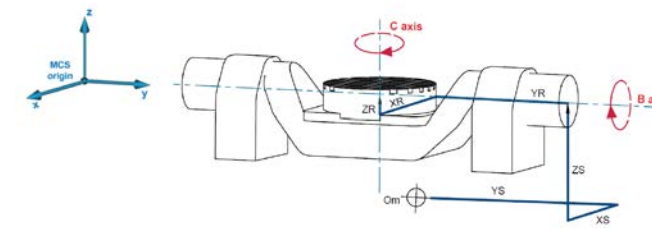*Figure 2: Kinematic type 17: tilting turntable, C rotary table carried on A axis*

Figure 3: Kinematic type 18: tilting turntable, C rotary table carried on B axis

ANGLES
The function ANGLES (see Fig. 4) activates the inclined plane and computes the movements that have to be performed by the rotative axes of the kinematic to ensure the right orientation between the tool and the inclined plane. No movement is performed. The computed coordinates are saved on suitable E parameters (E88256 for A, E88257 for B, E88258 for C) so that the user could refer to them for analysis and possibly program it by himself. This function is useful not only in case of a pre-analysis of the movement, that leads to an accurate evaluation of obstacles that could get in the way, but also in case of a not servo-controlled rotative axis that has to be moved manually. Notice that once this function is programmed, the inclined plane is activated, so in case of a manual movement of the rotative axes, the system is already ready to machine. If it is desired to do only a pre-analysis, then the inclined plane has to be deactivated before any movement of the linear axes is performed.

E88256 = A rotation
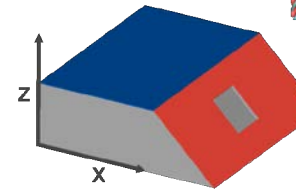E88257 = B rotation
E88258 = C rotation

Figure 4: ANGLES function. No movement is performed but the computed coordinate for rotative axes are saved in the E parameters depicted in the figure

ROTATE
In addition to ANGLES, the function ROTATE (see Fig. 5) automatically moves the rotative axes, in an interpolated movement, so that the right orientation is obtained. With this movement no conditions on the Tool Center Point (TCP) is imposed, so linear axes are held still. This has to be kept in mind to avoid undesired collisions between the machining tool and the workpiece.

PLACE
The PLACE function (see Fig. 6) is similar to ROTATE, but the movements of the rotative axes are done after the activation of RTCP (Rotation around Tool Center Point). This ensures that the TCP remains in the same position even while the table moves. This function is particularly useful when we want a higher control on the position of the TCP or when the TCP is already in the desired starting position and it is only desired to reorient the system to start machining.
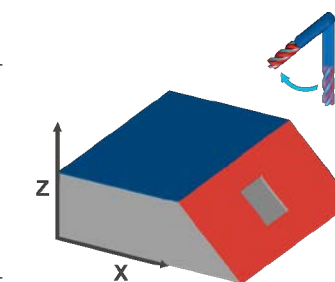
Figure 5: ROTATE function. The figure is taken in the inclined plane frame to help understand the relative movement between the tool and the part. So even if the table rotate, and so the part does the same, the result in the inclined frame is a reorientation of the tool leading it to be orthogonal to the face to be machined

Once an inclined plane is programmed, with any of the above functions, there are always two possible solutions: one that moves the tilting axis in the positive direction, and the other in the negative direction. In different situations and on different machines, one solution may be more suitable than the other. By default the positive movement of the tilting axis is chosen, but if the user wants to perform the other solution or explicit the choice for each case, the EQ parameter is added. Thereby EQ1 denotes the positive and EQ2 the negative movement of the tilting axis.

Figure 6: PLACE function. As for Fig. 4, the picture is taken in the inclined plane frame. The difference with the previous one is that the TCP stands still

Finally the inclined plane origin is declared by the user when the iPlane macro is programmed. The coordinates of this point are specified in the standard (not inclined) frame so that it is easy for the user to determine the right coordinate and it is not necessary to do tedious calculations to obtain the coordinate of the desired origin in the inclined frame. The macro takes care of appropriately transforming this point (defined with parameters EU, EV and EW) in the new inclined frame.

The new functionalities achieve multiple goals while working with a tilting turntable machine:

1. the orientation of the tool so that it is perpendicular to a specific inclined surface is made easy, also for surfaces inclined around 2 or 3 axes;
2. a part program that has to be replicated on different faces could be programmed in the standard (not inclined) frame and then the iPlane macro takes care of machining it on inclined faces, without the need of modifying the part program, which makes programming much more efficient;
3. a wrong positioning of a part to be machined could be compensated so that the tool always works orthogonal to the surface;
4. the same part program could be machined unchanged on a kinematic type 17 and 18 since a rotation around the missing rotative axis is compensated by others.

num

Tool Management System

Simply by using in Flexium 3D the IP address of the tool database instead of the tool data file, it is possible to request the tool list (with all information and Duplo) and use it for simulation in both online and offline modes. The complete tool change process can be simulated and visualized in offline mode.

Operator Views of the tool management
With different HMI views, the operator is always informed about the status of the tools located in the spindles, buffers or tool changers, as well as in the magazines.

Tool view
This page displays the tool view itself with relevant characteristics.

Magazine view
This page displays all tools loaded in the machine in the magazine view.

1	Pocket: (see Tool view)
2	T number of the tool
3	Duplo number of the tool
4	The name of the tool. All tools with the same T number have the same name
5	A comment about the tool
6	Pocket type: • Variable pocket: The tool has a variable pocket place • Fixed pocket: The tool has a fixed pocket place • Partial blocked: A tool with the size medium uses this place. • Blocked: a tool with the size big uses this place
7	Size: (see Tool view)
8	Status • Ready: The tool has never been used • Used: The tool has been used already • Life warning: The tool is in life warning status • Life end: The tool is in life end status • Blocked: The tool is broken

Tool Management System

NUM's tool management software is designed to track tool data and to ensure that at any moment the location and characteristics of each tool are perfectly known and can be managed by their respective application.

One of the benefits for end users of NUM's tool management system is easy and reliable access to tool life and tool change management, independent of whether the processing tool is in the magazine, changer, or spindle. Clear dialogs help the operator to add new tools, find existing tools, and get free pocket locations and data defined by tool and Duplo number. The system also includes various logical HMI list pages for spindle and magazine view, as well as tool view and tool data tables, allowing operators to visualize the complete contents of tool data and the current status.

The OEM/machine builder simply uses the NUM Flexium Tools software to extend the project scope to the database server. Comprehensive API functions allow the implementation of all necessary tool operations, along with a number of special functions in the NCK firmware. As a result, NUM's system helps the OEM save significant operating and development costs.
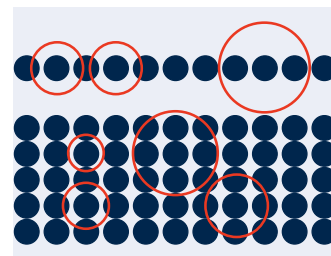
The software meets various mandatory requirements:

• Tool life and tool change management
• Equivalence criteria
• Management of stepped tools (multiple cutting edges)
• Data transfer via network and database
• Tool measurement
• Organization of an unlimited number of magazines

This advanced database-driven tool management software simplifies control of diversified tool types, e.g., cutters and dressers with different tool sizes (small, medium, and large) in magazines. The red circles characterize the required place for pockets inside a typical magazine.

Sizes are:

• Small: the tool uses 1 pocket place
• Medium: The tool uses 1 ½ pocket places in all directions
• Big: The tool uses 2 pocket places in all directions

The configuration of the magazine type and pocket place is done inside the PLC project configuration in Flexium Tools, which offers the machine tool builder a complete development environment with a user-friendly wizard configurator.
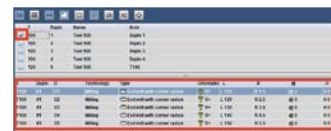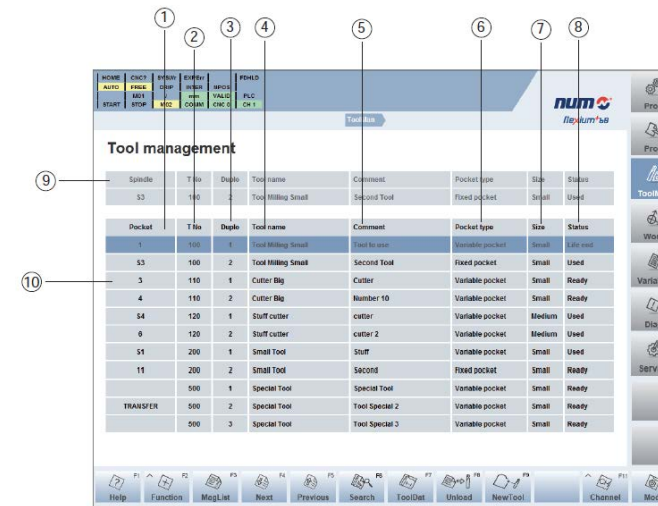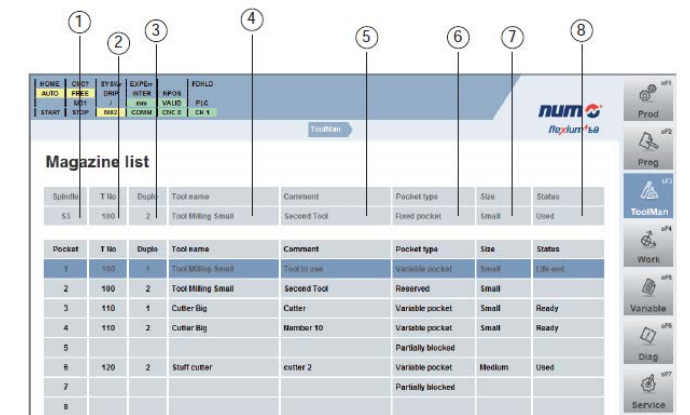
Three different tool magazine types are supported:

• Chain type
• Disc type
• Cartridge / Rack-style or Pickup

NUM has released this software package for the Flexium+ CNC platform starting from revision 4.1.10.00.

