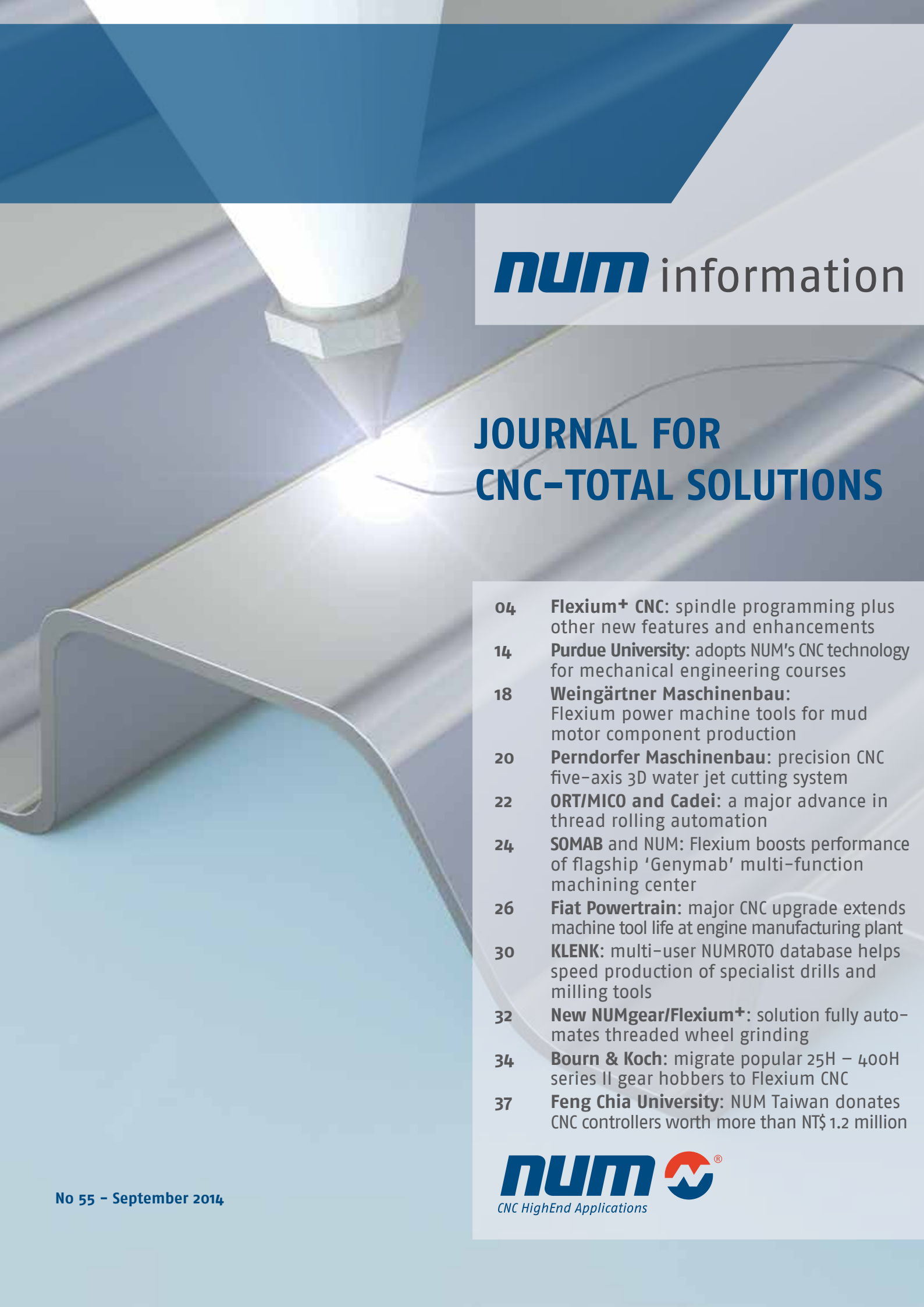

num information

JOURNAL FOR CNC–TOTAL SOLUTIONS

num®
CNC HighEnd Applications

No 55 – September 2014

Editorial

Peter von Rüti, CEO NUM Group

Dear Readers

For NUM, active participation in IMTS and other global trade fairs provides us with a unique opportunity to present exciting new developments in CNC system hardware and software technology. This year's highlights include an extremely cost effective two-channel CNC control system for designers of small and medium-sized machines with up to five axes, a scalable safety architecture which can easily be adapted for all kinds of machines, and new functions in closed loop software for complex geometry tools.

Flexium+ 8, the youngest member of the Flexium / Flexium+ family, is cost-effective and extremely simple to install. With the CNC system, machinery can be controlled that has up to 5 CNC axes and which requires a high degree of flexibility. The developments, which utilize the openness and flexibility of the system, are carried out by the NUM Technology Centers (NTCs). It is also possible for machine manufacturers or even end-users to develop specialist functionality themselves, as they are able to access the same functions as the NTCs.

NUM strives to invest in research and development, not only to guarantee continuous market prominence for our customers through technology, but also to assist in the training of junior staff members. As you can read in this edition of NUMinformation, students at the renowned Purdue University in the USA and at Feng Chia University in Taiwan are acquiring specialized knowledge of NUM CNC Control Systems.

"For NUM, active participation in global trade fairs provides us with a unique opportunity to demonstrate exciting new developments in CNC system hardware and software technology."
(Peter von Rüti, CEO NUM Group)

With the aid of Flexium and Flexium+, students and graduate scientists are now able to research CNC technology in depth. All CNC, servodrive, I/O and PLC set-up and programming is carried out with the help of a single software tool, which helps to reduce the learning curve, increase productivity and job satisfaction, and foster collaborative endeavors. The systemically open NUM CNC architecture offers students numerous advantages and opens up undreamed-of possibilities. With industry standard editors and languages, such as HTML, JavaScript, Visual Basic, Delphi, C , C++ etc., custom-designed HMIs (human-machine interfaces) can be created or altered very easily. The 3D graphical simulation possibilities with Flexium+ will significantly increase the flexibility of work and the option of implementing directly into CNC core code facilitates a deep understanding of CNC technology.

I hope you enjoy reading this edition of NUMinformation and hope to meet you in person at IMTS.

Peter von Rüti
CEO NUM Group

Imprint

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NUM`s global trade fair presence

In order to be closer to our customers in the future, we are expanding our global trade fair program. During 2014, NUM is taking part in a total of 13 international specialist trade fairs from North America to Asia. Participation in more new exhibitions is also planned for 2015.

NUM attaches considerable importance to meeting customers in their home markets. One of the highlights of 2014 will certainly be participation in the IMTS in Chicago, (September 8 to 13), the largest specialist trade fair for manufacturing technology in North America, where we will be exhibiting for the first time with our Flexium+ 6 / Flexium+ 8 display stand. Shortly after the IMTS, we will be making our first appearance at AsiaMetal in Guangzhou. Here is the full list of trade fairs that feature in NUM's 2014 exhibition program:

Feb. 2014	CCMT, Shanghai, China
March 2014	Grindtec, Augsburg, Germany
March 2014	Industrie, Paris, France
April 2014	SIMTOS, Seoul, South Korea
May 2014	SIAMS, Moutier, Switzerland
May 2014	SPS IPC Drives, Parma, Italy
June 2014	BIEMH, Bilbao, Spain
June 2014	CIMES, Beijing, China
Sept. 2014	IMTS, Chicago, USA
Sept. 2014	AsiaMetal, Guangzhou, China
Sept. 2014	BI-MU, Milan, Italy
Nov. 2014	EMAF, Porto, Portugal
Nov. 2014	SPS IPC Drives, Nuremberg, Germany

NUM Event Calendar 2014

IMTS
September 8-13, in Chicago, USA
Booth 5135, East Building

AsiaMetal
September 15-17, in Guangzhou, China
Booth N12, hall 2.1

BI-MU
September 30 - October 4, in Milan, Italy
Booth G35, hall 11

EMAF
November 19-22, in Porto, Portugal

SPS PIC Drives
November 25-27, in Nuremberg, Germany
Booth 3-668, hall 3

Events

Flexium+

Spindle programming and other new features

A summary of new features in Flexium+

This article summarizes some of the new features of our latest Flexium+ CNC platform. Building on the outstanding success of Flexium, which has an installed base of well over 10,000 worldwide, Flexium+ advances CNC control to an entirely new level. It incorporates new high performance firmware, software and hardware, while retaining all the power, flexibility and user-friendliness for which NUM products are renowned.

A key aspect of Flexium+ is the platform's scalability – machine tool manufacturers can apply the same CNC architecture across a broad range of applications, regardless of size and complexity. A choice of three CNC kernels allows cost-effective, performance-optimized solutions to be created for diverse applications. The largest CNC kernel, Flexium+ 68, can control up to 32 drives. Innovative spindle management allows any connected device to be an axis or a spindle – and control allocation can be changed on the fly. This simplifies spindle/C axis commutation and provides an excellent foundation for multi-spindle applications such as large transfer machines. Logical addressing helps to keep programming simple – an example is included later in this article.

Flexium+ also features a modular, system-wide safety architecture. A safety PLC, using distributed safety I/O modules and the safe motion monitoring facilities of our new NUMDrive X servo drives, oversees all critical system operations. Machine designers can implement high integrity safety functions with very few additional components – and by using our new single-cable servomotors with these drives as described later, they can also reduce cabling costs and improve machine reliability. NUMDrive X servo drives also offer new tandem application options to help simplify the design of very high torque axes.

The Flexium+ HMI is now designed to be even easier to use and takes full advantage of new peripherals such as the large landscape format touch panel described in this article. New graphical FXCAM software helps machine operators to handle 'shop floor programming', while the powerful Flexium+ 3D simulator uses the NC code being processed by the CNC interpolator to provide a true picture of machine operation. The following pages include details about the simulator's support for advanced 5-axis machining, and show how a CNC oscilloscope function can be used to further improve online visualization accuracy.

Why does the new Flexium range addition deserve a + ?

Perhaps it is because of the new features that it provides?
Like its famous and successful predecessor, Flexium+ exists in three configurations: Flexium+ 6, Flexium+ 8 and Flexium+ 68. Each has the same axes and options structures as its Flexium counterpart, but pushes the performance boundaries even further. Not visible at first glance but of the utmost importance is the completely reengineered firmware. This provides the opportunity to create new control methods to accommodate the latest developments in the machine tool industry. Some of these features are already available. For example, the new tandem drive configurations, which include a winding duplication function for use with extremely powerful spindle motors. Other features like Volumetric Error Compensation (VEComp) are also ready – and there are many more to come. The new firmware also helps to surpass existing speed and travel limits. It is now possible to imagine axis travel of 1km with sub-nano interpolation – at double the original maximum speed and with even more precise acceleration control. More visible is the new DISC NT+ digital bus that allows optimal control of our new NUMDrive X range of servo drives. This provides faster communication, enhanced precision and higher performance, as well as exciting new solutions like single cable motor connections.

Or its advanced spindle management?
One particularly important improvement is in the area of spindle management. Flexium+ has the ability to manage up to 32 spindles. One main spindle and up to three auxiliary spindles can be programmed and controlled in each channel (details are given later in this article). The notion of axis or spindle has been generalized to provide the capability of quickly switching mode at any time. This opens the way for a large range of applications, from live tools to the most sophisticated transfer machines, and in keeping with NUM's tradition it is achieved without any break in compatibility with current machines.

Is it due to the new safety architecture?
Based on the FSoE (Functional Safety over EtherCAT) protocol, Flexium+ provides a comprehensive, modular safety solution with distributed I/O modules and drives equipped with an embedded NUM-STOX board for Safe Torque Off functionality or a NUM-SAMX board for the full set of functions (Safe Operational Stop, Safe Limited Speed, Safe Direction and much more). Connection is with standard Ethernet cables; no exotic software tools are required as programming and maintenance are done through Flexium Tools.

Or maybe it is the Human to Machine interfaces?
Flexium+ comes with a new set of peripherals. The most obvious being the portrait oriented FS192i operator panel. This 19' touch screen accommodates dual touch gestures and can display the redesigned Flexium+ HMI simultaneously with a choice of virtual panels: a full keyboard, an ISO programming keyboard or a fully customizable machine panel. Associated with the MP05 wired panel, the latter provides efficient and ergonomic machine control. The attractively priced portable nPad provides a convenient solution for remote machine operation and is available in wired and safety certified wireless versions. More peripherals are described elsewhere in this edition of NUMinformation.

But let's talk about the Flexium+ HMI: based on the Flexium HMI to maintain ease of use, it provides different contexts that have been completely redesigned for an up to date look and feel. Data can be accessed even more easily thanks to redesigned pages with new fonts and a new color scheme. The diagnostics page, for example, now provides more information, using message extensions to detail the cause of any error. Error messages are still backed by help functions, so troubleshooting assistance can include graphics or parts of manuals – or even access to an online knowledge database.

Could it be due to single cable motors?
The development of Flexium+ and NUMDrive X servo drives has enabled us to introduce two new ranges of servo motors – SHX and SPX – that feature a single cable connection for both the power and the certified digital sensor. An innovative embedded digital interface scheme allows the encoder power and position feedback data – together with diagnostic information and thermal data from the motor's temperature sensor – to be carried on just two shielded wires contained within the motor's power cable. In addition to lower cabling costs and smaller/lighter cable chains, the reduced number of interconnections improves reliability and immunity to electromagnetic interference. It is estimated that for a typical high-end CNC machine installation involving 20 meter cable lengths, this new technology can reduce total motor cabling costs by as much as 20 percent per axis.

Or the powerful shop floor programming feature?
Notwithstanding the numerous other facilities of Flexium+, shop floor programming remains an important need for some users. Flexium+ therefore introduces FXCAM, which uses graphics to help guide machine operators through the process of creating and executing a program from scratch. An important point is that the operator is always guided but at the same time enjoys maximum freedom of choice. The program that is created can subsequently be executed on any Flexium+ system. Forming part of the Flexium+ HMI, FXCAM is already available for sophisticated processes like gear machining. But there is more. To differentiate their products from those of competitors, machine builders can easily create their own programming interface or adapt an existing one using FXCAM Designer. Running on a PC, this powerful tool automatically creates all the files necessary for FXCAM as soon as the machining process is defined. Text translation in different languages doesn't require any additional design effort.

