LIGNA⁺

HANNOVER   26 – 30 May 2003
World Fair for the Forestry and Wood Industries

Num – Hall 19 Stand B05

"2003 Will Be a Year of Convalescence!"

Andrea Riello - UCIMU
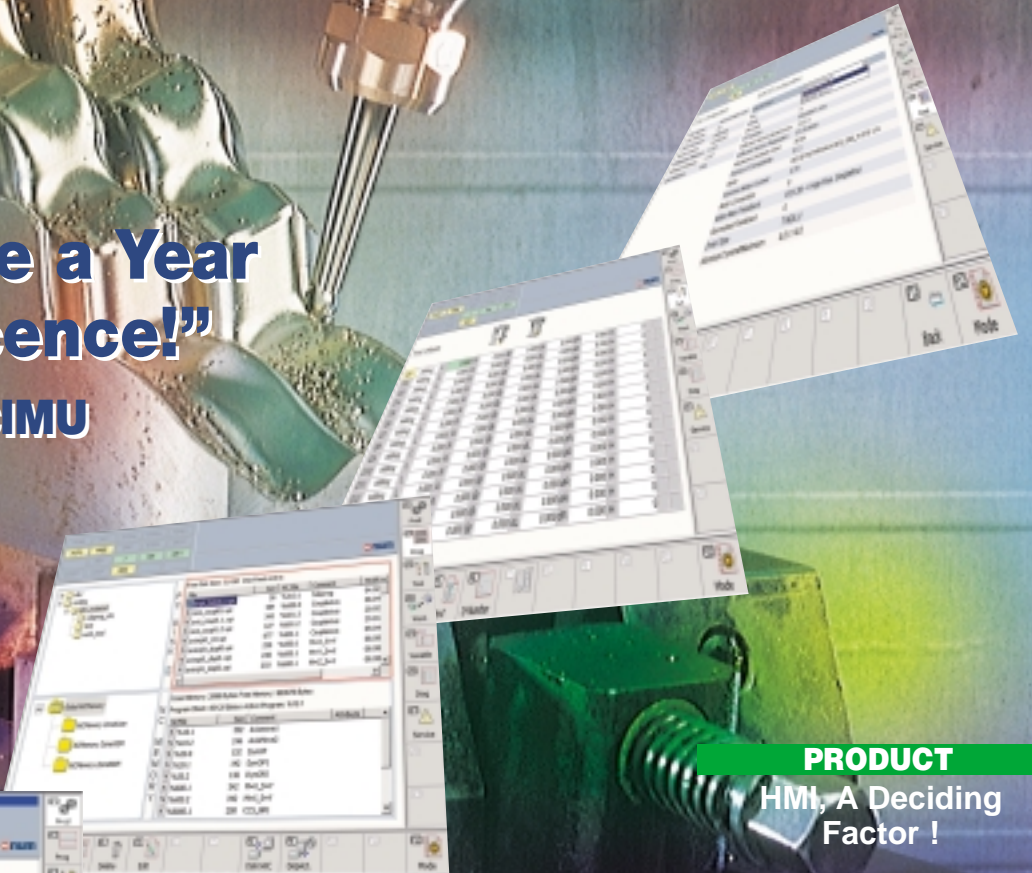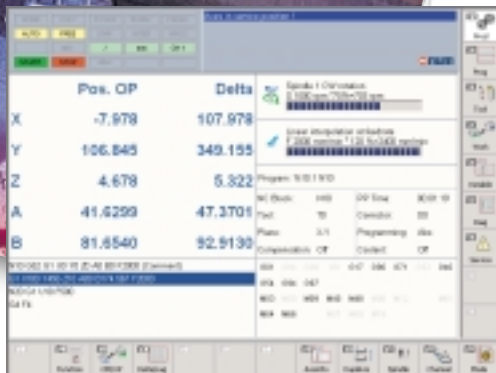
PRODUCT
HMI, A Deciding Factor !

SOLUTIONS
JEUMONT Choose Num!

Schneider Electric
Num : CNC Complete Solutions

Num

"2003 Will Be a Year of Convalescence!"

