



**NUM** information

## JOURNAL FOR CNC-TOTAL SOLUTIONS

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# Editorial

## Peter von Rüti, CEO NUM Group



Dear readers

We have some exciting product news for you! We are very pleased to announce our new FlexiumPro CNC control system. Based on our experience with the flexible Flexium+ CNC system, we were able to significantly increase the computing power, speed, connectivity and usability aspects of the FlexiumPro system by developing new concepts, new hardware and new software compared to the Flexium+ system, among other things. To mention just one figure here: the NUM FlexiumPro system is more than 10 times faster and more scalable than the Flexium+ system, which of course opens up new opportunities for the use of this system. In the last few months we have worked very intensively on the completion of the new CNC system and we are convinced that with the NUM FlexiumPro system we can offer you a product that is absolutely suitable for your automation projects.

What is new with FlexiumPro? The Realtime Kernel (RTK) now hosts both the CNC and the PLC. Both processes run on the same main-board, which is based on system-on-chip technology with an ARM multicore processor. The user interface runs on an industrial PC, but can also run on a standard office PC with the Windows operating system. The system-on-chip technology used on the RTK main board is also used on the matched NUM DrivePro drive systems. The extremely high level of integration that can be achieved through the use of system-on-chip technology leads to a significant reduction in the number of components required, which further improves

the stability and availability of the system. In order to facilitate the changeover from Flexium+ to FlexiumPro, we have paid attention to the greatest possible software backward compatibility during development.

It is not only the hardware architecture and firmware that have been optimized. NUM's FlexiumPro also features a new dedicated Human Machine Interface (HMI). Among other things, the NUM FlexiumPro HMI focuses on simplified operation, improves the user experience, simplifies visualizations and allows the user to customize views.

See our new CNC system, as well as our new linear motors, live for the first time at IMTS (International Manufacturing Technology Show) in Chicago, the largest manufacturing technology show in North America, September 12-17, 2022.

**"NUM FlexiumPro: even more scalable, even more attractive, even simpler; this system simply fits all automation tasks", says Peter von Rüti, CEO NUM Group.**

## Imprint

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In addition to the further development of our hardware and software, you will also find interesting user reports from various industries in the USA, Switzerland, France, Taiwan and Germany in this edition of NUMinformation. Experience the fascination and development of a digital twin at elumatec from Germany or find out about our latest cylindrical and non-circular grinding technology at our partner Palmary in Taiwan. The modernization of an enormously large gantry machine at Bunorm Maschinenbau in Switzerland clearly shows the potential of such high-quality machines. Be inspired by our successful projects and talk to us about your future investments and automation projects.

I hope you enjoy reading this edition of NUMinformation and hope to see you in person at one of the next trade fairs.

Peter von Rüti  
CEO NUM Group

## Year of the Tiger – NUM Expands into Southern China

According to the Chinese zodiac, 2022 is the Year of the Tiger, which is usually a year of great change. It will be an adventurous and challenging year, in which everyone will find enthusiasm again and hearts will be rekindled and brave enough to allow change and progress.

In line with this interpretation of the Chinese zodiac sign of the tiger, NUM AG is opening another branch office in China this year. In addition to its existing headquarters in Shanghai, NUM is expanding further into the south of China, to Guangzhou.

With the expansion in China, the international company, headquartered in Teufen, Switzerland, is further establishing itself as a technology leader in the field of CNC controls. By expanding into southern China, NUM is increasing its local service presence as well as its customer-oriented sales and application development. Of course, this will also enable the company to further expand its service offering in this area. In this region, there are many private companies dedicated to the construction of special machinery. The requirements of tailor-made technical solutions are well covered by NUM.

“The Guangzhou location will allow us to respond much faster to customer requests and further expand our business. We have been represented in China, Taiwan and India for many years and are now further strengthening our position in Asia”, says Mr. Adrian Kiener, CSO Asia.



Guangzhou city in China

## Events

### NUM Event Calendar 2022/2023

#### IMTS 2022

September 12–17, in Chicago, USA  
East Building Booth 134523



#### DMP 2022

November 9–12, in Shenzhen, China



#### IMTEX 2023

January 19–25, in Bangalore, Indien



#### CUTTING WORLD 2023

April 25–27, in Essen, Germany



#### EMO 2023

September 18–23, in Hanover, Germany





## NUM FlexiumPro CNC System

Take the most flexible CNC system (NUM Flexium+), improve calculation power, speed, connectivity and reliability and the result is NUM FlexiumPro.

Both main processes, PLC and CNC, are now embedded and running together on a single board based on a multi-core ARM processor. The extremely high integration level, achieved by using System on Chip technology, results in a huge reduction of components which improves system reliability and availability.

The hard real-time operating system reduces latency and avoids the overhead of complex "soft" operating systems. Every detail is optimized to maximize machine productivity and availability.

NUM FlexiumPro is more than 10 times faster than its predecessor – CNC/PLC interface, block per second, axis task, boot time – everything become much faster, setting new standards.

NUM FlexiumPro retains and extends all NUM Flexium+ behaviors and functions. For example:

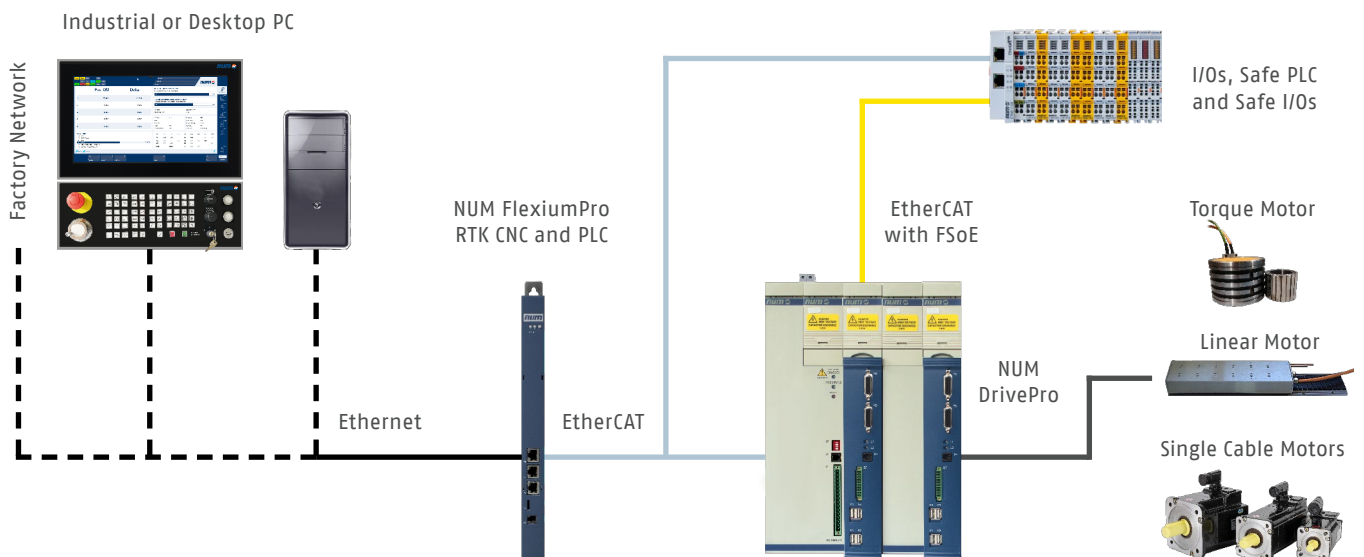
- 32 axes and/or spindles
- 32 machining channels

- Nanometer interpolation
- RTCP (Rotation Tool Center Point)
- HSC (High Speed Cutting)
- Specific technology functions and machining cycles
- Improved diagnostics
- Etc.

PLC application, part programs, machine configuration, calibrations, etc., are all safely saved on a removable microSD card – and to secure shutdown processes, the NUM FlexiumPro RTK (Real Time Kernel) integrates a super-capacitor, which keeps the system alive for the time needed to save all data in the case of hard power off.

OEMs used to Flexium+ will easily migrate to FlexiumPro. The FlexiumPro PLC programming languages and environment are identical to Flexium+, part programs remain compatible with both systems, software interfaces to OEM's custom HMIs (Human Machine Interfaces) remain very similar, EtherCAT terminals and safety devices are unchanged.

### NUM FlexiumPro system architecture:



To overcome the limitations of the standard servo drive device profiles, NUM has decided to use a custom one. The need to exchange floating point variables, 64 bits position data and offsets, multiple parameter structure etc. could not be achieved with a standard device profile.

Highlights:

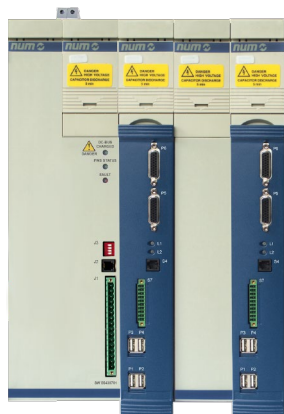
- Multi-core ARM architecture with hard Real Time Operating System
- High level of integration thanks to System on Chip technology
- CODESYS V3 embedded PLC
- The use of industrial PC is suggested but not mandatory (no real-time on PC)
- EtherCAT fieldbus for servo drives, I/Os and safety (with Fail Safe over EtherCAT)
- Extended PLC/CNC interface
- Faster CNC/PLC exchange

- Extended high speed and real time data capture (to further improve NUM solutions for process monitoring, edge computing, condition monitoring with AI, etc.)
- Removable micro SD card to store all machine data, application, part program, retained variables
- New Human Machine Interface, running on Windows OS, which can be customized by OEMs/users (see dedicated article)
- One commissioning tool for entire system: PLC programming, CNC/Drive configuration and tuning, safety programming etc.
- Super-capacitor to avoid data loss during hard power OFF
- NUM FlexiumPro RTK has a fan-less and very compact design (25 mm width)
- CNC more than 10 times faster than predecessor
- Faster boot time

## NUM DrivePro and New Quad-Axis Power Unit

A great orchestra conductor needs great musicians to achieve the best performance. It is the same for a CNC system – a great CNC needs great servodrives. The CNC unit defines the ideal trajectory that should be followed, but the servodrives and servomotors have a duty to keep the real trajectory as close as possible to the ideal one. NUM DrivePro – with its high switching frequency, high resolution in sampling physical quantities (like current), floating-point calculation capabilities, and specific algorithms (like active damping functions) – allows the overall system to achieve its widest possible bandwidth. It consequently provides the highest fidelity in following the ideal trajectory and the highest regulation stiffness (disturbance rejection).

Like NUM FlexiumPro, the NUM DrivePro control unit has a very high integration level, thanks to its use of System on Chip technology incorporating a multi-core ARM processor. To avoid latency and overheads, there is no operating system between the CPUs and the software – it is a bare metal programming. As a result, the NUM DrivePro control unit can pilot up to 4 axes simultaneously, with a position loop sampling time of 50  $\mu$ s.



MDLUF line up

Just like its the predecessor, when equipped with the NUM-SAMX option, NUM DrivePro implements all the needed safety motion 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). The safety functions are activated through the system's Safe PLC by means of FSoE (Fail Safe over EtherCAT) – so there's no need for any local wiring.

A novelty introduced with NUM DrivePro is the Safe Brake Control function (for the moment available only for the smaller drives sizes).

It is fully automated, when drive power is cut-off the brake is safely engaged.

There are various reasons that requires different servodrive set-up, for example: machine where axes/spindle can be changed/configured based on the type of machining or processes where the blank weight need a dedicated tuning; to meet these requirements NUM DrivePro supports up to 99 different saved parameter sets!

NUM DrivePro is a modular drive system optimized for multi-axis applications. A typical NUM DrivePro architecture consists of a common power supply that distributes power to a drive line-up via a DC bus; this reduces overall system energy consumption by utilizing an ENERGY BALANCE function.