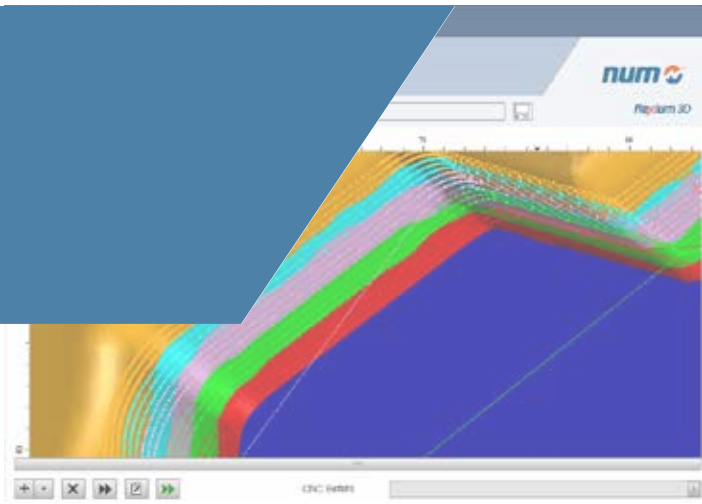
It is difficult to decide which is the single most exciting feature of this new CNC system. But whatever your choice, we are sure you will agree that the + is fully deserved. Do not hesitate to get in touch with our sales people to discover how Flexium+ can help you to easily build more powerful machines and secure a competitive advantage.

Flexium+ Spindles

Overview
One of the most important new features of Flexium+ is advanced spindle management. Thanks to the enhanced DISC NT+ digital bus, Flexium+ has the ability to control up 32 to drives, any of which can be associated with an axis or a spindle – and the control allocation can be changed on the fly. It is therefore possible to imagine a unit with up to 32 spindles. Of course, in most cases there will not be as many spindles as this, but combined with the power and flexibility of our CNC and drives, this performance opens the way for a huge field of applications, from live tools to transfer machines.

Flexium+

New features and enhancements



Programming
While it is good to have such advanced features, will they remain an advantage if they are difficult to program? NUM has paid considerable attention to this issue; the company is renowned for its commitment to software compatibility and ease of use. The main spindle is programmed by the usual functions M3, M4, ... and S for the speed, making previous programs totally compatible on machines that are already fitted with one spindle per channel. In the case of auxiliary spindles, as these are a new concept, a new programming strategy was of course necessary. We have therefore introduced the concept of logical addresses. Each spindle is associated with a unique number (1 to 32) used only for programming. This number, when used as a suffix, will allow each spindle to be addressed individually. For example:

S2500:4	set speed of spindle number 4 at 2500rpm

Alternatively, the operator has the choice to access the spindles by their rank (Main, Auxiliary) in the channel:

M19#2	Index the second auxiliary spindle

On top of this, each spindle can be assigned a symbolic name like 'Drilling Unit' or 'Dressing Wheel' to further help the machine operator.

For extended flexibility it is possible to change the spindle rank on the fly and to pass spindles from one channel to another, provided that this is authorized by the 'giving' channel. This is performed by three particular codes:

M61	– Releases spindle to make it available in another channel
M62	– Declares a spindle as main or auxiliary with the suffix #
M66	– Uses a spindle as reference for feed/rev

Each of these codes can be applied to a logical address or a particular spindle rank.

Performance
Thanks to the faster DISC NT+ digital bus, the performance capabilities of each spindle are increased.

Speed:	0.01 rpm to more than ... 600000 rpm
Resolution:	more than 8M counts/rev according to the max speed

With Flexium+, NUM is now more able than ever to honor its mission statement: to provide machine builders with advanced and flexible solutions that offer a real competitive advantage.

Flexium+ 3D simulator continues to evolve

NUM's Flexium+ 3D simulation software combines work piece simulation and collision monitoring/detection with other powerful features. This allows machine builders to optimize tools and NC programs to suit the kinematics of a specific machine using virtual prototype techniques, enabling the entire machine part production process to be optimized for reduced tool wear and efficiency, without creating scrap. The simulator visualizes the tools, the machine's kinematic properties and the work piece blank as 3D volumes. Material volume is removed from the work piece as the tool moves along the machining path defined by the CNC program, while the same volume is continuously subtracted from the work piece blank.

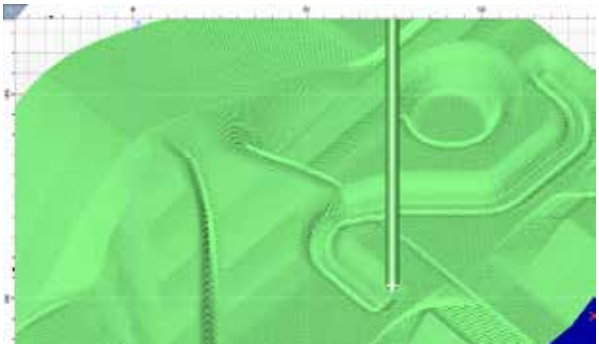
Unlike many competitive CAD/CAM visualization programs, the Flexium+ 3D simulator uses the NC code being processed by the NUM CNC interpolator – in both online and offline mode – to create a true picture of machine operation, which increases the opportunities for improving the overall process. Flexium+ 3D handles part programs for milling, turning,

and water jet cutting applications written in ISO-Code (DIN66025 with NUM dialect) and the operator can choose between work piece, machine or split views.

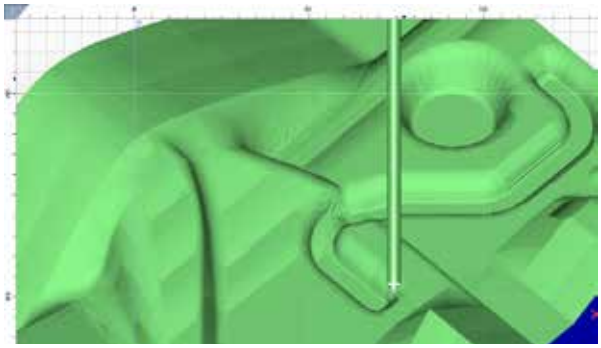
Flexium+ 3D simulation software is available in 2 different versions:

- Office version: Flexium+ 3D as standalone simulation software used in production planning without CNC
- Machine version: Flexium+ 3D as part of the Flexium+ HMI panel software used for
  - -> Pre-simulation of part programs; different part programs can be executed on CNC contemporaneously
  - -> Online simulation with simultaneous execution of part program on CNC (simulation of axes' positions)

During simulation the TCP (tool center point) path is visualized (pic 1b), material removal on the work piece (pic 1a) is simulated and checks are made for collisions between tool and machine components.



Pic 1a

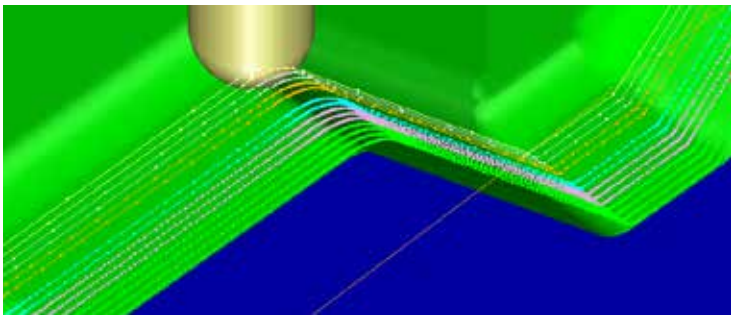


Pic 1b

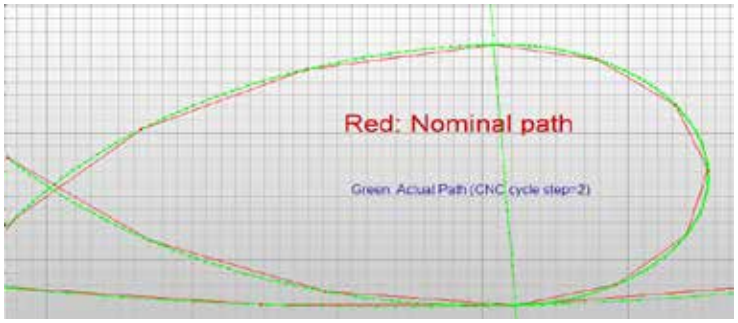
3D online simulation with CNC oscilloscope function

As mentioned above, Flexium+ 3D online simulation provides the opportunity to visualize the movement of axes during CNC part program execution, while simultaneously showing the removal of material with the tools that are in use.

Integration of a CNC oscilloscope function allows the behavior and accuracy of Flexium+ 3D online simulation to be improved substantially. The CNC oscilloscope function provides configurable access to record, read and visualize position and spindle data from the Flexium+ CNC in synchronism with its real time clock. The system transfers this recorded position data, together with data related to the tool (tool and tool cut number), to the Flexium+ 3D simulator for simultaneous visualization; this information, in combination with the real position data, gives the real tool path and material removal.



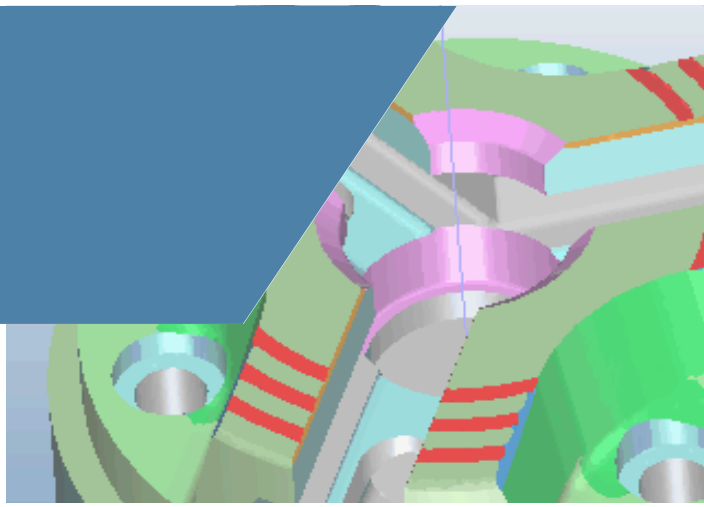
This improvement to online simulation enables the user to analyze critical geometries (edges, small radii, corners etc.) or to visualize the behavior of axes with regard to velocity predictions, acceleration and accuracy, as well as unexpected position oscillating.



It also allows any differences between the nominal and actual paths, (partially zoomed overlaid online simulation) to be evaluated.

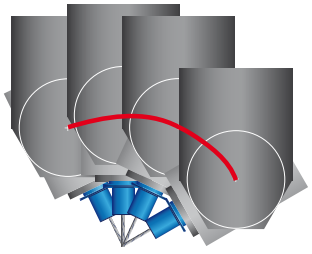
Flexium+

Flexium+
3D simulator enhancements

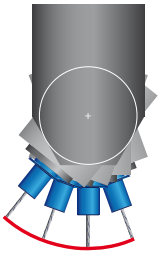


3D simulator now supports advanced 5-axis machining

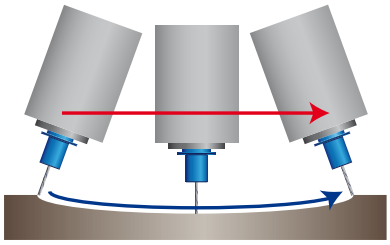
For many years, the CNC firmware of each new generation of NUM CNC has included integrated RTCP (rotate tool center point) and Inclined Plane functions. The RTCP function is used for machine kinematics with additional rotary axes (A, B or C) to change the tool orientation without leaving the contact point on the path between tool and part. It provides automatic compensation of the main linear machining axes for the offsets caused by the movements of the rotary axes. Meanwhile 16 standard as well as specific 4- and 5-axis kinematics are defined and supported. With an Inclined Plane defined in the space referenced to original coordinates, a new logical coordinate system can be used to program and execute geometrical shapes.



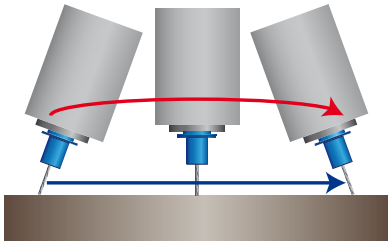
RTCP on



RTCP off



Without the tool tip control

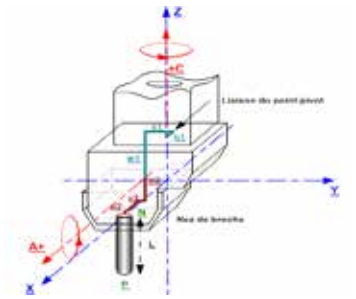


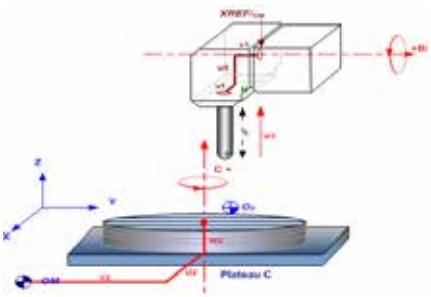
With the tool tip control

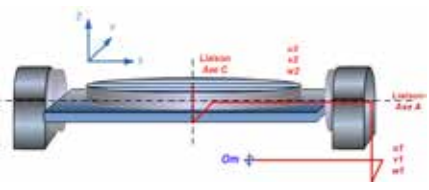
To be able to analyze and simulate part programs for these kinematics, the complex coordinate transformation functions are now integrated into Flexium+ 3D software. The main kinematic structures which were taken into account for this RTCP/Inclined Plane consideration are shown below. Other kinematics are derived from the three main kinematics.

- Dual Rotary Twist Head
  Type# 2:
  Dual Twist Head A carried by C
- Simple Rotary Twist Head and Simple Table
  Type# 12:
  Simple Table C and Simple Twist Head B
- Dual Tilting Table
  Type# 15:
  Dual Tilting Table: Table C carried by A

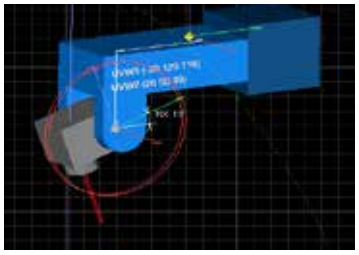
Theoretical model

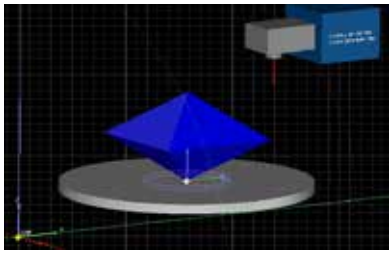


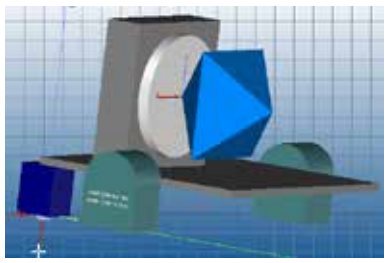




Simulation model



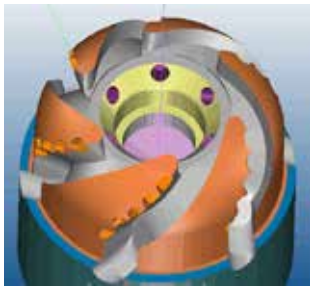




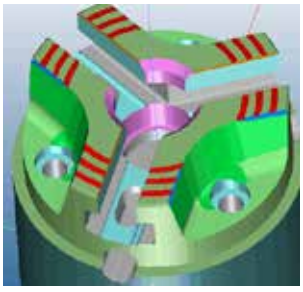
With these kinematic models, offline-simulation of the part program is possible without moving the specific axes of the 5-axis machine. Analysis and evaluation of part programs, as well as collision detection for machine components like the table, tool and part holder, are also possible during the coordinate transformations.