The machine tool management database can be installed on a server platform somewhere in the production plant, with the complete set of tools needed for production, supporting multiple machines with dedicated tool magazines. Alternatively, the tool management database can be used autonomously on a single CNC machine as an extension of the Flexium+ HMI software.

Starting from the Flexium+ version 4.2.00.00, Flexium 3D (NUM's 3D simulation software) also supports tool management via database. This functionality extends the standard tool table, giving the possibility to add more information about tools, manage twin tools, tool changes, and much more.

1	Pocket: • Information, where the tool is loaded • Number: pocket place in the magazine • Sxx: spindle • Buxx: buffer • Name: The tool is loaded on another machine, name of the machine • No value: The pocket is empty, no tools are in it
2	T number of the tool
3	Duplo number of the tool
4	The name of the tool. All tools with the same T number have the same name
5	A comment about the tool
6	Pocket type Variable : the tool is managed in variable positions Fixed: The tool is managed in fixed position
7	Size: • Small: the tool uses 1 pocket place • Medium: The tool uses 1 ½ pocket places in all directions • Big: The tool uses 2 pocket places in all directions
8	Status: Actual tool Status (ready, used...)
9	Display of the active spindle
10	Display of all tools in the database

Tool data view
This page allows the tool parameter to be displayed, controlled and edited.

Description of the special tool manager parameter	
LT	Different display types are supported: Machining Time, Number of Parts…
LW	Limit life warning
LE	Limit life error
LV	Count of the current life value
MS	Max spindle speed
MF	Max feed

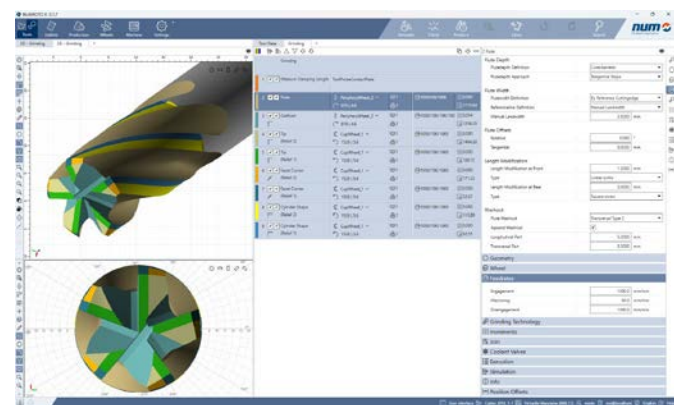|	
1	Cut in error LV > LE The life value is displayed in red
2	Cut in warning LV > LW and LV < LE The life value is displayed in orange

num

NUMroto X

NUM FlexiumPro CNC System

NUM FlexiumPro CNC System

Take the most flexible CNC system, Flexium+, improve computing power, speed, connectivity, flexibility, integration density, and energy consumption, and the result is NUM FlexiumPro!

Let's first have a look at the hardware configuration. The CNC system basically consists of a Real-Time Kernel (RTK), which integrates PLC and CNC, servo drives (NUM DrivePro), servo motors, a PC, and various accessories. The use of a NUM industrial PC is recommended but not mandatory. Both the RTK and the servo drives use the latest system-on-chip technology with an ARM multi-core processor. The resulting extremely high degree of integration leads to an enormous reduction in components, which positively affects the reliability and availability of the system. In addition, the computing power has been massively increased compared to the Flexium+. The FlexiumPro CNC is more than 10 times faster than the Flexium+. All data, such as the PLC program, workpiece programs, machine configuration, calibration data, etc., are stored on a replaceable microSD card, and the safe shutdown of the CNC system is ensured, even in the event of a power failure, by a built-in super-capacitor.

The peripheral devices, such as I/O modules or safety components, are identical to those of the Flexium+. The servo drives (NUM Drive-Pro), when equipped with the NUM-SAMX option, have all the required safety functions: Safe Torque Off (STO), Safe Stop (SS1/2), Safe Operating Stop (SOS), Safe Limited Speed (SLS), Safe Limited Position (SLP), Safe Direction Monitoring (SDM), and Safe Cams (SCA). In addition, the Safe Brake Control (SBC) function is available as default. The size of the CNC system has been significantly reduced. For example, the fanless RTK is now only half the width of the Flexium+, and a quad-axis version is available for the servo drives in addition to the mono-axis and bi-axis versions.

The software of the CNC system consists of various components. All software modules have been adapted and optimized for the modern hardware architecture, allowing maximum performance to be extracted from the hardware. For example, to avoid latency and overhead, the servo drives completely dispense with an operating system between the CPUs and the "actual software" – it is pure hardware programming. As a result, even with the quad-axis module (4 axes), a sampling time in the position control loop of only 50 µs is achieved.

Although the FlexiumPro is a completely new control generation, particular care has been taken to ensure that it is as compatible as possible with the Flexium+ for the user, allowing for seamless migration. This also means that the FlexiumPro has all the functions and flexibilities of the Flexium+. For example, the PLC programming languages and environment of FlexiumPro (CODESYS V3) are identical to those of Flexium+, and the part programs are upward compatible.

FlexiumPro HMI Production page

The HMI of the FlexiumPro system differs from that of the Flexium+ system and focuses on interoperability with the user (touch, keyboard, and hardware buttons). Another significant strength of the new HMI is its flexibility. Thanks to a powerful SDK (Software Development Kit), the FlexiumPro HMI can be customized, extended, modified, and personalized. Users can easily integrate customized FlexiumPro HMI modules into the HMI or customize the predefined plug-in HMI components according to their needs. Multi-HMI configurations (one machine with more than one HMI) are also supported, as is the Flexium 3D simulation software. During the simulation of the part program, the user can see the simulation of machine movements, material removal from the workpiece, and possible collisions during the simulation of the part program, the user can see the simulation of machine movements, material removal from the workpiece, and possible collisions between machine components, workpiece, and tool.

The NUM IIoTgateway, which is based on modern Industry 4.0 technologies, also enables seamless integration of FlexiumPro into the manufacturing environment.

Thanks to its flexibility, scalability, and configurability, as well as its high energy efficiency, the FlexiumPro system is suitable for automating a wide range of machines. This spectrum almost certainly includes your machine, whether it is a retrofit or a new machine. Our subsidiaries will be pleased to support you in the investigation and automation of your machine.

NUMroto X

With NUMroto X, NUMROTO introduces a new product line that will complement and successively replace the existing software package.

NUMroto X has been developed from the ground up, with special attention paid to using the most modern approaches and up-to-date technologies. This allows for the implementation of demanding requirements for tool grinding and enables the use of the latest possibilities and functions of modern computer systems. After NUMROTO DOS and NUMROTO*plus*, a new chapter is being opened with NUMroto X, which will provide our customers with the usual high standards of NUMROTO technology in the long term.

Like the existing solution NUMROTO*plus*, NUMroto X is also designed as a desktop application and will be available in the same version for use on both the grinding machine and the workstation computer. Proven concepts such as a multi-user database, process analysis with NUMROTO-3D, and product documentation using NUMROTOdraw will continue to exist with NUMroto X.

During the development of NUMroto X, various innovative development focuses were implemented. Instead of nested dialogs, the user interface relies on scrollable areas that clearly display the numerous parameters. User inputs are immediately evaluated and converted into machining paths, allowing for fast workpiece visualization. This makes it possible to observe the effects of parameter changes in real time. For this purpose, the novel visualization calculates a pixel-precise image for each zoom level, making every detail visible, no matter how small.
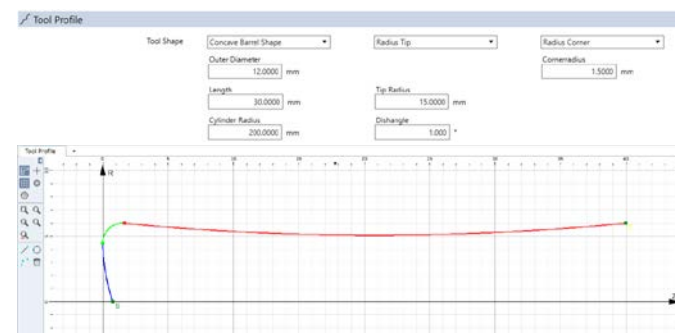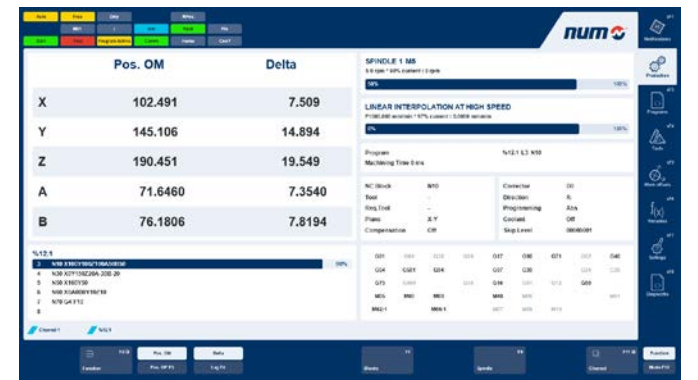
NUMroto X breaks new ground in the definition and organization of probing cycles. These can now be recorded in sequences, analogous

to grinding operations. In this way, the various probing processes can be clearly displayed and set up by the user. Any number of sequences can be created for the same tool, containing grinding operations, probing and dressing cycles, or both. With the ability to execute other sequences from within sequences, they can be combined in any way, allowing complex manufacturing sequences to be configured while remaining clearly displayed.