Various control unit options and power unit versions/ratings are available for driving one (mono-axis), two (bi-axis) or four (quad-axis) motors each.

The quad-axis power unit is a new product; it has been developed to further reduce the drive line-up dimensions, to minimize cabling and to offer a more cost effective solution for multi-axis machines.

Highlights:

- Multi-core ARM architecture with bare metal programming and floating point calculation
- High level of integration thanks to System on Chip technology
- EtherCAT as servo and safety bus (with Fail Safe over EtherCAT)
- Optimized for single cable motors
- Up to 3 sensors per axis (2 encoders + accelerometer)
- One control unit able to pilot up to 4 axes with position loop sampling time at 50  $\mu$ s
- New industrial USB connectors for single cable motor's encoder (NUM SHX/SPX)
- Removable control unit for easier and cost effective after sales management
- Quad-axis drive module to increase compactness and minimize cabling
- Up to 99 complete parameter sets to easily manage different machine configurations and/or optimization



Quad-axis

# New FS184i Operator Panel and MP07 Machine Panel

# NUM FlexiumPro HMI

## New FS184i Operator Panel and MP07 Machine Panel

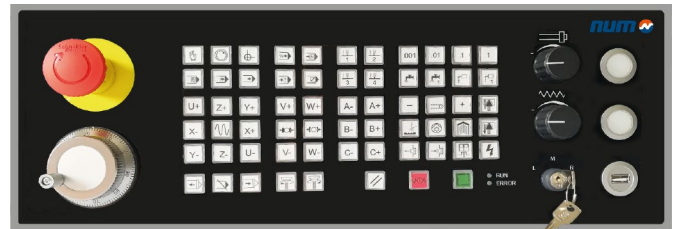
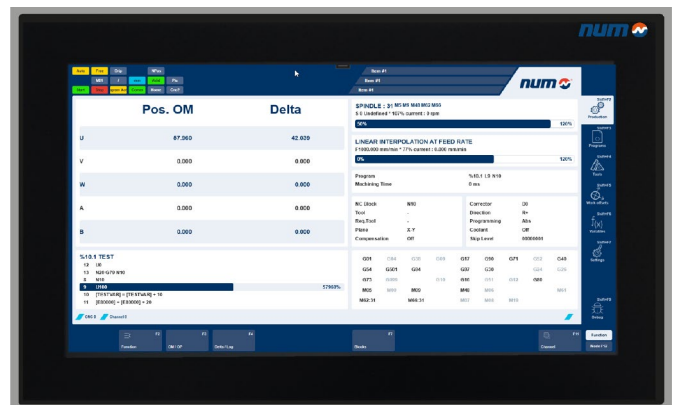
To host the new NUM FlexiumPro HMI (Human Machine Interface) NUM launches a new wide screen WXGA operator panel and a dedicated machine panel. The operator panel, called FS184i, has a tablet like design, integrates the latest multi-touch technology and is powered by an Intel i5 quad core industrial PC with the Windows 10 IoT Enterprise LTSB operating system.

The FS184i operator panel provides a durable, modern front-end for machine control. The anti glare glass used to protect the display makes the operator panels suitable for difficult lighting conditions and contributes to the panel's IP65 ingress protection.

The offering is completed with a dedicated machine panel, MP07, which is connected to the NUM FlexiumPro system by means of EtherCAT.

MP07 includes:

- 60 configurable buttons with blue LEDs
- 2 Override potentiometers or selector for spindle speed and feed rate
- 1 Handwheel
- 1 Emergency stop button
- 1 Three-position key switch
- 3 Dedicated buttons: Reset (white LED) Cycle Stop (Red LED), Cycle Start (green LED)
- 2 Dedicated LEDs for EtherCAT state: RUN and ERROR
- 2 switches for powering ON/OFF the machine
- 1 USB connector IP65



FS184i and MP07

# NUM FlexiumPro HMI

It is not only the hardware architecture and the embedded software that have changed – NUM’s FlexiumPro has a new dedicated Human Machine Interface (HMI).

The new FlexiumPro HMI sets the focus on user interoperability (touch, keyboard and hardware buttons), improves the user interaction experience, simplifies and optimizes the visualized information, and allows the user to customize the views.

A smart phone without Apps would not be as smart, and it’s the same for an HMI. Thanks to a powerful SDK (Software Development Kit), NUM’s FlexiumPro HMI can be adapted, completed, modified and customized. OEM’s no longer need to develop a dedicated HMI for a specific technology – they can now develop specific FlexiumPro HMI modules, with integrated technology-related features. For example, a waterjet cutting machine does not have a spindle and the operator might like to see parameters that are related to the water nozzle. To adapt the FlexiumPro HMI, the OEM just needs to develop the water nozzle module, then remove the spindle from the UI configuration and replace it with the water nozzle module. The page structure is made of “areas”, each containing a two di-

placed on different HMI pages; brand new pages can be added and the overall layout can also be themed and skinned.

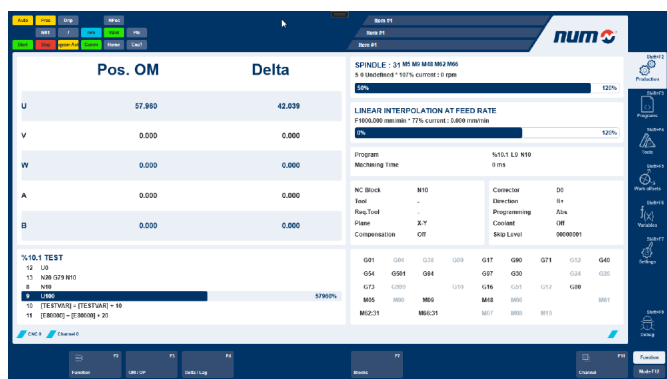
During the development of NUM’s FlexiumPro HMI, great care was taken to separate the service layer from the UI layer in an intelligent manner, and to keep it expandable. This software concept allows any part program preprocessing that might be necessary (for example, for part programs generated by CAD/CAM) to integrate/modify technology-dependent data and parameters; the part programs are adapted before being sent to the FlexiumPro RTK.

To ensure maximum performance in terms of speed and consumption of resources, NUM’s FlexiumPro HMI is written using the latest software technologies – C# for the software development kit and WPF for the user interfaces. The modules are started and stopped at each page change; this minimizes the use of resources and allows a fast switch between pages.

Like its Flexium+ predecessor, NUM’s FlexiumPro HMI runs under the Windows operating system; it can either be directly connected to a FlexiumPro RTK (Real Time Kernel) or it can run remotely on any PC connected to the same LAN as the FlexiumPro RTK. Furthermore, multi-HMI configurations are supported (one machine with more than one HMI).

The FlexiumPro HMI can be extended by using PLC-based visualization pages such as CODESYS remote TargetVisu and CODESYS WebVisu; using a simple graphical method, the machine builder can create fully custom visualization pages, developed inside the PLC programming environment.

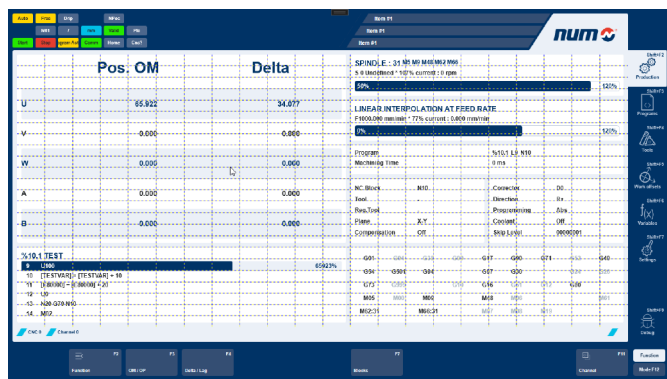
The FlexiumPro HMI solutions are completed by Flexium 3D; this is a graphical simulation software for part programs written in ISO-code (DIN 66025 with NUM extension) suitable for different applications like milling, drilling, turning, circular and non-cylindrical grinding, as well as water jet and plasma cutting, etc.



New HMI production page

mensional grid where modules can be placed. By using a simple configuration tool, customers can change the module’s settings and properties – and the modules can also be placed/replaced.

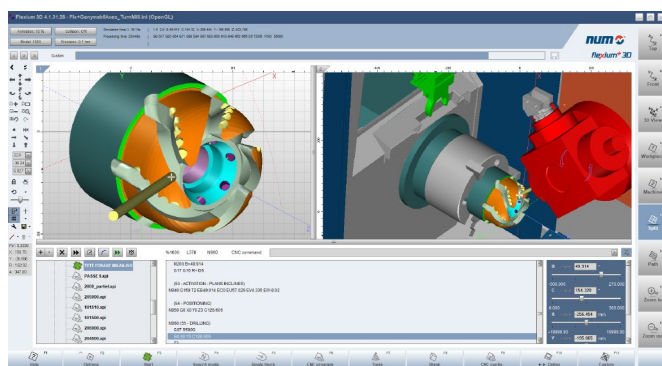
The new modern design provides integration consistency, conveying a homogenous look and feel to all the modules.



New HMI showing the grid

The user Interface modules are predefined plugins that can be used to customize the FlexiumPro HMI. For users and/or machine builders who want to push HMI customization even further, a graphical configuration tool allows customized/newly-created modules to be

During part program simulation, users can visualize the path of the TCP (tool center point), simulate material removal from the work piece, and check for collisions between machine components, part and tool. The main features of the 3D simulation are: wired path simulation, workpiece and machine view, material removal, collision detection, tool editor, blank editor, machine editor, online simulation, SEARCH mode (graphically supported part program re-engagement) and 3D-path editor (contour reworking/path optimization).



3D simulation

## NUM IloTgateway

**IloT (Industrial Internet of Things) or Industry 4.0 is about merging IT technologies with production technologies and creating new, innovative products and solutions. Efficient communication protocols are required to link the technologies, which the NUM IloTgateway offers.**

A "Smart Factory", a manifestation of Industry 4.0, is intended to enable the profitable manufacture of products even with individual customer requirements down to a batch size of one. To this end, production systems are linked with dynamic business and engineering processes. A basic prerequisite for this is the linking of plants with production management systems. At the physical level, Ethernet has become established for this purpose. This is not the case with protocols. Three protocols stand out here: OPC UA, MTConnect and MQTT.

NUM has enabled networking of its controllers ever since the 1990s. Solutions for the above-mentioned protocols have also been available for several years.

The NUM IloTgateway (FXSW282509 for Flexium or Flexium+ systems, APSW282509 for Axiom or Num Power systems) combines and replaces the previous solutions in one product and extends their functionality. In general, the data of all NC channels are now available. It is even possible to access multi-NCK applications.



MQgateway (FXSW282311) offers many data points that already cover the current requirements quite well. The MQTT solution of the NUM IloTgateway takes over the previous data structure and extends it by the transmission of \$-messages. The \$-messages are text messages that the CNC program can send. For NUMROTO applications (tool grinding), the information from the NrToolInfo.xml can also be queried. This file contains information about the tool to be ground and the grinding operations required for it.