That is how Andrea Riello, Chairman of UCIMU-SISTEMI PER PRODURRE, the Italian association of machine tool manufacturers, forecasts this year.

Andrea Riello, Chairman of UCIMU-SISTEMI PER PRODURRE, the Italian association of machine tool manufacturers

Could you describe UCIMU-SISTEMI PER PRODURRE briefly for us?
UCIMU-SISTEMI PER PRODURRE was created in Milan in 1945. It is the association of Italian machine tool, robot and automatic control manufacturers. It includes some 210 companies which cover 70 percent of the industry and have been ranked among the world leaders for years. UCIMU is the official representative of Italian manufacturing equipment industry, and the ambassador for Italian technology. UCIMU contributes to promoting a leading sector of Italian industry in the world.

How does UCIMU stand with respect to CECIMO ?
CECIMO is the European Committee for the Cooperation of the Machine Tool Industry. Like the other European associations in this industry, UCIMU collaborates and cooperates with CECIMO to develop support, development and promotional programs for the industry.
For over a year, UCIMU has been participating in the Mantys project of CECIMO aimed at promoting the development of research and technological innovation in the manufacturing industry through the creation of a European network of companies, universities and research centers. Currently, UCIMU is contributing to preparing the next EMO, the itinerant international trade fair organized by CECIMO, which will be held in Milan on October 21- 28, 2003.

What happened in 2002?
The disappointing trend in the world economy had serious consequences in 2002 for Italian machine tool, robot and automatic control manufacturers: their production did not exceed €4.397 billion euros, i.e. down 5.1% (in real terms) from 2001.
This slump, which followed eight years of uninterrupted growth, is mainly explained by the decrease in exports, down 11.5% at €2.072 billion.
For the first ten months of 2002, there was a substantial drop in the main markets for this Italian industrial sector: -15.6% in Germany; -16.1% in France; -40.9% in the U.S. By contrast, the exports to Spain (+4.9%) and China (+24.2%) place these countries among the emerging markets for the Italian manufacturing industry.
There were some positive points, such as deliveries to the domestic market, which, despite the drop in consumption, grew by 8.8% to €3.560 billion, up from 1.2% at €2.370 billion. However, the decrease in demand in Italy had a negative impact on imports, whose value dropped to €1.189 billion (-23.9%). The import/consumption ratio fell to 33.4%, down from 40% in 2001.
The trade balance has been positive for more than 20 years, with an increase of 15.2% in 2002.

What are the differences between this crisis and the one in 1990-1992?
There are two differences between the current crisis and the one in 1990-1992. First of all, the current crisis affects all the sectors of the economy and almost all the main markets, both traditional and emerging, almost uniformly. Secondly, the generally negative situation of the global economy is compounded by the uncertainty related to the possible conflict between the Unites States and Iraq, which adds to the climate of instability on all the markets. The 1990-1992 crisis did not include the variable of war.

What can be said about the fact that the drop in Italian industry was moderate by comparison with the major difficulties experienced by Germany, Switzerland, Spain and the U.K.?
You're right, although the figures were negative, Italian industry has been able to keep going and limit losses to a minimum. The positive result recorded for the last quarter of 2002 shows that our companies are better able to react to crisis situations than more traditional competitors, and are fast to take decisive advantage of all the opportunities offered by the markets, both traditional, like the U.S. – where investments have been spurred by the Bush administration stimulus plan including a depreciation bonus – and emerging, such as China.

What do you forecast for 2003?
It is always difficult to make forecasts, especially at a time as uncertain as today. Based on available data, I would say that 2003 will be more a year of convalescence than of recovery. After beginning in fits and starts, recovery could gain momentum during the second half of the year, allowing the Italian machine tool, robot and automatic control manufacturing industry to recover at least some of the ground lost in 2002.

* The war hadn't started when the interview was made.

The forecast is that production will rise to €4.400 billion (+0.1%), but will be hindered by exports, which will drop by 3.3%, and not exceed €1.960 billion.

Deliveries to the domestic market should increase by 2.9% to €2.440 billion, but imports should drop by 5.4%, to €1.125 billion

If these forecasts are confirmed, the trade balance should be around €835 million (-0.3%). There should be practically no change on the employment market.