For the calculation of machine movements, the kinematics module was implemented with a completely new approach. It offers interesting possibilities, including support for interpolating 6-axis movements. New strategies have been implemented for the transfer movement between two grinding processes, which are not only more efficient but also control the axes more optimally.

When creating a new workpiece, the user is supported by an extensive default value system. If required, the default values can be configured almost arbitrarily by the user himself and adapted to the properties of the tool pallet to be produced.

NUMroto X in its first version will provide the range of functions for the production of complex standard milling cutters. There is a large selection of templates for face, shell, and corner profiles that can be combined as desired to form a tool profile. Just as flexible are the combination of shell cutter, face cutter, and clearance definitions.

Even if NUMroto X does not initially match the functional scope of NUMROTO*plus*, the new software package boasts the latest functions and innovative solutions. It is important to us to continue supplying our customers with the proven and high-quality NUMROTO technology, which is why NUMROTO*plus* and NUMroto X will be available in parallel for several years.

Industrial or Desktop PC

Factory Network
NUM IIoTgateway

NUM FlexiumPro
RTK CNC and PLC

Ethernet

EtherCAT

EtherCAT
with FSoE

I/Os, Safe PLC and Safe I/Os

NUM DrivePro

Torque Motor

Linear Motor

Servo Motors

Keyence Digital Microscope

Often underestimated are surface problems that arise due to grinding wheels that do not run completely true.

Regular grooves can be seen on the relief angle 1 and especially at the transition between the relief angles (red arrow). These cannot be seen with a magnifying glass. They occur when the grinding wheel is not dressed very cleanly and consequently hits slightly during rotation. In the above case, the grinding wheel moved forward by 12 μm during one rotation. With the digital microscope, this groove pattern can be seen exactly at 12 μm intervals. After dressing, a much better surface is produced and only slight shadows and a very sharp transition between the relief surfaces remain. The digital microscope thus enables a quick check whether the grinding wheels are grinding optimally.

Dynamic limits often occur at transitions between geometry elements, for example in the case of the radius cutter between the ball nose radius and the cylinder. The critical area is often traversed in less than 0.1 seconds. During this time, the swivel axis stops and the rotary axis must accelerate strongly.

If the mechanics are in perfect condition and the drives are optimally adjusted, there will be no visible mark in the surface. Otherwise, grinding-in (see Fig. 4) can occur: The Keyence digital microscope is therefore also an important tool for checking and optimizing the drive settings.

Figure 1 Transverse cutting edge measured with the Keyence digital microscope (magnification 200:1)

Figure 3 Image of the 1st relief in 200x magnification, top with a non-dressed grinding wheel, bottom with a dressed grinding wheel

Perfect Workpieces Thanks to Analysis with Keyence Digital Microscope

Today, the paths of NUMROTO are calculated so precisely that theoretically micrometer-precise tools should always result. This high quality standard has been established over the years, on the one hand due to the perfectly calculated NUMROTO grinding paths, but also thanks to the very high resolution of the 3D simulation, which allows the machine-independent control of the calculated paths below one micrometer.

Unfortunately, this high accuracy does not always reach the ground tool. Mechanical limits and wear are primarily responsible for this. By measuring the tool on a measuring machine, such errors can be determined and generally corrected. However, details can often be better analyzed with a high-resolution digital microscope in order to be able to correct deviations in a targeted manner.

This can be shown well on a cutter cross cutting edge. The transition of the S-cross cutting edge into the radius cutting edge should be exactly tangential. With the digital microscope, the precision of the cross cutting edge can be continuously checked during production and corrected with micrometer accuracy using the cross correction in NUMROTO.

It becomes more difficult when dynamic limits of the "CNC interpolation-drive-mechanics" process chain lead to geometry errors, such as small marks. Or when disturbance variables such as resonance frequencies, vibrations or imbalance of the grinding wheels cause surface problems. It can be very costly to find the causes of such non-idealities and to eliminate them. At the NUMROTO Technology Center in Teufen, such problems are analyzed with the help of a high-resolution digital microscope from Keyence.
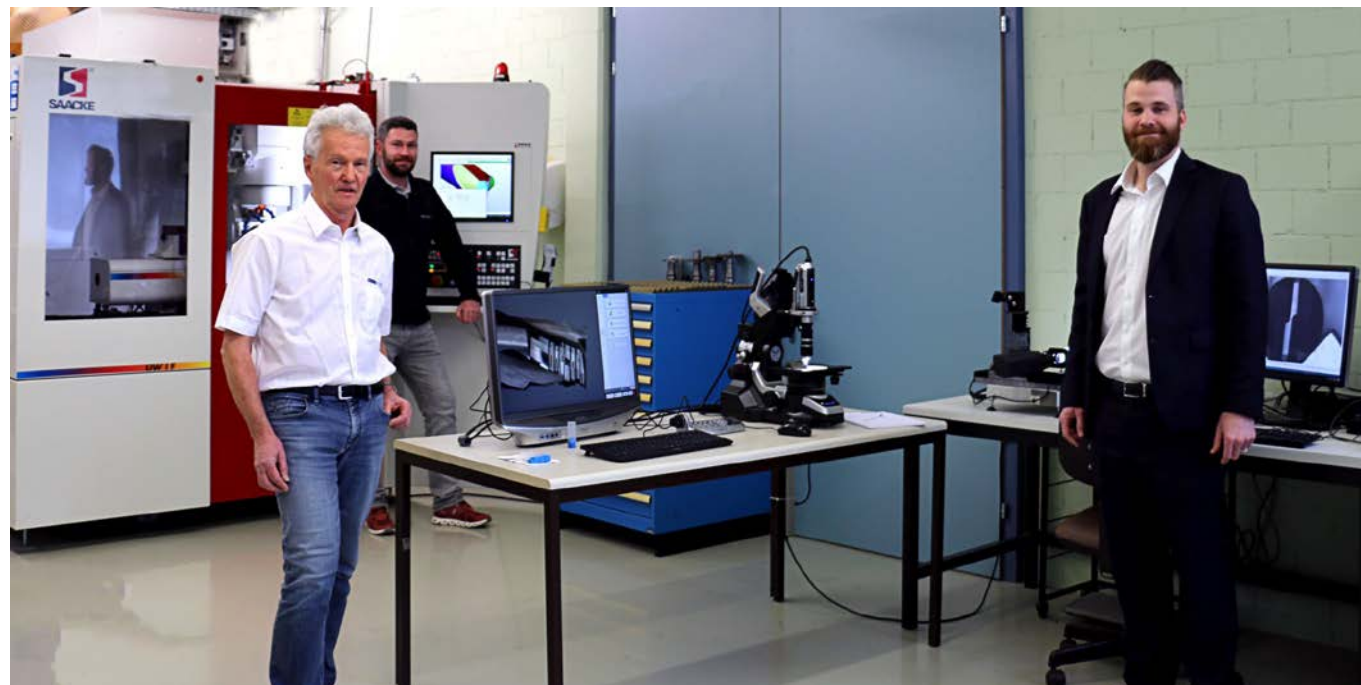
Figure 2 Keyence digital microscope in the NUMROTO Technology Center, Mr. Jörg Federer, Application Manager NUMROTO NUM AG and Mr. Michael Knorr, Application Engineer NUMROTO NUM AG with Mr. Manuel Schneider, Keyence Switzerland
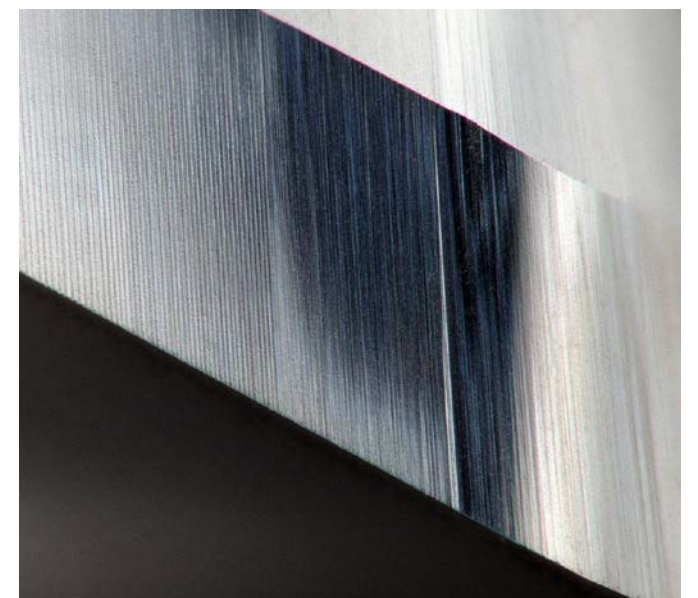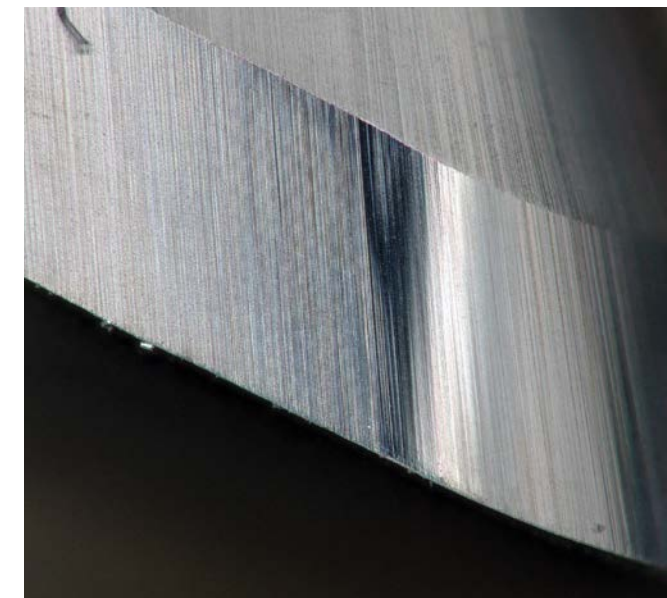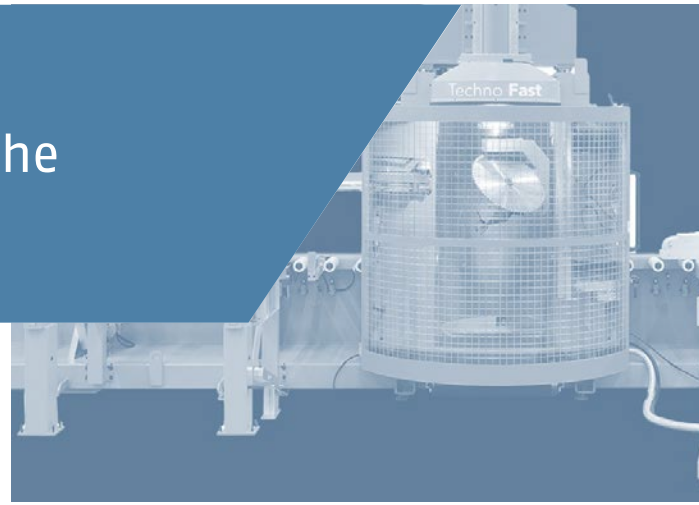
Figure 4 Transition between radius and cylinder photographed with Keyence digital microscope at 200x magnification, no mark visible on the left and visible mark on the right