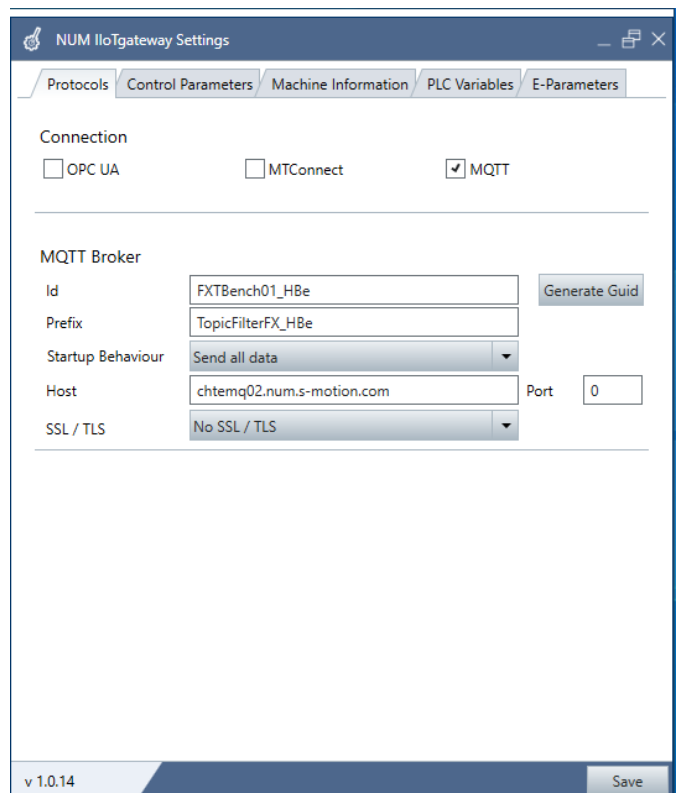
The previous OPC UA solution (FXSW282309) did not offer the protocol. Data had to be recorded in the PLC program and could then be made available via it. The OPC UA solution from NUM IloTgateway additionally offers pre-defined data nodes. The data nodes offered have the same structure as those of the MQTT solution. With NUM IloTgateway it is now also

possible to connect to the NUM CNC controls Axiom Power or Num Power via OPC UA.



With MDT0 (FXSW283100), NUM offered a product for MTConnect. This has now been aligned with the other two protocols, i.e. the MTConnect solution offers the same data as the other two protocols.

As already mentioned, NUM IloTgateway can establish connections to a Flexium or Flexium+ of all expansion types and to an Axiom Power or Num Power of all power types. The software version of the Flexium or Flexium+ system should be at least 3.6.00.00, while that of the Axiom Power or Num Power system must be at least R2.





In addition to the gateway software, NUM IloTgateway contains a configuration program and a small control program from which the gateway can be stopped and restarted. The configuration program "NUM IloTgateway Settings" is used to select the desired protocol (or several protocols) including any protocol parameters, and to define the number of NC channels and NCKs. Then machine information can be entered and PLC variables and E-parameters can be defined, which are then transmitted.

The NUM IloTgateway is delivered on a memory stick. It is installed on the target PC by means of an installation program, which is also located on this memory stick. The target PC is either integrated in

the NUM CNC or a PC or iPC connected to the CNC control can be used. The operating system of the target PC must be at least Windows 7. Of course, the target PC must also be connected to the company network.

The NUM IloTgateway (FXSW282509 or APSW282509) combines and replaces the previous solutions in one product and supports all three protocols (MQTT, OPC UA and MTconnect) simultaneously.

## Search Mode

**The ability to resume execution of a part program practically anywhere in its sequence, in a simple and practical manner, has long been one of the strong features of NUM's control systems. From memory, the search mode will scan the part program from the beginning, storing all functions encountered as well as axes' positions, in order to restart exactly in the conditions that appertain at the resume point. Over time, this mode has been expanded to allow searching by not only sequence number, but also by line number or by a particular string.**

With the increasing size of part programs, it may take a significant amount of time to scan the file from the beginning, especially if there is a considerable amount of data to send to the PLC (e.g., obtaining the correct tool offset in the case of tool management). To help circumvent this, NUM has added a quick search mode, which facilitates very fast operation at the cost of just a few drawbacks. However, what happens if the resume block is very long (e.g. flame cutting) and has already been largely executed?

Restarting from the beginning of this block will be time consuming for no good reason, and in the above example, relighting the torch must be executed just before the resume but outside of the part. Will it be necessary to edit the program without the option of testing first, or incur an additional time overhead by restarting at a previous main position?

Once again, Flexium has an efficient and easy answer to this situation. An additional search mode has been added: Restart at the interrupted position. When you select this mode from the HMI, you will get the dialog on the right:

No need to worry, most fields are filled automatically; let us just concentrate on the most relevant:

### Line progress

This defines the percentage of completion of the block at the time of the interrupt. It will be used to restart at this position, instead of at the beginning of the block. This field can be updated to restart just a little bit ahead of this point.

### Approach path

Here you have a choice of three resumption strategies, each following a certain trajectory, for a smooth entry and/or to start a device outside (e.g., cutting torch) before coming into position. It is even possible to call a subroutine, for example to change the tool. If the strategies do not fit your needs you can of course fill out the different fields yourself.

The last line just shows the command line that will be sent to the NCK in order to restart.

To cut a long story short: in the case of an incident, or if the operator has not memorized the line at which to restart, just select Search mode, then Restart at interrupted position, pick an Approach path

strategy, optionally decrease the Line progress value and finally press Cycle start to resume the execution in safe conditions. This mode is also available in Flexium 3D with visual assistance – and of course you will find full details in the HMI operator's manual.

Once again, this shows the power of the Flexium architecture and a side of NUM's philosophy: to provide our customers with powerful and easy to use features in order for them to concentrate on their expertise and increase their competitive advantage. Should you have any questions about the Search and Resume mode or any other, please ask your NUM technical contacts; they will be happy to demonstrate some of the inherent possibilities of our products.

### Restart at interrupted position X

Search type	Restart at Interrupted position <span style="float: right;">&gt;</span>	
Fast search	<input type="checkbox"/>	
NC Block		
CNC Program	15.0	
Line number	68	
CNC Block index	62	
Line progress	67.70	% 67.70
NC Block	N1033 X27	
Channel	0	
Approach path	2 <span style="float: right;">&gt;</span>	X <span style="float: right;">&gt;</span>
Correction side	Auto <span style="float: right;">&gt;</span>	
Plane	G17 (XY) <span style="float: right;">&gt;</span>	
Distance	0	mm <span style="float: right;">&gt;</span>
Radius	0	mm <span style="float: right;">&gt;</span>
Angle	0	° (grad) <span style="float: right;">&gt;</span>
Height	10.000	mm <span style="float: right;">&gt;</span>
Feedrate	0	mm/min <span style="float: right;">&gt;</span>
Subroutine	<span style="float: right;">&gt;</span>	

:68 H15.0 #62 EP67.70 G2 X0.000 Y0.000 EX0.000 EY0.000 IO.000 JO.000 ER10.000

Send

## NUM LMX Linear Motors, Designed for Machine Tools

There is a variety of linear motors available on the market but most are mainly designed for general automation (ie. fast movements from A to B).

Before developing it's own linear motor, NUM has taken a conservative approach and waited until the market was mature. The new LMX linear motor is specifically designed for machine tools:

- Primary section includes stainless steel and is fully encapsulated and protected to withstand the harshest environment
- Designed for continuous duty applications and low temperature rise
- Liquid cooling circuit with larger diameter piping, to accept low specific heat capacity liquids
- Short pole pitch to increase force density and reduce temperature
- Big air gap to reduce impact of mounting tolerances on motor characteristics

The advantages of using direct drives (torque motors) for rotary axes are easy to identify ; rotary axes with traditional kinematics were a clear weak point in term of accuracy, efficiency and wearing. In case of linear axes it is not easy to arrive to the same conclusion, existing ball-screw solutions do not have many limitations. So a machine builder might wonder, when to use linear motors in place of servo motors with traditional kinematics.

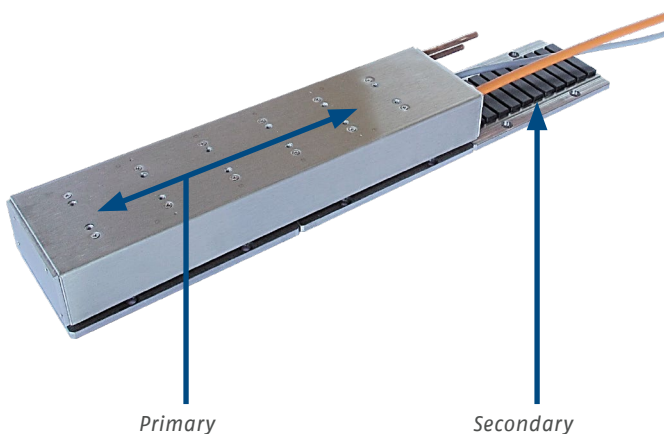
Linear motors bring important advantages in the following cases:

- Machine's axes are very stiff and high bandwidths are reachable
- High mechanical accuracy is required
- Backlash and mechanical wear cannot be accepted
- High acceleration rates must be met, higher than those reachable with traditional kinematics

Important considerations when implementing linear motors:

- The use of linear motors on vertical axes adds complexity. To avoid the axis falling, special brakes need to be used and counter-balance compensation can reduce the performance advantages achieved by using a linear motor
- For machine tool applications where efficiency is a key factor, linear motors typically behave worse than traditional ball-screw kinematics (linear motors running at typical machine tool speeds never reach the maximum efficiency point). Furthermore, cooling circuits are not loss free
- Machine service (exchange of linear motor) can be very complex
- Linear motor magnet plates (secondary) must be well protected against the intrusion of metal chips
- A kinematic made with a linear motor is typically more expensive, because a water cooling system is needed

The best kinematic solution must be chosen for each machine – it's a trade off of different factors. As well as torque motors, NUM provides both traditional servo motors and linear motors, and can support machine builders, during the machine's design phase, with the selection of the most suitable solution.



# Single Cable Motors with 24 Bits per Revolution Fully Digital Encoders

NUM first marketed single cable motors back in 2014 and they were an immediate success story.

The advantages are huge:

- Easier and faster installation; encoder cabling made with just 2-wires. Encoder supply voltage, single and multi-turn position as well as the motor's thermal sensor information are transmitted over 2-wires
- Fully digital protocol; no loss of resolution/accuracy due to noise
- Possibility to monitor the quality of the encoder communication
- Lower system costs by eliminating the need for a separate encoder cable and reduction of cable chain's dimensions

Available in frame sizes 75, 95, 126 and 155 mm, and in up to three different lengths each, SHX and SPX brushless servomotors offer machine builders a wide choice of output power and speed ratings to match different machinery applications. Both motor ranges feature high mass moments of rotor inertia, optimized for machine tool feed axes, and combine excellent dynamic performance with very smooth running, even at low speeds. The SHX range is intended mainly for cost-sensitive applications and includes models with continuous torque outputs from 1.2 to 20 Nm. For applications demanding motors with maximum power-to-volume ratios and a high degree of protection (IP67), such as high-end machine tools, grinding machines and robotics, the SPX range offers units with continuous torque ratings from 1.4 to 23 Nm.

The commercialization of SHX and SPX single cable motors started with digital encoders with medium, 20-bit (1,048,576 positions per turn) resolution and plus/minus 60 arc seconds accuracy.

To offer medium and high-end solutions, the SHX and SPX single cable motor families were extended with the introduction of high-resolution, 24-bit (16,777,216 positions per turn) resolution and plus/minus 25 arc seconds accuracy, encoders targeting demanding applications in terms of regulation performance and ultra-precise positioning.

NUM's strategy is to accompany all customers to single cable motors, showing their concrete benefits.

Encoders for Single Cable Motor (SHX/SPX)	Technical Characteristics			
	Encoder Y	Encoder Z	Encoder I	Encoder L
Sensor Type	High Resolution Multi-Turn	High Resolution Single-Turn	Medium Resolution Multi-Turn	Medium Resolution Single-Turn
Accuracy	< ±25 arcseconds		< ±60 arcseconds	
Operating Temperature Range	-20°C / +115°C			
Supply Voltage	7V - 12V			
Measurement Step per Revolution	16777216 (24 bits)		1048576 (20 bits)	
Turns	4096	1	4096	1
Electrical Interface	Fully digital fast serial 2-wire interface integrated in the motor power cable			
Functional Safety	STO, SLS, SOS, SS1, SS2, SLP, SDM, SCA with NUM drives and NUM-SAMX board <sup>1</sup>			
Other Info	Motor thermal probe information integrated in the encoder protocol (no need for cabling)			

<sup>1</sup> See NUM-SAMX manual for details and limitations

# Intersample and Timed M Function

# NUMcut HMI: Getting Back on Track

## Intersample and Timed M Function

A laser cutting machine may require very precise pulses, for example, to cut a grid at high speed. A water-cutting machine may need precisely timed commands to stop the abrasive before stopping the water flow. For such functionality and many others, Flexium+ has the answer.

