num information

JOURNAL FOR CNC–TOTAL SOLUTIONS

num ®

CNC HighEnd Applications

Editorial
Peter von Rüti, CEO NUM Group

Dear readers,

It is no secret that many companies attempt to differentiate themselves from their competitors through propriety features, the so-called USPs (Unique Selling Proposition). Contrary to the mass-market business, that mainly functions through price, the niche markets NUM operates in are different. Apart from the price which obviously should be right, other factors like customized engineering, flexibility, quality and a good after-sales service are important.

To distinguish themselves from the masses, our customers require innovations so they can be at the forefront of their market segment. To make this possible, we need to be willing to adopt the ideas of our clients and develop them into unique solutions. Such innovations, when developed in close cooperation, lead to success.

With its engineering and in-house developed and produced open products, NUM supports its customers in bringing up-to-date, unique solutions to the market. Because of the fast-paced development in the most varied fields, the requirements for the machine manufacturer are also constantly on the rise. To keep increasing productivity even more, we obviously want to take these requirements into consideration and further develop solutions such as for

"Using our unique solutions let's to say goodbye to the "me too" and let's stand above the rest."

(Peter von Rüti, CEO NUM Group)

processing of gears, cutting of materials or quite generally the volumetric compensation of machinery.

It is our goal to further enhance the flexibility and performance of our products. At the IMTS 2016 in Chicago we will present additional new functionalities of the Flexium$^+$ System such as the NUMmill application, volumetric compensation in various designs, an enhancement concerning servo controllers, new functions with regards to tool grinding, and so on.

Thanks to the valuable experience with our partners, we are ready – both today and in the future – to supply customized solutions for the challenges of the future in cooperation with our partners. This close cooperation allows us to jointly bring solutions onto the market very rapidly. Using our unique solutions let's to say goodbye to the "me too" and let's stand above the rest.

I hope you enjoy reading this edition of NUMinformation and I look forward to greeting you in person at the IMTS in Chicago.

Peter von Rüti
CEO NUM Group

www.num.com – NUM's new responsive website

In this day and age, in which everything moves at a high pace and technology constantly overtakes itself, the NUM group has also adapted its website to the latest requirements of the World Wide Web. With immediate effect www.num.com will display perfectly on any device thanks to a responsive design.

Apart from a refreshed design that matches the NUM corporate design guidelines completely and entirely, you will also find application examples as well as references of NUM CNC projects. Similarly, all NUM publications such as brochures and catalogs in PDF form can be obtained directly from the download section. Even NUM press releases going back several years can be viewed and procured with the help of a link. NUM's website is available in a number of languages, including English, German, French, Italian and Chinese.
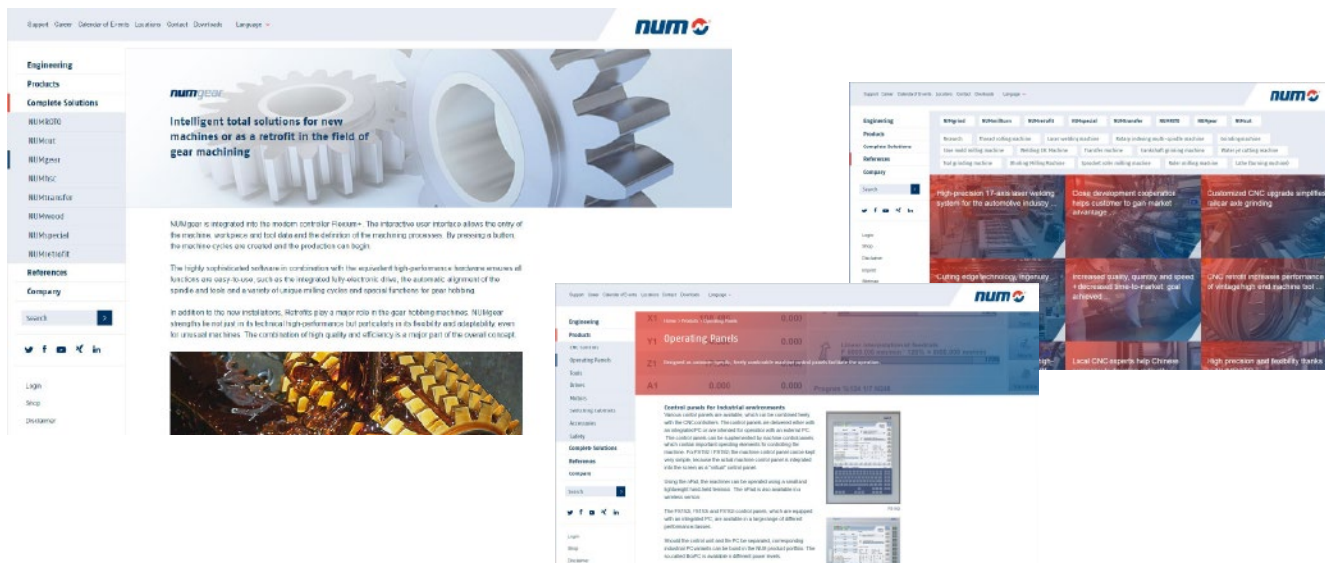
NUM Event Calendar 2016 / 2017

IMTS
September 12–17, in Chicago, USA
East Buildung, E-4837

FMB 2016
November 09–11, in Bad Salzuflen, Germany

EMAF 2016
November 23–26, in Porto, Portugal

TIMTOS 2017
March 07–12, in Taipei, Taiwan

Industrie Lyon 2017
April 04–07, in Lyon, France

Events

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Software-enhanced precision!

VEComp is a Flexium⁺ software function which stands for Volumetric Error Compensation. It enhances machine tool volumetric accuracy and workpiece precision. The purpose of the function is to minimize the spatial error of the tool center position at any arbitrary point in the work space. A volumetric positioning error is a deviation in a spatial direction – not necessarily in the direction of the axis motion. The VEComp function is based on a rigid body kinematic model. For each machine having a serial kinematic structure, the error model is originally designed as a superposition of error motions of linear or rotary mechanical components, starting from the workpiece side to the cutting tool center.

The geometric errors, compensated by VEComp, follow the same terminology that is used in the ISO 230-1 and TR 16907 standards, and are described as follows:

- Each linear axis has six error motions (linear positioning error, vertical and horizontal straightness error motions, and three angular error motions – roll, pitch and yaw). Straightness deviations have a direct influence on machine path accuracy and a small angular error can cause a significant effect at the tool center point (Figure 1).

- Each rotary axis motion can also be affected by six error motions: an axial error motion, two radial deviations, an angular positioning deviation and two tilt angular error motions, known as wobble effect (Figure 2). Each error motion depends on the current position of the axis motion.

- The position and orientation errors between axes of linear motion (Figure 3). Two type of errors are considered: parallelism error related to linear and rotary axes of motion, and squareness error related to linear or rotary axes of motion.

- Location and orientation errors of rotation axis. The rotational axes are represented by their axis average lines that are defined by five parameters: two position error coordinates, two tilt angles and a zero position error with respect to a reference frame Xa, Ya, Za (Figure 4).

- The VEComp system is a real time application based on kinematic error modeling. It supports more than 40 different kinematic types (3 axis, 4 axis and 5 axis machines – even with gantry axes) and different machining technologies such as turning, milling, grinding, etc.

VEComp exists in different versions:

- **VEComp 5-axes** is designed to compensate all errors of five axes machines; the tool center point deviations are corrected even with active RTCP (rotation tool center point). It allows to compensate location and orientation (perpendicularity) errors as well as the 6 motions errors of three linear axes + 2 rotary axes including one gantry.

- **VEComp 3/4-axes** is identical to VEComp 5-axes but limited to three linear axes + a rotary table or three linear axes in cluding one gantry.

■ **VEComp Rotary** is specifically designed to compensate the errors related to rotary axes of five axes machine (linear axes are not considered). Due to leverage effect, such errors might result in important deviations at the tool center point. Linear deviations and squarenesses of the linear axes can be compensated by standard axis calibration functions.

The typical compensation process is as follows:

■ A measurement session is needed to identify the magnitude of error sources. This uses precision instruments such as an interferometer laser, a laser tracer, laser levels, or 1D or 2D dimensional calibrated artifacts.

■ An identification of geometric deviations, in conformity with the ISO standard, needs to be performed. The identified errors are then collected in symbolic variable files and imported by a macro file into the Flexium+ machine controller, and directly used to compensate for systematic errors.

Not only is VEComp scalable, but its application can also be scaled! Even if VEComp allows compensating location, orientation (perpendicularity) errors as well as 6 motion errors per axis, the user, based on measurements, precision requirements and past experience, can decide to compensate, among such errors, only those generating the highest deviations at the tool center point. Doing so greatly simplifies the whole calibration process. This results in an easier use of this powerful function and increases the precision of machines.