num

Timber Construction: Technology Cooperation that Starts Early in the Project Phase

Like most solutions developed by Essetre, the Techno Multiwall machining center consists of a basic structure that is then adapted according to the application. "Depending on the number and type of machining operations to be performed by the customer", Nicola Sella continues, "the machining center is equipped with two or three heads (effectively distinguishing the type of machining operations to be performed). Further, it is decided with how many tool magazines the machining center should be equipped, what length the roller conveyors should have, etc. "

Another interesting feature of the Techno Multiwall, which distinguishes it from similar solutions offered by our competitors, is the patented automatic turning system, integrated into the machine and also controlled by the NUM Flexium+ 68 numerical control. This automatic turning system moves the workpiece to the most suitable position depending on the program and the machining operation. "Thanks to this system", says Nicola Sella, "we can turn walls weighing up to 4 to 5 tons."

A practical example of the collaboration between Essetre and NUM is the Techno Multiwall, a CNC machining center for processing large wooden walls

When a customer turns to Essetre, it is usually because they are looking for a tailor-made technology for a specific application. In fact, the Thiene-based company specializes in the development of customized and innovative solutions that meet the customer's exact requirements. Marco Battistotti, Managing Director of NTC NUM Italy: "As these are very specific machines, a technical collaboration has developed over time between Essetre and NUM, starting from the design phase of the machines. This also applies to the Techno Multiwall machining center."

A unique selling point that sets Essetre apart in the market is "creative genius". The founder Gianni Sella has always been a genius in inventing machines and technologies for the furniture and woodworking industry. He was able to pass this genius on to his children Cristina, Nicola and Andrea, who now run the company alongside Gianni. "It's important to know the market, the customers and the technology", says Cristina Sella, who is in charge of the company's marketing and administration department. "But Essetre's real strength is that it has managed to build a successful team over the years."

The history of Essetre began more than forty years ago in the garage of the house of Sella with not much more than a simple CNC router. The company was founded as a specialist in the manufacture of milling machines and machining centers for the woodworking industry. Throughout its history it has developed machines for the construction of windows, sofas, chairs, curved elements and so on. This covers more or less all trendy segments of the woodworking industry. For the past 20 years, the company has also been active in carpentry and wood construction, a market segment that now accounts for about 90 percent of its business. "We started with a machine for processing large beams, Cristina Sella recounts. "Then the market evolved and today Essetre offers numerous solutions for the construction industry. The spectrum ranges from the machines

for the smallest beams and therefore for the simplest machining operations to the Techno Fast machining center, our workhorse, which we have been producing in series for some time. Of course, this is also always adapted to the customer's needs with small modifications."

Essetre is based in Thiene (Vicenza province) and has a recently expanded production facility with a surface area of around 9,000 square meters. The company employs more than 50 people and supplies customers all over the world, also thanks to the recently opened sales office in Charlotte, North Carolina USA. The machines designed and manufactured by Essetre are all customized, meaning they differ from one another. "That's what makes us so special", explains Cristina Sella. "The customer comes to us and asks us to develop a solution for a specific application. Sometimes that's not easy because we face complex design challenges, but that's what drives us."

The NUM/Essetre partnership is long lived, in fact the first NUM control in the wood industry was installed at Essetre. The introduction of a numerical control, as so often happens, changes the perspective of a company. "As these are very special machines", says Marco Battistotti, Managing Director of NTC NUM Italy, "a technical collaboration has developed over the years between Essetre and NUM, starting at the machine design stage. In addition to supplying CNC controls, motors, and drives, software implementations are sometimes required to map the specific functions required by the machines. We help Essetre make their machines more competitive and profitable."

A practical example of the collaboration between Essetre and NUM is the Techno Multiwall, a CNC machining center for machining curved beams, X-LAM/CLT walls, SIPS walls and frame walls up to 6000 mm wide, 480 mm thick and unlimited length. The Techno Multiwall is a 5-axis machining center with a 55 kW work spindle. It is equipped with a NUM Flexium+ 68 numerical control with SHX single-cable motors and MDLUX modular drives, and can operate at machining speeds of 20 m/minute and more. "This machine is mainly used for machining the walls of wooden houses", explains Nicola Sella, sales and software manager at Essetre. "In practice, this means that once the wall is loaded, the machine performs all the necessary machining. For example, it creates the openings for doors and windows, for installations, etc. The advantage of this solution is the automation of the entire process using software developed in-house, which, starting from the architect's design of the house, can create a production list including the machining macros. In this way, the technicians only have to define the machining sequence of the optimized panels. And all this is, of course, controlled by the NUM Flexium+ 68 numerical control."

From left: Cristina Sella, Gianni Sella, Andrea Sella, Marco Battistotti and Nicola Sella

Techno Multiwall is equipped with Flexium+ 68 numerical control system supplied by NUM with motors and drives

The strength of this solution lies in the automation of the entire process using software developed in-house and managed by the NUM CNC system

Techno Fast machining center that Essetre has recently started mass producing

num

Renowned Indian Gear Manufacturer Chooses NUM for CNC Grinding Machine Upgrade Project

BHARAT GEARS LIMITED

Bharat Gears Ltd., one of India's largest manufacturers of quality gears, has successfully retrofitted a Reishauer RZ361A gear grinding machine with an advanced NUM Flexium+ 68 CNC system.

Founded in 1971, Bharat Gears Ltd (BGL) has grown steadily to become a world leader in gear technology. Nowadays, it operates three large gear manufacturing plants in India, at Mumbra, Faridabad and Satara. The company produces an extremely wide range of ring gears and pinions, transmission gears and shafts, differential gears, and gear boxes, primarily for the world's automotive and agricultural machinery industries. BGL also manufactures specialist heat treatment furnaces, including sealed quench and pusher continuous gas carburising product lines.

All three of BGL's production facilities are extensively automated. Over the years, the company has invested heavily in gear manufacturing automation and its production floors feature a large and diverse installed base of CNC controlled gear cutting, hobbing, shaping, shaving and grinding machines.
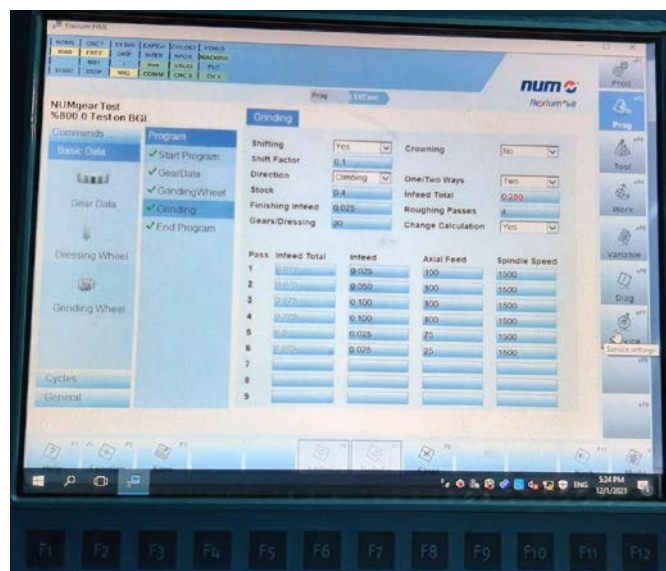
BGL routinely replaces older-generation gear production machines with the latest models, but occasionally it makes more economic sense to upgrade the control system technology of a machine instead of completely replacing it.