The images below show the two simulated parts and the two real parts machined on a combined 5 axis milling and turning machine (C rotary axis in the part and B rotary axis in the tool). Note the excellent correlation between the simulated and real parts.

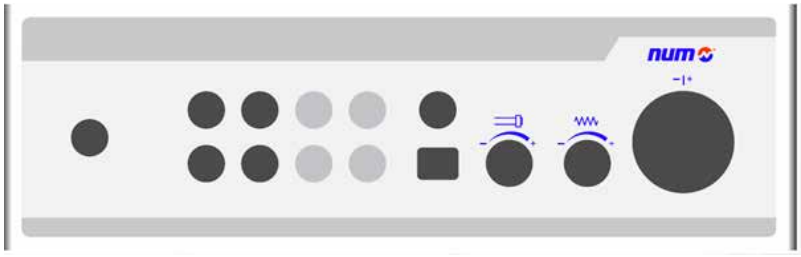
RTCP processing (5 axis):
Offline simulated work piece and machined part



Inclined plane and RTCP processing (5 axis):
Offline simulated work piece and machined part



FS192 landscape format touch-sensitive operating panel



When NUM introduced its vertical format 19-inch projective capacitive (PCAP) touch screen in 2012, it set a new standard for operating panels in the machine tool industry. Following valuable feedback from customers, NUM has now developed a landscape format version. The new FS192L-TS operator panel features the same modern, ergonomic design as the vertical format version, and has the same IP65 front protection and IP20 rear protection ratings. A new matching version of machine panel – the MP05L – is also now available.

Flexium+

Flexium+ FS192 landscape touch panel and HMI enhancements

FS192 landscape touch panel and HMI enhancements

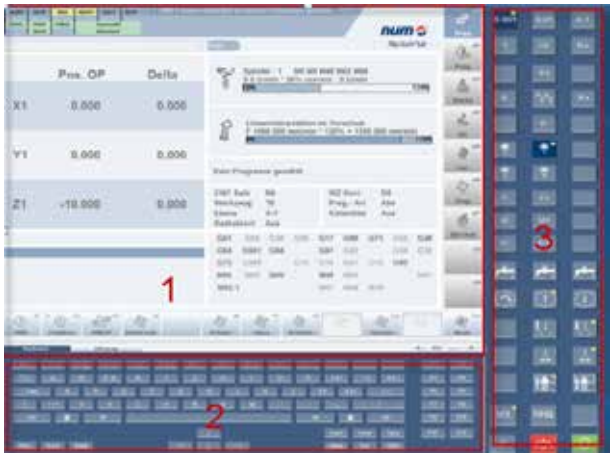
NUM's new FS192L-TS landscape format touch panel has the same visible screen area as the FS192i, but is rotated by 90 degrees, and provides a symmetrical horizontal and vertical viewing angle of about 170 degrees. The screen is protected by non-reflective 4 mm hardened high-quality glass. Narrow brushed aluminum frames with rounded edges provide complete side protection for the glass and multi-touch sensor.

Product code	**FXPC19LCNNNNNoo (FS192L-TS)**	**Details**
Display	19" TFT pcap Touchscreen	(projective capacitive touchscreen)
Resolution	SXGA	1280 x 1024 (ratio 5:4)
View angle	170° horizontal and vertical	
Communication	3 x USB V2.0 rear	Type A,1.5/12/480 MB
	1 x USB rear (PC)	Type B
	1 x DVI (<= 50m)	Integrated 4 port USB Hub

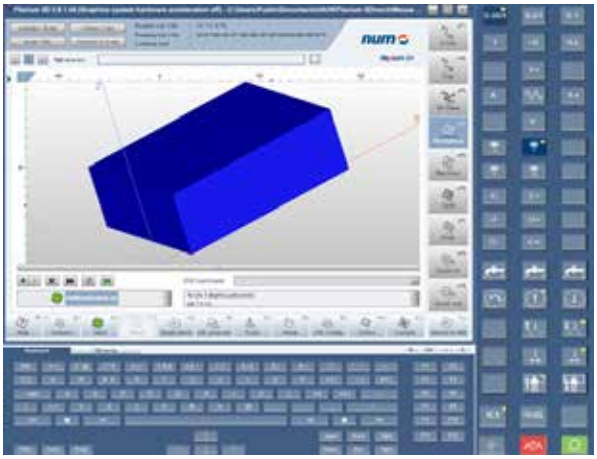
This modified design introduces new requirements for the HMI, virtual keyboard and virtual machine panel software, as well as for customer-dependent applications.

The screen is divided into 3 areas, each with specific software components:

1. Flexium HMI (or other applications such as Flexium+ Tools, Flexium+ 3D, NUMROTO, NUMROTO 3D or customer HMI solution) runs under optimized 1024 x 768 resolution
2. Virtual keyboard (full Qwerty keyboard, ISO programming keyboard) runs under 1024 x 256 resolution
3. Virtual machine panel (CODESYS target visualization or area for customer application bar) runs under 256 x 1024 resolution



Divided Screen



Divided Screen

Visualization and keyboard configuration windows control the position, size and behavior of areas 2 and 3. This flexible configuration capability allows applications to be displayed full screen, or as a structured partition of the 19" monitor. All application areas can be operated with a mouse or keyboard, as well as single-touch gestures. Flexium+ HMI and Flexium+ 3D dual-touch gestures can also be used – these require that the panel's integral PC is running the Windows 7/8 operating system.

Due to its 19 inch screen size and sensor frame, the new landscape format FS192L-TS operator panel has different dimensions to NUM's well-known FS152 panel family; however, its overall dimensions are identical to those of the FS192i/FS192. A simple cabinet cut-out shape helps machine builders to incorporate the new panel very easily. Used with the new MP05L machine panel, the FS192L-TS operator panel offers the very latest in machine control ergonomics – providing OEMs with the means to clearly differentiate themselves from the competition.

Tandem applications with MDLUX drives

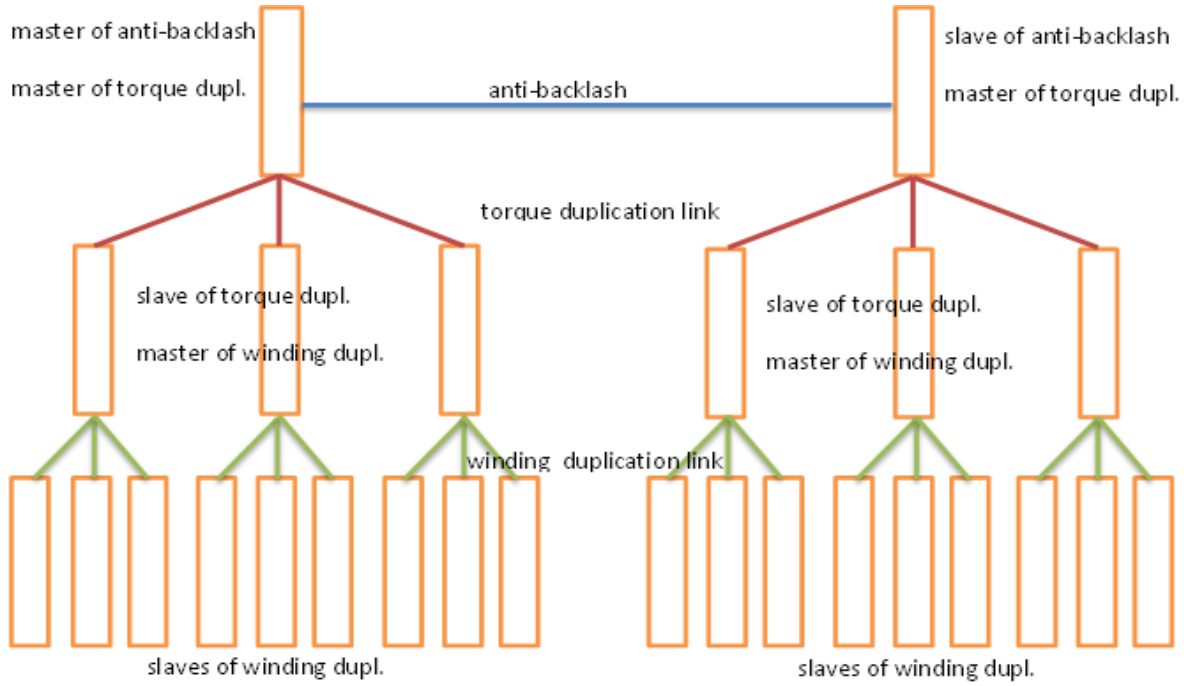
First of all let's explain what NUM means by 'tandem' applications: these are where two or more drives exchange information with each other (related to references or different types of feedback), using a proper communication bus other than the standard DISC NT+ bus that is used by the CNC.

Usually, in a NUM tandem application we have one drive that is referenced as the 'master' drive and controlled directly by the NCK, and one or more 'slave' drives, that receive their command references directly from the master drive. A well-known example is the 'anti-backlash' application of MDLU2 and MDLU3 drives.

Compared to MDLU3 drives, MDLUX drives come with a wider range of tandem applications:
- anti-backlash application
- torque duplication application
- winding duplication application
- mechatronic applications using the new 'drive embedded macro' functionality

Furthermore, with MDLUX drives it is possible to create very powerful hierarchic structures of tandem applications. For example, with MDLUX drives we could create a tandem application involving 26 drives, organized in the following hierarchic structure:
- an anti-backlash pair of drives (master/slave)
- where both, master and slave, are master of a group of 4 drives involved in torque duplication
- then, each torque-duplication slave drive is, on its own, master of a group of 4 drives involved in winding duplication

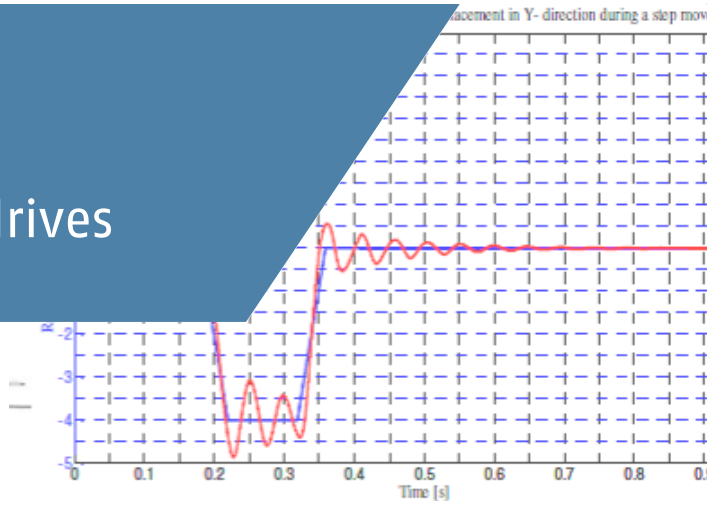
The picture below shows the full hierarchic structure:



The only drive receiving commands from the CNC is the anti-backlash master, while all other drives receive their commands from their own direct master of the tandem application. So, the positioning command from the CNC will be sent only to the anti-backlash master; this drive then propagates the command through the 'tandem hierarchic structure', down to all the slaves. Let's now explain how the various tandem applications work.

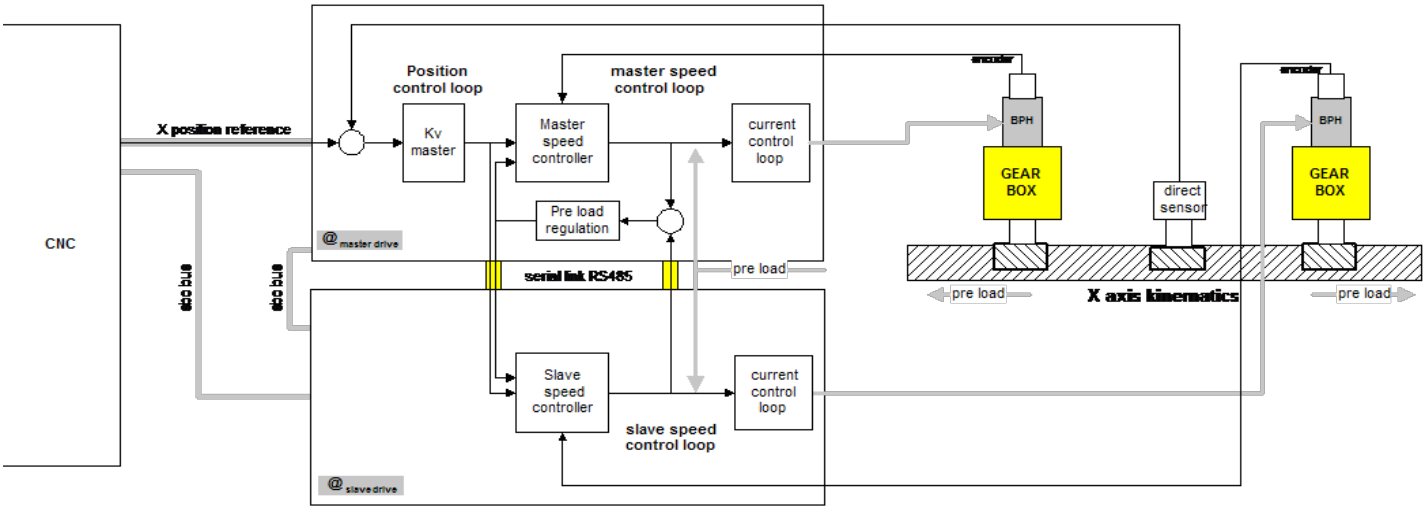
Flexium+

Tandem applications with MDLUX drives

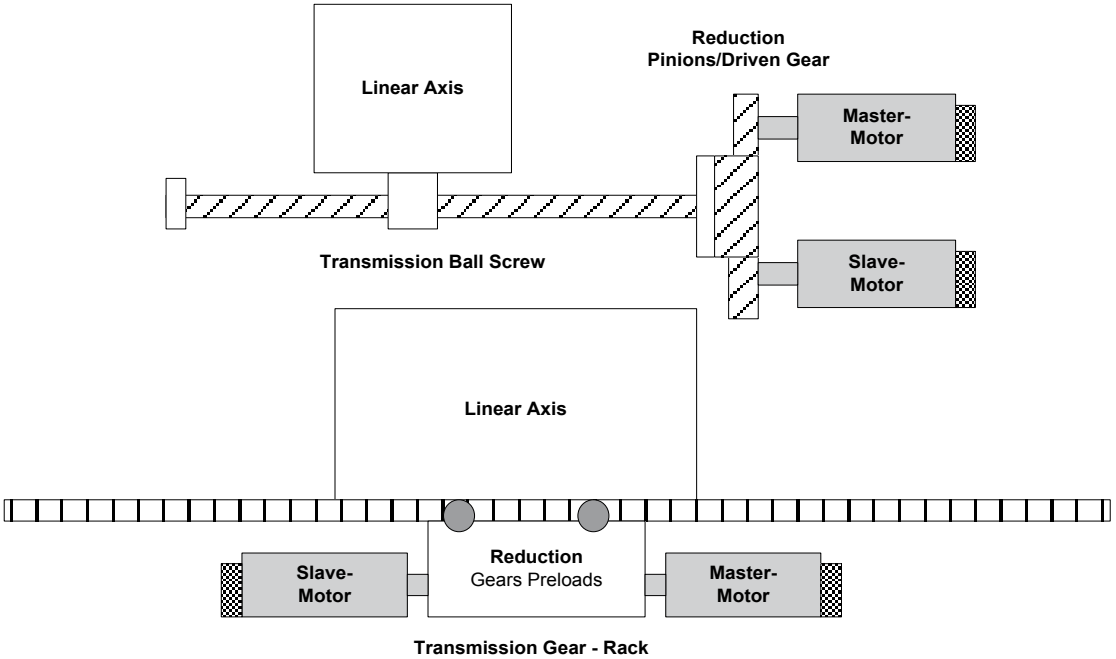


Anti-backlash

This tandem application involves two drives: one master and one slave. Its aim is to implement an electronic gear pre-charging on a rack-pinion coupling in such a way that any backlash effect is eliminated. The master tries to keep the torque difference between master and slave as constant as possible during the movement of the axis (thereby keeping the rack-pinion gear pre-charging constant), while allowing the axis to follow the CNC position reference without any backlash. In such applications, the CNC sends its position reference to the master, which in turn sends a proper speed reference to its slave partner. The amount of 'electronic gearbox pre-load' is, of course, programmable via drive parameters.