Does this mean that OEMs can now get away with building less accurate machines? No, it most certainly does not! VEComp enables machine precision to be improved by means of software, but the best results can only be achieved if the machine quality is high (no backlash issues, low dynamic deformation, high stiffness, high thermal stability, etc). The highest improvements in precision will be gained on 'big' machines, where due to geometry, small local deviations generate high inaccuracies in the working volumes.
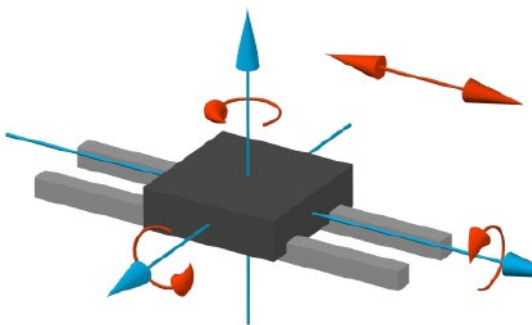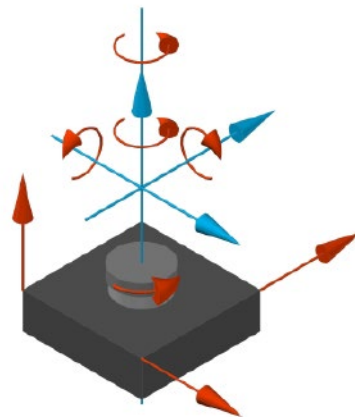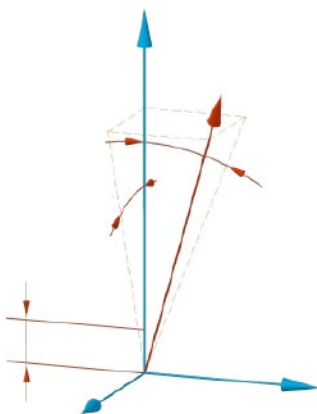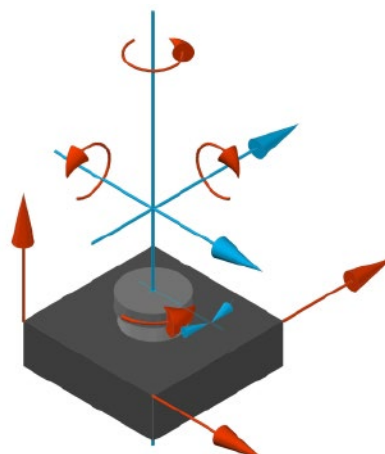

Figure 1

Figure 2

Figure 3

Figure 4

Engineering

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Increasing complexity requires new solutions

Modern machines for plasma cutting or water jet cutting produce increasingly complex and precise work pieces. Thus, they keep conquering new areas. Tridimensional machining heads are required for the increasing complexity of work pieces, be it only for balancing blanks or for complete 3-D processing. In the metal-cutting technology there are many successful 3-D head structures, which are, however, too heavy for plasma- and water jet applications. In addition, they are often unsuitable for cutting nozzles and for transport of energy supplies sensitive to torsion or bending. The target is to find an appropriate solution, which fulfills the respective special requirements and is light enough to be mounted on a rather light machine.

In order to meet the given market requirements, the machine manufacturers are often forced to provide specially customized head structures. The task for the control unit manufacturer is to then integrate the different structural concepts in the CNC firmware, making it possible to drive precise 5- axis movements. Thereby, for cost efficiency, it is necessary that the part programming can be performed with a standard CAD/CAM system without special geometric functions.

In the best-case scenario, the selected structure can be managed with the modules available in a modern CNC control. However, in several cases, due to mechanical design there is no standard structure available. For these cases, the Flexium+ system provides the option to implement structure-dependent, trajectory control functions. The theoretical trajectory will be converted in real time to axes movements dependent from the specific mechanical structure. Also, in order to recognize the real machine position and orientation at power up, a reverse transformation is required that will take into account the axes position to determine the machine attitude.

Generally a change in orientation also results in a translation of the tool center point (TCP) or nozzle tip in the XYZ referential. Therefore the control system must also take this into account and adjust the linear axes to compensate this phenomenon. But that's not all the axis speeds must also be converted in such a way that the speed at the contact point of the tool or jet in a 5 axis movement is respected or reduced in case of quick changes of orientation.
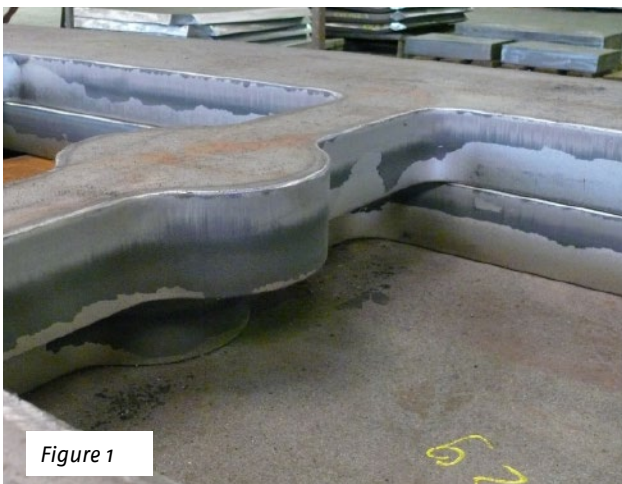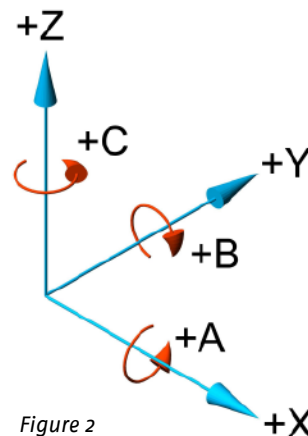

Figure 1

Figure 2

Figure 1: Workpiece example.

Figure 2: Standard system with X Y Z and A B C.

On a programming point of view the 3D design of the part can be done with respect to the A and B axes (i.e. rotation around the main axes X and Y) but this generally requires a large number of NC blocks for a simple arc segment that only a CAD/CAM system will have the possibility to manage.

A considerable simplification of programming is achieved by designing the transformation using the also standard-compliant version B- and C-axis, i.e. as deflection angle and as rotation of the deflected nozzle. For the work piece example in Figure 1, only 6 simple ISO- sets are required instead of several hundred CAD/CAM sets, which also enable manual sample cuts in a cost-effective manner. In addition, the polygon effect is eliminated in case of an insufficient number of sets in A/B approach. All this is possible in NUM CNC Flexium+.

Depending on the design solution and the intended programming, the necessary transformations can be simple to very complex. As shown in figure 6 (NUM-head), even very complex transformations can be successfully implemented with NUM CNC control.
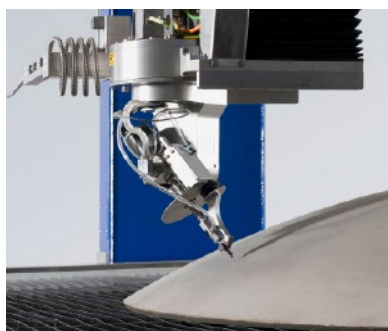
Application – water jet

Figure 3

Figure 4

Figures 3 and 4 show successful solutions for water jet cutting machines in which the machine manufacturers have successfully implemented their objectives.

Figure 5 plasma cutting with NUM-head, figure 6, NUM-head and figure 7 expert under-floor welding head for gas welding.
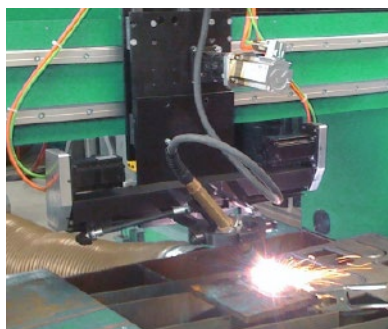
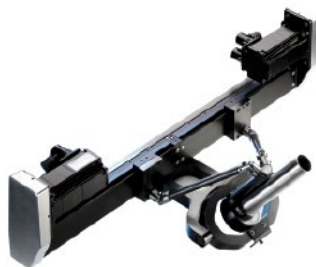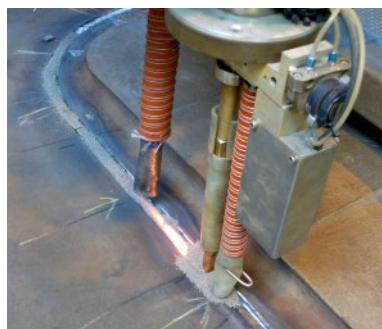**Application – plasma cutting:**

Figure 5

Figure 6

Figure 7

Height control:
A distance control system is integrated in NUM for automatic height readjustment and this can be combined with coordinate transformation. Thereby, the required distance can be in the direction of the jet, or vertical parallel to the Z-axis. During plasma cutting, the measurement signals can be measured with the voltage of the arc, whereas additional distance sensors are required for water jet cutting. Many different interfaces are available for coupling such sensors to the CNC.