Traditionally, M functions are intended to handle this, but to be perfectly in phase with the axes' positions, M functions require the axes to be stopped and the so-called "on the fly M functions" may experience a certain jitter which, regardless of how little it might be, would not permit the necessary accuracy. Additional hardware is often necessary, which increases the cost and risk of potential problems.

To handle these functionalities, two new types of M functions have been created, Timed M and Intersample M.

### Timed M

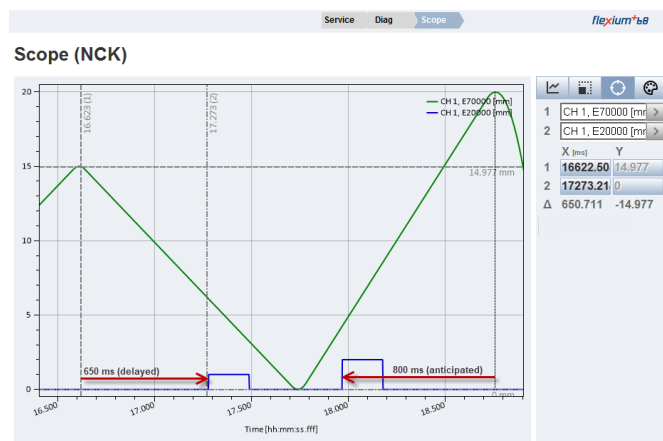
The 32 timed M codes are sent to the PLC after the movement (post functions) and do not require acknowledgment. Consecutive blocks are linked without stopping the axes. In this matter, they are similar to the "on the fly M functions" except that they can be delayed or advanced by up to 32 seconds. The time shift is defined by an E parameter, positive for delay and negative for advance. The range of these M codes is between M932 and M963.

Example:

```
N5 Go X0
E3000032 = 650 E3000033 = -800 // Delay M932 by 650 ms advance M933 by 800 ms
G1 F800 X15 M932 // M932 delayed with respect to X15
X0
X20 F1200 M933 // M933 advanced with respect to X20
Go X0
M2
```

### Intersample M

Unlike other M codes, the 32 Intersample M codes are not issued in the PLC, but directly on the NCK digital output terminal. They are grouped two by two respectively to set and reset one particular output of the sixteen that are available. They are also post functions, and do not require acknowledgment. The main specificity with respect to the intersample M code is that their time shift in relation to the end of the block defined via E parameters is given in  $\mu$ s. They can be advanced up to one real time scan (P50) and delayed up to 32ms with respect to the end of the block. To obtain a precision in the  $\mu$ s range they can be issued between two real time scans. The range of such functions is between M900 and M931. A typical application is to inhibit the laser cutter while jumping from one figure to the next.



Graph of the program above. Axis position in green, M codes in blue. The data on the right indicates the time shift between X5 and M932

Example :

```

E300000 = 0 E300001 = 25500    \ \ No delay for
                                M900, M901 is
                                delayed by 25.5 ms

X500 M900                      \ \ Digital output OUt0
                                is set when
                                position X500
                                is reached

X550 M901                      \ \ OUt0 is reset
                                25.5 ms before X
                                reaches the
                                position 550
    
```



Example use of Intersample M, the laser will be interrupted between each hole and restarted immediately

This short description is just intended to show another example of the power and flexibility of Flexium to handle an infinite number of applications. Additional information is available in the programming manuals and from your technical contact, who will be happy to show you some other advanced features to maximize your competitive advantage.

## NUMcut HMI: Getting Back on Track

**With all cutting technologies, an interruption of the cut can occur, for example, due to the abrasive failing during waterjet cutting, or an interruption of the plasma during plasma cutting. The NUMcut HMI offers several ways to get back on track.**

In NUMinformation 61, we presented the general solutions offered by NUMcut. This article is dedicated to a special topic: re-entry on the web, by means of graphical support. The NUMcut HMI provides various functions for this requirement.

The different options are selected by means of icons in the graphical area of the NUMcut HMI. As long as there is no cutting problem, the cutting process starts at the first cut of a part. Of course, one or more parts can be skipped in a job list. If there is a cutting problem, the operator can select from several stop options: immediate stop, stop at the end of the current cut, or stop at the end of the current part. The problem must then be corrected. This usually involves moving the axes to a specific point. This can be done in any machine mode, usually in manual mode, but even in MDI mode.

Then, the operator can start at the beginning of a part or a section. The desired part or section is selected with the mouse. The starting point is displayed at the start flag of the selected part or section (see Figure 1). At the start of the job execution, the corresponding part program is freshly calculated with the desired starting point at the corresponding shot flag. The axes move to the starting point and the tool (waterjet, laser, etc.) is activated. The operator can also select the start point in the job list by clicking on the part or cut.

With slow movements or long paths, it could take a long time to reach the point where cutting should be resumed, which is undesirable. Therefore the operator can also start in the middle of a cut. By means of the mouse the starting point within a cut is selected. The subsequent procedure is the same as described above.

An essential method for an interruption is to stop the axis movement and then to return on the traversed path. To do this, the cutting program is restarted. An input window appears in which the retraction amount is entered (see Figure 2) and the movement is started. The axes move back on the path by the input value, at most to the beginning of the cut. Then the cutting tool (waterjet,

laser, etc.) is activated and the cutting program is executed again from the current point.

Despite the various possibilities to re-enter the path and resume cutting, not all parts can be "saved". The machine operator can mark the individual parts as good or bad in the job list. With this information, a new job could be created with the "bad parts" and these could be cut again.

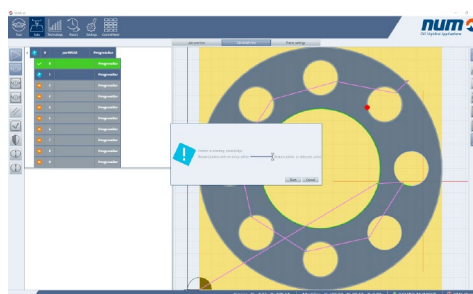


Figure 1: Starting point section

As you can see, the NUMcut HMI provides a comprehensive and helpful range of re-entry options on the web, enabling operators to perform their work efficiently.

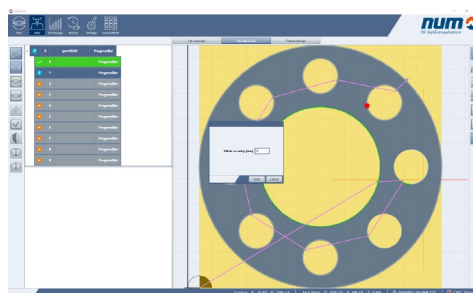
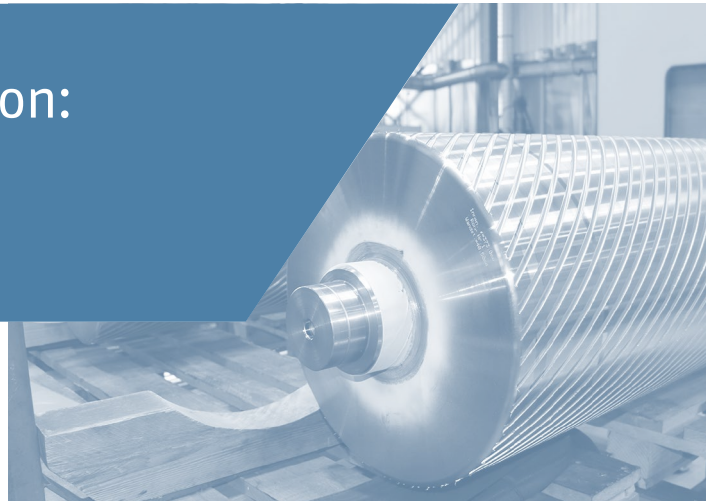


Figure 2: Re-entry via "back on track"

# Steinemann and NUM Collaboration: Swiss Precision par Excellence

**steinemann**



In the increasingly globalized wood panel industry, Steinemann Technology AG is represented all over the world. A dense network of subsidiaries and representatives creates great market and customer proximity. When it comes to innovations, Steinemann relies on Swiss precision and reliability, which have characterized every Steinemann sanding system for more than half a century. The cooperation between Steinemann and NUM has a very long tradition, which has been increasingly consolidated and proven over time. That is why Steinemann once again relied on a complete CNC package from NUM for a retrofit of the Geminis GE-870S groove milling machine.

## From textile machines to wide belt sanding machines for the panel industry

Founded in 1917, the family-owned Steinemann company has evolved from a manufacturer of textile machines to the world's leading supplier of wide belt sanding machines and sanding systems for the wood-based panel industry. The company clearly differentiates itself from its competitors in the market through the outstanding quality of first-class surfaces. With modularly expandable products and services, Steinemann offers comprehensive solutions for surface finishing. Steinemann pursues a clear strategy: maximizing customer benefits and securing decisive competitive advantages through "Total Surface Quality". The company is headquartered in St. Gallen, Switzerland, and employs around 90 people. The St. Gallen textile tradition is reflected in the origins of the company; in the early days, it manufactured textile machines and then in 1960, it began manufacturing wide belt sanding machines for the wood panel industry.

The know-how goes far beyond development and production. Customers benefit from seamless services, in-depth process knowledge, and directly available spare parts and consumables. Thanks to this depth of service, Steinemann increases the quality, safety and efficiency of its customers. In addition to the headquarters in Switzerland, there are two subsidiaries. These are located in Malaysia and China to cover the growing Asian market with Swiss precision. In addition, there are country representatives in 42 other countries, and Steinemann employs a total of 130 people worldwide.

## Fully integrated and automated grinding process

Steinemann is a full-range supplier of wide belt sanding machines for surface finishing. It focuses on the continuous development of



*Geminis GE-870S*

machines and abrasives and supports customers in the integration of the sanding line as well as the optimization of the entire sanding process. In addition, there are further competences such as: development of abrasive systems, worldwide customer service, spare parts and consumables, and innovative automation technology.

The central elements for optimal sanding results are, among others, the rollers of the wide belt sanding machine. All rollers for all generations of machines are produced at the headquarters, including those for the company's latest satos TSQ machines. The roller production process is very demanding due to the size and weight of the rollers. For example, rollers weighing 1.5 tons are balanced with an accuracy of less than 5 grams to avoid resonance of the grinding machine. The rollers are manufactured with very small tolerances. The finished rollers serve as a carrier for the sanding belts. MDF, particleboard and plywood up to a width of 3.2 meters are processed. Depending on customer requirements, the machine is composed of different numbers of "heads". Highest precision is a central requirement at Steinemann and it is here that NUM makes a significant contribution.



*satos TSQ*

**Cooperation for over 20 years**

Let's go back in history about 20 years. As a progressive and innovative company, Steinemann decided to purchase a complete CNC system from NUM in 2000. The starting point was the conversion of a Geminis GE-870S lathe into a groove milling machine. The project involved a new control cabinet, new motors, a NUM 1040 CNC system and NUM MDLA drives.

Due to the aging control system and material fatigue of the electric cables caused by oil and contamination, in 2021 Steinemann decided to modernize the grooving machine in accordance with the latest technological requirements and safety regulations. This was of course also done with a view to avoiding possible future production downtime. For the new NUM CNC control, the company opted for a Flexium+ 6 with safety functions, NUMDrive X servo drives, and BPG motors with absolute measuring systems.