Electrically preloaded rack and pinion drive with two motors in tandem

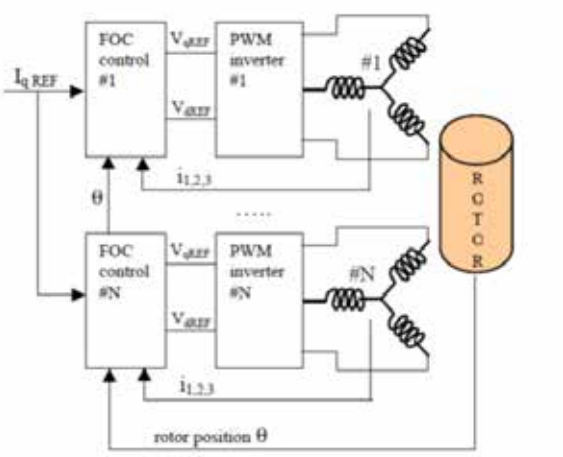


Torque duplication
This is a tandem application where up to 4 drives are involved: one master and up to 3 slaves. Its aim is to increase the delivered axis torque/force by making two or more (up to 4) motors act in parallel on the same mechanical axis. Such an application could be used even in the case of non-reversibility of the mechanical coupling between motor and axis. In this case, the CNC sends its position reference to the master, which then propagates the torque current reference to all its slave partners. Each involved drive controls its own motor. All motors drive the axis in parallel (they apply their torque to a single axis).

Winding duplication
This is another tandem application where up to 4 drives are involved: one master and up to 3 slaves. Its aim is to increase the delivered drive current to a single motor by making two or more (up to 4) stator windings act in parallel on the same motor.

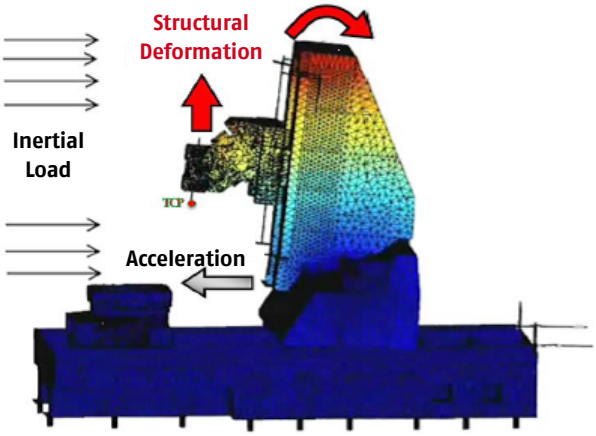
In an application such as this, each involved drive controls its own stator winding. All stator winding currents contribute, synchronously, to the creation of proper torque on the single rotor of the motor.

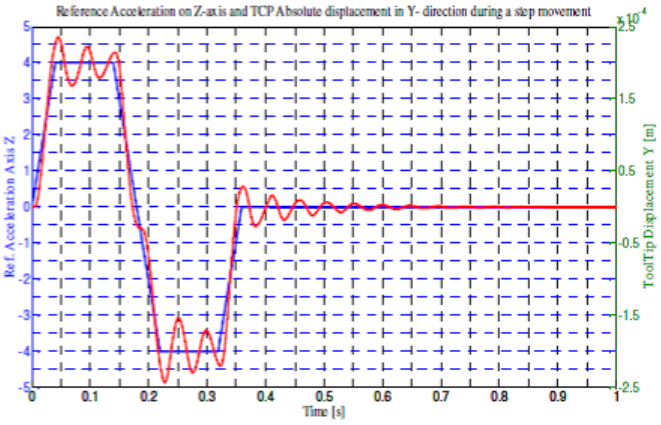
Only the master drive receives feedback data from an encoder position sensor; all slaves are 'sensor-less' drives. The NCK sends its position reference to the master, and this then propagates the three-phase voltage reference to all its slave partners.



By means of the winding duplication application, NUM was able to control the axis of a special machine that required 1000 Arms (1400 A peak) of torque current. The motor was built with 1 rotor and 4 separated stator windings, each one carrying up to 250 Arms. While NUM's biggest drive is rated at 280 Arms, by using this function we were able to 'parallelize' the 4 motor windings and implement a 'virtual' drive that is capable of delivering up to 1000 Arms of torque current.

Mechatronic application
This tandem application involves two MDLUX drives, one master and one slave, and uses their embedded macro (DEMX) functionality. The aim of the application is to 'experiment' and implement new inter-axis mechatronic functions such as that shown below, which could be useful for eliminating axis vibrations induced by the movements of other axes.





Tilting Effect: Inertial Forces due to acceleration along the Z axis and Tool-Tip Oscillation in Y direction

In this example, the new mechatronic functionality tries to eliminate the Y axis oscillation induced by acceleration on the Z axis, via a proper compensating torque on the Y axis, computed via the 'drive embedded macro' function based on the Z axis acceleration information received via the tandem application!

Both drives are commanded directly by the CNC so both axes follow their own position references because they both have to interpolate as usual. The mechatronic tandem application acts only as an additive 'compensator' inserted in the control loop of both drives.

This shows the enormous power of MDLUX drives!

Flexium+

Leading university adopts NUM's open-architecture CNC and 3D for mechanical engineering courses

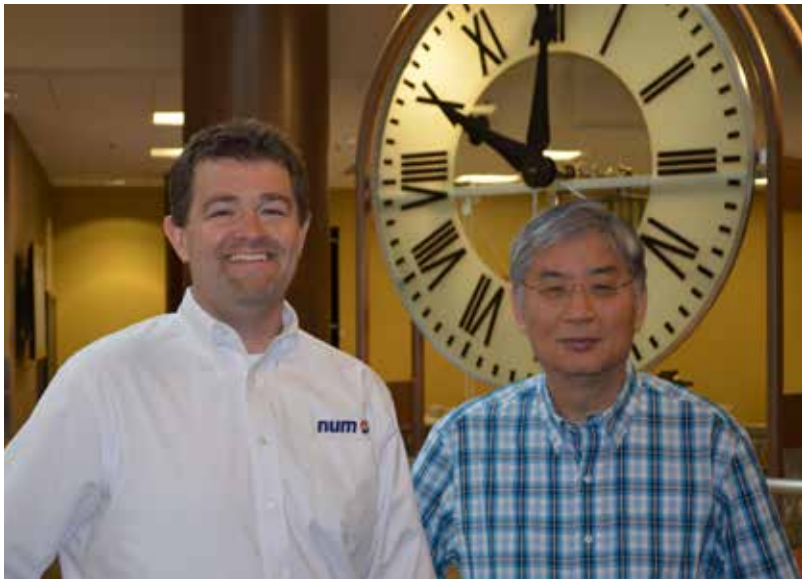
simulation software

Purdue University's prestigious College of Engineering has chosen to equip one of its key educational laboratories with NUM's open-architecture CNC systems and 3D simulation software. The equipment will provide students with hands-on CNC programming experience and help to familiarize them with advanced CNC machine tool operation and control techniques, using a powerful combination of virtual machines and physical high performance CNC demonstrator systems.

Purdue University is one of the USA's leading academic research institutions and hosts one of the nation's largest engineering faculties. Its College of Engineering comprises 14 schools and departments – each specializing in a particular engineering discipline – and is currently undergoing further major expansion. As part of the expansion, Purdue University is upgrading the mechanical engineering laboratory at the university's main campus. This laboratory is principally used for teaching students the basics of CNC control and programming, and introducing them to machine-based manufacturing processes and techniques. It is currently equipped with several 2-axis CNC demonstrator machines based on NUM 760 and 10xx series CNC systems, together with a NUM 2D simulator.

According to Professor Yung C. Shin, who oversees all CNC-related education and research activities at the School of Mechanical Engineering, "When we set up the mechanical engineering lab in the 1990s, we looked at CNC systems from many manufacturers. However, most of the systems were like black boxes so their operation was difficult to understand, which was far from ideal when we wanted to teach the basics of CNC control. We therefore decided to base our educational platform on NUM's CNC systems, primarily because of their open architecture and the fact that the NUM was enthusiastic about helping us to use their products in this role. The openness of NUM's CNC, especially with regard to NC code and I/O facilities, enables us to clearly demonstrate the exchange of data between the PLC, CNC and drive electronics, and simplifies integration with other lab equipment. Also, many of the CNC machines that we use in our manufacturing research labs are based on NUM CNC systems, so there is a high commonality of coding."

NUM has acted as a CNC partner to the School of Mechanical Engineering for some 24 years. Steven Schilling, General Manager of NUM Corporation in Naperville, Illinois, points out the importance of such long-term support for educational establishments, "The staff at Purdue always have access to our technical support people and receive engineering help whenever they need to reconfigure or reprogram CNC systems for new projects. This close cooperation ensures that Purdue's laboratory CNC equipment



Right: Steven Schilling (left), Managing Director of NUM Corporation, and Yung C. Shin (right), Professor of Mechanical Engineering at Purdue University, standing in front of the university's historic Heavilon Hall clock

Education

Purdue University's prestigious College of Engineering has chosen to equip one of its key educational laboratories with NUM's open-architecture CNC systems and 3D simulation software

has the latest features and tools to aide students in developing new machining technologies."

The latest upgrade to the mechanical engineering laboratory's CNC equipment is extensive. NUM has supplied two Flexium 68 CNC systems configured for milling applications, each with an NCK (Numerical Control Kernel), PLC, HMI and 3D simulator hardware and software, plus additional simulator dongles for four PCs. Flexium 68 provides a very versatile foundation for educational and research applications such as this, where the type of machine and the control approach change over time. As standard, the NCK accommodates up to 5 axes/spindles on a single channel, with full interpolation on 4 axes. Single NCK options can expand this to 32 axes/spindles in up to 8 channels, with up to 9 interpolated axes per channel, while multi-NCK configurations can handle more than 200 axes.

To help improve ergonomics, the laboratory has installed two desktop consoles for human-machine interaction. Each console is equipped with a NUM FS152i operator panel and an MP04 machine panel, fitted with CAN interfaces. The operator panels feature 15 inch LCD screens and integral industrial PCs with solid state drives, run an embedded version of Windows, and are connected to the university's Ethernet network. Each console can be used for simulation or for controlling the laboratory's CNC demonstrator machines.

NUM has also supplied all the motors, drives, power supplies and associated hardware for two additional 2-axis demonstrator machines. Both of these combine latest-generation bi-axis NUMDrive C servo drives with BPH brushless servo motors. One of these machines uses the HP version of the drive with high performance control loops, to facilitate research into applications involving very fast or precise kinematics.

Using Flexium, Purdue University's students and post-graduate researchers can now investigate CNC techniques to a very detailed level. All CNC, servodrive, I/O and PLC setup and programming is performed using a unified software toolset to help shorten the learning curve, increase productivity and work satisfaction, and encourage collaborative effort. The system's inherent open architecture has multiple advantages. Application-specific HMIs (Human-Machine Interfaces) can be easily created or modified using industry-standard editors and languages such as HTML, JavaScript, Visual Basic, Delphi, C or C++, while the PLC can be programmed using any IEC 61131-3 compliant object-oriented graphical or textual language. In addition, students who need low-level control of the NCK – for example, for real-time axis transformations – can use dynamic operators in the code, while techniques such as real-time compensation can be developed using embedded loop control macros in the servo drives.

The Flexium 3D graphical simulation capabilities that Purdue University is installing in the mechanical engineering lab will improve work

Many of the CNC machines in Purdue University's manufacturing research laboratories are based on NUM CNC systems, such as the laser-assisted machining system for ceramic materials below. The new laboratory will have six computer workstations, each capable of true 3D workpiece simulation without needing access to a CNC system.

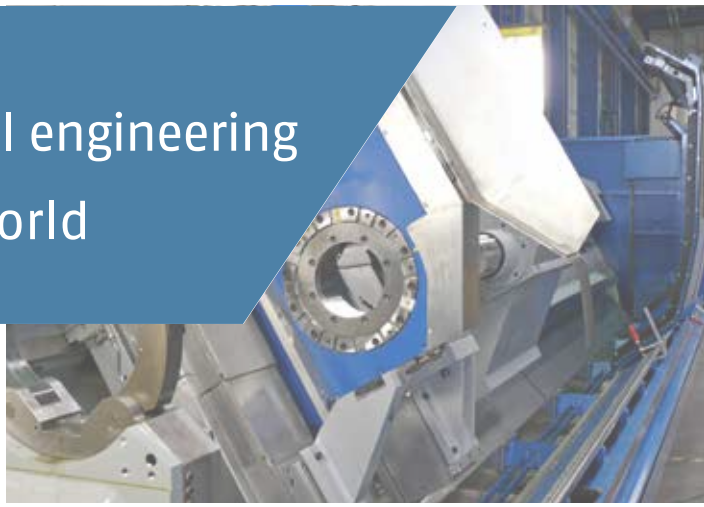
flexibility significantly. Until now, the simulation software required physical connection to the CNC system – which meant that only one student at a time could use it – and was limited to basic 2D simulation of path lines. The lab now has six separate simulator stations – two on desktop consoles and four on standalone PCs – each capable of true 3D workpiece simulation in standalone mode, without needing access to a CNC system. A further six networked PCs are also being installed, allowing students to perform simulation at different locations.