Head correction:
In reality, the desired accuracies are seldom achieved due to cost constraints as well as the necessity of a light-weight design. Frequently, process-related deviation corrections are added. In order to compensate these errors, mechanical improvements are very rare due to the same reasons. Provided that the deviations can be measured, electronic improvements are developed at NUM for increasing the overall accuracy. Since these calibration functions are dependent about the head structure, NUM primarily offers customer-specific solutions in addition to the standardized tools. Such diverse solutions are being successfully used by the customers. Thus, a significant increase in the overall accuracy can be achieved. e.g. the mechanical and process-related errors have been reduced from almost a millimeter to a few hundredths mm. This is precisely the objective of NUM: develop such customer-specific solutions to help you increasing your competitive advantage.

Engineering

NUMgear – Super flexible EGB
NUMmill – Advanced CNC solution

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NUMgear with super flexible EGB

NUM provides a very flexible and powerful electronic gear train with the current generation of Flexium+ control systems, with accuracies in the sub-nano range. Higher speeds increase the productivity and new technologies improve the precision.

NUM's Electronic Gear Box (EGB) is integrated directly into the CNC kernel and can be used for gear production as well as for other applications. There are two basic types, static and dynamic gear mechanism. With this EGB, tool speeds of up to 25,000 revolutions per minute are possible.

Static gear mechanisms use the factor specified in its definition factor for the axis coupling. Each axis of a machine can be the leading or controlled axis. Gear mechanisms can be combined and connected in series. Several axes can control an additional axis – this can also be virtual – and become the leading axis of another gear mechanism. In this case, linear and rotary axes can be combined with each other. In addition, it is possible to superimpose further movements to controlled axes. Dynamic gear mechanisms use curve tables instead of the fixed coupling factor. The interpolation between two table points is done linearly or as a spline. Thus, the movement of the tool for non-circular gears, for special flank shapes can be controlled more flexibly. Static and dynamic gear mechanisms can also be combined. A calibration or parameter set changeovers are not needed; the EGB takes care of it.
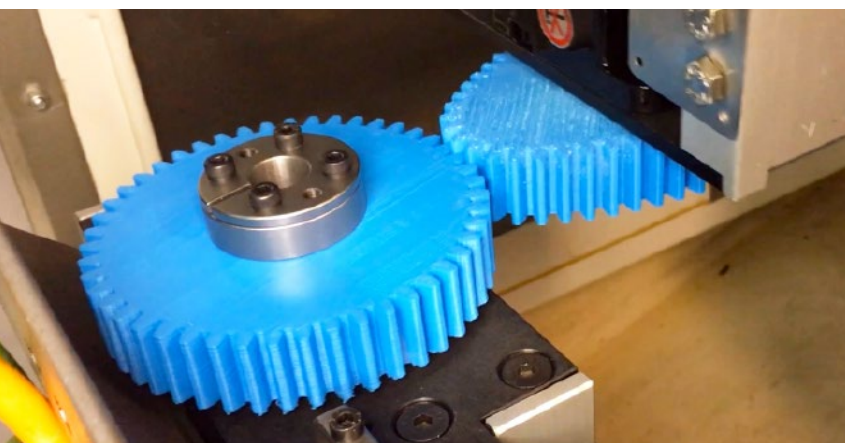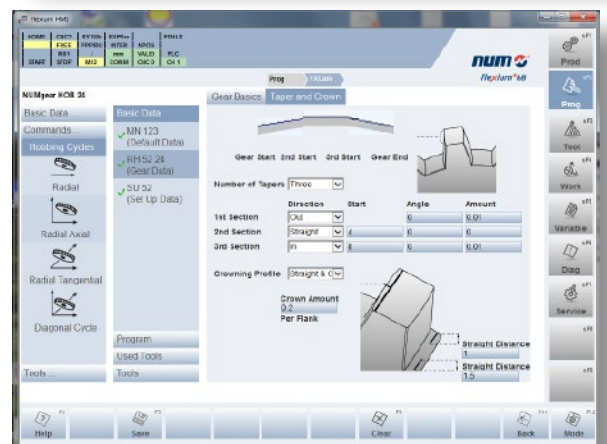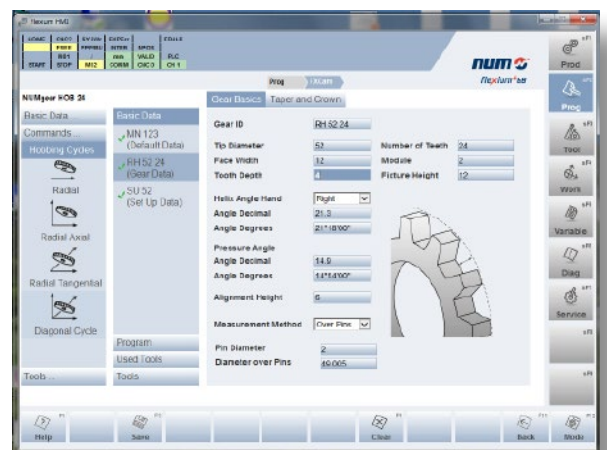
Above: Flexium+ 68 with NUMgear HMI.

Bottom left: Electronic Gear Box (EGB) Test.

NUMmill – Advanced CNC solution for precision milling machines

NUM has launched an advanced control solution for CNC milling machines that features a highly intuitive conversational style user interface. Known as NUMmill, the CNC hardware and software provides a fully scalable control system and is supplied as a complete 'off-the-shelf' package.

NUMmill is designed specifically for CNC milling machine manufacturers and control retrofitters. It offers an extensive suite of canned cycles, ranging from simple center drilling, boring and threading to pocket cycles and complex profile milling cycles. All with 3D simulation for pre-process verification. The package is suitable for a wide range of precision milling applications in markets as diverse as metal cutting, woodworking, plastic, and high precision machining.

Based on NUM's market-leading Flexium$^+$ modular CNC platform, NUMmill is typically configured with 3 or 4 linear axes and a single rotary axis, though it easily scales to suit any size and type of milling machine application. All motorized axes are equipped with high performance brushless servo motors, controlled by NUM's latest-generation NUMDrive X digital servo drives. The NUMmill software features an exceptionally easy to understand graphical user interface which employs an interactive, conversational style dialog to radically simplify machine operation. In fact, it is so simple to use that end-users can operate machines without any prior knowledge of ISO code programming techniques.

NUMmill Windows-based software provides graphical shop floor programming screens that depict the tool, the workpiece and all associated setup data in a concise and unambiguous manner. The operator is prompted to fill in the appropriate data fields presented by the human-machine interface (HMI), after which the machine control program is generated entirely automatically and then stored, ready for execution. On-line help files and step-by-step video tutorials are included for ease of operation. This conversational style programming helps to save considerable development time, as well as significantly reducing the learning curve for new operators. NUMmill is supplied as a complete, ready-to-run package that includes
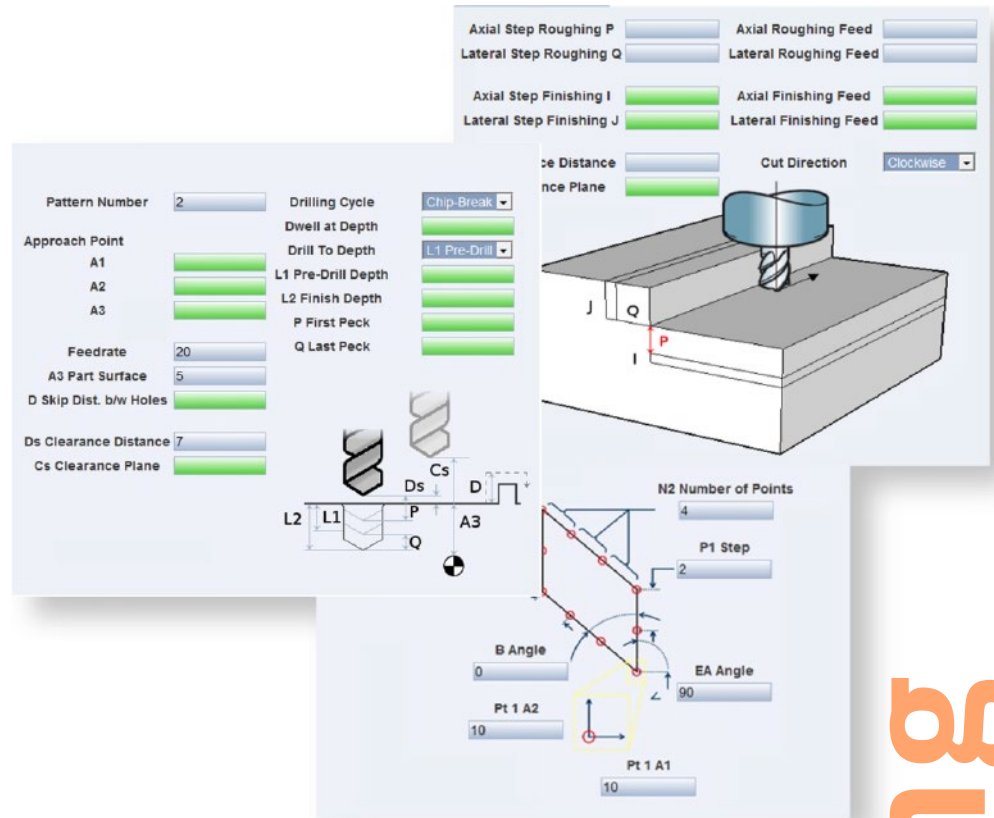
the Flexium$^+$ CNC system, software, and a 19'' touch-sensitive machine control panel, together with all necessary drives and motors. The system can also be equipped with NUM's MT-Connect interface or OPC-Server, which simplifies the integration of CNC machine tools with third party manufacturing software.