How do you think market recovery could be promoted?

In the current situation of economic stagnation, I think actions should be planned to give a boost to consumption. Because the industries upstream of production such as the manufacturing industry will not be able to recover unless the consumer market does.

Especially for our industry, we Italian manufacturers urge the government to adopt at long last industrial policy actions aimed at promoting industrial investments and supporting the competitiveness of Italian products, which should not be penalized by comparison with foreign products. In this respect, it would perhaps be a good idea to extend the Tremonti bis law for all of 2003, possibly with some modifications.

* The Tremonti law encouraged investments via tax allowances.

Num Trains Nearly One Hundred People at Airbus France

Stéphane Nicolas, operator:
"I would now like to do more programming."

After being chosen to produce certain prototype parts for the Airbus A380, Airbus - Saint-Nazaire decided to organize a vast training program for nearly 100 people involving all the Num systems installed (760, 1040, 1060, and 1050).

There were two aims; to expand the technical knowledge of the maintenance departments and to allow the production operators to work more independently.

A Global Approach: Teaching Engineering

"In accordance with the teaching engineering established at the Institut de Formation Schneider Electric (ISF: Schneider Electric Training Institute), we first evaluated the trainees' background by individual meetings," explained Gilles Bailleul of the Num Training Department (ISF). "This allowed us to target the contents of the training courses together with the supervisors of the departments concerned, specify their duration and optimize the budget.

"At the same time, to achieve maximum efficiency," he continued, "we adjusted the contents of certain courses during the training. You will appreciate the support required when you realize that special material was developed for each course."

Twenty-three sessions were held over a period of several months. Throughout that time, Num's technical and teaching equipment remained in Saint-Nazaire. "On average, our courses included nearly 50% practical training," said Gilles Bailleul. "We had dedicated training units and our instructors were not only teachers but also Num service technicians. They therefore had long field experience and were able to illustrate their courses with practical examples."

That was one of the reasons why Num was chosen: applied training that the trainees could put to use immediately. One example is Stéphane Nicolas, operator: "The older generation CNC uses a rather symbolic language, which is why some of the functions aren't easy to understand at first. After the training, the use of the homing system (datum shifts) was much clearer to me. This was also true for execution of certain G functions, giving me a better understanding of how a program runs. Actually, I would now like to do more programming."

In accordance with ISO 9000-version 2000, the trainees were evaluated at the end of the course by an MCQ*. It demonstrated that the training met the needs.

Results: An overall satisfaction rate of 90%!

* Multiple choice questionnaire

China Nanchang Aircraft
Turns to Num

Making sure production equipment is still profitable is a basic, even crucial concept to guarantee the quality of the end product and avoid breakdowns. When a machine tool is more than 10 years old, several questions are invariably asked; is it still performing as well as in the past? does it need mechanical refurbishment? is the CNC system obsolete?

The time needed to do the retrofit is also very important, because the machine is out of action whilst the retrofit is taking place. So this time has to be in weeks or even days, instead of the months needed to develop a new machine.

Just Two Weeks on Site!

China Nanchang Aircraft Manufacturing Company (CNAM) is one of the leading Chinese aviation manufacturers. They chose Num to retrofit two Heller milling machines, initially equipped with Heller UNI-PRO NC80C CNCs. These two 5-axis machines (3 interpolated axes) are now equipped with Num Power 1060 CNCs.

This operation was a real success, not only technically through the improvement in performance but also timewise, because it was completed in only two weeks on site. Because the machines were fairly complex, it required close collaboration between the OEM and Num engineers and a high quality of preliminary preparation. Num not only sells systems in China, but also provides technical advice and assistance, a necessary component of successful operations, whether equipping new machines or retrofitting existing ones.

Heller machine being retrofitted at China Nanchang Aircraft Manufacturing Company

More Customer
Oriented Than Ever!
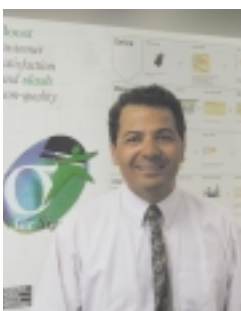
Brahim Maklouf, Organization and Quality Department, Num Process Manager: "Orienting all our processes towards customer satisfaction allows our organization to be more efficient."