*Rolls after machining by the groove milling machine*



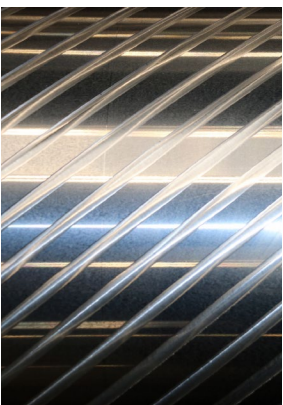
*HMI before retrofit*



*Optimized HMI after retrofit*

The wiring of the machine has been simplified and the use of the absolute measuring systems has eliminated referencing of the axes. The machining programs have been completely revised and parameterized so that the operator can create a new program in the shortest possible time. Data input is now done directly in the HMI (Human Machine Interface) on the corresponding variable pages.

During the modernization of the machine, it was also possible to optimize user-friendliness at the same time. This retrofit has led to a convincing added value of the groove milling machine. Operation has been significantly simplified, the setup time shortened, and process reliability increased. When you talk to the machine operators, you immediately gain an impression of how much they enjoy working on this machine.



*Close up of milled grooves on the roller*

It is also remarkable that this project could be realized by the same software developer, Mr. Konrad Näscher, Software Engineering NUM, who carried out the original retrofit 20 years ago. This long experience proved to be a great advantage in this retrofit. Mr. Näscher knew the machine characteristics and the programming very well and was involved in the project from the very beginning. Mr. Daniel Merkofer, Drums Department Manager at Steinemann, says: "The optimized user-friendliness leads to great satisfaction in operating the machine."

The problem of re-entry has also been improved. Re-entry after a program abort has become much easier. The operator enters the approximate Z position of the groove, the control calculates the exact C position, moves to the Z-C position at rapid traverse, pierces the groove and finishes machining the groove. It is important that no groove marks are created during this process. Mr. Näscher says,

"Experiencing the machine operators' joy while working on the machine is very satisfying to a developer."

**Minimal downtime during retrofit**

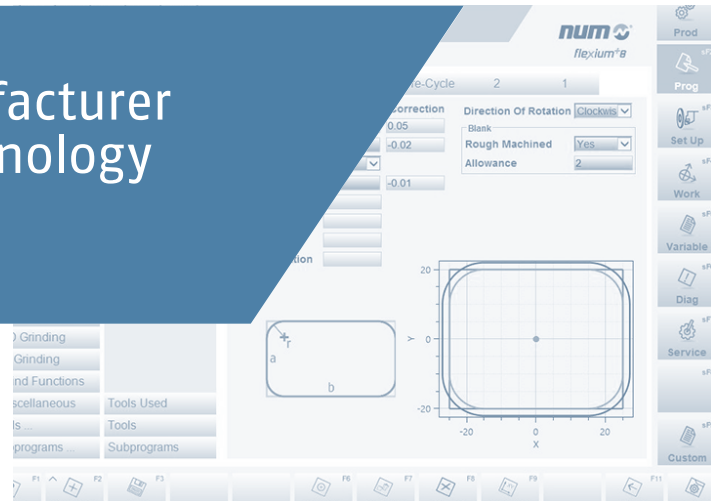
Mr. Ilhan Hasdemir, Head of Quality Control/Warehouse/Production at Steinemann, adds: "From kick-off to commissioning, the retrofit went smoothly. Only a few fine adjustments were necessary during commissioning and the planned reserve time was not used. The machine downtime was kept as short as possible. The project was also a precision landing in terms of cost planning. From the quotation to the invoice, everything just fit and no additional budget was needed here either." The entire planning process up to commissioning was uncomplicated and professional implementation was guaranteed on both sides. Mr. Hasdemir further enthuses: "The support from NUM was highly professional. You could always feel that there was a lot of passion, know-how and interest in the implementation of the retrofit."



*From left to right: Mr. Ilhan Hasdemir, Head of Quality Control/Warehouse/Production Steinemann, Mr. Christian Schuster, Area Sales Manager NUM, Mr. Konrad Näscher, Software Engineering NUM and Mr. Daniel Merkofer, Department Manager Drums of Steinemann*

# Leading Grinding Machine Manufacturer Adopts NUM's Flexium+ CNC Technology

**PALMARY**



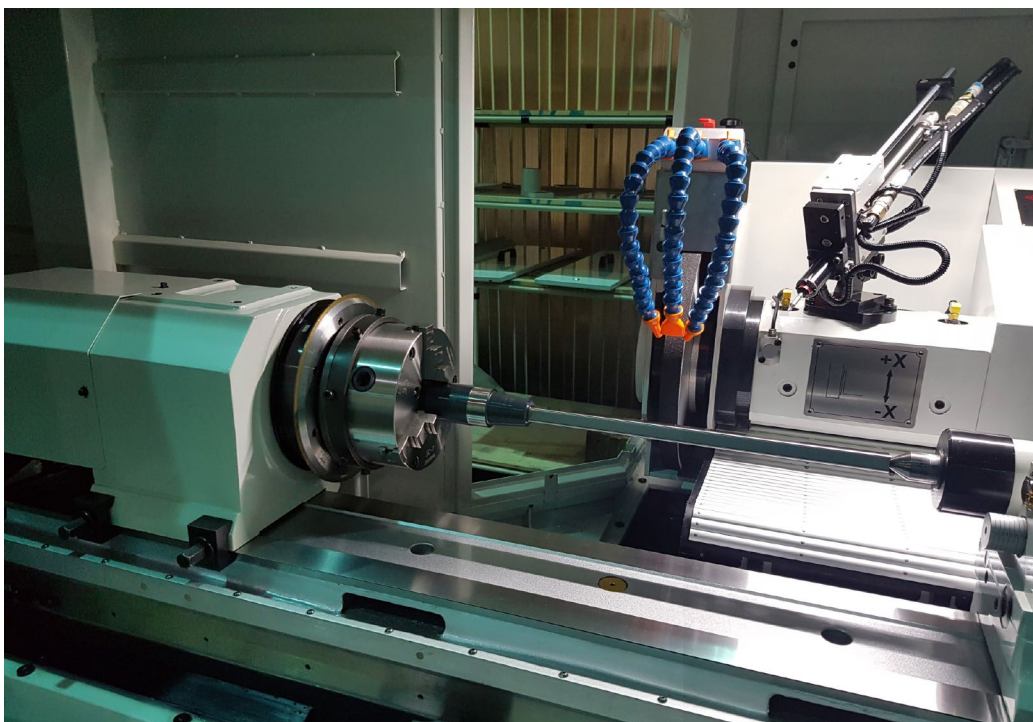
**Palmary Machinery Co., Ltd, the Taiwan-based manufacturer of high performance CNC grinding machines, is migrating control of its advanced CAM series of cylindrical grinders to NUM's Flexium+ CNC technology.**

Founded in 1998, Palmary Machinery has grown to become one of the world's leading manufacturers of CNC grinding machines. Based in Taichung, Taiwan, the company has nearly 200 employees and operates two large production facilities with more than 20,000 square meters of space. It produces a wide range of manufacturing automation – including centreless, cylindrical, internal, vertical and surface grinders – which is sold worldwide through an extensive sales and support network. The company's principal markets are in the USA, Europe, China, Taiwan and Japan. Currently, there are over 6800 Palmary grinders in daily service, manufacturing nearly 4000 different types of component parts.

Palmary Machinery has traditionally based its automated grinders on CNC systems produced by manufacturers such as Fanuc and Fagor. However, back in 2017, following Palmary's acquisition of Top Work Industry – another Taiwanese company that specialises in CNC tool cutters and grinders – it became aware of the unique advantages of NUM's tool grinding software.

As Johnny Wu, General Manager of NUM Taiwan, explains: "Top Work and NUM have collaborated very successfully for years. A number of its products are based on NUM's Flexium+ CNC platform and use our NUMROTO software, which presented Palmary with a very good image of NUM's technology. When we added non-circular grinding capabilities to NUMgrind in 2020, Top Work immediately drew this development to the attention of its parent company. After fully evaluating the software and host Flexium+ platform, Palmary has elected to adopt NUM's CNC systems for its CAM series of cylindrical grinders."

Palmary launched its CAM series of CNC cylindrical grinders in 2020. The grinders met with considerable acclaim – and won the prestigious 28<sup>th</sup> Taiwan Excellence Award. The family now comprises four models, offering a choice of workpiece length capacities from 250 mm to 1000 mm, which are used in a wide variety of automated manufacturing applications, such as the production of camshafts, crankshafts, cams and eccentric shafts.



According to Tiger Wang, General Manager of Palmary, "Until now, the CNC systems we used in our CAM series machines necessitated our customers using third-party software to generate the grinding path. However, NUM's CNC technology provides a complete, fully integrated solution. This has several important advantages. It effectively gives us a 'one-stop shop' for the machines' CNC hardware and software, furnishes a very ergonomic, unified HMI (human-machine interface) for machine operators, and offers considerable flexibility for customisation and future development."

*OCD-32100CAM cylindrical grinder*



The first Palmary machine to be equipped with NUM's CNC technology is the OCD-32100CAM cylindrical grinder. Capable of accommodating workpieces weighing up to 150 kg and as long as 600 mm, this machine features a direct drive spindle motor (C axis), a brushless servomotor with a precision angle decoder for dynamically controlling the grinding position (Z axis), and a linear motor with a precision optical scale for very accurate control of the grinding wheel in-feed (X axis). Each of the three motors is driven by a NUM MDLUX drive.

The machine's new controller comprises a NUM Flexium+ CNC system, with an FS153 operator's panel and an MP06 machine panel. The system's NUMgrind software helps to completely automate non-circular grinding. The operator simply determines the sequence of the process via the HMI and enters the necessary grinding data. Programming is further simplified by the fact that the HMI is supported by a comprehensive library of 15 predefined external shapes, including eccentric circles, hexagons, pentagons, polygons, Reuleaux triangles and rhombic. Palmary's customers can also import any customised profile of their choice in the form of a standard DXF file, without involving any third-party CAD/CAM software.

NUMgrind enables machine operators to define the closed shape of the workpiece in the XY plane. Grinding is subsequently performed by interpolating or synchronising the X axis with the C axis. The Flexium+ CNC system's NCK transforms the contour from the XY plane into an XC plane, and calculates the corresponding compensation and in-feed movements, taking the grinding wheel diameter into account. The speed profile is also transformed, so that the speed and acceleration are automatically adapted to suit the physical attributes of the machine.



NUMgrind software helps to completely automate non-circular grinding

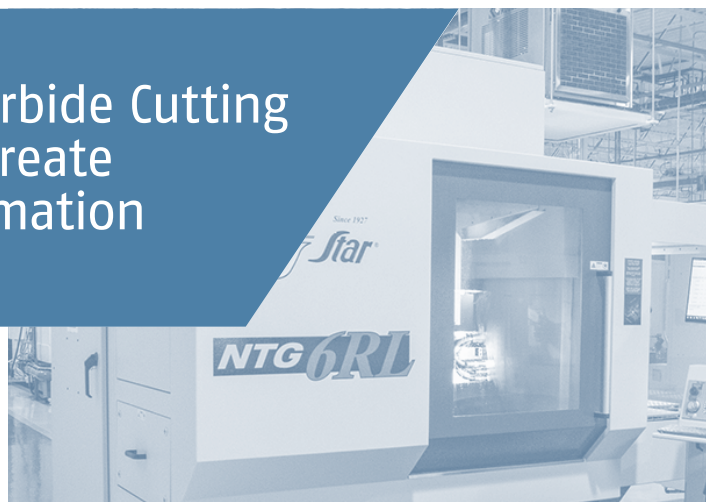


From left to right: Mister Adrian Kiener, CSO Asia of NUM, Mister Johnny Wu, General Manager of NUM Taiwan and Mister Tiger Wang, General Manager of Palmary

# CNC Machine Tool Company and Carbide Cutting Tool Manufacturer Collaborate to Create Next-Generation Production Automation



**GARR TOOL**  
High Performance Solid Carbide



**US manufacturers Star Cutter Company and Garr Tool have jointly developed an innovative 5-axis CNC machine tool that completely automates the production of complex profile end mills – from blank to finished tool.**

Star Cutter Company specializes in carbide and preform manufacturing, cutting tools and CNC machines for tool/cutter grinding and hob sharpening. Founded in Detroit back in 1927, the company nowadays operates six manufacturing facilities at strategic locations throughout Michigan. Its Elk Rapids Engineering division is responsible for the renowned Star brand of CNC tool and cutter grinders.