In addition to a large number of canned cycles, the NUMmill software provides functions for material removal of basic pockets; these can be defined as circular, oblong, reticular and square. The hole pattern definitions can use a wide variety of geometries, including Arc, Cover Patter, Drilling with Rotary Axis, Grid, Pitch Circle, Row, and Single Points. Milling operations can be performed on circular, oblong, rectangular and square pockets. The drilling cycles that can be performed on hole patterns include Center Drill or Chamfer, Peck, Chip, Counter Bore, Tap, Ream-Feed Out, Bore-Dwell/Feed Out, Bore-Stop/Rapid Out, Thread Chase, and Taper Threading.

The NUMmill system also provides measurement and probing cycles, to help users meet precision and quality targets, as well as full 3D simulation with collision monitoring for pre-process verification.

The Flexium$^+$ architecture also offers machine designers, builders and retrofitters an easy means of implementing functional safety. Available as a build-to-order option for all Flexium+ CNC systems, NUMSafe includes a safety PLC, safety input and output (I/O) modules, digital servo drives with built-in safe motion monitoring facilities, and compatible brushless servo motors. NUMSafe is a system-wide architecture that puts functional safety features precisely where they are needed, thereby reducing the number of components and wiring, which simplifies design and most importantly saves time in implementing 'safe motion' functions.

Engineering

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More than 7000 different servo / spindle motors

The comprehensive motor series of NUM offer an excellent volume/output ratio, as well as first-class dynamic properties optimized for the machine industry. They satisfy highly accurate and reliable requirements with perfect concentric run-out even at very low speeds. The so-called "single cable" motors offer the advantage of the complete measuring system cable being eliminated. This simplifies the wiring of the machine considerably and thus saves costs.

The asynchronous motors of the AMS series offer excellent quiet running at low speed, quick and accurate positioning and are ideally suited as a C-axis and for the spindle indexing.

Key data of the motor series:
- Servo-motors from 0.318 to 160 Nm (IP65, IP67)
- Rated speeds of the servo-motors up to 8000 rpm
- Spindle motors up to 55 kW
- Special kit motors
- "Single cable" motors
- Custom motors
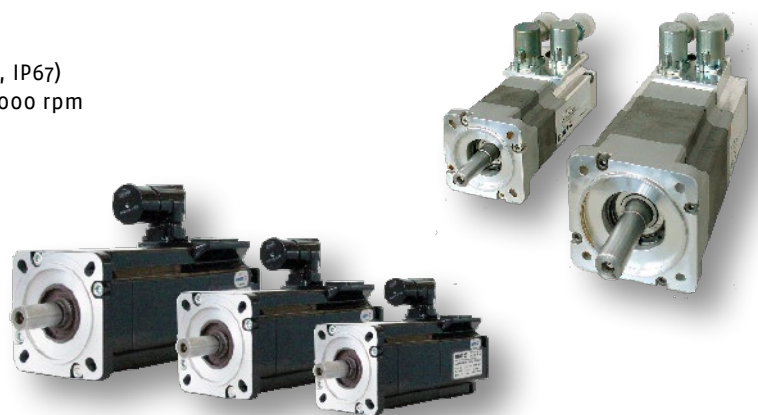
IDAM – direct drive specialist and strong partner of NUM

IDAM
INA DRIVES & MECHATRONICS

In the area of direct drives (torque motors), NUM relies on the partner company IDAM. IDAM has extensive experience in the field of direct drives and its customers include renowned European machine manufacturers. The combination of NUM control technology and IDAM direct drive technology creates a strong team. IDAM: Precise. Fast. Efficient. These are the qualities that distinguish Suhler Schaeffler subsidiary INA – Drives & Mechatronics AG & Co. KG (IDAM). The company stands for the highest quality, outstanding technology and excellent innovative ability. For NUM, IDAM torque motors are ideal for the use in gear machining. Therefore, IDAM has recently launched an innovative motor: the RIB. This new torque motor series is for thermally optimized direct drives, for higher productivity and lower energy consumption of tooling machines. Due to improved heat transfer, the RIB can be operated depending on the operating strategy with 12% more maximum torque or with 30% less heat dissipation compared to the RI series.

Smaller width and more power –
new NUMDrive X servo drive modules

NUM has introduced three new NUMDrive X servo drives – each with a mechanical width of 150 mm – to help machine builders reduce the cost and cabinet space requirements of high performance automation control.

■ New mono-axis MDLUX100A (100 amp) drive provides an intermediate option between the existing 75 amp and 130 amp modules.

■ New mono-axis MDLUX150A (150 amp) drive provides a more powerful alternative to the existing 130 amp module – and has 50 mm less width!

■ New bi-axis MDLUX075B (75 amp) drive further extends the current capability of this product line.

NUMDrive X drives are renowned for their compactness. These new modules continue this tradition, enabling users to pack even more power into tight spaces.

The scalability and performance of NUM's MDLUX series is of course also applicable to these new drive units; certified safety functions and different performance levels are available.

Mono-Axis		MDLUX100A…		MDLUX150A…	
Switching Frequency	kHz	5	10	5	10
Rated Current (S1)	Arms	45	31	60	38
Maximum Current	Arms	71		106	
Protection Degree (EN60529)		IP20			
Overall Dimensions (WxHxD)	mm	150 x 355 x 206			

Bi-Axis		MDLUX075B…	
Switching Frequency	kHz	5	10
Rated Current (S1)	Arms	27 + 27	18 + 18
Maximum Current	Arms	53 + 53	
Protection Degree (EN60529)		IP20	
Overall Dimensions (WxHxD)	mm	150 x 355 x 206	

Engineering

US machine tool control specialist chooses
NUM CNC for precision grinding applications

Advanced CNC systems from NUM are helping US machine tool control specialist CNC Onestop, Inc. to maintain its competitive market edge through use of ultra precise positioning techniques. Based in Xenia, Ohio, and also operating in Toronto, Canada, CNC Onestop is a CNC engineering company that specializes in full CNC, motor and drive retrofits for machine tools, as well as machine rebuilds and troubleshooting. Its main area of business is in grinding machines – including OD, ID, non-round and punch grinding, as well as thread grinding – that provide sub-micron accuracy. The company's customer base spans a diverse mix of aerospace, medical, marine, defense and high-tech industries.

According to CNC Onestop's President, Ven Swaminathan, "We aim to develop solutions for machine tool applications that are deemed impossible by competitors. Many of the grinding machines that we retrofit are required to work to sub-micron accuracies. To help achieve this, we need CNC technology with exceptionally precise positioning capabilities. NUM is the leader in this specialized area of CNC and their application support is unparalleled, so we have chosen to standardize on their open architecture hardware and software for all future grinding machine retrofit projects".

The core of NUM's cylindrical grinding CNC solutions is a flexible software package known as PCProCAM. This features a highly intuitive graphical human-machine interface (HMI) which uses simple conversational style programming. It is used in conjunction with embedded CNC grinding and dressing cycles, with direct hyperlinks to CAD files or other pertinent grinding production data, to facilitate efficient manufacturing of a diverse range of workpieces with a variety of wheel forms. PCProCAM software is designed primarily to address the requirements of OD, ID or OD/ID with either a horizontal or vertical machine layout.

NUM's PC-based PCProCAM software can be easily and quickly configured for a variety of machine configurations. The basic configuration has the X-axis or radial direction into the part and the Z-axis or axial along the length of the part. The same X/Z axes can be used to drive the dressing operations, or alternatively the software can also set up to manage a rear mounted independent U/W dressing axis set. Embedded grinding cycles include OD/ID Plunge/Multi-plunge, Plunge with inclined Axes, Oscillating Plunge/Multi-plunge, Cylinder Traverse, Complex Profile Traverse, Taper Traverse, Oscillating Shoulder, Shoulder Traverse and Shoulder Cylinder Blend.