"Today, doing well is consistently not enough. You must keep doing better!" Schneider Electric have understood this for a long time ago, so it is not surprising that the Group ranked its customers and quality foremost among the six challenges in its corporate program, New 2004.

From the outset, Num has been strongly committed to that part of the program called Good Morning Quality, aimed at achieving total quality so as to improve customer satisfaction.

A Customer-Oriented Approach

The intention of this approach is to concentrate on customer needs. All projects are chosen for
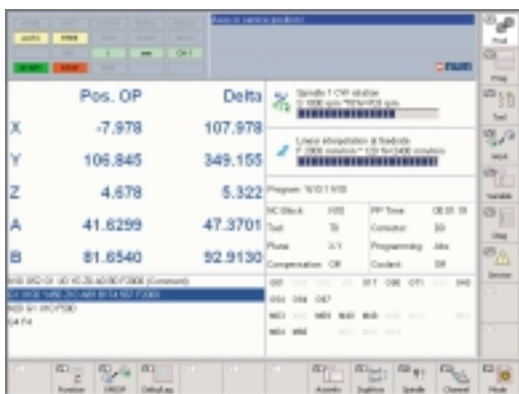
Wolfgang Steinwender, R&D Manager, leader of the Cuggiono MBLD project: "We intervened as experts to analyze possible design improvements and diminish component obsolescence."

their ability to increase customer satisfaction. Totally targeted quality actions, specific to each site have been set up; product variations, production improvements, quality partnerships with customers, etc.

A leader has been appointed to each project to keep an eye on how the actions are proceeding. The leader can take any actions deemed necessary and is responsible for their customer's project, regardless of the company department concerned. To do their job, the leader is supported by a multi-disciplinarian team including people from the marketing, technical, production, sales departments, etc.

Measurement indicators assigned to each action are an essential feature of this approach. The purpose is to confirm that the action is worthwhile, and check progress is made towards achieving the objective. In addition, regular reviews are held with certain customers to measure the results in terms of satisfaction. Problems detected so far have been identified and eliminated and an expert database is now being set up, which will be used to establish a list of good practice for future projects. So far, the operation has been a real success. By better meeting our customers' expectations, it has allowed us to improve certain processes by making them more clearly customer-oriented.

HMI, *A Deciding Factor !*

After getting a general impression of a machine from its build and any particularly important mechanical features, a user always returns to the Human-Machine Interface (HMI). There is no doubt that it can be the deciding factor in the overall choice.

With their sophisticated graphics, the Axium Power HMI pages are very easy to understand.

Production Context

Programming Context

Tool Context

Fully aware of how important the HMI is, Num's engineers have taken special care with Axium Power's HMI. Two approaches were developed to do so: offer end users a user-friendly, intuitive, clear and esthetic interface and give OEMs all the "keys" they need to create and customize their own HMI when desired.

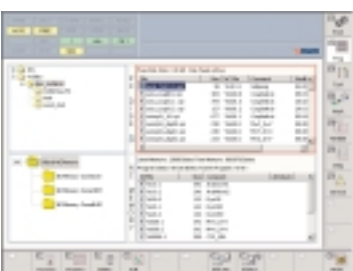### Savings of Programming and Operating Time

The end user will particularly appreciate the general ergonomics. All the pages are divided into readily identifiable fields; a multi-window display presentation; the vertical icon bar on the right-hand side of all the pages making it easy to change contexts, etc.

Each context of the interface corresponds to a particular type of use of the interface. Since the contexts are displayed as icons, learning to use the interface is fast and natural. The contexts enhance the relevance of the display by bringing to the fore all the important information specific to the selected category (production, programming, maintenance, etc.). This HMI runs on a PC panel and can be used together with other applications specific to the user, such as machining and CAD/CAM, production control and even remote maintenance/diagnostic programs.