This was recently the case with a Reishauer RZ361A gear grinding machine at BGL's Faridabad plant, as the company's Gear Technologist, Mr. B.L. Pansare, explains: "We have come to regard these machines as something of a workhorse – they represent Swiss engineering at
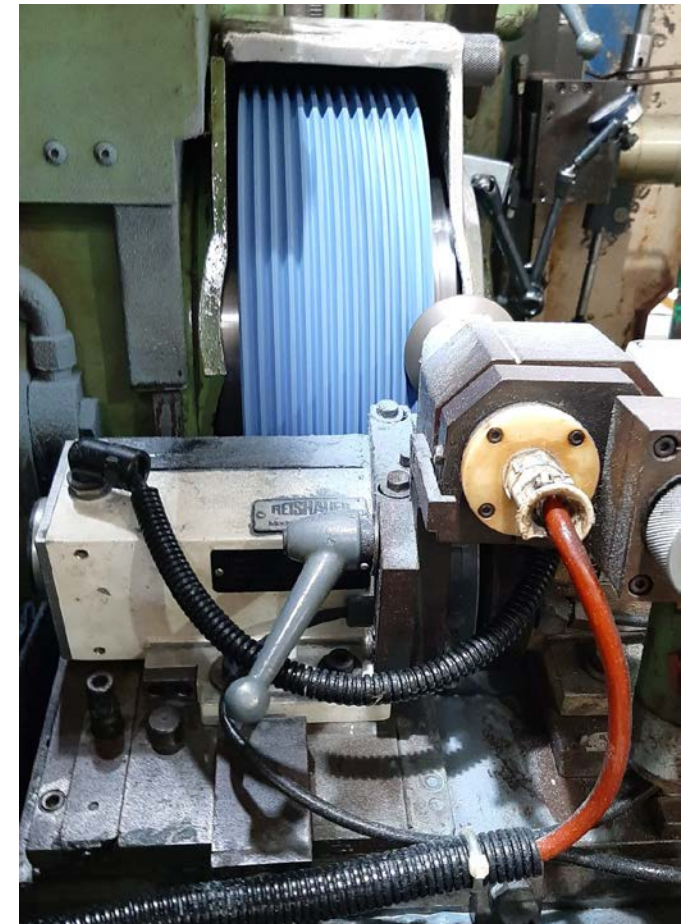
its best, consistently providing precision grinding capabilities. However, for machines which are 15~20 years old, it is often problematic keeping them production-worthy due to difficulties getting support for component failures, and they can therefore lack the reliability we need for efficient production of some of today's more complex gear profiles."

BGL took the decision to upgrade the control system of the Reishauer machine with a CNC system from NUM primarily on the strength of NUM's reputation for providing complete solutions, including hardware, software and project support. NUM's Swiss background was another confidence-boosting factor. In this instance, the upgrade involved retrofitting the machine with a high-end Flexium+ 68 CNC system – including drives and servo/spindle motors – and was carried out by engineers from BGL's in-house retrofitting team with assistance from NUM's newly-established branch in India, backed by additional technical inputs from NUM Switzerland.

All component parts were delivered and interfaced on schedule. There were a few technical challenges along the way, which is to be expected given the complex nature of the project. But these were all encountered head-on and resolved satisfactorily. Initially, a few of the software cycles did not perform as intended when grinding an atypical gear for a USA-based customer. After troubleshooting, the NUM team determined that it was perfectly possible to grind the gear profile, but that it would require detailed modifications to the standard software. NUM undertook the necessary modifications and delivered the revised code to the satisfaction of BGL. The mechanical structure of the RZ361A gear grinding machine was found to be less robust than originally expected, which was affecting the accuracy, so remedial mechanical modifications were also carried out.

In the final analysis, BGL is delighted with the performance of the upgraded Reishauer machine, which now combines accurate and repeatable gear grinding capabilities with the reliability and ease-of-use of modern production automation. According to Rajesh Nath, Managing Director of NUM India, "This was probably the first time that an end-user has retrofitted a Reishauer RZ361A in India. We are grateful for the trust placed by BGL in NUM technology. In reciprocation, NUM has walked the legendary extra mile to provide high quality support and customization services to its customer."

BGL has successfully retrofitted a Reishauer RZ361A gear grinding machine with an advanced NUM Flexium+ 68 CNC system. Photo shows (Left to right): Mr. Pritam Singh (Maintenance Head, BGL), Mr. B.L. Pansare (Gear Technologist, BGL) and Mr. Andreas Hartig (CSO NUM Group)

num

Retrofit of a Bevel Gear Hobbing Machine for Manufacturing Straight Gears

LANZI
MANUTENZIONI E RETROFIT

If the cost difference is small, the customer will always choose to purchase a new model machine rather than a retrofitted one. However, when the price difference becomes greater, the conversation changes dramatically. This is exactly why thirty years ago the company Lanzi – Manutenzioni e Retrofit from Emilia began offering retrofits on machines, and specifically on gear cutting machines thanks to an ingenious idea of Gian Luigi Lanzi, from the second generation of the family. The retrofit challenge is far from simple, but one which has evolved over the years relying on a technological partnership with NUM.

Retrofitting a gear hobbing machine, including changing the operating concept, is a very complex operation that requires specific know-how and technical skills at the highest level.

The company Lanzi – Manutenzioni e Retrofit was founded over fifty years ago in 1964 by Francesco Lanzi who specialized in the maintenance of traditional machines like lathes and milling machines. About twenty years later, Luigi Lanzi, from the second generation of the family, recognized a new and untapped market niche, and gradually shifted the company's core business from the original segment to the field of modernizing gear cutting machines. This is when the company first began collaborating with NUM. The new focus of the company, based in Ozzano dell'Emilia (province of Bologna), is still the same today: retrofitting gear cutting machines, with particular attention to the bevel gear sector, and also including spiral and spur gears.

machines have a slightly lower output, typically a production deficit of about 30%, but that doesn't change the fact that the end user can buy three [or], four hobbing machines [for the same budget] instead of just one. So, if the customer does not have space problems in his plant, it is much more advantageous to buy a retrofitted hobbing machine." It is also interesting to ask about the service life of a retrofitted gear hobbing machine. This is almost as long as that of a new machine, if not longer, due to the rather large cast iron machine beds with which the original machines are equipped in most cases. Today, when a hobbing machine leaves the Lanzi factory after a retrofit, it is basically a new Lanzi brand machine, CE certified and equipped with Industry 4.0 functions. This means that anyone who decides to buy such a machine can benefit from all the advantages they would get if they had bought a new machine.

There are many key performance gains when retrofitting a gear cutting machine originating from the 1960s and 1970s. First of all, it can be noted that the new retrofitted CNC machine performs the same machining operations as the conventional mechanical machine, but – quite clearly – with an exponentially higher output. This is thanks to a reduction in set-up and production time, and with a significantly higher quality of the finished gear. "Compared to a conventional machine", adds Marco Battistotti, Managing Director of NUM NTC Italy, "the CNC machine is also much more flexible in terms of programming. This is because Lanzi has developed their own HMI (operator interface) using functions from our system. This makes it much easier for the specialist to create the machining program."

The retrofit of a hobbing machine always starts with an initial evaluation phase to understand whether it makes sense to carry out the retrofit at all from a technical/economic point of view. "After an

The cooperation between NUM and Lanzi has existed for a long time and has deepened over time through various projects. The most recent project is the retrofit of an old bevel gear hobbing machine for cutting straight teeth

"There is a significant difference between the purchase price of a new machine and the retrofit of a hobbing machine", explains Federico Lanzi, who has been managing the company alongside his father in the third generation since 2007. "Of course, the retrofitted

For this project, NUM supplied the complete CNC system NUM Flexium+ 8, with integrated safety functionality, MDLUX drives and BPX motors
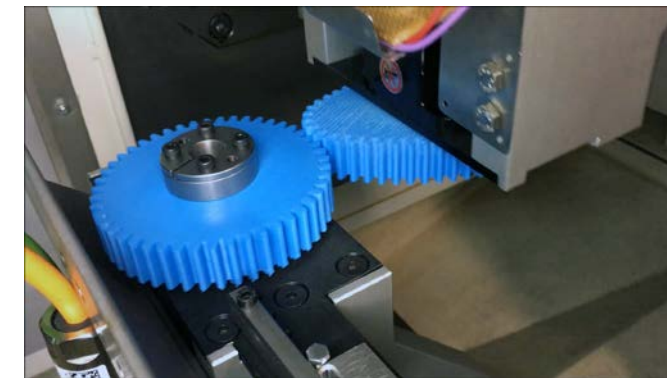
initial analysis, the machine is completely disassembled and re-painted", explains Federico Lanzi, "so that we can then move on to the next phase, which is one of the most important. It consists in fitting the latest generation motors – NUM in our case – to the old mechanics." The machine is then connected to the new electrical cabinet, which houses the numerical control system that controls the machine's three axes.

The project focused on the design of the two milling heads (originally driven by a single motor) by inserting two motors into them to achieve a higher speed

The long-standing collaboration between NUM and Lanzi has deepened over the years through various projects. The most recent project was the retrofit of an old bevel gear hobbing machine for straight-toothed work pieces. For this, NUM supplied the complete CNC system NUM Flexium+ 8 with all safety functions, MDLUX drives and BPX motors.