Students are now able to simulate and optimize any ISO-code part program that they have written, with full visualization of the tool centre point path and workpiece material removal, backed by automatic checking for collisions between machine components, the tool and the workpiece. The simulation software currently supports 3-5 axis turning and milling/drilling, as well as water jet and plasma contour cutting, and can be transferred between applications very easily. It creates a dynamic color image, showing the workpiece as a 3D volume than can be rotated and viewed from any perspective.

Purdue University plans to make the new CNC facilities available to students in the fall, as Professor Shin explains, "We need to be able to provide more students with hands-on experience of CNC programming and visualization as soon as possible. There is now a resurgence in the domestic automation market thanks to new processes like additive manufacturing, and CNC programming skills are once again in short supply. Students are excited by CNC programming when they can see the results of their efforts – whether that's on a simulator, a CNC demonstrator or machine tool – which is why our new facilities are such an important educational tool. Some 65% of our graduates go on to pursue careers in manufacturing – and many have become professors in their own right. I like to think that when they set up their own laboratories they will remember the grounding that we gave them."

Education

Future-oriented Austrian mechanical engineering company successful all over the world



Weingärtner Maschinenbau GmbH, which was founded in 1965, is an international company that manufactures machine tools for the energy sector. For more than 35 years, it has been producing processing machines for the oil drilling industry and the plastics sector, as well as combined turning/milling centers for the complete processing of heavy, complex components. Weingärtner and NUM have been working in close partnership, from initial machine configuration through implementation to commissioning, for over 20 years.

Weingärtner mainly utilizes NUM controllers in machines for the production of machine components, such as pumps or core parts for drill drives used in the crude oil and gas industry. These components are typically used for drilling and subsequent production of oil and gas, but they also have applications in other industries wherever eccentric screw pumps are used for pumping various liquids and viscous materials. The core parts for drill drives are also produced on Weingärtner machines with NUM controllers. These machines offer peripheral milling and skimming of stator cores and single- and multi-lobe rotors used in industrial and petrochemical pumps and in mud motors. For processing, it is very important that the tool speed is exactly synchronized with the workpiece speed, and that the speed ratio can also be influenced by the interpolator. This used to be done mechanically. These days, this function is carried out electronically using a NUM CNC system to guarantee extremely high levels of precision.

Weingärtner's current machines, like the Vario shown in the picture below, use a NUM Flexium CNC system with specialist synchronization software. Depending on the machine type, this controls up to eight axes and two spindles with power ratings of between 22 and 90 kilowatts.

"For Weingärtner Maschinenbau, the huge flexibility of NUM CNC systems and NUM as a company is a real boon", explains Klaus Geissler, Sales Manager for machine tools at Weingärtner. Special solutions are worked out and implemented as part of a close partnership. This is not merely a customer-to-supplier

Below: Vario production machine from Weingärtner Maschinenbau GmbH with a NUM Flexium CNC system

Right: Final inspection of the Vario production machine from Weingärtner Maschinenbau GmbH with a NUM Flexium CNC system

Below: Eccentric screws as used in pumps in the oil and gas industry

Below right: Klaus Geissler, Sales Manager for machine tools at Weingärtner Maschinenbau GmbH (left) and Andreas Lumesberger, Sales Manager at NUM Austria (right)

relationship, but real cooperation between two system partners, which has an impact on the success of both Weingärtner and NUM. Weingärtner's main customers are in the supplier industry for oil and gas exploration. This means that Weingärtner is active all over the world – its main sales markets are America, the EU, Russia and Asia.

Just like NUM, Weingärtner also offers complete solutions for its customers. These consist of a machine, tools, process engineering and CAD/CAM software, and are used not only in the production of eccentric screws for pumps, but also in the production of large crankshafts, turbine and generator shafts for power stations and in roller processing for the paper and steel industries. The range of Weingärtner machines thus incorporates numerous high-performance machine tools for the metal processing industry. These high-quality systems are all characterized by a consistent strategy based on a robust machine with optimized process and machining technology and fully integrated software.

As comparatively small companies in the global market Weingärtner and NUM have set themselves apart from their bigger competitors by means of continuous development, innovative solutions worked out as part of a close partnership, a strong team of highly qualified employees and an excellent global service network. These qualities are also the basis for the success of the two companies.

Advanced

Precision 3D water jet cutting guarantees top quality results

Global company Perndorfer Maschinenbau KG specializes in water jet cutting, water jet cutting systems and water jet cutting machines. Perndorfer's products include high-technology CNC-controlled 2D and 3D water jet cutters. Together with NUM, it has now built a five-axis water jet cutting system which can process large workpieces with external dimensions of up to 9000 × 4000 mm very efficiently and accurately.

Founded in 1985 by owner Franz Perndorfer, Perndorfer Maschinenbau KG is now one of the most innovative companies in the industry. With around 60 qualified employees, Perndorfer is permanently and successfully engaged in the international market and demonstrates ongoing competitiveness based on innovation, precision and quality. Its cooperation with NUM started around 20 years ago and has grown constantly since. Decades of experience in the design, development and production of CNC-controlled water jet cutting systems and special machine construction enable Perndorfer to offer a wide range of products and services in this technology sector. Specific customer requirements are flexibly and capably implemented in close cooperation with NUM. This includes prototype construction through to the provision of complete solutions and individually customized systems, as well as training, specific on-site consultancy and 24-hour service.

The machine shown here is a five-axis water jet cutting system which can cut through steel with a thickness of up to 140 mm and aluminum with a thickness of up to 180 mm very efficiently, using just water and suitable abrasive material at a pressure of 4000 bar. The bottom end cap of a pressure tank shown here is

Top: Control panel for the NUM Flexium CNC system with specific Perndorfer HMI

Left: Overall aerial view of five-axis water jet cutting machine from Perndorfer with workpiece in place

Right: Peter Asböck, Project Manager for water jet cutting, Perndorfer Maschinenbau KG, Johann Humer, Sales Manager, Perndorfer Maschinenbau KG, and Andreas Lumesberger, Sales Manager at NUM Austria

Below: The water jet cutting through a 6 mm thick pressure tank end cap

made of 6 mm thick steel and can be cut precisely at 330 mm per minute. The cut can be programmed to any angle required. This makes it possible to cut facets on three dimensional preformed parts, in preparation for the subsequent welding on of other components such as flanges, pipes, heat exchangers, etc. This guarantees efficient workflows.

This machine can be used to cut workpieces with maximum lateral dimensions of 9000 × 4000 mm and heights of up to 500 mm. Customers are free to choose the working height to suit their requirements at the machine design stage; this then determines the appropriate height for the portal that supports the Z axis and the 3D cutting head.

It is therefore suitable for 2D sheet cutting of any kind, or for 3D cutting of various workpieces such as pipes, containers or covers for pressure tanks, like the end caps which can be seen in the pictures. The machine can also be configured for welding applications; it is designed to accept a five-axis welding head as an alternative to water cutting jets.

The workpieces are placed on the table to allow optimum processing with the CNC-controlled five-axis cutting head from all sides. This water jet cutting machine is fitted with the NUM Flexium CNC system with six axes, gantry function as well as water jet and five-axis technology. For both Perndorfer and NUM it is important to implement a complete solution. This is the only way to guarantee the quality of all working stages and produce a high-precision, high-quality end result. The cooperation between Perndorfer and NUM involves close dialog from the very start of a project, i.e. from design through to approval and commissioning of the machine on the customer's site. It goes without saying that the company provides capable, smooth services for many years after acceptance of the machine by the customer.

The precise, high-quality end product provided to the customers in the form of a Perndorfer machine with a NUM CNC system guarantees them a competitive advantage in their market. This competitive advantage is both objective and motivation for Perndorfer and NUM.

5-Axis

Major development in thread rolling automation from Italy

In collaboration with NUM, the Italian machine builder ORT, today owned by MICO S.r.l, and the end user engineering company Cadei have developed an advanced thread rolling machine. The new machine provides improved control and accuracy of the thread penetration process. Thanks to its use of a NUM Flexium CNC system, the machine is also very simple to operate – the necessary skills can be learned very easily and quickly. Almost anyone can now handle the production process, which helps to reduce costs and provides Cadei with a unique competitive advantage.

Engineering company Cadei S.n.c. was founded in 1972 by Giacomino Cadei. Since 2005 the company has been managed by his children, Massimo, Cristian and Michela, who each have more than twenty years of experience in the business. Cadei primarily specializes in the manufacture of parts for hydraulic molding presses, but its technical know-how also enables the company to provide customers with a diverse range of products, such as component parts for bending equipment, axles for railway rolling stock, and various types of pneumatic and hydraulic machinery. Size is no object and parts can measure up to 650 mm in diameter and 9000 mm in length. Cadei has invested extensively in state-of-the art machine tool technology, including high quality CNC lathes controlled by NUM equipment, to ensure that its products are machined with the utmost precision and reliability. In recent years the company has also developed special skills in the deep hole drilling of cylindrical and other sections, in sizes ranging from 6 mm to 150 mm in diameter.

When it acquired ORT Italia, MICO S.r.l also bought all the intellectual property rights to the company's range of thread rolling machines (including the machine drawings, commercial component definitions, electrical/hydraulic diagrams, software and market references). MICO now produces these machines and associated spare parts under the trade name of ORT Italia, as well as providing technical support services to end users.

However, MICO's philosophy extends beyond simply manufacturing and supporting the original ORT machines. The company decided to invest in the automation of the machines to further improve their accuracy and productivity, and to simplify their operation in order to

Above: Crude steel part on the left and pressed thread for a hydraulic press as the final product, on the right

Left: The thread rolling machine in the production hall of Cadei

Top right: The thread rolling machine from the rear, showing 3 NUM motors. Lower right: The thread rolling machine from the front, with a mounted workpiece

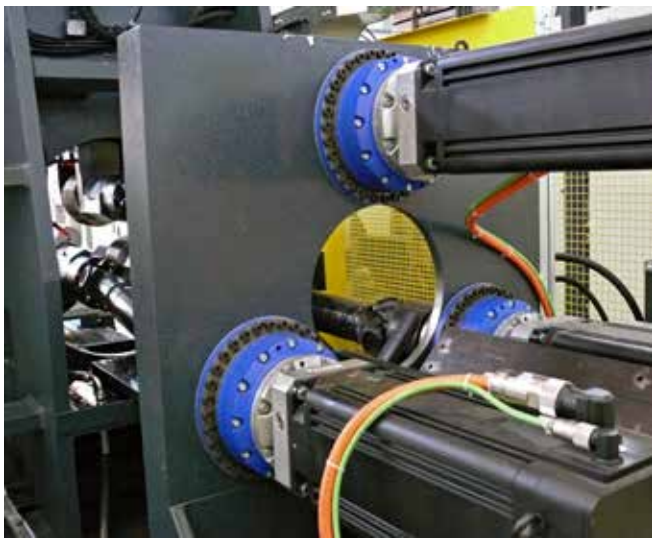
Below: The thread rolling machine in operation

Bottom: from left to right, Simone Farina, Technical Chief of ORT, Cristian Cadei, Director of Cadei S.n.c. and Marco Battistotti, Director of NUM Italy

make it less dependent on workers' experience. MICO also reviewed the machines' overall structure and mechanical components, with the aim of making them even more robust and reliable.

One of the key benefits of the new machines is an improvement in the accuracy of dynamically controlling thread penetration throughout the thread rolling process. The new automation system enables the mechanical force exerted by the thread rolling dies on the workpiece to be defined and controlled more precisely – which also helps to extend the operational life of the dies. The tilt and shift angles of the dies are calculated automatically (it takes less than five minutes to establish the correct phase, without incurring any loss of workpiece material) and the dies are then moved into position entirely automatically. All automatically-derived parameters associated with the requested manufacturing cycles for a specific thread (taking into account dimensions and material) can be monitored online. All the steps required for a particular manufacturing sequence can be carried out fully automatically. Particular attention has been paid to the design of a flexible interface, so that any type of dedicated loading system or specialized auxiliary equipment can be easily integrated with the main machine.

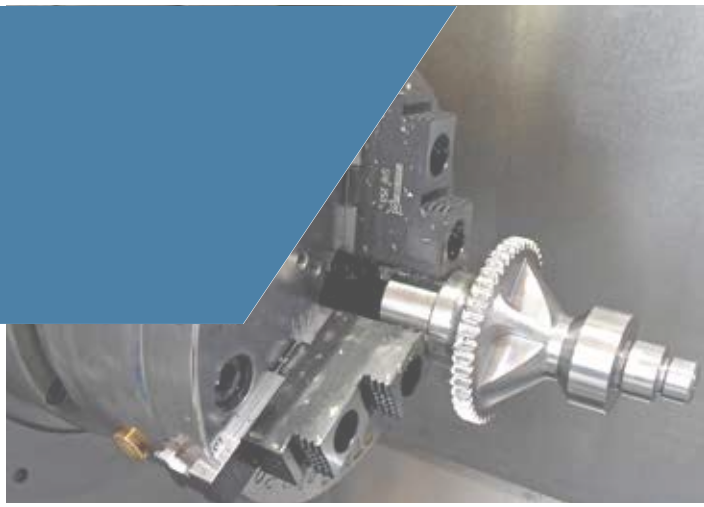
With this new thread rolling machine, Cadei is ahead of its competitors. This is not only because



of the precise results which can be achieved with this innovative machine, but also due to the fact that it is controlled by a NUM CNC system, which makes it very easy to handle. In fact the control has become so easy, that Cadei can let anyone handle the machine. This simplicity of operation has a major productivity benefit; if an employee is absent their work can easily be handled by someone else, thereby avoiding any downtime in production. "In addition, a consistently high quality final product is guaranteed to the customer at all times," says Cristian Cadei, Director of Cadei S.n.c.. "Close cooperation with NUM has enabled us to create a highly accurate and easy-to-use machine which brings a competitive advantage to the customer," says Simone Farina, Technical Chief of ORT.

Powerful

SOMAB and NUM, a successful, long-standing partnership



Five-axis machining, three-axis turning, trimming, grinding, slotting and much more: when SOMAB decided to equip its flagship machine, the Genymab, it was only natural to turn to NUM, its long-standing partner. Founded in 1985, the SOciété de Mécanique d'Automatismes du Bourbonnais has inherited the expertise of Ernault Somua whose machines are known around the world.

Genymab is based on a simple concept: To pass directly from the blank to the finished product regardless of the operations involved. For this reason, two additional axes, Y and B, have been added to the classic X, Z and C axes. Many options allow for adapting this machine to specific needs: a number of tools available in store, various touch-sensing probes, a second mobile head and a machining surface, to mention just a few. These components are installed on a reconstituted granite base which naturally dampens vibration. The boundaries were pushed even further thanks to the NUMDrive C servo drives with their high performance control loop algorithms.