Because it was developed under Window 2000™, the Axium Power HMI benefits from the features of this system: the environment looks familiar to the user, who becomes operational faster; high security is guaranteed by the access controls available with Windows 2000™.
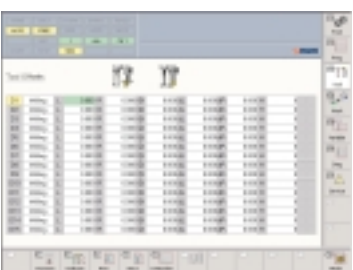
Customization and Ease of Adaptation

The OEM will be especially attracted by the HMI's openness and high flexibility. Developed in HTML, the Axium Power interface is not only open but also portable. All the adaptations and development of additional pages can be carried out using off-the-shelf tools: HTML editor, Java, Visual Basic, Delphi, Visual C, C++, etc. This is an essential aspect, because OEMs have ready access to such tools and they do not require extensive material or human resources.

For those who wish to do more, i.e. develop their own interface, a CNC/PLC data server gives access to all the system data.

Like all Num CNCs, Axium Power supports the integration tools that have made the reputation of our company. The HMI offers direct (though protected) access to all the configuration, machine setting and servo system optimization tools offered by Num. Furthermore, new features have been added to reduce integration times and therefore cost. Last but not least, this added operational and customization flexibility does not in any way diminish the support available from Num. Quite the contrary. The application teams are available to provide assistance and advice whenever necessary.

Woodworking Features

Woodworking machine manufacturers are particularly attracted to customized interfaces. It is true that productivity is of prime importance, so the use of predefined shapes is widespread. The operator simply enters the dimensions and the program is generated automatically. But a dedicated technical interface is required for this. In addition to its use for programming, such an interface can also optimize control of the toolhead. (In order to increase efficiency, a toolhead, is often equipped with several tools, some of which can be used simultaneously.) Finally, an additional application can shows the operator how to load the workpiece on the machine.

Axium Power, with its HTML interface, its PC panel, its high quality display and its large storage capacity, has everything needed to satisfy the needs of any market. Its PC panel includes all the resources necessary to support a CAD/CAM system and related applications. This software can even be displayed concurrently on the screen. In addition, as the text above shows, it is a simple task to modify or create a dedicated HMI on the Axium Power!

Centre d'usinage 5 axes

Flexibility *and* Productivity,
Values Shared by Num and Bulleri

Bulleri Brevetti, a well known Italian woodworking machine manufacturer, has provided innovative solutions featuring both operational flexibility and productivity, since 1935. It is because of these two objectives that Bulleri Brevetti decided to join forces with Num and start an active collaboration
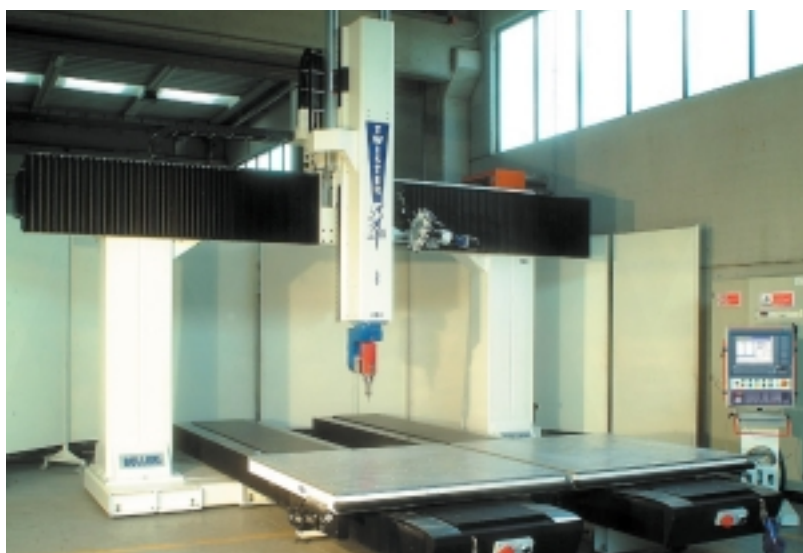
The Twister machining center has given Bulleri Brevetti an international reputation. Its customization into separate groups makes it suitable for a vast number of applications, such as the production of furniture, doors and windows

With customers all over the world, Bulleri of Sicar group produces CNC machining centers and dedicated woodworking machines in its Cascina plant, near Pisa. These systems are used not only for furniture-making but also for model building, nautical, caravan and automotive applications. Being on a par with world leaders in this field, means having the recognized know-how whilst striving to remain innovative. It also requires a Darwinian capability to adapt to changing market conditions and customer demands, especially for a company like Bulleri, which works in various fields whose major aim is to combine esthetics and comfort, plus creativity and user-friendliness, leading to specific and complex forms.