PCProCAM also supports a wide variety of auxiliary grinding functions, including straight and special profile wheels, roller dressing, automatic wheel profiling, in-process dressing,

Bottom left: CNC Onestop President, Mr. Ven Swaminathan in front of the retro-fited grinding machine.

Right: View of the retrofited grinding machine and the Flexium⁺ HMI.

Bottom: View of NUM's cylindrical grinding CNC solutions with the flexible software package known as PCProCAM.
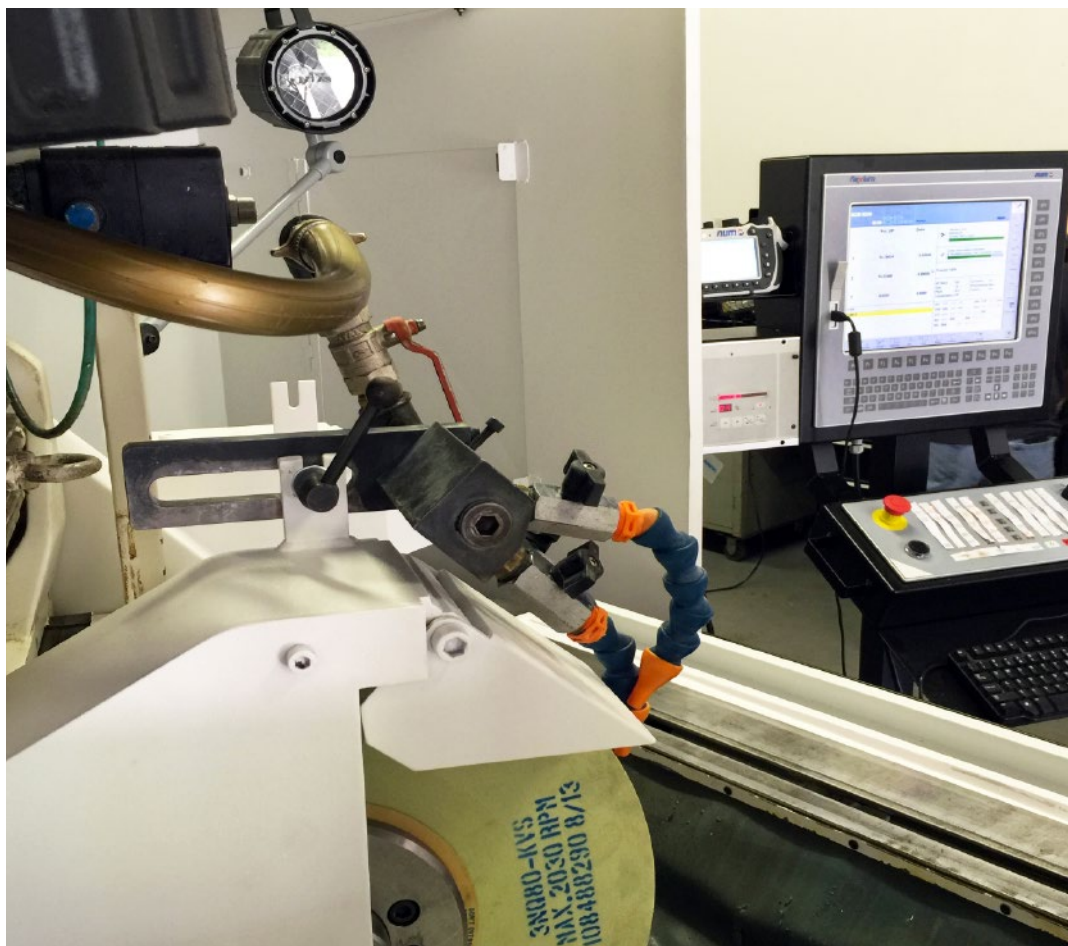
and automatic wheel surface speed calculations.

Steven Schilling, General Manager of NUM Corporation in Naperville, Illinois, points out, "Our PCProCAM grinding solutions are based on NUM's latest-generation Flexium⁺ CNC platform. This provides machine tool retrofitters and manufacturers with a modular and fully scalable CNC system that is very cost-effective across a wide range of applications. We are currently supplying Flexium⁺ 8 systems to CNC Onestop, which are extremely flexible and powerful configurations. CNC Onestop's decision to base its future cylindrical grinding developments on NUM's CNC products is a great accolade and we wish them every success".
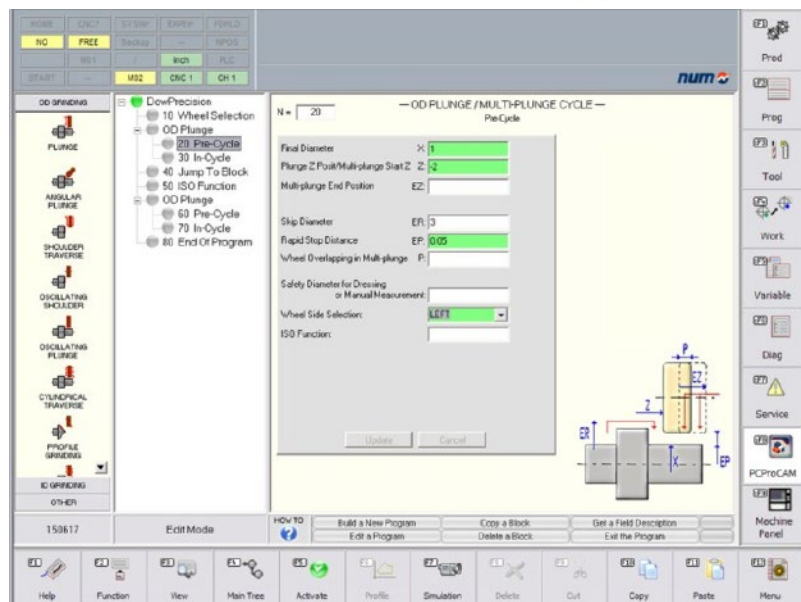
Precision

Flexium⁺68 and Rafale combat aircraft

Although the commercial successes of the Falcon aircraft are undeniable, the Rafale has just recently won several export victories confirming, if any proof was needed, its performance and high technical nature. While these successes are of course welcomed, by the manufacturer, Dassault Aviation, realizing them while providing their customers with the expected quality within the agreed time also impose industrialization constraints.

The Dassault facility in Biarritz has been an integral part of this challenge; this factory with its rich history – created by Pierre-Georges Latécoère, one of the pioneers of aviation – specializes in the manufacturing of composite parts combining titanium and carbon fiber as well as the assembly of complex structures. For its part, the Fives group, over the course of more than two hundred years of history, has signed some superb technical innovations such as the first steam locomotives or the elevators of the Eiffel Tower. Represented in more than a hundred countries, Fives took over another well-known player in the field of aeronautics, Forest-Liné, who started more than 60 years ago by fabricating aircraft propeller pro-

duction machinery as well as developing expertise in the field of five-axis machining. Concerning NUM, it is a long time partner of Dassault and Fives.

Following the philosophy of active cooperation at NUM, these three conducted a joint project around a Forest-Liné V-Star, one of the jewels of Fives Machining, which combines speed, flexibility and high dynamic precision. This high speed milling machine dedicated to the machining of large aerospace parts is comprised of five-axis machining including a gantry. The longitudinal axis is propelled up to a speed of 60 m/min by four linear motors coupled two by two; it encompasses two secure work

areas, each with its own tool magazine and that can be used alternately or merged. Ten EtherCAT stations of more than 90 I/O modules, a tool measuring bench, two tool breakage controllers, an RFID chip reader and of course integrated security complete the machine that is controlled by a Flexium⁺ 68 which in in combination with the NUM-DriveX servocontrols, demonstrated its ability to pilot such configurations.

Some ergonomic and security details. The installation includes three FS192i type panels, each with a 19'' screen oriented vertically to display simultaneously the machine control GUI and a virtual touch panel. Two of these panels, each aided by an MP05 machine operator panel, are assigned to their respective working area. They are both completely independent but only one at a time will be able to control the machine. The third FS192i panel is dedicated to the management of the two tool magazines so as to ensure loading and unloading jointly with the measuring bench; it is completely independent of the other two and equipped with all required safety.

The management of the device was developed according to the desires of Dassault Aviation. It provides the use of devices equipped with a chip with up to 45 settings. Without going into more confidential details, these settings control the equivalent tools but also feeds and spindle speeds,

Top left: Fighter jet Rafale, Produced by Dassault Aviation in France, image source: www.meretmarine.com.

Top right: NUM engineer Stéphane Bellet demonstrates the machine to DASSAULT's Clement Duval.

Bottom left: The Tool magazine dedicated HMI.