Garr Tool is the USA's leading manufacturer of high-performance solid carbide cutting tools. From humble beginnings with Fred Leppien in his garage in 1944, it now operates a state-of-the-art 200,000 square foot manufacturing facility in central Michigan with over 150 CNC grinders. Garr Tool specializes in solid carbide cutting tools, including end mills, drills, reamers and routers.

Garr Tool makes extensive use of CNC automation, including tool grinding machines from Ulmer Werkzeugschleiftechnik (UWS) and Star-Cutter. All of these machines are based on control technology supplied by the specialist CNC company NUM. Star Cutter, for example, has partnered with NUM for cooperative development of application-specific CNC hardware and software since 1998, and nowadays bases nearly all its machine tools on NUM's open-architecture Flexium+ CNC platform.

According to John Leppien II, Vice President of Garr Tool, "We use NUM's NUMROTO software for tool production and reconditioning on all of our Star and UWS machines. Our operators regard it as very flexible and user-friendly, and we find that it encourages interdepartmental knowledge sharing and also helps to reduce our training overheads."

A few years back, Garr Tool began producing a series of large diameter tools for use on high torque machines employed in the aerospace industry; however, manufacturing the tools involved multiple machines and multiple processes. The company therefore embarked on a collaborative project with Star Cutter's Elk Rapids Engineering team, to develop a multi-process machine capable of handling the entire production task. The result was a 2018 development of a Star CNC Tool grinder which included NUMROTO endmill software, cylindrical grind, along with linear motors and drives, with all 5 axes on a closed loop chiller/coolant system. This thermally stable machine allows Garr Tool to maintain .001" in diameter on the OD of these tools during lights out for 48 hour unattended runs.

Star's latest machine, the NXT tool and cutter grinder, now also incorporates these same features that were introduced to Garr Tool. Based on NUM's Flexium+ CNC system and NUMROTO software, this new 5-axis machine tool features linear motors instead of ball screws on the X, Y and Z axes, direct drive torque motors on the B and C rotary axes, and a liquid-cooled spindle motor. There is a choice of three different types of spindle motor, to best suit application needs; these include a very high speed unit capable of 24,000 rpm, and a very high power unit rated at 28 kW.

The NXT has an exceptionally small footprint (including the spindle/axis chiller) of just 7' 6" x 6' 6" (2300 x 2032 mm), and an installed height of only 7' 5" (2284 mm). These dimensions mean that the machine can easily be accommodated on the shop floor, where space is often at a premium. The base of the machine is cast in Zanite® Plus polymer composite to ensure mechanical rigidity and thermal stability.

Despite its diminutive size, the NXT offers a substantial grind zone, with maximum X, Y and Z travels of 19.7", 25.6" and 29.5" (500 mm, 650 mm and 750 mm) respectively. The machine can accommodate up to 15" (381 mm) end work and up to 10" (254 mm) diameter parts. Automated wheel changing and probing is standard with up to 8" (203 mm) diameter wheels, and the NXT can also run up to

*Star Cutter's new NXT 5-axis tool and cutter grinding machine is based on NUM's Flexium+ CNC platform*



10" (254 mm) diameter wheels with coolant manifolds and up to 12" (305 mm) diameter wheels without.

The ability to use large diameter grinding wheels for profiling applications or small, sub 1" (25 mm) diameter wheels for PCD pocket grinding on the same machine introduces a remarkable level of production flexibility.

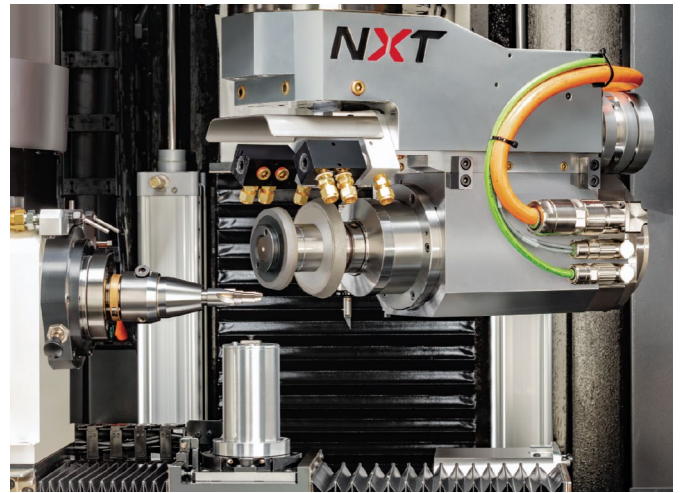


*Garr Tool specializes in solid carbide cutting tools, including end mills, drills, reamers and routers*

Star Cutter's new NXT tool and cutter grinder features a fully integrated Fanuc 200iD compact 6-axis short arm robot to facilitate fully automated processing of round and flat tool blanks; the standard gripper can handle from 5 mm to 32 mm blanks, with other options available. In-process measurement data is fed directly to the CNC system's NUMROTO software, to provide adaptive real-time control of the entire grinding process.

Based on a modular architecture, the NXT is designed for ease of integration with other forms of industrial automation and handling robots. An extensive range of factory-build and retrofit options include a traveling W-axis and a 12,000 rpm wheel dresser.

Aaron Remsing, Jr. Sales Manager for Star Cutter's Elk Rapids Engineering Division, points out: "We believe that the NXT is the smallest and most capable CNC tool and cutter grinder on the market. Even though it is an evolutionary design, its performance is nothing short of revolutionary."



*All 5 axes on Star Cutter's new NXT tool and cutter grinding machine are controlled by a NUM Flexium+ CNC system*



*Garr Tool operates a state-of-the-art 200,000 square foot manufacturing facility in central Michigan*

# Machine Control in Virtual Realities



elumatec AG has set up a system for virtual commissioning of its control software. This significantly shortens the test times for the software on the real profile machining centers. The NUM Flexium<sup>+</sup> CNC platform was structurally adapted for the system.

"Our programmers are now allowed to test everything they have previously tested on a machine on the digital twin. Only then can they apply their program to the real machine," says Felix Schlachter, head of software development at elumatec AG, summarizing the result of a project in which a system for virtual commissioning was set up for elumatec's SBZ 151 rod machining center. Core elements are the ISG-virtuos simulation platform and the NUM Flexium<sup>+</sup> control system.

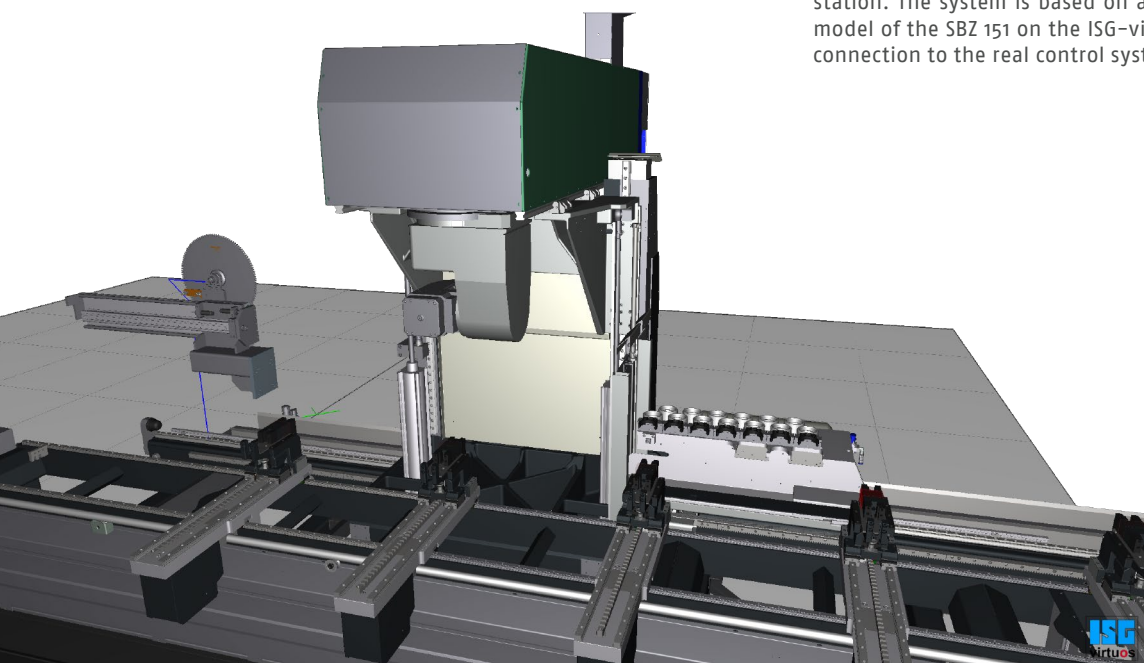
## The company and its products

elumatec AG in Mühlacker builds and develops saws, milling machines, corner crimping presses and bar machining centers, suitable measuring and stop systems, assembly and logistics equipment, and software. The approximately 700 employees worldwide support around 30,000 customers and generate annual sales of around 125 million euros. In the bar machining center (SBZ) product area, the company specializes in machines that finish profiles made of aluminum, plastic or thin-walled steel. CNC-controlled, they perform operations such as milling, drilling, tapping, thread milling, notching and sawing to a high quality standard. The SBZ 151 5-axis machining center has proved particularly popular, with over 60 machines sold each year. The series, which has been available since 2006 and has been continuously modified, is used in classic metal construction as well as in industrial companies and the automotive sector; other user sectors include rail vehicle, body and trailer construction as well as office furniture construction and shipbuilding. The machines

mainly process profiles with lengths of 6–15 meters. These usually come directly from the press shops and are processed into finished parts on the rod machining centers.

"With these profiles, the challenge is to ensure consistently high quality at high speed in profile machining over this length," emphasizes Felix Schlachter. To achieve this, the SBZ 151 works with stationary profiles clamped on the work table and a movable machining head complete with automatic tool changer and tool magazine. Regardless of the length, in practice each profile has different requirements for handling, clamping and machining. For this reason, elumatec's application engineers first check for each prospective customer in their test center whether all customer requirements can be implemented on the customer profile with a standard machine. If this is not the case, we adapt the machines to the end product for the customer," says Felix Schlachter. In some cases, this can be done with additional equipment and/or adjustments to the control software are sufficient. Thanks to the possibility of parameterization in the NUM Flexium<sup>+</sup> CNC system, most adjustments can be realized by changing the corresponding parameters without modifying the series software. "This is the flexibility we bring to the table. We deliver the SBZ specifically optimized for the customer, but for us it is a standard machine," emphasizes Schlachter.

Until now, software adjustments or changes at elumatec involved time-consuming tests on the real machine. With the new system for virtual commissioning, this is largely shifted to the office workstation. The system is based on a kinematic simulation of the CAD model of the SBZ 151 on the ISG-virtuos simulation platform and its connection to the real control system.