The electronic gearbox (EGB) developed by NUM is a very flexible and powerful feature that enables production at high speeds while improving productivity and precision

"Originally", says Federico Lanzi, "this machine consisted of two milling heads where the cutting edges were synchronized so that the two sides of the workpiece's teeth could be machined simultaneously. The focus of our project was to design the two heads with direct drives inside, in order to be able to achieve a higher cutting speed and eliminate the mechanical backlash, which is usually the main cause of machining errors. With this implementation, we were very optimistic that in the future we will be able to work with carbide cutters, a modification already used in the spiral bevel gear hobbing machines. The special feature of tungsten carbide is that it can significantly increase the cutting speed and thus the machining feed rates, which shortens production times. One challenge in implementing this project was to keep the two cutting heads synchronized. Originally, they moved synchronously because they were mechanically connected and drive by a single motor. However, once they were electronically controlled they became two completely

separate heads, and NUM's support was critical to keeping them synchronized." To this end, NUM has developed a special function – Electronic Gear Box. It ensures that the two heads remain fully synchronized at all times so they don't collide or misalign with each other which would eventually cause a malfunction.

Much of Lanzi's energy went into increasing machine performance, for example by replacing the crown wheel spindle with a direct-drive ball screw for moving the carriage. It also added optional extras that the conventional machine did not have, such as the connection of robots for loading and unloading the work pieces, and programmable work piece clamping and cutting force controls. On top of all this is the issue of sustainability. "Today we are trying to make people aware of the importance of retrofitting also from the point of view of sustainability", concludes Federico Lanzi. "Upgrading an older machine instead of scrapping it is undoubtedly a much more sustainable decision rather than buying a new one."

With the retrofit of this hobbing machine, Lanzi is consistently pursuing the goal of enabling the use of carbide cutters

num

Retrofitting with the Right Partners Pays Off

A well-equipped machine facility, regularly updated with the latest technology, is the backbone of every manufacturing company. This "rejuvenation" usually takes place through the procurement of new machines, but often also through machines that have undergone a comprehensive retrofit. These machines thus embark on a second life, like the Ceres 330 cylindrical grinding machine at Karl Bruckner GmbH, which was retrofitted by the specialist HDC Huttelmaier. Also on board: CNC and software manufacturer NUM.

With his innovation of the rotating center, Karl Friedrich Bruckner set significant changes in motion over 100 years ago. Today, the third generation at Karl Bruckner GmbH in Weinstadt, Swabia, is already responsible for the production of high-precision centers for turning and grinding as well as face chucks, face drivers and quills. The products are supplied as original equipment to renowned German machine manufacturers and to customers all over the world.

In the recently completed new building, 64 employees take care of all customer needs on an area of around 6,500 m², including 35 well-trained specialists in production. The demands are high, as the precision required for the clamping devices must be achieved consistently. Production is carried out across all types of machining, using machines capable of achieving this high precision with robust process stability. To date, this has included the Ceres 330 universal internal and external cylindrical grinding machine from Schaudt Mikrosa BWF, which was purchased in 2004 and was designed for workpieces up to 300 mm in diameter.

Production foreman Marc Sigle, who is responsible for the smooth flow of production, is not only responsible for the machining performance of the machines, but also shares responsibility for their procurement and replacement. When it became challenging to achieve the required accuracy with the Ceres 330, Marc Sigle explored various options: "In terms of dimensional accuracy and process stability, the Ceres has been exemplary over the years. The machine has a relatively simple design, but was perfectly matched to our product and ran as a pure production machine for us all those years without any problems", recalls Sigle, who worked on the Ceres himself for several years and knows it inside out. As it turned out, this was advantageous in every respect.

At the time of purchase, the Ceres 330 was one of the last machines in its series. The manufacturer's entire machine program was then completely discontinued. When neither spare parts nor service were available any longer, the competent production manager Sigle had been able to handle many tasks himself over the past years. According to Marc Sigle, cost played a major role in the decision not to purchase a new machine, but to retrofit the Ceres 330 instead.

The Ceres 330 is loaded manually. It is easy to retool and program, making it ideal for small batches

Compared to a new machine, a retrofit is roughly 50 percent less expensive. However, considering all the costs, the savings are even more significant. The opportunity to continue using existing tools and grinding spindles should not be underestimated. "We had a large number of suitable tools and four high-quality grinding spindles worth several 10,000 euros still in stock, which we would not have been able to continue using if we had bought a new one. That was a weighty argument for a retrofit", says Sigle.

Additional arguments were presented by Jörg Huttelmaier, owner and managing director of the retrofit specialist and special machine builder HDC Huttelmaier, whom Marc Sigle had known from a successfully completed partial retrofit. In its own machine building plant in Schorndorf-Weiler – merely 12 km away from Bruckner – HDC Huttelmaier is currently upgrading used grinding machines to

the latest state of the art, now in the third family generation. The extensive team of Huttelmaier specialists for maintenance, modernization, and overhaul of machine tools and equipment, and, if needed, qualified subcontractors, ensure a professional complete mechanical, geometrical, and electrical overhaul for every project.

Retrofit Challenge

The general question about whether retrofitting old machines is worthwhile is also affirmed by Jörg Huttelmaier. "One of the arguments in favor of a retrofit, apart from the lower costs, is that the machine operator knows the machine well and therefore does not need any training time. The space requirement remains the same, and as a rule the foundation can continue to be used", says Jörg Huttelmaier, adding, "Sustainability and recycling are important topics today. From an environmental point of view, a retrofit is always a good thing, because the CO_2 footprint is much lower than with a new machine."

Retrofit with a sense of proportion: all important components were replaced where necessary

Jörg Huttelmaier continues, "Retrofitting is not about simply replacing all the old parts with new ones. Rather, a decision must be made with a sense of proportion and experience as to which process should be used where. Our retrofit procedures always start with a detailed survey of the machine and documentation of all damage. The machine is completely disassembled for this purpose. The individual measures and steps of the general overhaul and the customer's requirements are then recorded in a specification sheet, which is then agreed with the customer."

For the Ceres 330, the main challenge wasn't the condition of the machine, but rather the requirements of the machining programs – in other words, the control system. Initially, they considered replacing the old control system with a new one from the same manufacturer. But the program adaptations, which were essential for Bruckner, would have required an immense amount of programming because, among other things, special features for internal grinding and dressing were needed. However, this would only have been possible at an equally immense cost with the self-contained software packages provided by this manufacturer.

The HDC specialists had gained a picture of the requirements on site before the project began. "At HDC, we have our own programmers who write programs for a wide variety of control systems. But in this case, the effort and the associated costs went far beyond the normal level", says Jörg Huttelmaier. "Our assessment was that we needed a CNC control and software partner whose system was comprehensively flexible and open enough to implement the wide range of machining requirements that Bruckner had for the Ceres 330."

For this problem, Jörg Huttelmaier used his contacts to Marc Riedl, sales manager for southern Germany at the control and software manufacturer NUM. The intensive discussions revealed that NUM was exactly the right partner for the application at Bruckner.

The team responsible for the successfully renewed Ceres: Jörg Huttelmaier (HDC) and Marc Riedl (NUM)

Control software that leaves nothing to be desired

NUM has a global presence as a manufacturer of high-end CNC solutions and is particularly successful in the markets of Asia, the USA, France, and the Scandinavian countries. In Germany, Austria, and Switzerland, the company is primarily known for its control software, which is available in different variants for milling, turning, grinding operations, and gear cutting.

The Swiss company, headquartered in Teufen, offers a wide range of perfectly matched products such as CNCs, drive amplifiers, and motors. In addition, they provide training, support, and service lines. NUM CNC controls are characterized by a complete openness of the system to the operator, enabling easy implementation of their know-how and perfect adaptation to a wide range of machines. To fully leverage this flexibility, NUM provides the necessary development tools, or the NUM staff can implement special functions according to customer specifications and put them into operation.

At NUM, the focus is always on the customer's needs. This means that the various HMI are pre-configured, but can be adapted depending on the application. A team of specialists at NUM takes care of this customization work. "Our scalable and flexible Flexium⁺ series CNC systems are excellent for retrofitting because they can be perfectly adapted to any need and any machine", Marc Riedl elaborates.

The NUMgrind workshop programming solution offers a wide range of possibilities

num

"With support for over 200 axes, more than 40 channels, 4,000 EAs, more than 1 GB of PLC memory, and over 30 MB of CNC user memory, Flexium$^+$ is easily capable of controlling even the most demanding applications. So we were also able to easily meet Bruckner's diverse requirements and integrate any desired machining."
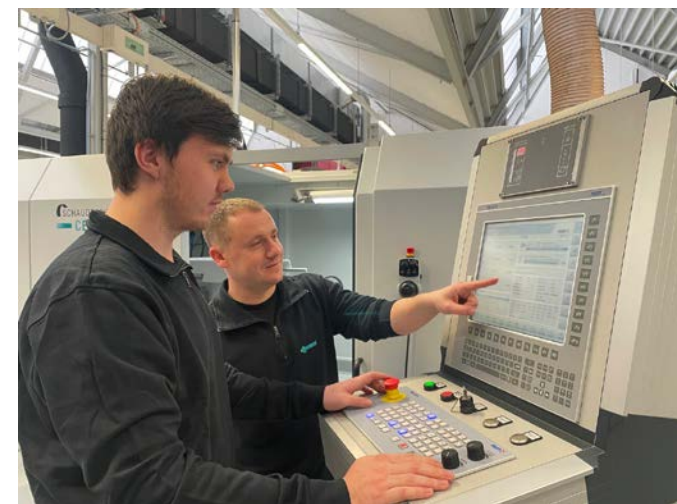
NUM operates three independent technology centers with application departments where customer-specific solutions are developed, one of them in Holzmaden, Swabia. "A special feature is that our three technology centers are in active exchange with each other", says Marc Riedl. "Therefore, recurring customer adaptations are integrated into each of the new versions that are released each year; only very customer-specific details are left out here. In this way, our systems are always one step ahead of the market."