Bottom right: A view of the large machining area.

tolerance stacks, types of irrigation etc. All these data are displayed on pages developed to the specifications of Dassault. A group of pages is dedicated to the visualization and modification of data, another to loading and unloading tools.

A modern machine is inconceivable without an integrated security system. Flexium proposes a complete solution, drives included, based on the FSoE (Functional Safety over EtherCAT) protocol. This solution marries performance, simplicity and economy. Indeed, the machine and security terminals are distributed according to the needs of the I/O bus that combines standard features and security features. The security of the

drives, SAMX, is connected along the EtherCAT bus by a single RJ45 connection and the entire configuration is programmed with the help of Flexium Tools software.

The notion of partnership is very important for NUM; Mr. Leroy, the business manager at Fives, commented: "Given the technical challenges of this project, we chose to directly approach the manufacturer of the CN selected by the customer. This mode of operation, with an automated systems component and external CN, is new to us and allowed us to re-evaluate certain practices and to formalize exchanges that are usually done internally. This choice paid off as NUM has worked as a true part-

ner throughout the project. We particularly appreciated the involvement and responsiveness of the teams at NUM, who allowed us to take our customer's specifications into account, all while respecting deadlines."

The ultimate goal is of course to bring satisfaction to the end user, listen to the views of Mr. Holtzmann in charge of this case at Dassault: "Our primary objective in choosing Flexium$^+$ has been to ensure the sustainability of our investment by choosing a product compatible with our already established machining programs. Of course we also wanted to take advantage of the latest performance improvements and advanced techniques. We had requirements especially in regard to safety and ergonomics. The teams at NUM showed great skill and care in the realization of this project, they have proven to be ready to listen and offer good advice whenever decisions were to be made."

As noted by Elia Barsanti (Managing Director of NUM France): "The motto of NUM, 'offer machine manufacturers solutions to enable them to develop a competitive advantage', is fully illustrated in this project. Using the latest technology developed by NUM and their effective implementation can drive this machine, in the best conditions, to be used to produce among the most advanced of aircraft components."

Ergonomics

Achieving a competitive edge by short response times, innovation and advanced development – as well as precision production

Hofmann & Vratny is one of the leading manufacturers of solid carbide tools, with its production headquarters in Assling near Munich, and another facility, the re-sharpening center, in Nuremberg. The company can look back on a successful 40-year corporate history characterized by continuous growth. With NUMROTO, NUM has played a significant role in the development and production of milling tools and drills at Hofmann & Vratny for around 22 years. Nowadays, it is impossible to imagine a production company that does not use milling as a production method. For machining workpieces quickly and precisely, Hofmann & Vratny relies on modern CNC machining centers, the majority of which are equipped with NUMROTO. At present, about 1.6 million tools are produced each year.

The core product range offered by Hofmann & Vratny primarily includes solid carbide milling tools. In the 1980s, the company was one of the first to launch these tools on the market. Today, the manufactured products include micro-tools for the medical and semiconductor industries, and high precision milling tools for mechanical engineering, aerospace technology and, last but not least, the automotive industry. "With the help of very close and long-term cooperation with partner companies such as NUM AG, carbide suppliers and coating companies, as well as by quick response times

GFRP, CFRP and graphite end mills
By cutting in opposite directions, delamination of the top and bottom edge is prevented. Thanks to the simultaneous effect of the tensile and sliding forces on the cutter and the special arrangement of the cooling ducts, you achieve excellent results. In order to increase the service life, the tool is provided with the latest generation of diamond coating.

Left: The new GFRP, CFRP and graphite end mill sets new standards for milling of GFRP materials. The cutter was developed by Hofmann & Vratny itself.

covering everything from inquiries for a new application to the delivery of the appropriate tool, Hofmann & Vratny has managed to position itself in the premium tool grinding segment", says Marius Heinemann-Grüder, CEO at Hofmann & Vratny.

Hofmann & Vratny produces tools for the aerospace and automotive industry, as well as for the medical sector. At present, great emphasis is placed on the development of new CFRP tools (carbon-fiber-reinforced plastic), since this material is being increasingly widely used in production, especially in automotive construction. However, even tooling materials such as aluminum, titanium and sandwich materials for the aerospace industry are also enjoying an increasing demand. Even tools for machining tempered steel hardened to up to 75 HRC (Rockwell hardness) are no problem at all for Hofmann & Vratny.

In order to manufacture such special tools, you need motivated employees in addition to a good working environment. "The goal is that every employee looks forward to coming to work in the morning", says Robert Wendl, the Production Manager at Hofmann & Vratny. In order to achieve this goal, the company makes large investments regularly. The new production hall with a heat recovery system and a UPS system has been commissioned recently in Assling. This enables a considerable part of the energy that is consumed for production to be recovered and thus saved. This helps to further reduce production costs in this fiercely competitive market. Hofmann & Vratny also invests regularly in the latest generation of

Right: from left to right, Stefan Maier, Production Manager Microtools, Andreas Vratny Managing Director, Marius Heinemann – Grüder, CEO and Robert Wendl, Production Manager at Hofmann & Vratny.

CNC machines. On specific request, these are fitted with a NUM controller and NUMROTO software. "The advantage of NUMROTO is that it is easy to operate and can be deployed universally, and yet offers a large number of options for designing and manufacturing new and special tools" says Robert Wendl. "Even if something does not work out at the first attempt, an alternative solution is sought immediately by making a personal telephone call to NUM AG. Partnership based cooperation ensures that the problem is resolved promptly, in the minimum", adds Wendl. At NUM AG they rely on good, intensive partnership with the customer and on the user-friendliness of the applications. As a result, a new employee engaged by a customer using NUMROTO can be trained quickly, and then deployed at various machines. For standard, special and micro tools, the suitable machine can be procured, and still, all machines use the same programming system of NUMROTO. With the help of perfectly coordinated development and production processes, Hofmann & Vratny is in a position today of achieving production figures of 1.6 million tools per year, and producing a range of 7,000 different solid carbide tools for machining.

An example of the innovative and development strength of Hofmann & Vratny is the high-performance milling tool illustrated here. This diamond-coated milling tool is used within the automotive industry for machining CFRP and GFRP (glass-fiber-reinforced plastic) materials. Thanks to the special shape and the cooling ducts, the fibers are first pressed in one direction and then in the other, which causes them to tear without leaving residues and without fraying. As a result of the neat edge produced in this first work step, the next step of edge finishing is normally superfluous, which saves cost and time. This is a very significant factor under present day circumstances.

High-Precision

NUM and Feng Chia University jointly develop intelligent CNC gear hobbing machine

NUM (NUM Taiwan Ltd) and Taiwan's Feng Chia University have jointly developed an intelligent CNC gear hobbing machine with an advanced electronic gearbox that completely eliminates the time overheads of changing mechanical gears on traditional machine tools. Development of the machine began in 2014, under the initiative of Professor Ruihong Xu, who works for the Bachelor's Program in Precision System Design at the College of Engineering in Feng Chia University. Professor Xu is responsible for a number of industry-university collaborative research and development projects at the university.

Following detailed discussions between NUM and Professor Xu about the potential machine control possibilities of its latest Flexium$^+$ CNC system – which offers an advanced precision electronic gearbox – the company donated a series of CNC controllers to the university in 2014. With the assistance of other providers, the intelligent CNC gear hobbing machine, which utilizes five-axis electronic gear synchronization techniques, is now complete. It is currently being exhibited in the first floor laboratory of Feng Chia University's College of Engineering.

The open architecture of NUM's Flexium$^+$ CNC makes it an ideal platform for research and development projects such as this. The human-machine interface (HMI), together with loop programs for gear machining, have been specially created by Professor Xu, who was previously in charge of HMI development at HOTA Industrial Mfg. Co., Ltd. He continues to foster tight collaboration between the university, HOTA, Hiwin Technologies Corp. and NUM.

The new intelligent gear hobbing machine is based on a significant upgrade to a traditional NC gear hobbing machine that featured a mechanism provided by Chang Feng Gear Machinery Co. Ltd. Developed under the Industry 4.0 planning and design concept, it offers powerful expansion capabilities through use of a CNC-PC communication framework. Facilities for monitoring parameters such as spindle speed, temperature and motor current have been added. Transmission of network data, calculation of cloud data, analysis and prediction can be performed via suitably equipped tool wear monitoring systems. This facilitates online compensation and product measurement to provide optimal cutting parameters and precision.