Often, the best solutions are recognized by their ease of application. Genymab is no exception. Originally featuring Axium Power, this multi-function machining center has been remodeled to use Flexium CNC and take advantage of its most advanced features. The change of the C-axis spindle from turning to milling and vice versa, and the validation of an inclined surface are done naturally through a simple G code which validates the structure changes and authorizes the corresponding features.

Let's take a closer look at the trimming aspect. NUM added an 'electronic speed drive' to its standard software which allows for synchronization between the main milling cutter and the piece to be cut; the many parameters for straight or helical gears for trimming, with different options for shifting, are also taken into account. Linked to its design, the rigidity of the tool head enables these operations to be carried out with the required machining quality. Safety hasn't been forgotten. The synchronization process is constantly monitored in order to signal an emergency in the case of an unexpected event. The drives store enough energy to keep the machine going in the event of a power outage.

Genymab's work surface with the tailstock and the milling work table on the right

This machine does not have the classical trimming structure; it features the necessary assets to produce all kinds of structural shapes. Here, the workpiece is on the main turning spindle

From left to right: Mr Roland Vesvres, Sales Manager SOMAB, Mr Bernard Jacquard, Director SOMAB and Mr Elia Barsanti, Director NUM France

Below (top): Example of a workpiece created using only Genymab: Turning + Milling + Trimming

Below (bottom): Genymab's instrument console comprises an FS152i operator panel and MP04 machine panel

rather than on a specific axis – the X (pass engagement) and Y (shifting) axes are inverted. It was a simple matter of adapting the algorithm's parameters to this feature. Programming a trim is done in a single line which gives the number of gear teeth to trim, the number of threads on the main milling cutter, and the angle of the helix. Different depth cycles allow the final product to be obtained.

Flexium's increased power allows performance to be improved even further; benefits include a shorter selection time and more efficient automation, whilst maintaining complete programming compatibility –excluding the new functions of course. The HMI customization options, particularly in terms of graphics, will simplify the machine's operation. The FX3D simulation allows a 3D model of the workpiece to be created (milling is in the process of being developed), but even more importantly, it prevents any serious consequences by detecting potential collision problems, which are sometimes hard to foresee when it comes to complex structures.

The programming at the heart of the machine has not been forgotten. Genymab is equipped with specific ergonomics programming which is supported by the FXCAM.

However, even the best system cannot function without human input. This is another area where NUM offers customers a choice to help secure the optimum solution for each project. There are three options:

- Active participation: NUM offers its expertise in automation and guarantees assistance and advice.

- Active co-operation: Sharing of know-how between the client teams, and production in partnership with the client.

- The global solution: NUM becomes the project manager and takes care of everything from the project specifications to the commissioning, training and maintenance.

In this case, participation and co-operation strategies have been developed to help familiarize SOMAB with the new aspects of the equipment, such as simulation and trimming.

This co-operation certainly proved efficient but let's hear what Mr Jacquard, Director of SOMAB, has to say: "Genymab is a machine that can do almost anything if it's coupled with efficient digital control. NUM proved to be the supplier that is able to efficiently operate this type of machine. The proof is that the integration of the gear trimming function has been done quickly and without problems."

Once again, NUM's slogan applies perfectly: Offering advanced digitalization solutions to our partners in order to develop a competitive advantage that's in everyone's interest.

Efficiency

Major CNC upgrade program enables engine manufacturer to life cycle of vital production lines

extend

Fiat Powertrain is upgrading the CNC systems of 20 key machine tools used on the crankshaft and cylinder block production lines of its engine manufacturing plant in Campo Largo, Brazil, in order to extend their life cycle and minimize future maintenance downtime. Each machine requires a custom upgrade kit, comprising a high performance CNC unit, servo drives and motors, specifically designed by NUM to facilitate fast installation and to provide improved diagnostics and simplified spares handling.

Part of Fiat Chrysler group, Fiat Powertrain operates manufacturing plants at strategic locations around the world, including four in South America. Its Campo Largo plant on the outskirts of the Brazilian city of Curitiba specializes in the manufacture of 1.6 litre and 1.8 litre 'E.torQ' flexfuel engines for medium size cars, which can run on petrol or ethanol. Originally set up by Chrysler and purchased by Fiat in 2008, the plant is one of the most modern in South America and plays an important role in Fiat's leadership of the Brazilian automotive market – a position it has held for the past 12 years. The Campo Largo plant currently produces about 230,000 engines a year.

The Campo Largo plant make extensive use of multi-axis CNC transfer machines, machining centers and specialist machine tools throughout its manufacturing operations. These include a wide range of Cinetic-Landis crankshaft grinding machines, Heller machines for the external milling and grinding of crankshafts, and transfer machines produced by Comau – a Fiat subsidiary – for engine block machining. In total, the plant's crankshaft and cylinder block production lines are equipped with 20 key CNC machines, involving more than 120 feed axes. Each of these machines was originally controlled by a NUM 1050 series CNC unit, with NUM MDLU1 servo drives and NUM BMH series servomotors.

As the CNC systems aged, Fiat Powertrain became increasingly concerned with the likelihood of increased downtime. Troubleshooting and sourcing spare parts, as well as performing general machine maintenance, was threatening to take too long and impact production throughput. Since mechanically the machines were perfectly serviceable, in 2012 the company took the strategic decision to extend the life cycle of the production lines by upgrading all 20 machines with modern CNC controllers, drives and motors.

After reviewing various CNC manufacturers' products and services, Fiat Powertrain concluded that NUM offered the best upgrade solution for the specific needs of the plant because it is the CNC OEM for the current machines and was able to provide a faster-to-implement solution with the best benefit/cost ratio. As Tarcisio Cruz Filho, Technical Support Manager at the Campo Largo plant, explains: "The fact that we are upgrading machines used for everyday production imposes some very demanding conditions. We needed a CNC supplier with the expertise and resources to collaborate on the design and installation of systems here in Brazil, while the systems themselves had to provide exactly the same level of functionality as our existing CNC equipment. We are impressed by the commitment to the project shown by NUM's management team in Switzerland and by the quality of technical support – includ-

Left: Fiat Powertrain's engine manufacturing plant in Campo Largo, Brazil

Right: The front entrance of Fiat Powertrain's engine manufacturing plant in Campo Largo, Brazil

CNC upgrade

ing several on-site visits – provided by their USA office, especially given that the Brazilian market for this CNC series is not huge."

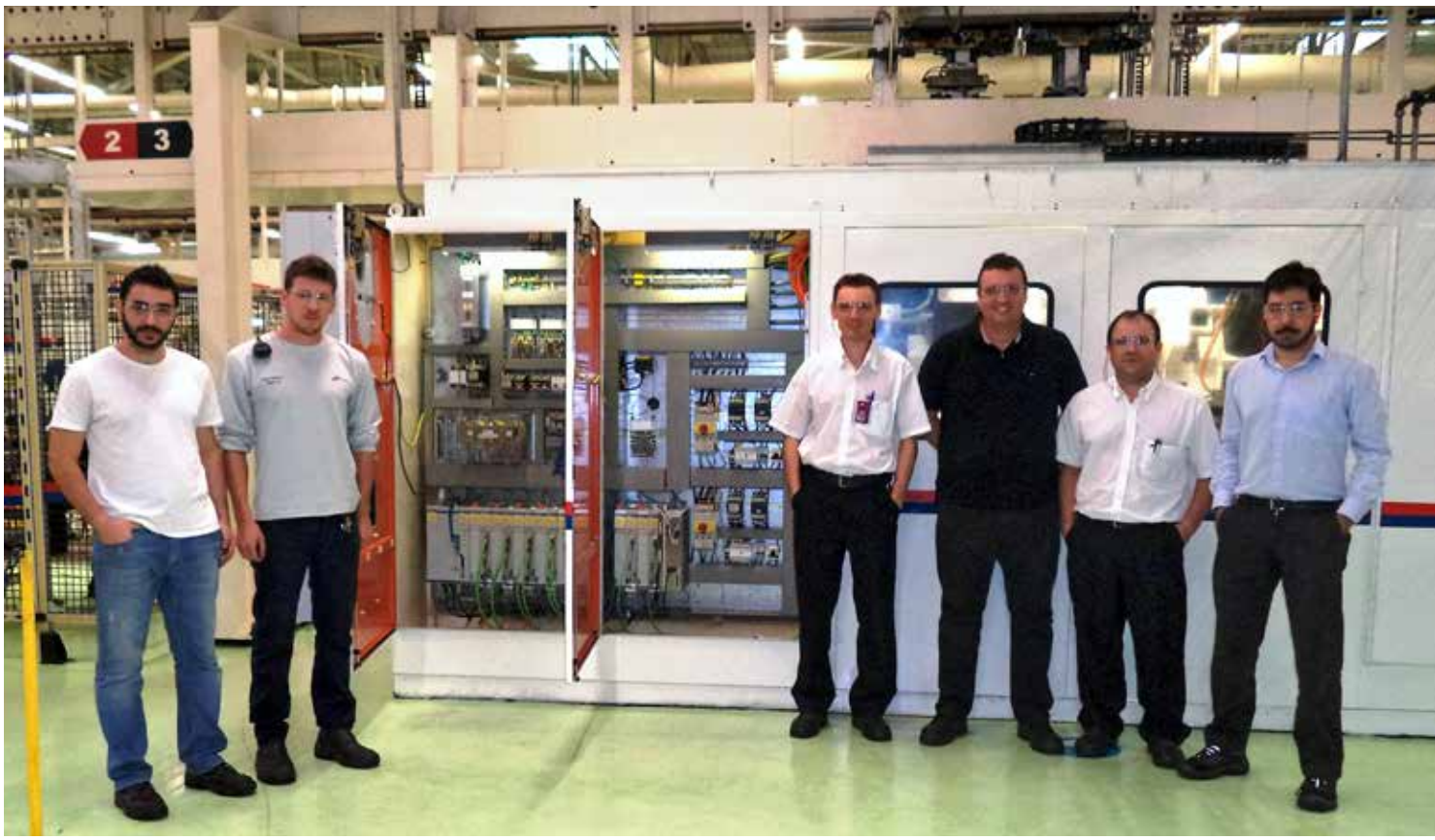
A key requirement of the replacement CNC systems was that they needed to be engineered in such a manner that the upgrade could be accomplished as quickly as possible to minimize manufacturing disruption. Using video conferencing, technical teams from Fiat Powertrain and NUM quickly established that NUM's Axium CNC platform provided the least invasive upgrade solution for the machines, by using the same robust architecture as the earlier generation 1050 series CNC to keep wiring and software modifications to a minimum.

As part of the CNC upgrade process, the servo drives on each machine are being replaced by models from NUM's latest NUMDrive C range; these are some of the most efficient and highest power density drives on the market, which further simplifies installation by obviating the need for complex rack cooling arrangements.

Top: Prior to the upgrade, the controllers for each CNC machine on the crankshaft production line were based on early-generation NUM 1050 series CNC

Middle: The new machine controllers are based on NUM CNCs and the latest NUMDrive servo controllers

Below: The crankshaft production line at Fiat Powertrain's Campo Largo plant makes extensive use of CNC machines



From left to right: Wilson Netto, Controls Engineer, Frederico Ferrarini, Maintenance Technician, Everton Stroparo, Maintenance Supervisor, Alexandre Machado, Engineering Coordinator, Mauricio Lopes, Controls Engineer and Tarcísio Cruz Filho, Plant Technical Support Manager of Fiat Powertrain, in Campo Largo, Brazil

CNC upgrade

The upgrade program also calls for the motors on all the feed axes of the machines to be replaced. Originally, these were fitted with NUM BMH series brushless servomotors, which are robust medium inertia designs that were popular with machine tool designers for diverse positioning applications. However, they have now been superseded by NUM's BPH series motors, which provide enhanced performance and environmental protection. The new BPH motors have physically identical shaft ends, pilot diameters and flange squares as their earlier-generation counterparts – again, making replacement a simple task – and the orientation of their power and sensor connectors can be altered during installation to suit the machine configuration. NUM also provides short adapter cables so that the existing motor wiring does not need to be changed, which saves a significant amount of time.

Tarcisio Cruz Filho points out that speed of upgrade is vital to Fiat Powertrain's production schedules, "We allowed for a maximum of four days out-of-service time for each CNC machine on our crankshaft and cylinder block production lines. Most of the machines on these lines have now been upgraded and in each case – even on complex machines with seven controlled axes plus spindles – it has taken less time than we allocated, which says much for the CNC design and planning. The machines' diagnostics are now much better, allowing us to perform more efficient preventative maintenance, and our technicians are now familiar with the CNC systems, all of which will help reduce production downtime in the future. We are on-schedule to complete the upgrades by the end of this year."

In fact, collaboration in knowledge transfer proved to be another valuable point of the partnership. As Claudio Rocha, Manufacturing Engineering Director for Fiat Powertrain's Latin American operations states: "The exchange of information and the training that NUM provided for our maintenance staff during the upgrade were important. We appreciate this open approach and the commitment demonstrated by the supplier in this program."

According to Steven Schilling, General Manager of NUM Corporation in Naperville, Illinois, "Our engineers have considerable experience with highly specialized CNC machines of this type used in the automotive industry – we have a history of servicing the 'Big Three' in Detroit, Canada and Mexico. In this case, Fiat was fully involved at each phase of the upgrade, working under NUM's guidance. This has enabled Fiat's control technicians at the Campo Largo plant to gain a high level of NUM system know-how, to help achieve the project's overall goal of maximizing the production lines' life cycle. This a prime example of NUM's ability to provide customers with end-to-end service options, allowing Fiat to keep 'one step ahead' of the competition."

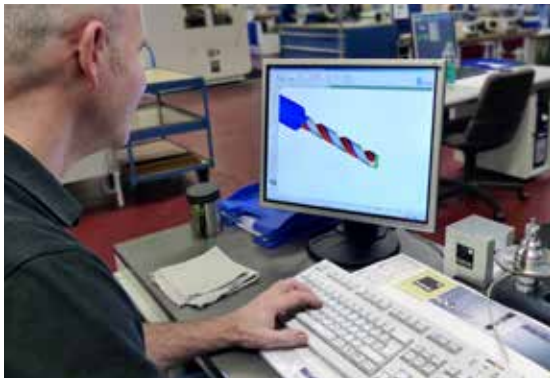
Over 50 years of experience and know-how in high-quality drilling and milling

Above: high-performance step drill countersink, for applications in aviation

Right: step drill countersink with diamond coating for processing of CFRP

This statement applies equally to both companies, KLENK and NUM with NUMROTO. Decades of experience and research, cooperative partnerships – such as in this case between KLENK and NUM – and close collaboration with users and leading research institutes, serve to guarantee successful and high-quality drilling and milling tools. These tools are used mainly in high-tech sectors such as the aviation, automotive and medical equipment industries.