The software package used at Bruckner is the workshop programming solution NUMgrind. This offers an almost infinite variety of possibilities in grinding and contains many ready-made features for cylindrical and non-cylindrical grinding as well as dressing. These can be easily adapted by the operator to the specific grinding needs with intuitive workshop programming and 3D visualization.

The retrofit measures in detail
The Ceres 330 was in relatively good condition, particularly in terms of sheet metal parts such as the housing, so repainting was sufficient. During the mechanical overhaul, the ball screws and the roller recirculating unit were replaced in the X1 and Z1 axes. Worn and defective parts were replaced in the workpiece spindle slide and workpiece headstock, as well as in the pneumatic system, the oil-air lubrication system, and the coolant system. New absolute measuring systems were installed.

The electrical equipment, including the control cabinet, cabling, and control panel, was completely renewed. Additionally, new drives and electric motors, as well as a new CNC control with suitable software, were installed. The entire retrofit ultimately took eight months. Since July 2022, the Ceres 330 has been back in full operation at Bruckner.

Marc Sigle and machine operator Tommy Gerstenbühler are enthusiastic about the possibilities of the new control system

Marc Sigle is very satisfied with his new machine. "For one thing, the machine is as reliable as a new machine in terms of process reliability, repeatability, and precision. The software provides support especially for taper grinding, in the area of face pendulum grinding, and grinding from both sides in a way that the old control could not. Radius and contour grinding are now possible without any problems. Grinding processes are more variable, programming is faster. The on-site support was great, but we also communicated with NUM a lot via Team Viewer."

The conclusion of the three partners? "Good teamwork", says Marc Sigle, praising the joint project. "The proximity to the retrofitter HDC and the associated possibility of running tests at any time were unique. Marc Riedl adds, "We established a good partnership during the project and incorporated the customer's suggestions and requirements during the process. In the future, new developments from our company can easily be incorporated at Bruckner. In this way, the control system always remains up-to-date." Retrofitter Jörg Huttelmaier sums up: "The challenges in this project were quite significant. But when the right partners with the best know-how come together, as they did here, then nothing can really go wrong."

NUMROTO in India: Precision and Efficiency in Tool Manufacturing

The versatile tool design software NUMROTO is widely used in India and worldwide. This also brings benefits for end users.

NUM is specialized in providing control systems and software solutions for the machine tool manufacturing industry and amongst other countries India is an important and fast pace growing market for machine tools and cutting-tools manufacturing.

With NUMROTO, the NUM Group offers one of the most versatile tool design software and thus the perfect solution for tooling requirements in various industries. The core of the NUMROTO system is the NUMROTO*plus* programming system, which can produce an enormous variety of tools. Currently, NUMROTO is used in over 7000 machines worldwide, including a vast installed base in India.

India as an important market for NUM
India has a long history of manufacturing tools for various industries and is therefore a major player in the global tooling market. Key industries for cutting-tools consumption include motorcycles, automobiles, agriculture, electronics and railroads.

The fast-growing market for cutting tools is correspondingly large in India and is worth around 1.25 billion US dollars. In particular, it is anticipated that there will be significant growth not only because of increase in conventional metal cutting processes but also due to tremendous growth in the electronics and railroad industry.

Large manufacturers rely on NUMROTO
About 80 percent of the tools manufactured in India come from small and medium-sized companies. The remaining 20 percent from large corporations including multinationals, one of which is the Machining Solutions Group of Kennametal India ("WIDMA" brand).
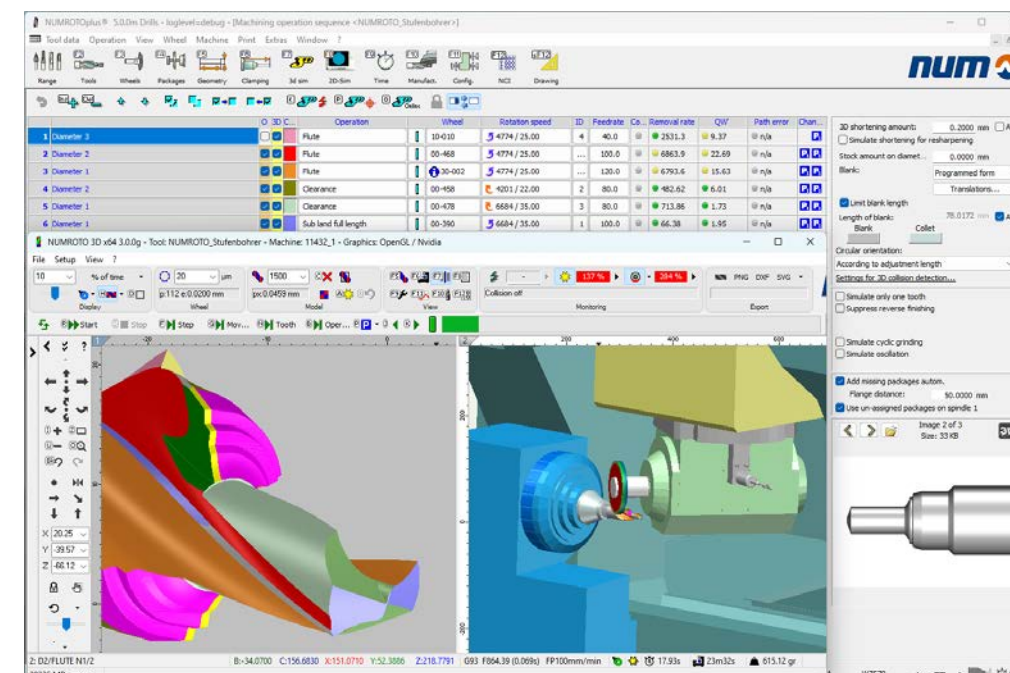
WIDMA leverages the NUM controls and NUMROTO solutions for its 5-axis tool grinding machines. Additionally local Indian tool grinding machine manufacturers are using NUM and NUMROTO technologies, building their market presence and accordingly, the installed base of NUMROTO machines in India is constantly increasing.

For the NUM Group, this historical continuity in the Indian market is a strategically important interlocking piece of our global market presence. As a result, NUMROTO has become the tool grinding solution in India with the highest acceptance among end users.

End users profit from large network
For many industrial companies in India, NUMROTO is a key differentiator in the purchasing decision for the Tool Grinding Machine. This is not only due to the versatility of the solution and the cooperation with important manufacturers, but also the global network of NUMROTO users is a big plus for providing quick solutions and information sharing.

The NUM Group itself also offers customers training, upgrades and comprehensive support. End users thus always have a point of contact for questions about complex tools or special requirements for NUMROTO.

NUMROTOplus user interface

NUM Partners with Taiwanese Specialist for Hydrostatic Grinding Machines GRINTIMATE

GRINTIMATE
全鑫精密工業股份有限公司

For the first time, NUM solutions were successfully integrated into a wafer grinding machine from the Taiwanese specialty machine manufacturer GRINTIMATE.

GRINTIMATE is a specialist in the Asian market for hydrostatic grinding machines. Like NUM the company founded in 2015 is based in Taichung. The company has gained a name primarily for its hydrostatic cylindrical grinding machines, rotary surface grinding machines and wafer grinders.

How it came to cooperation
Adrian Kiener, NUM CSO for Asia, got to know GRINTIMATE back in 2018 at the CIMT (China International Tool Show). Since then, loose contact has been maintained. They met about every six months and exchanged information about the latest developments. And it was this that led to the actual collaboration, as NUM had significant advantages to offer in terms of automation and grinding technology. Especially for their wafer grinding machine.

Why NUM?
NUM's NTC Manager in Taiwan, Johnny Wu, knows that GRINTIMATE had already tried other integration solutions:

"NUM is not the first controller GRINTIMATE used for a wafer grinding machine." Tricia Tsai VGM of GRINTIMATE adds: "We also use other Taiwan PC based brand controls. GRINTIMATE GTR-wafer grinder already meet the request of wafer thinning process (see box) for SiC, Si, GaN etc. However, another challenge in semiconductor fab acceptance is the integration of SECS/GEM and loader/unloader system for the GTR, which the NUM system will help to fulfill."

Automation of wafer grinding machine
Ultimately, the challenge was to automate a GTR-1215 grinder. Johnny Wu explains what the real challenges were:

"First, there might be two or more robots that transfer wafers in and out (it's so called EFEM/Equipment Front End Module) to the

Machine GTR-1215

Wafers are the basis for integrated circuits (chips). During production, only wafers with a certain thickness can be used. Usually, before the integrated circuit is "packaged", material is then removed from the back of the wafer. This process is called the wafer backside thinning process.

GTR-1215. A special protocol for the communication of the selection of front-end robots, the logistics method between EFEM and the host machine, the communication between SECS/GEM and the host system, and the integration of BC (Block Control) was needed.

Therefore, the controller should be able to receive the signal from the robot and start the rest of the process. After the GTR-1215 finishes grinding, our controller also needs to send a signal to the robot to ask it to transfer the wafer. Developed by the SEMI (Semiconductor Equipment and Materials International) organization, SECS/GEM is the standard defining a semiconductor's equipment interface protocol for equipment-to-host data communications. Integrating the SECS/GEM protocol was easy because our controller is open and flexible.

Second, the precision of the grind process requires extensive spindle current monitoring. The NUM controller can directly collect current information from MDLUX drives and then the HMI software collect all this information in one database. We also offer special functions for AC grinding, which include not only monitoring but also adaptive

control of the feed to stabilize the current. This achieves better surface quality and shortens grinding time."