Founded in 2008, NUM Taiwan Ltd. is a subsidiary of NUM, and is based in Taichung, where many machine factories are located. NUM Taiwan Ltd. is responsible for businesses throughout south-east Asia, Korea and Japan, including CNC project development, after-sales service, education, and training. The company offers a variety of special machining software for gear applications, including an elec-
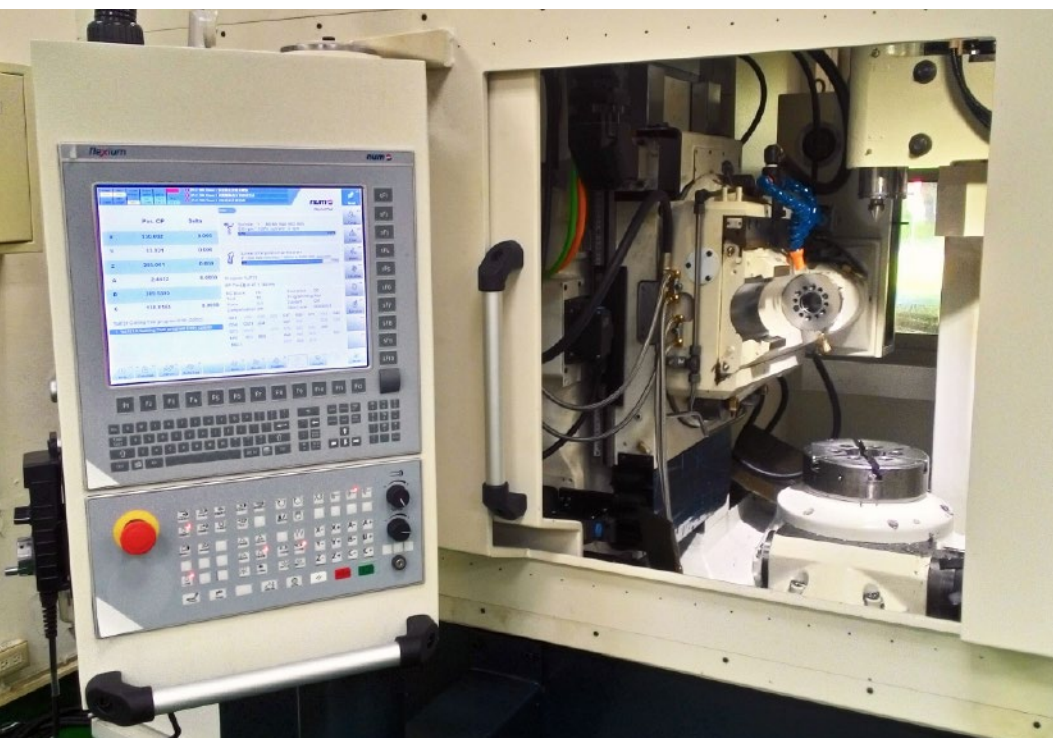
Bottom left: NUM machine panel FS152i and NUM human-machine integration.

Top right: FCU Gear hobbing machine with NUM Flexium+ 68 CNC system.

Below: Interior view of the machine with hobbing tool.

tronic gearbox function (five-axis synchronization transmission) and an automatic tooth alignment function, which are essential for CNC gear hobbing applications. NUM Taiwan also actively supports Professor Xu in the development of teaching aids for PLC programming, parameter acquisition and machine commissioning.

According to Professor Xu, "NUM has complete applications related to CNC and gear machines, backed by abundant engineering knowledge and resources. During this development, NUM was willing to help us solve problems, and to provide relevant training to help us integrate our human-machine interface with

the Flexium+ controller. The company also spent considerable time on on-site commissioning, in order to let students become fully conversant with the system. NUM's CNC systems provide exceptional expandability. We can easily access the information relevant to the machine and share the information via the network. Furthermore, the electronic gearbox system included in the Flexium+ CNC system is superior to the traditional tooth matching gearboxes. It can achieve high precision and output without spending time on changing gears, and without the back clearance problems that occur in gears with traditional tooth matching."

Cooperation

50% time saving in wooden beam processing – thanks to ingenious woodworking center

The new Flexium controlled Techno Turn wood processing machine from Essetre, featuring two independent double exit milling heads, is able to process all 6 faces of the beam without turning it. This means that the time that was needed up to now to work on a wooden beam can be reduced by 50%. This is because the wooden beam does not have to be turned or replaced to finish the work, as the work can be done simultaneously on two of its sides. There are almost no limits for wood processing on the Techno Turn, thanks to the brilliant machine construction of Essetre combined with the control flexibility of the NUM Flexium CNC system.

Essetre S.p.A. was founded in 1979 in Thiene, in the North of Italy, and began its business by designing and manufacturing woodworking machinery, with particular attention to kitchen processing. NUM has cooperated closely with Essetre in the development and production of machines for woodworking since 1981. Today, Essetre is an established company, well-known on the Italian and foreign markets, and renowned for its innovative ideas, specifically with regard to the design and manufacturing of multi-purpose working centers for the processing of wood, plastic and light alloys.

The working centers, studded with advanced technologies, structures and software, meet the requirements of numerous production fields: from kitchen manufacturers to window and door manufacturers, joinery companies to carpenters, chair manufacturers to companies working in the building industry, and from furniture manufacturers to sofa manufacturers. The working centers, often special because they are built to satisfy individual customer's requirements, meet the needs of craftsman as well as big companies, with single or completely automatic in-line machines which guarantee flexibility, highest quality and productivity. When such broad functionality machines are developed, the CNC control also has to be many-sided and flexible in use, which is guaranteed on this machine by NUM's Flexium CNC system. Essetre is constantly at its customers' service, first by analyzing the working center that is most suitable for their needs, then with a highly responsive and professional after-sales service. Its new industrial structure, inaugurated in 2013, is today the guarantee and point of reference worldwide, as well as the engine for achieving more goals and innovation.

The Techo Turn machine has 12 axes and 2 spindle motors on which 4 tools – like saws, milling cutters or drills – are mounted, one on each side of the spindles. The 12 axes are driven by NUM Drive C drives, which control the BHX motors using absolute encoders. Each of the 2 powerful spindle motors offers up to 45 Nm of torque, which allows the operator to utilize large saw blades for fast and powerful woodworking. The spindle motors were developed by Essetre themselves and are therefore perfectly matched to the concept of this innovative machine. The Techno Turn is controlled by a Flexium CNC system from NUM. It is equipped with an RTCP function that is specially personalized for Essetre, so that both heads with the spindle motors are able to work synchronously at the same time (interpolation). Due to this working method, the wooden beam does

Bottom left: Mr. Giovanni Sella, President of Essetre S.pA. and Mr. Marco Battistotti, Director of NUM Italy, in front of the Techno Turn woodworking center.

Top right: View of the two independent double exit milling heads, the heart of the Techno Turn woodworking center and some examples of wood work.

Bottom: wooden beam loading station of the Techno Turn woodworking center.

not have to be repositioned once the machine has started working. This results in a time saving of about 50%, compared to conventional working methods in this field of work. In fact, because the two working heads operate simultaneously, no time is wasted when one of the heads needs to change a working tool at the tool loader. This is a big advantage compared to competitors' machines in this specific market.

The Techno Turn machine is able to work 24/7 as an assembly line production machine. This gives users the opportunity to save money and time. Machine downtime is limited to maintenance tasks. The machine is also very compact, which is an advantage for customers, because the space which is needed for this machine is less than that of other woodworking centers on the market that are capable of handling this kind of work.

The HMI, which which runs in in the back-end of the Flexium CNC-System, was also developed by Essetre themselves. The operator is kept simple and is easy to learn, so any woodworking operative can handle the machine in a short time period. It is also possible to read CAD plans, which are produced by architects or engineers, directly into the machine. The Techno Turn then automatically generates the machine control program directly from the CAD data, so all the operator needs to do is to start the machine. The ingenuity of Techno Turn demonstrates yet again, that if niche market partners work closely together to create a new, innovative machine, which simplifies the working process for the end user in a significant way, they will certainly gain a competitive advantage in the market.

CNC Virtuosity

Innovative riveting machines for enhanced productivity and manufacturing quality on aircraft doors

CYBERMECA, located in Fontenay-le-Comte on the French Atlantic Coast, is a company that is part of the Ledoux Group. The group offers its customers diverse industrial skills in a wide range of fields such as engineering, mechanical design, automation, programming, hydraulics, sheet metal work, painting, assembly and geometric positioning, in addition to manufacturing electrical cabinets. The broad scope of its expertise has contributed significantly to the success the group has experienced over the past 12 years.

In collaboration with leading industrial companies, CYBERMECA provides joint project management in fields such as aeronautics, automobile, aerospace and defense – which all require exacting standards. Its success can be attributed entirely to its multi-skilled workforce working in close collaboration with companies such as NUM, a pioneering company in the CNC field which has specialized for more than 50 years in auto-

mating high-end, specialized machine tools. Over the past few years, NUM France, in particular, has worked on a number of highly technical aeronautics projects, including the Dassault Falcon private business jets and the famous Rafale multi-role fighter aircraft.