*On the SBZ 151 5-axis rod machining center, profiles made of aluminum or plastic are drilled, milled, threaded, cut to length and notched in a single clamping operation*

"We map the control components one-to-one in our system. Together with the control computer unit, we interconnect everything that is done virtually via the system bus. We make this real controller believe that the system bus is fully equipped as if it were connected to a machine," explains Felix Schlachter. In fact, however, there are no real drives or IOs connected to the EtherCAT, but rather another PC that simulates them. "This allows us to program as if we were at the machine, without having to adapt the programming for this," adds the software developer. On the one hand, this relieves the programmers because they can program without the risk of a real crash, and on the other hand, the programs also work on the real machine right away.



*An employee simulates the functions of an SBZ 151 on the virtual commissioning system at elumatec AG*

The development team at elumatec developed the system in close cooperation with NUM. For 20 years, elumatec has been working with NUM controls and uses almost the complete product range of NUM's Flexium+ CNC system in the SBZ 151, from the drives to the control computer. In this respect, it was thanks to both the many years of close cooperation and the convincing presentation of the elumatec project, that NUM made some structural changes to Flexium+, which included connecting the ISG-virtuos simulation platform.

#### Digital twin instead of real machine

"It is important to us that we have the SBZ 151 as a digital twin and do not always need the machine in physical form", emphasizes Felix Schlachter with regard to the future of the project. This will be expanded, he adds. Everything that is available on the machine and everything that elumatec obtains from NUM on the hardware side will be simulated in the future.



*In the virtual commissioning system at elumatec, all control components are virtually reproduced one-to-one. The machining head of the SBZ 151 can be seen on the screen*

The potential applications of the digital twin and virtual commissioning seem enormous. For example, troubleshooting on machines that are running in production at the customer's site is very promising. "We then get all the relevant data from the customer, play it into ISG-virtuos and virtually track how this error occurs. This is actually very practical and it works well," explains Schlachter. In addition, new employees can be trained on the digital twin without blocking the real machine. Even studies to determine the machining times of certain profiles can be carried out virtually, by importing the CAD profile data into the simulation platform, where machining takes place virtually in real time.



*Felix Schlachter, head of software development at elumatec AG: "It's important to us that we have the SBZ 151 as a digital twin and don't need a real machine for many jobs."*

"In the case of additional equipment, special designs or even robot connections, the digital twin also gives us a head start in terms of time," says Felix Schlachter. "We can start developing the software immediately after designing with the digital model, without waiting for a special design to be physically built."

#### Automation and standard interface

Robot connections in particular will play a greater role in the future, as demand for them is increasing. "But at present, we only use robots in special individual cases, but an interface integrated in the standard machine is available." Thus, elumatec is open to third-party automation projects, as was recently the case with the integration of an SBZ 151 into a robot cell for automatic loading and unloading of the machine. On the control side, the robot cell acts as a master that interacts with the SBZ controller. The overall system is then operated via the cell controller, which in turn prompts the SBZ controller to process certain orders, for example. In this project, elumatec was able to take advantage of the flexibility of the NUM controller on the software side to adapt processes for connecting robots and ultimately develop a standardized robot interface. "We now know how a robot connection works, and we can interact with robots. We have created a document that says what signals we provide to the robot at the interface. This means that everything is standardized so that it can be implemented in a reasonable project time," sums up Felix Schlachter. If adjustments are made to the connection, the digital twin will be used to ensure high software quality.

# Bunorm Maschinenbau Relies on Retrofit



For more than 20 years, Bunorm Maschinenbau AG has relied on CNC controls from NUM AG for its Forest-Liné series of machines. Bunorm provides its customers with the opportunity to purchase small and large single parts, as well as small series or complete assemblies and plants, from one source. Another important competence is its own metalworking shop. With qualified metal workers and welding robots, complete in-house solutions are offered. Awarded numerous certifications, Bunorm is still one of the few machine builders in Switzerland with its own metalworking shop, where welded constructions weighing up to 20 tons are manufactured.

## From simple individual parts to complicated assemblies

Bunorm was founded as a family business back to 1965. Its core business was initially mechanical engineering, while nowadays the company focuses on the machining of very large machine parts. In 2020, the company repositioned itself by joining the SwissFactory Group. This association of innovative SMEs with complementary manufacturing technologies aims to create new market offerings for apparatus, plants and machinery in the B2B sector throughout Switzerland.

Bunorm is represented at two locations in Switzerland and employs over 90 people, including 11 apprentices. In total, the group has 300 employees.

Bunorm Maschinenbau has been active in the field of CNC manufacturing for over 37 years. The company's huge 10,500 m<sup>2</sup> production halls contain 45 CNC machines, on which components of up to 60 tons are machined. For comparison: about 10 elephants weigh 60 tons! The dimensions of the workpieces to be machined range from 20 mm to 18 meters. The machining time of a workpiece on the portal machining centers ranges from 15 minutes to 30 hours, depending on the requirements. Most of the work involves single parts of large components, rather than serial production. The components are mainly produced for the mechanical engineering, automation and construction industries. The production of these highly complex parts requires comprehensive technical knowledge, the highest quality standards and sound know-how. This is where NUM comes in, as a reliable and experienced partner in the CNC sector, to help improve the quality and productivity of CNC gantry machining centers.

## Over 10,000 programs in the database

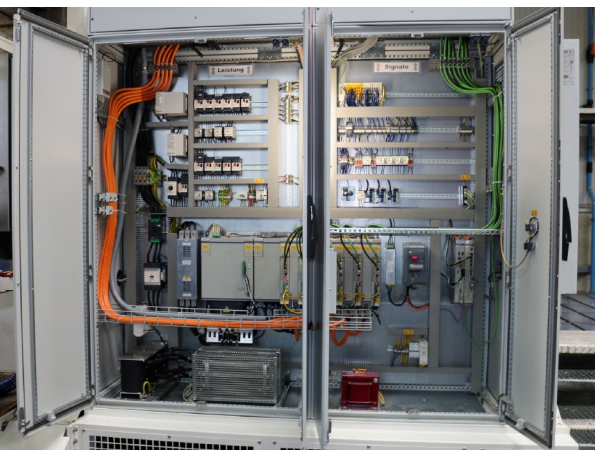
Bunorm has used Forest-Liné Seramill and Modumill CNC portal machining centers for more than 20 years. As part of a major retrofit project, the company recently upgraded the machines' CNC systems. A prerequisite of the CNC upgrade was that all functions of the machines could still be utilized and that additional safety adjustments and optimizations could be made. According to Mr. Urs Morgenthaler, CEO of Bunorm, "From the outset, we again chose to partner with NUM, because in our experience they are the best. We have more than 10,000 CNC programs in our production database, so backwards compatibility was a key issue – being able to use the programs on the upgraded machines, without having to carry out extensive reprogramming, saved us a lot of time and money. We have also been able to integrate many new programs very easily, enabling us to further optimize control of the machines."



Control panel

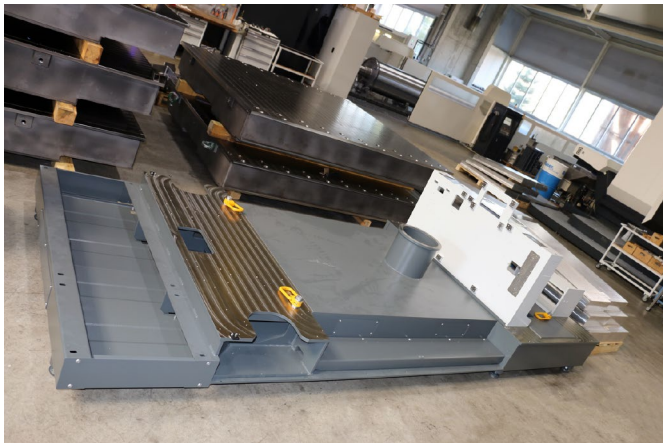
Bunorm's Department Manager for Mechanical Processing, Mr. Manfred Wiesenfarth, has been responsible for the Forest-Liné machines ever since they were installed. As he points out, "Despite precise work and many years of know-how, occasional malfunctions and defects are part of the job. Years of experience led us to believe that many of these could be eliminated and corrected by the retrofit project. And indeed, since modernization, the machines are much more reliable – and fault monitoring has also improved enormously."

Further time and cost savings resulted from the fact that employees did not need any additional training. Operation of the machines remains much the same. Another advantage of the retrofit was that no new foundations had to be constructed. While the downtime was longer than with a new purchase, one must not forget the structural



Control cabinet of the Modumill

measures that are necessary with such large processing machines. Existing foundations are much more stable, which puts the downtime due to structural measures into perspective.



*Typical component: machine chassis welded and milled on portal machining center*

Both machines are now equipped with the latest version (4.1.30.00) of NUM's Flexium+ CNC system and MPO4 control panels, and the control cabinets have been completely rebuilt by NUM. Each machine has four linear axes (the X and U axes are coupled for the gantry). For this purpose, the spindle heads can be positioned by the C and A rotary axes. Due to the enormous size of the machines, each is installed with six of NUM's largest NUM servo motors.

From the control cabinet to the motors and the Human Machine Interface (HMI), NUM was able to offer a one-stop solution. Mr. Morgenthaler and Mr. Wiesenfarth both commented that the entire retrofit project was elegantly implemented by the NUM team. Bunorm particularly appreciated the fact that the project managers were very experienced and competent, and that only a few people were involved. This allowed for efficient planning and communication.

According to Mr. Morgenthaler, "NUM offers the best and easiest way to process inclined planes." This allows the coordinate system can be rotated, so that users can program machining very easily on the sides or across inclined planes.



*From left to right: Mr. Fouad Rafik, Application NUM AG, Mr. Manfred Wiesenfarth, Department Manager Mechanical Processing Bunorm Maschinenbau AG and Mr. Christian Schuster, Area Sales Manager NUM AG*

### More automation in the future

Another benefit of the retrofit is automated measurement. This increases the number of workpieces that can be measured in a given amount of time, and by reducing human operator error it increases measurement accuracy. Both reduce scrap and effectively lower costs.

The goal of Bunorm is to realize high spindle hours. In general, increased automation of the machines, such as automated pallet change, should increase efficiency. Since machining some large parts takes longer than one work shift, automation can make shift changes more efficient and avoid time-consuming shift handovers. Most importantly, automation means increased productivity and efficiency. Many manual tasks otherwise performed by machine operators are eliminated by the increased use of fully automated machines. However, the company is keen to emphasize that the benefits of accelerated and automated processes should not be over-estimated, pointing out that behind every piece of automation there is a highly prized human being!



*Modumill portal machining center with NUM CNC control Flexium+*



*Seramill portal machining center with NUM CNC control Flexium+*

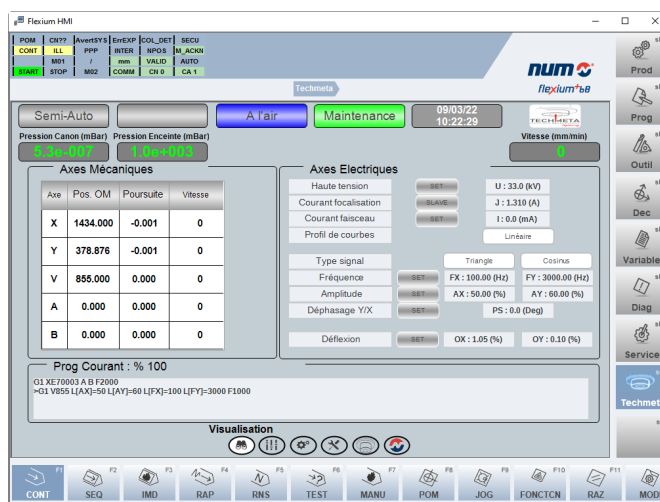
# Ultra Fast Interpolation and Near Absolute Vacuum

**TECHMETA**  
ELECTRON BEAM EXPERT  
*Engineering*

From the depths of the ocean to the farthest reaches of the atmosphere, from parts weighing just a few grams to those requiring nearly a megawatt at the spindle, from clocks and watches to gears over a meter in diameter, from machines for mass production to those designed to be used only once, there are few areas that NUM has not addressed.