Experience from this cooperation
The project highlights NUM's ability to support GRINTIMATE in the integration of a complete production line for wafer grinding. Current monitoring and pressure monitoring were integrated and NUM created a special HMI for GRINTIMATE to ensure optimum machine operation. NUM also provided PLC NC machining macros, motor tuning and commissioning for this project, so a total solution for GRINTIMATE. This means that GRINTIMATE could concentrate fully on its main competencies in machine and grinding technology.

Sapphires, SiC, Si, Oxide/bumping wafers

According to Johnny Wu, NUM's NTC Manager in Taiwan, NUM is a renowned name in the grinding industry. NUM's open and flexible system makes it easy to access information and provides interpolation at Nanometer level. Furthermore, the NTC Taiwan offered GRINTIMATE a complete solution, which also included adaptive feed control. All these features prove our statement: "NUM CNC solutions provide machine builders with a competitive advantage."

Machine GTR-1215 and HMI

From left to right: Arger Lee (NUM Taiwan Application Engineer), Johnny Wu (NUM Taiwan GM), Tricia Tsai (GRINTIMATE VGM) und Gary Guo (GRINTIMATE Assistant Project Manager)

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NUM and Yuhuan as Partner – First Vertical Total Solution for Non-Circular Grinding

Flat surface grinding

ID profile grinding

NUM and Yuhuan enter into a partnership, and the result is nothing less than one of the most modern, universally applicable, CNC-controlled high-precision vertical grinding machines in the world.

It is not always easy to enter into a new partnership. After all, this kind of cooperation requires trust above all else. Trust in one's own competence and that of the other.

NUM was known to the machine manufacturer Yuhuan at the latest since the CIMT 2019 (China International Machine tool exhibition). It also had heard about a NUM total solution for non-circular grinding.

Yuhuan CNC Machine Tool Co., Ltd. is a national key company with its own technology research centers based in Changsha and an internationally renowned manufacturer of high-precision CNC machines. It was founded in 2004 and has since received numerous national and international awards.

Project: High Precision CNC Universal Vertical Grinding Machine
With the two companies now familiar with each other and having decided to team up, they were faced with the challenges ahead. A total solution for vertical grinding machines was needed for the project, and all the software had to be changed from horizontal to vertical.

In this context, we asked the NTC (NUM Technology Center) China Manager Longwei Jiang about potential competitors: "Yes, we had well-known competitors for this project. The reason we have won is our total solution with the NUMgrind software. Yuhuan does not need to develop the software itself, and this also means that they

YHJMKG2880, a high precision CNC universal vertical grinding machine

Automatic dressing of grinding wheel

Grinding of special curved surface

are able to launch the product quickly. Apart from a delivery time of more than a year, also the support from the well-known competitor for Yuhuan is less effective."

What NUM was ultimately able to bring into the project was fully functionally integrated software based on Flexium+. This system is also suitable for larger drives, for larger motors, and also open for third-party motors, especially large linear motors.

In addition, NUM supported Yuhuan with engineering services during the development phase so that the project schedule was not jeopardized.
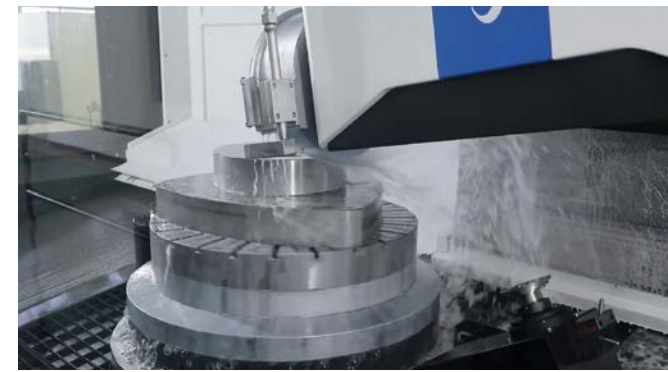
NUM Support
As with all projects of this type, continuous support and monitoring play a significant role. In this case, NUM is providing support for non-circular grinding, internal and external cylindrical grinding, flat grinding, in process measurement, and shaping of grinding wheels.

The result of the collaboration of NUM and Yuhuan is the YHJM-KG2880, a high-precision CNC universal vertical grinding machine. It is designed for processing products with high standards of precision and surface quality. The target markets are plant engineering, the mechanical processing industry, and the high-precision machining industry. The grinding machine can machine inner and outer contours, as well as internal bores, outer circles, end faces, etc., of discs, rings, and sleeves, together in one setup.

Grinding of special curved surface

Taper grinding

NTC Shanghai Chief Engineer: Miss Jane Liu; YHJM General Manager Mr. Li, YHJM Technical Manager Mr. Ye, and NTC Shanghai Managing Director Mr. Longwei Jiang

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Industry–Leading Manufacturer of Solid Carbide Tools Standardizes on NUMROTO

Værktøjsslibning

TN Værktøjsslibning produces a comprehensive range of standard and custom high-speed end mills, step drills and rotary cutters

TN Værktøjsslibning, Denmark's second–largest precision tooling company, is deploying NUMROTO, the renowned programming system for tool grinding from NUM across its entire production floor. The company cites highly successful long–term experience of the software, together with excellent technical support from NUM, as the key reasons for choosing to standardize on NUMROTO.

Founded by Torben Nielsen in 1987 – which coincidentally is the same year that NUMROTO was launched – TN Værktøjsslibning has grown steadily to become a leading player in the manufacture of special solid carbide tools, with an enviable reputation for the quality and precision of its products. Operating from a modern 2000 m² industrial facility in Bjaeverskov, some 50 km southwest of Copenhagen, the company serves the world market and currently exports about 70 percent of its production.

One of TN Værktøjsslibning's prime business advantages is that it handles every aspect of manufacturing and can therefore track the movement of individual tools from initial order through to delivery. The company maintains a large stock of high–quality "subnanograin carbide" materials in the form of rods with internal cooling channels and solid bars, ranging in diameter from 2 to 70 mm. Using multiple advanced CNC grinding machines, TN Værktøjsslibning produces a comprehensive range of standard "TN" brand high–speed end mills, step drills and form cutters, the design and dimensions of which can be tailored to meet customers' needs for "exactly the right tool for the job".

TN Værktøjsslibning also operates advanced in–house tool polishing and coating technology. Tools can optionally be coated both before and after polishing, to extend their service life and to help optimize chip evacuation. The company additionally offers tool regrind and recoat services. Provided that a tool is physically undamaged, it can often be returned to full service after regrinding and possibly recoating, for less than 50 percent of the cost of a new tool.

Every aspect of tool manufacturing at TN Værktøjsslibning is extensively automated. The main production hall is equipped with fifteen

5–axis CNC grinding centers, complemented by cylindrical grinding machines. All of these machines are controlled by NUMROTO software and are networked together to help simplify production management and software maintenance. Each machine has a dedicated programming station, enabling part programs to be created while grinding is taking place, and the company is also in the process of expanding its multi–user programming facility, which currently has capacity for seven users.

High precision gear hob with Ø32 to be produced with very high accuracy in a single operation

An interesting facet of TN Værktøjsslibning's operational structure, which is quite possibly a factor behind the company's consistent year–on–year success, is that it deliberately has a flat hierarchy – there is no design department. Each CNC machine operator is responsible for programming, grinding the tools and fully documenting the process.

According to Torben Nielsen – who is still at the helm of the company, nowadays as TN Værktøjsslibning's CEO as well as its owner, "We try to make work as interesting and satisfying as possible for people, and over the years we have built up a dynamic team of highly qualified and committed employees. Another important point is that by standardizing on NUMROTO for the bulk of our CNC machining operations, we benefit immensely from our employees sharing a common pool of expertise and knowledge about state–of–the–art tool production technologies and processes. Many of our more specialist tools are only required in small batch sizes – sometimes just 2 or 3 – and yet we aim to supply these to customers within the same 9–day timeframe as our standard tools. To help meet this goal, our operators need fast, simple and unambiguous machine control facilities – which in turn demand very flexible, accurate and reliable software, with a modern user interface."

TN Værktøjsslibning regularly enhances its machining capabilities to meet the changing tool needs of its customers. The company first started using NUMROTO software back in 2002, when it purchased two Deckel S20 CNC grinding machines, which have since been followed by a further ten Deckel S22 machines. The company's

current complement of NUMROTO–controlled CNC grinding machines comprises the twelve Deckel machines, plus a UWS SF40 cylindrical grinder and two Vollmer VGrind 340S machines.

The programming and machining of special tools, which constitute the majority of TN Værktøjsslibning's production output, is usually carried out during the day by skilled operators. Larger standard tools are processed at nighttime, using robotic part loaders and unmanned machining centers, but with a high degree of feedback such as in–process measurement and run–out compensation to ensure consistent product quality.

All tools produced by TN Værktøjsslibning undergo thorough inspection prior to shipment. The company's quality assurance facilities include an air–conditioned, positively pressurized measuring room, equipped with a 5–axis CNC measuring machine and other precision optical measuring equipment.

We will leave the final words to Torben Nielsen. "Our experience with NUMROTO has been fantastic. The software is perfect for grinding both simple and highly complex tools and is extremely reliable. It is very easy to work with and the simulation is very precise. In a period of just over 21 years, there have been very few tools that we have been unable to create. Due to our very short delivery times, we rely on good support – and this has always been forthcoming from NUM."

From left to right: Gustav Heer, NUMROTO application engineer, Kent Nielsen and Henrik Larsen, both CNC operators at TN Værktøjsslibning, and Torben Nielsen, founder, owner and CEO of TN Værktøjsslibning

Polished special drill

Microscope image of microtools (lollipop and thread milling cutter ball diameter 1 mm)

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