The new riveter described in this article is designed for manufacturing aircraft doors. During the design phase, the

main challenges CYBERMECA and NUM faced were reducing production time, facilitating processes and optimizing work quality. To achieve this, the machine is equipped with twelve digital axes, a riveter head and a state-of-the-art operator console. It allows for complex riveting cycles to be run at a high rate, with an unparalleled level of reliability. Each cycle takes only six seconds to complete! The entire production process takes place under video surveillance through cameras allowing for specific work stations to be viewed. The machine is driven by the Flexium⁺ CNC platform. The 12 axes are equipped with NUM SPX single drive-to-motor cables and NUMDrive X servodrives equipped with NUMSafe safety functionality. A number of different functionalities devised by the LEDOUX Group are available as an option (VAO, electrical heads, electrical consoles, a B axis, the use of different types of rivets, etc.).

The LEDOUX Group and NUM's pooled experience gained over many years concerning the development of specific applications has offered great flexibility in producing riveters, allowing for solutions to be optimized in line with customer requirements. The machine's riveting cycles and movements have been vastly optimized thanks to the continual technological progress made by both partners.

"Particular attention is paid to choosing high-quality components and selecting experienced partners such as NUM

On the left: Image of the innovative riveter designed for the production of aircraft doors.

On the right: From left to right in front of the riveter: Olivier Millet, CYBERMECA; Werner Krüger, LEDOUX Group; Didier Ledoux, Managing Director, LEDOUX Group; Vincent Sauvion, CYBERMECA; Gilles Gouraud, Commercial Engineer NUM France and Anthony Dupas, CYBERMECA.

Below: focus on the riveting process:
1) View of the riveting head
2) Insertion of the rivet
3) Controlled crimping of the rivet
4) Retraction of the rivet set
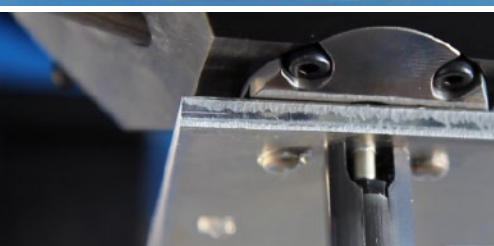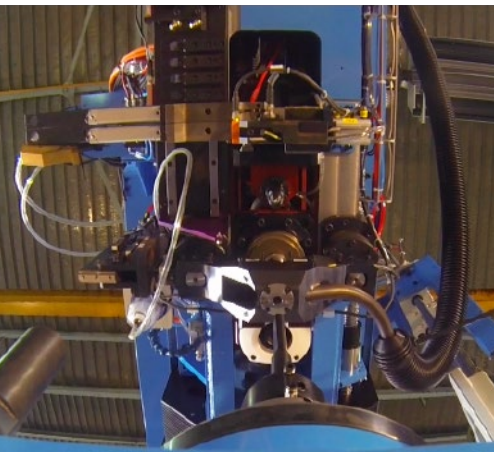
to ensure we supply our customers with a reliable machine. This reliability is recognized by our customers, who are key players in the aeronautics fuselage manufacturing sector where production speed requires high-performance equipment", explains Didier Ledoux, Managing Director of the Ledoux Group.

But the experience contributed by both partners has also allowed the duration of the entire process – which includes positioning of the door, drilling of the rivet hole, positioning of the rivet, securing and compression of the rivet head – to be reduced to only six seconds. The crucial role played by the thousands of rivets fitted to aircraft requires a process of optimum quality. It is easy to imagine that the innumerable temperature and pressure changes as well as the resulting expansion and contraction that aircraft undergo over their lifetime puts the rivets to the absolute test.

CYBERMECA and NUM have worked together for almost four years to develop this special riveter for aircraft doors, which has been fully aligned with customer requirements. The Airbus A320 is a very popular aircraft requiring an increase in production rates, which in turn calls for a faster riveting process, naturally without compromising quality. Riveting is a crucial component in aeronautical safety.
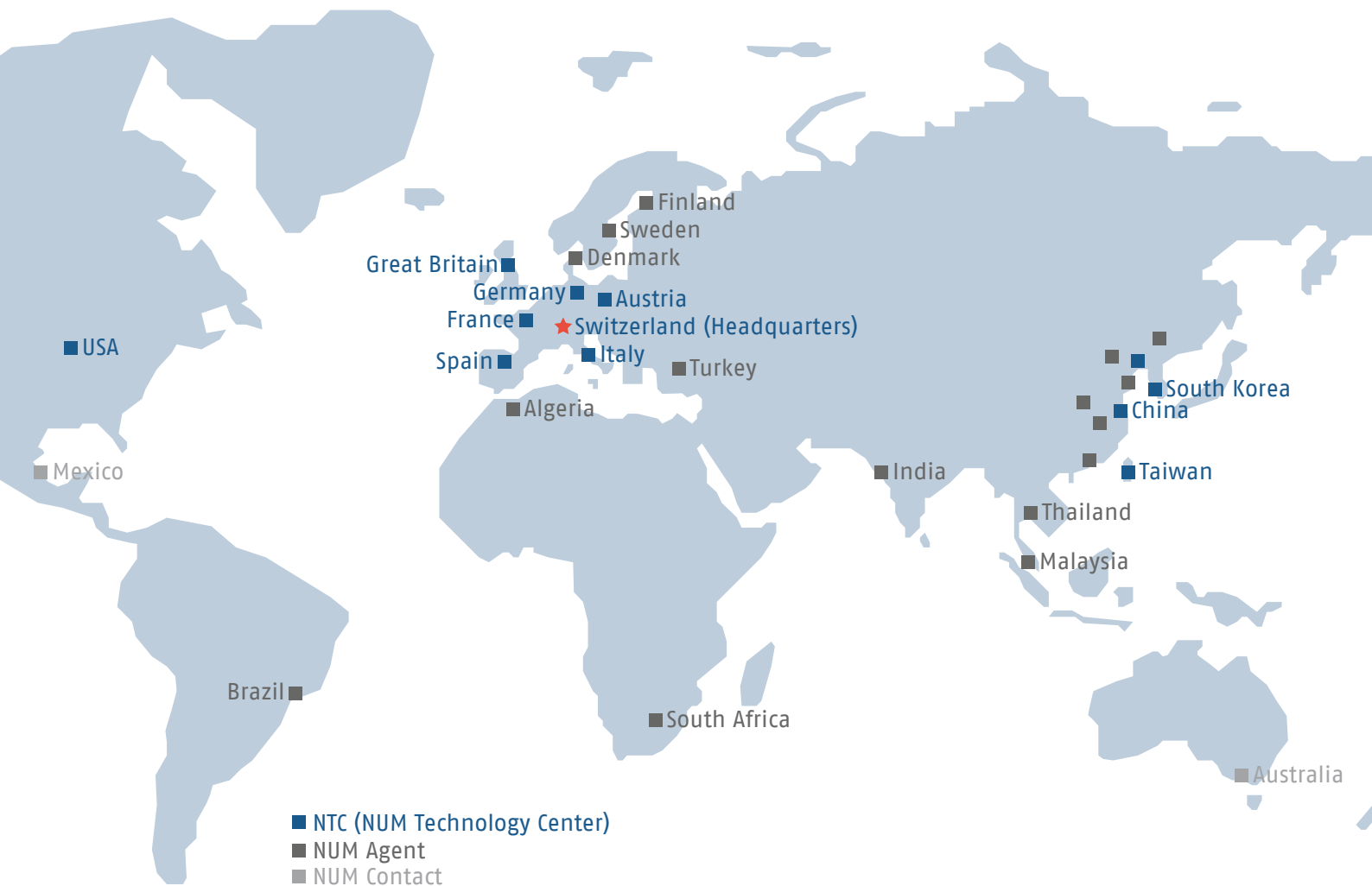
From the outset of the project, both companies were faced with a major challenge: the machine needed to be developed and assembled around the finished product. This product, namely the aircraft door, was produced prior to the design of the riveters and had, up until that time, been manufactured on other machines following different processes. The riveting machine therefore had to allow for orifices to be drilled according to the existing positioning of the rivets on the doors, bearing in mind that no change or adaptation would be possible. This also explains the specific design of the machine. The aircraft door is assembled on a specially developed frame supported by two arms. These arms raise and rotate the door to the desired angle on both sides, ensuring that the driver is able to carry out the drilling and riveting work. The driver still works in a vertical direction with partially adjustable stability, unlike the standard movements of the usual X, Y, Z axes.

The technical progress made during the development of this riveter has already been further utilized for the design of larger machines able to carry out riveting on entire sections of fuselage. Despite the fact that specialized machines are used to execute key tasks such as riveting are rarely in the limelight, they are vital. Their flawless quality allows for complete safety in flight; spare a thought for this during your next flight.

Essential

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Great Britain
Germany
Austria
France
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Italy
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Malaysia
Brazil
South Africa
Australia

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■ NUM Agent
■ NUM Contact

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