A new frontier has been crossed with TECHMETA Engineering; this time in the field of near absolute vacuum with the realization of electron beam welding machines.

Founded in 1964 and located in Haute Savoie, France, TECHMETA Engineering is the world leader in electron beam welding machines. This vacuum welding process does not require the addition of material, the welding being done by melting the metal of the part. The result is high quality joints, without oxidation or pollution from the environment, and welds that can reach significant penetrations, thus guaranteeing excellent mechanical properties. In addition, thanks to the single-pass process, the deformation of the part is minimal, which often makes post-welding machining unnecessary. The fields of use are numerous: defense, nuclear, aeronautics,



Monitoring of the electrical axes of the gun

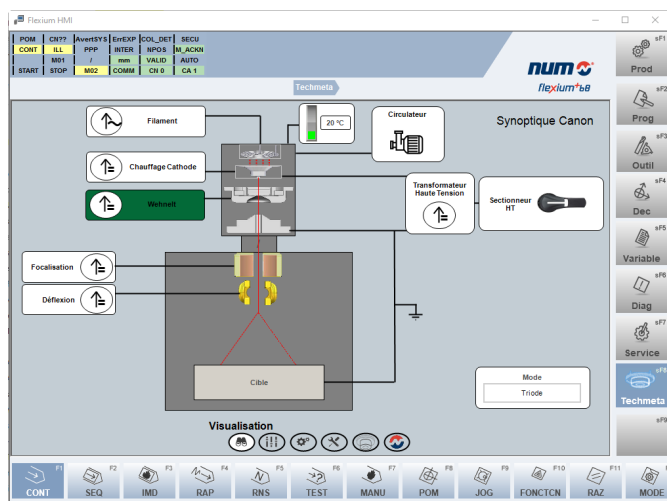
automotive and research. In order to facilitate its export development, which represents nearly 80% of its production, and to focus on its know-how, TECHMETA Engineering needed a reliable and trustworthy partner for high performance CNC systems. After a test campaign where numerous challenges were met, TECHMETA Engineering decided to adopt a collaborative approach with NUM.

The basic principle of electron beam welding may seem familiar to those who knew television before the advent of LCD and LED versions, but the magnitude of the parameters involved bears no similarity to those of our old television set. A cathode, heated by a filament and brought to a potential of several tens of kilovolts, will emit electrons (at a few hundred mA) that will strike the part to be welded at a speed of several km/s. On their path, these electrons will encounter several devices designed to modulate the intensity of the beam, then focus it and eventually make it vibrate according to a well-defined profile before its impact on the part with such energy that the metal will melt locally. All these parameters, as well as the positioning of the part, must be able to evolve during the process, which takes place in a quasi absolute vacuum.

View of the welding chamber, note the watertight connections of the motors that will work under vacuum







Synoptic of the "electrical axes"

Before the more sophisticated functions could be used, it was necessary to ensure that the Flexium+ system was compatible with the environment. Knowing that even the earth's magnetism affects the beam path, it is necessary that the motors do not create disturbances and that they are compatible with vacuum operation. This ranges from the ability to limit heating, where convection is by definition impossible, to the absence of electromagnetic radiation, to the lubrication of the bearings. NUM's motors meet these criteria perfectly, and their ability to connect to a single cable limits the number of interfaces between the atmospheric and vacuum zones. The adaptability of NUM's equipment also helps to avoid the risk of electrical ignition, which reaches a maximum at a certain pressure value: at  $10^{-2}$  atm., 300 V is sufficient to create an arc between two elements a few mm apart (Paschen's law).

Of course, it took more than excellent hardware features to make Flexium+ a success. The project in question, for an Asian customer, includes five machines with well-defined requirements.

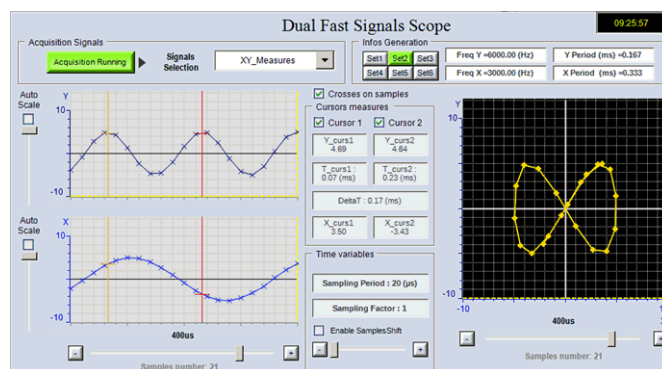
The fine control of the electron gun parameters (intensity, acceleration, focusing, etc.) in real time while the workpiece is moving continuously does not pose any particular problems thanks to the symbolic programming and the customizable G functions. However, to ensure a perfect weld, it is not enough for the impact point of the electron beam to follow the defined trajectory precisely; all the expertise of the manufacturer and the welder comes into play here. This point of impact must, depending on the case, be able to "vibrate" around the theoretical point, not in a random way but



From left to right: Jérémy Betemps Technical Director TECHMETA Engineering, Elia Barsanti Director NUM France, Nathan Vaudaux Automaticien TECHMETA Engineering, Jean-Pierre Creton Electrical Engineer TECHMETA Engineering, Stéphane Bellet Application Engineer NUM France

on the contrary according to a selected or programmed profile as well as at a programmable frequency. The elements of this vibration trajectory can be of the order of ten  $\mu$ s, which is far from the usual interpolation capabilities. By means of additional deflection coils, the Flexium+ system will impose all the desired characteristics on the beam. These beam control values are known as "electrical axes", and it is thanks to the power and modularity of NUM's numerical control system that such high performance has been achieved, but we won't go into that here. There remains the calculation of the parameters, particularly for the vibration path, which was far from being the least challenging. Flexibility and openness of the system also facilitate the bidirectional dialogue with a vision system that serves both to accurately locate the position of the beam (sensitive to the slightest magnetic disturbance) and to monitor the parting line. Any deviations are corrected in real time by dynamic operators.

The whole setup also includes a supervisor running on an FS194i which, in addition to generating ISO programs with up to 512 cells, controls the parameters of each weld (vacuum, speed, focus, deflection etc.) and ensures the traceability of welded parts.



Example of vibration generation: here 6 kHz on the Y axis and 3 kHz on the X axis

Mission accomplished for Flexium+, but what is the customer's opinion on this case? Mr. Vaudaux and Mr. Creton from the design office said they appreciated the modularity of the system and the ability to communicate with additional elements, as well as the integration tool (Flexium Tools), which allows the entire installation to be programmed and set up using a single software package. The technical director, Mr. Betemps, emphasized the quality of the relationship with NUM, which has always been able to provide the necessary support and answers. This is in line with NUM's philosophy of providing the best hardware, software and service to enable our customers to develop their competitive advantages in a partnership approach. As Mr. Barsanti, Director of NUM France, says: "The power and flexibility of our products, combined with the experience of our engineers, have enabled us to offer TECHMETA Engineering a first class solution, but make no mistake, this is a story about people who are passionate about their work."

# Celebrating 50 Years of Excellence in Cutting Tool Manufacture



US cutting tool manufacturer Tool Alliance celebrates 50 years of highly successful business in March 2022. During this time, the company has grown steadily and in the process has built an enviable reputation for the quality and durability of its solid carbide and indexable carbide cutting tools.

Tool Alliance makes extensive use of CNC grinding machines from various manufacturers, but has chosen to standardize the machines' control systems on NUM's Flexium CNC platform and NUMROTO software, primarily for reasons of performance and production efficiency. Tool Alliance is one of the largest licensees of NUMROTO in the United States.

Founded in 1972 and still privately held, Tool Alliance operates a number of company-owned factories – its principal manufacturing facilities are located in Huntington Beach, California, and in Fort Myers, Florida. The company's cutting tool products and services include such renowned brand names as Ultra-Tool®, RoundTool Laboratories®, Tungsten ToolWorks®, Routco® and Mil-Tec®. All five brands are sold worldwide, and are supported by shared research, design, engineering, manufacturing, marketing and sales facilities.

The owner and President of Tool Alliance, Dave Povich, is no stranger to the cutting tool industry. A past-President of the United States Cutting Tool Institute (USCTI), he has worked for the company since 1987. According to Povich, "NUM is our CNC technology partner, which creates a win-win situation for both companies. We benefit from having a direct technical input to NUMROTO software development, while NUM gains valuable feedback on the design and production of the very latest cutting tools."

Tool Alliance's innovative Ultra-Tool Series 365 high performance end mills are a case in point. Designed specifically for the machining of exotic materials, these solid carbide tools feature a patented variable-helix geometry combined with a proprietary edge preparation/PVD coating combination that allows for world-class dynamic milling of tool paths, including most slotting cut applications. The tools are produced on high performance 5-axis CNC grinding machines using NUMROTO, employing monitored tool run-out, real-time deviation compensation and the latest diamond abrasive technology utilizing advanced wheel truing equipment.

Mark Wortsman, Tool Alliance's Technical Director, says that collaborating with NUM has multiple advantages. "The NUMROTO team is very supportive and always amenable to suggestions, which makes life a lot easier for us, as well as our customers. For example, we recently suggested adding categories for collets, and some new features for wheel probing and automatic 3D collision checking; these have all been implemented in the latest version of NUMROTO software."

"We consider the 3D-simulation capabilities of NUMROTO to be the most accurate in the tool grinding world; they help us to optimize tool programming by preventing any grinding errors that might otherwise be caused by imperfect wheel measurement or incorrect machine alignment."

Wortsman also points out that NUM's software helps simplify shop floor management. "Over the years we have built an extensive library of tools that we have produced with NUMROTO. The NUMROTO team has done a superb job of incorporating the library in a centralized industry-standard SQL database which can be accessed by any of our machines or programming stations. The database can store tens of thousands of tool programs which can be accessed by several hundred users – at the same time if needed."



*Tool Alliance's cutting tool products and services include such renowned brand names as Ultra-Tool®, RoundTool Laboratories®, Tungsten ToolWorks®, Routco® and Mil-Tec®*



*Tool Alliance has chosen to standardize the control systems of all its CNC grinding machines on NUM's Flexium CNC platform and NUMROTO software*

"It is much easier to backup a single centralized database file instead of having to backup files from the computers on each machine – we perform automated backups several times a day, just to ensure productivity continuity in the event of a machine breakdown. Software updates are also handled very efficiently. As soon as a key NUMROTO update is available, we can bring all our machines, regardless of make or model, up to the same software revision level."



*Tool Alliance's innovative Ultra-Tool Series 365 solid carbide end mills feature a patented variable-helix geometry and are produced on high performance 5-axis CNC grinding machines using NUMROTO software*

Many of Tool Alliance's CNC grinding machines are equipped with automatic loading systems to facilitate overnight production – in fact, some run for two days in a row without interruption and without the need for any manual compensation. To keep the tool dimensions within tolerance, the company relies on the NUMROTO software's "measurement in process" feature, which automatically measures tools after grinding and applies appropriate compensation.

A number of projects undertaken by Tool Alliance have warranted installing early generation CNC machines and then retrofitting them with NUM's latest motors, drives and CNC systems. According to Steven Schilling, General Manager of NUM Corporation, "Again, we were able to help. Our CNC team in Chicago provided local support, and we were able to improve the performance of the machines' spindles and axes. It has been, and continues to be, a pleasure to be a partner to the success of Tool Alliance."



*Photo shows (left to right): Mark Wortsman, Technical Director of Tool Alliance/Dave Povich, owner and President of Tool Alliance/ Patrick Schmid, NUMROTO Project Manager/Steven Schilling, General Manager of NUM Corporation*



*Tool Alliance makes extensive use of CNC grinding machines at its manufacturing facilities*

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