The family business KLENK was established in 1959 in Balzheim in the German state of Baden-Württemberg, and for over 50 years has specialised in the development, production, use and sale of high-quality carbide machining tools for drilling, countersinking, reaming and cutting. KLENK currently has over 100 excellently trained employees, many of whom have completed their commercial or industrial training at the company. This is how KLENK ensures that its knowledge and know-how of the production of specialist solid carbide tools, which account for around 85% of KLENK's sales, are in the best hands. Moreover, personal, skilled and technical advice and project planning with customers and partners are particularly important. And this is where NUM comes in: the productive collaboration with KLENK over the last 15 years is based on an honest and subject-oriented partnership that involves pursuing and realising a common goal, in keeping with the motto of "NUM CNC solutions provide machine manufacturers and users with a competitive advantage". KLENK also secures its know-how digitally with a multi-user database from NUMROTO. This enables KLENK to meet its own high expectations of full reproducibility of tools with repeat orders thanks to the NUMROTO data structure. All of KLENK's machines are connected to the multi-user database, making it possible to act flexibly within identically configured machine groups; this facilitates short reaction times and optimal capacity utilisation. Added to this is the benefit that every employee can work on almost every machine, as all machines use the same NUMROTO control system.



Left to right: Jörg Federer, NUMROTO Application Manager at NUM, Horst Klenk, owner and Managing Director of KLENK, and Klaus Kohlhepp, Head of Production at KLENK

Bottom: step drill countersink with an S-shaped point thinning and AF coating – for a high level of process and planning security

Its close connection to customers and suppliers enables KLENK to set itself apart from the masses and develop the perfect tool tailored to meet the needs of the customer. The images on this page are examples of the results of such developments. The flexibility of the NUMROTO software solution plays an important role in the process as a whole and significantly simplifies the procedure. From planning, simulation and, of course, production, to documentation and the subsequent management and securing of data – all of this can be done with NUMROTO.

Tools for the aviation industry

KLENK has been working successfully with the aviation industry for a long time, and in this industry, high-performance tools are required for the machining of aluminium, titanium and composite materials. With milling tools, flute design and tooth geometry in the area around the corner radius are crucial to the resulting surface quality in cutting, as well as to the lifetime of the cutter. In-process measurement guarantees a high level of accuracy, even across larger series.

CFRP – carbon-fibre-reinforced polymer: the trend material of the future!

CFRP is becoming increasingly popular, and KLENK is continuously developing new tool geometries for this material. CFRP is used to manufacture resilient and robust components with relatively little weight. In the aviation industry, CFRP is frequently used in combination with other materials such as titanium or aluminium. This results in connection points at which two or more different materials have to be drilled through simultaneously. Most of the materials used have specific, opposing properties, which make machining in the material package a real challenge. In addition to its undisputed positive properties, CFRP also has a crucial disadvantage: if the material is drilled or milled, it becomes extremely abrasive and quickly causes heavy wear to the tool. This is especially problematic because the machining results for CFRP applications must meet the highest possible quality standards. These require first-class surface finishes and the maintenance of diameter tolerances, as well as the avoidance of delamination and fibre projection. The specialist tools from KLENK meet all these requirements.

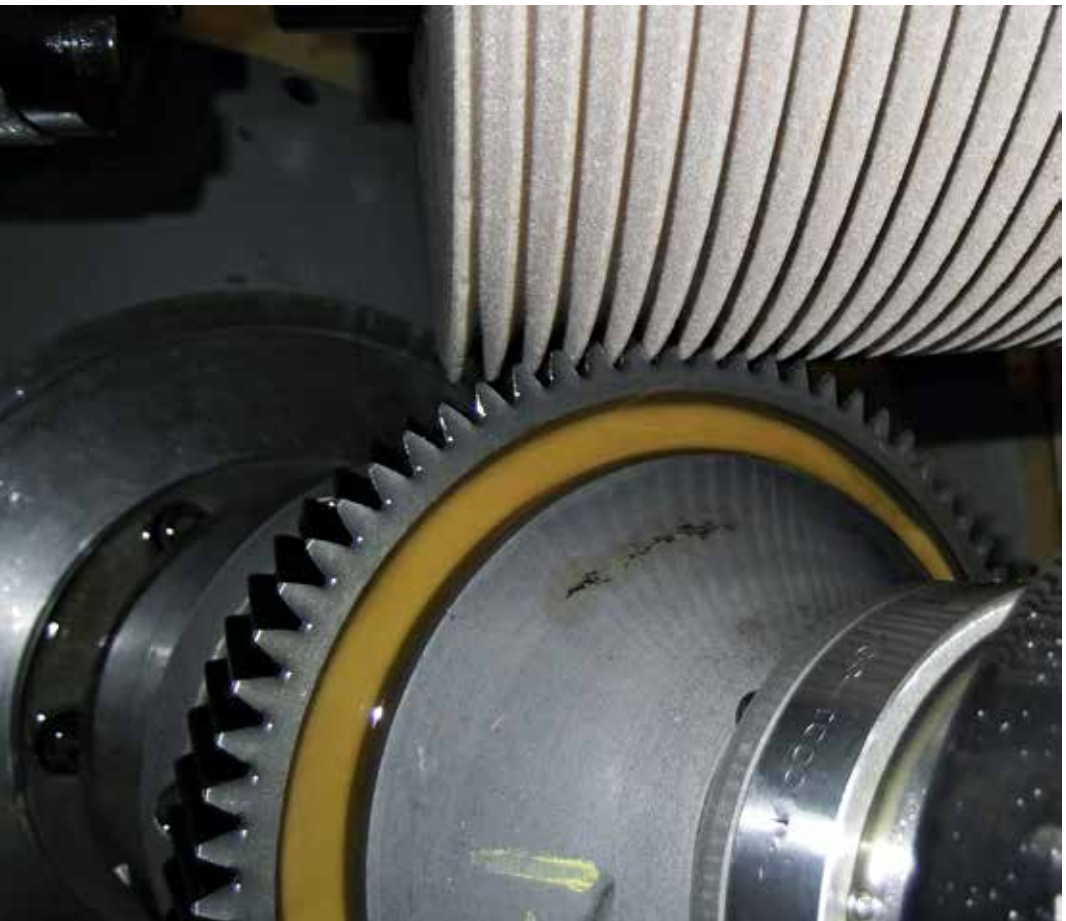
Experience

Automated threaded wheel grinding on gear production machines is boosted by new CNC solution

NUM has announced a high performance CNC solution for gear production machines that fully automates threaded wheel grinding. Incorporating unique high speed gear alignment technology that is believed to be an order of magnitude faster than comparable control schemes, the new CNC system dramatically reduces grinding machine threading-in times to accelerate throughput significantly. The comprehensive new solution is ideal for machine tool manufacturers seeking to improve the performance of their gear production machines, or to help companies expand their gear manufacturing range with threaded wheel grinders.

Based on NUM's new-generation Flexium+ CNC platform, the threaded wheel grinding solution joins the company's NUMgear suite of gear production software. Originally developed for gear hobbing applications, the capability of NUMgear has been continually extended and now includes solutions for a broad range of gear manufacturing processes, including shaping, grinding and honing, and is used by many of the world's foremost manufacturers of gear production machines.

NUM developed the latest addition to its NUMgear portfolio while helping an Asian gear manufacturing machine company to improve the performance of a prototype threaded wheel grinder. To improve grinding speed compared with current levels, NUM decided it needed to develop custom technology software. The principal aims were to reduce the time overhead of learning the teeth positions of the hardened gear prior to grinding, and improve the accuracy of the gear grinding process.



NUM's new product offers a comprehensive CNC solution for gear manufacturing machines. At the heart of the system is a high performance electronic gearbox that allows all master axes – such as the grinding, X, Y and Z axes – and the spindle (C axis) to be fully synchronized. As part of the development work on the new threaded wheel grinder, NUM has added a major new capability to the gearbox, which is now able to predict the acceleration of axes as well as their speed, in order to minimize synchronization time. Together with the Fast Gear Alignment, it forms part of the new NUMgear threaded wheel grinding application.

During gear production, 'threading-in' – the process of bringing the grinding wheel into contact with the gear blank – involves continuously adjusting the position of the grinding wheel relative to the work piece. A similar process is employed when

bringing the machine's dressing wheel into contact with the grinding wheel. Using acoustic emission sensors to learn the sound signatures of a master gear and then using them to control positioning during production runs is a common technique for automating processes like this. However, the speed and accuracy of NUM's newly-developed Fast Gear Alignment Function eliminates the need for this entirely. As an example, aligning the grinding wheel with a 180 mm diameter gear with 71 helical teeth takes just 0.5 of a second – without any need to acquire acoustic signatures or make manual adjustments.

A second aim of NUM's development required that the gear grinder CNC control should generate gears as accurately as possible. The latest machine from NUM's Asian customer produced gears with a tooth profile quality of DIN class 7. During the development process, NUM found that the diamond plated dressing wheel did not come up to specification.

To overcome this problem without incurring major tooling costs, NUM decided to support their customer by helping to modify the technology programs. The positive results of this action far exceeded expectations, and NUM's solution can help a machine to consistently grind gear teeth profiles to within 3.5 microns, comfortably achieving DIN class 3 – an improvement of four class levels.

The latest gear grinding development is an example of one of the major principles underpinning NUM's business philosophy: a willingness to customize its CNC technology for machine makers. NUM supports this with a decentralized R&D structure which locates engineering staff around the world to allow it to work closely with machine builders. In this case, the new gear grinding solution was jointly developed by NUM's HQ in Switzerland and the company's technology centre in Chanzhou, China, which is close to many major gear manufacturing machine builders and is currently undergoing major expansion.

"NUM is committed to helping its customers develop market-leading machines through close partnership", according to Peter von Rüti, CEO of NUM Group. "Our local presence and willingness to work directly with customers to resolve technical issues very quickly provides both parties with a key competitive advantage."

NUM is one of the longest established players in the CNC market, having brought out its first numerical controller in 1961. Expansion in Asia has become promising for NUM as Asian manufacturers have progressively improved the capabilities and quality of their machines. To support this development, NUM is currently making significant investments in its Asian infrastructure, including the recent opening of a new regional support centre in Seoul, South Korea, and the expansion of its technology centre in Chanzhou, China, which opened in 2010.

Peter von Rüti points out that the European market for NUM and its partners is also promising. "NUM's ability to create individual solutions for different machines provides medium-sized companies with a huge competitive advantage. The open and flexible nature of our products, and our decentralized development structure, combined with the know-how of our customers, provides unique market opportunities. We welcome the chance to become involved in new projects."

Precision

Advanced CNC systems help US machine tool manufacturer to

Advanced CNC systems from NUM are helping US machine tool manufacturer Bourn & Koch, Inc. to extend its competitive edge in the market by using state-of-the art machine control software. Following a highly successful project to migrate control of powerful 7-axis horizontal gear hobbers to NUM's Flexium CNC platform, the company is now standardizing on this control technology for an extensive range of its gear production machines.

Bourn & Koch chose to upgrade to NUM's Flexium CNC on its 25H – 400H Series II gear hobbers, starting with the 400H. The speed and power of this machine means that it can replace as many as seven older style gear production machines, making it a popular choice with companies machining large precision components such as bull and cluster gears, worms, shafts, splines and pinions. Capable of accommodating work pieces up to 400 mm (16 in) in diameter, the 400H has an axial travel capability of 1,168 mm (46 inch) as standard and can be customized for the production of even longer parts. Customers are typically prime and sub-contract manufacturers producing mechanical power transmission components and systems for the defense and aerospace, oil/gas drilling, mining, heavy equipment and power generation industries.

All seven axes on the 400H Series II gear hobber, including the 560 Nm work piece spindle motor, are controlled by NUMDrive C servo drives and a Flexium 68 CNC system

Bourn & Koch has partnered with NUM Corporation for over 25 years and today uses NUM's CNC systems in many of its gear shaping, hobbing and grinding machines, as well as in various other types of metal removal machines, and for numerous CNC upgrade and machine retrofit projects. Both companies and their customers benefit from this collaboration. Jointly-developed conversational software has been cited by a number of Bourn & Koch customers as a factor in their machine purchasing decisions.

The HMI (human machine interface) on the 400H gear hobber makes full use of the software's capabilities by combining a conversational style dialog with powerful graphics, which means that the machine operator does not have to use or even know about ISO languages. To produce a part, the operator simply inputs machine set-up information such as cutting speeds, work piece and tooling geometry via simple fill-in-the-blanks menus, while graphical images provide clear and unambiguous views of the hob tool and resultant gear part. All calculations involved in creating the machine control pro-

extend competitive edge

Bourn & Koch now offers NUM's Flexium CNC on its powerful 400H Series II 7-axis horizontal gear hobbing machine and intends standardizing on this control technology for many existing and new designs

gram for a particular part are handled completely automatically.

The company decided to migrate the design to NUM's Flexium CNC platform as a matter of course. Tim Helle, President of Bourn & Koch, explains, "We offer customers a choice of CNC – NUM is the standard on most of our gear hobbers – and have a policy of using the latest technology to maximize the performance and cost-effectiveness of our machines. This approach also results in progressively simpler machine operation, with less need for training, and means that spares are readily available, which contributes to machine uptime and reduces customers' support costs."

In this instance, moving to NUM's Flexium CNC also had technical advantages; the system's faster block

processing and loop update times offered the opportunity to reduce the machine's cycle time and further improve its accuracy.

Flexium also features more on-board NC memory, a much wider and unified set of PLC software development tools and increased freedom for OEMs to create application-specific HMIs. This additional control and HMI customization flexibility allowed Bourn & Koch to enhance various aspects of the gear hobber's operation.

When the latest 400H Series II gear hobber is offered with NUM CNC, the entire machine is based on NUM motion control technology, with the sole exception of its (C axis) work piece spindle motor, which is a special liquid-cooled direct drive unit capable of generating 560 Nm of torque at 110 RPM. In addition to a Flexium 68 NCK (numerical control kernel) – which is the most powerful model that NUM produces and is capable of controlling up to 32 fully interpolated axes or spindles – and its associated PLC, NUM is supplying all the I/O, drives and servomotors that are used on the machine.

According to Tim Helle, "We have received technical support from NUM Corporation to assist us in making the transition from Axium to Flexium CNC systems and have already started using this CNC platform across our range of gear hobbers. Longer term, we intend offering NUM's Flexium CNC technology on all our new gear hobbing machines."

All seven axes of the gear hobber, including the work piece spindle motor, are controlled by the Flexium 68 CNC and NUMDrive C servo drives. The radial (X) and axial (Z) feed axes, as well as the hob head shift (Y), hob head swivel (A) and tailstock (W) axes, are all programmable and are driven by NUM BPH series medium inertia servomotors. The force applied by the tailstock servo can be changed on the fly during the machine cycle, to accommodate the changing mass of the part and prevent the introduction of any lead error. The hob cutter spindle (B axis) is driven by an asynchronous NUM AMS motor fitted with a high resolution multi-turn encoder, controlled by a NUMDrive C servodrive; a further NUMDrive C module controls the machine's direct drive work piece spindle motor.

For simplicity and ease of operation, the 400 H gear hobber is equipped with a NUM FS152i operator panel and keyboard, mounted on the front external face of the machine with an ergonomic swing arm. The panel combines a 15-inch touch sensitive screen with an integrated industrial PC running the Windows Embedded operating system, equipped with a solid state disk and dual core processor to provide a fast and responsive HMI. A number of machine functions, such as positive/negative jog and speed override of selected axes, together with emergency stop, can also be controlled remotely using a cable-linked portable hand wheel.

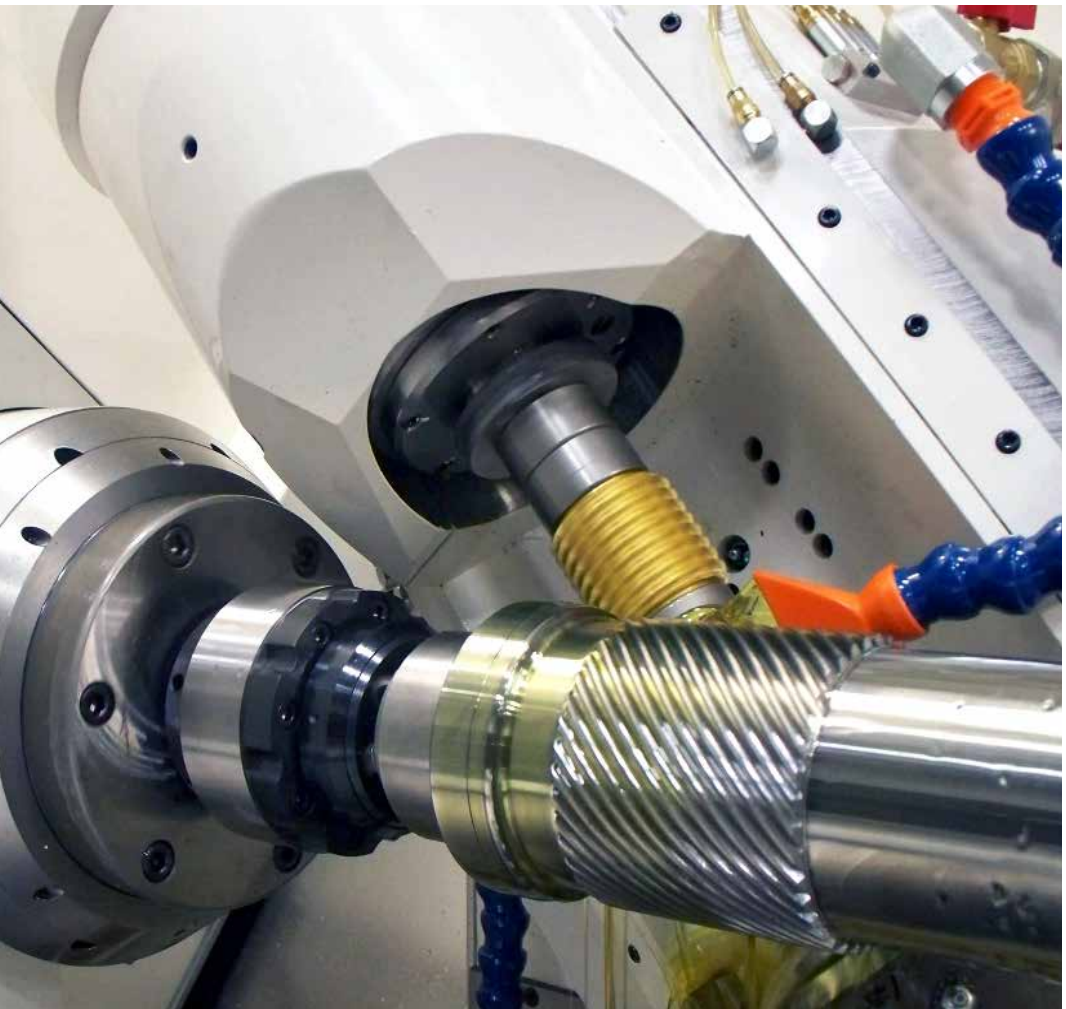
The machine utilizes the full four-axis electronic gearbox capability of NUM's popular gear hobbing solution, NUMgear, to help speed production of complex gear parts. In conjunction with built-in high-speed synchronization facilities this allows the

competitive edge

axial and radial feeds, and the hob head shift axis, to be geared to the work piece spindle. Use of the electronic gearbox is entirely automatic; the machine operator merely needs to enter basic gear manufacturing data, such as the number of teeth, the number of tool starts, the gear module – the 400H can handle a gear module of 6.4 – and the helix angle to define and activate a specific electronic gearing function.

Particular attention has been paid to tool wear management. The software continuously monitors the condition of the hob tooling and employs a pre-programmed tangential hob shifting sequence to ensure that an efficient cutting edge is always engaged during gear generation; the entire process is automatic – it can even be invoked during a machine cycle – and the operator is prompted whenever it is time to check or replace the hob. Undamaged hobs can be reground or recoated many times before they are worn out, which helps to keep tooling cost to a minimum. Hob head synchronization is maintained throughout the shifting process to minimize disengagement/re-engagement times and prevent tool or work piece damage.

The 400H Series II gear hobber utilizes the full four-axis electronic gearbox capability of NUM's popular gear hobbing solution, NUMgear, to help speed production of complex gear parts



Bourn & Koch also make use of the software's non-contact automatic gear alignment feature to improve throughput on the 400H, by enabling a work piece that already has teeth to be automatically synchronized to the cutting threads of the hob cutter. This is mainly employed for gears that are being re-cut or for hard re-hobbing (or skiving) of helical or spur gears after heat treatment to reduce distortion errors.

As Steven Schilling, General Manager of NUM Corporation in Naperville, Illinois, points out, "Bourn & Koch is one of our most valued customers and a key business partner. It has a large installed base of customers that use machines equipped with NUM's CNC systems, many of whom regard ease of operation as a prime machine tool differentiator. The company's decision to adopt Flexium as the CNC platform for all its NUM-based offerings is a considerable accolade, both technically and commercially. We are now in the process of increasing the level of in-depth product training that we provide for its engineering, machine start-up and customer support teams, to help support this initiative."

NUM invests in future CNC workforce in Taiwan

NUM's mission statement is to provide machine builders with a competitive advantage. To ensure that this advantage is retained in the long term, it is also important to actively support the future workforce.

To help foster tighter links between industry and academia and to promote industrial development, NUM TAIWAN Ltd. has donated CNC controllers worth more than NT$ 1.2 million to the Feng Chia University (FCU) of Taichung, Taiwan. The controllers will be used for five-axis electronic gear hobbing machines. The university's Principal, Dr. Lee, NUM's Global Business Director, Mr. Jan Koch, and NUM Taiwan's Managing Director, Mr. Adrian Kiener, signed the memorandum of cooperation, including details of the equipment donations, on April 29, 2014. The cooperation will benefit students and professors equally.

According to Dr. Lee, the machine tool industry is the main branch of industry in central Taiwan. This industry-academia cooperation will enable the university to align its curriculum and future personnel training more closely to the needs of the industry, so that students will be able to acquire the key knowledge and specialist skills they will need to succeed in the machine industry of the future.

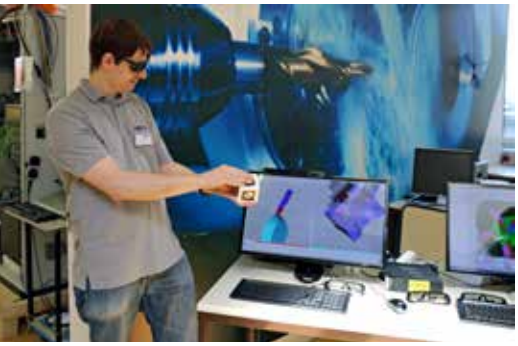
NUM for you...

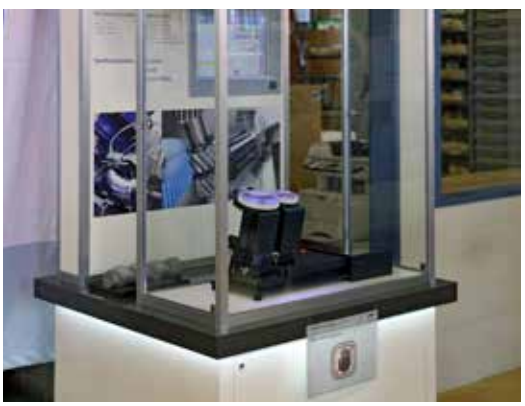
NUM for you

Your reliable partner

NUM opens new service and logistics center

The new service and logistics center next to NUM's head office in Teufen, Switzerland, the plans for which were announced in issue 54 of NUM Information, was completed on schedule towards the end of 2013. It was therefore possible to relocate the departments concerned from Bühler to Teufen last year, which allowed an active start to 2014.





The new service and logistics center has a total floor space of 2,525 m^2, spread over three storeys (each measuring 800 m^2), as well as an accessible basement which provides a further 125 m^2. In addition to several storage rooms, the top floor has a canteen with a magnificent panoramic view. The Minergie building draws the energy required for heating from nine boreholes, each with a depth of 170 m. Around two-thirds of the electricity needs of the site are produced by a large 447 m^2 photovoltaic system, set at an angle of 12° on the roof of the building. The power output of this system is approximately 74 kWp. The new center represents a significant investment of CHF 8 million (approximately 9.6 million USD).

The new building was inaugurated during an open day on May 17, which was attended by residents of Teufen and employees' families. The weather conditions were pleasant, and approximately 400 people visited NUM AG for a guided tour of both buildings, which gave them an insight into our business. Specialist personnel demonstrated some of the highlights of NUM's products. For example, interested visitors could use 3D glasses and a cube with glyphs, to look at and rotate an image on a screen.

New NUM technology center in Germany

Almost exactly a year after construction started, the new technology center in Holzmaden, Baden-Württemberg, Germany, is now complete. At the time of writing, interior work has just finished and we are due to move into the building at the end of July. Customers and employees will be able to enjoy spacious, modern, light-flooded rooms.

The new two-storey building provides 800 m² of space for offices and workrooms, plus an additional 200 m² of connected warehousing space. The total investment amounts to approximately € 2 million (about 2.7 million USD).

Incorporating the latest energy-saving techniques, the building is heated by an air-water heat pump, supported by a gas boiler to cover peak loads. Workflow will be improved significantly by means of shorter distances between offices and glass wall corridors – which also help to improve communication and create a feeling of togetherness. The offices are grouped into departments, arranged around a central communication area containing a printer and fax machine, as well as a kitchenette.

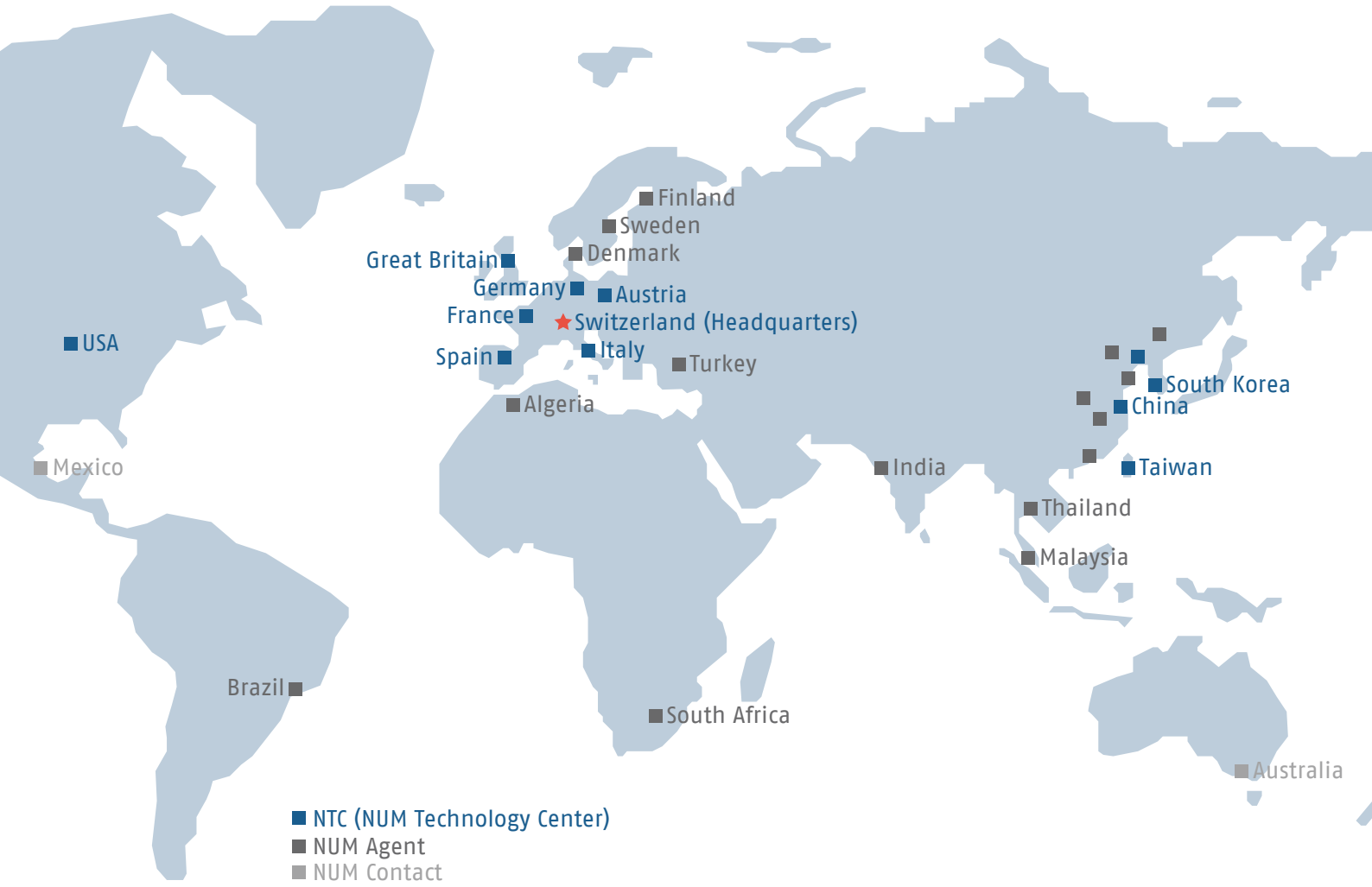
There are two training/meeting rooms, which can be opened up into one large room for internal and external events. Also, there are plenty of car parking spaces, so it will be easy to host large events with our customers.

The new technology center is at Zellerstrasse 18 – less than 100 m from our previous location – so we are still served by the same excellent transport links.

NUM for you...

CNC Complete Solutions Worldwide

CNC HighEnd Applications



NUM systems and solutions are used worldwide.

Our global network of sales and service locations guarantees professional service from the beginning of a project to its execution and for the complete life cycle of the machine.

NUM has service centers around the world. Visit our Web-site for the current list of locations.

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