"We have been building woodworking machines for a long time," said Michele Barsacchi, General

Manager of Bulleri, "and I well remember when we made all the machine components here in the shop, but that's no longer the case. However, because of international competition, we have to be increasingly dynamic to meet more exacting user demands with increasingly short lead times and better suited strategies. Today, this requires collaboration and synergy between specialists with the same industrial approach who remain close to field applications on a day-to-day basis."

The collaboration between Bulleri and Num is based on this need for complementary skills associated with common values.

Pooling Specialized Skills

"We produce proficient high tech systems for which we have many innovative patents," continued Michele Barsacchi. "Among our star products are the 5-axis Twister machining centers, the Tornado FPM mass production lines with fixed table and moving closed gantry; the FPF series with fixed gantry and one or two moving tables, as well as special moving gantry machines with a travel of more than 16 m and special self-loading machining tables."

"Optimal operation of a CNC depends primarily on the excellence of two factors: the mechanics and the electronics. Our technicians conduct thorough analyses in these areas. That is why we consider the Num Power 1000 system to be one of the best CNCs on the market today. Among Num's strong points are its PC panel and its simple, open human-machine interface. In addition, Num's powerful utilities that run under Windows allowed us to create a dedicated program for managing and making the most of our systems".

The procedures are run from a single, portable, user-friendly panel. The ease of use and reliability of the system, plus the machine functions which guarantee fast feed rates and cutting speeds on all the axes give us the accuracy and high speed characteristics we need. This ensures optimal productivity!

"Last but not least, the possibility of controlling more simultaneously interpolated axes allows us to obtain 3D parts using powerful CAD/CAM software to meet model making needs with very short programming and cycle times."

The major elements of Bulleri's strategy are high productivity and high precision. This requires great flexibility, which Bulleri found in the Num Power 1000 CNCs.

Houses *Produced* Singly
On an Assembly Line!

To make wooden houses profitably, Torwegge-Hüllhorst developed a production line whose main component is a machining center with two gantries. In collaboration with Num, these woodworking specialists gave their 20-axis machine a few refinements.

The workpiece is guided under the machining components by three clamping units equipped with their own CNC axis.

Any manufacturer who wants to sell his products on the wooden window, door, house and garden shed market needs to exhibit originality in his products, even when they are "mass produced". The German company Torwegge-Hüllhorst of Löhne, specializes in the production of woodworking machines They have developed a system allowing flexible, profitable production of wooden houses for Valcke en Zoon n.v., a Belgian house and garden shed manufacturer.

There was no doubt as to which CNC manufacturer would be chosen: Torwegge-Hüllhorst has been working in partnership with Num for more than 20 years. Jörg Halstenberg, Torwegge-Hüllhorst's Technical Divisional Manager, appreciates this cooperation. "This long collaboration allows us to work well together. It is ideal, because Num is always ready to engage in new developments with us. For instance, Num recently developed a similar system for us on which we used two robot heads that could be controlled in multi-channel mode in separate axis groups."

Fast Returns on Investment

Like all new machines, the latest model included additional functions that required significant capabilities of both the CNC and Num's experts. Helmut Rappe, Control Engineering Manager at Torwegge-Hüllhorst, explains: "First of all, the CNC has to have some basic capabilities. In our case, this includes 5-axis technology with the RTCP function (Rotation around Tool Center Point) and inclined plane. Axis group control is also very important for our system. This means that the axes must be able to be distributed dynamically in groups between channels while the program is running and work independently of one another. This makes the entire system very flexible."

Exactly what the machining center requires of the Num Power 1080 CNC becomes clear upon closer examination. The machine is equipped with a fixed gantry at the front and rear on which moves a Y-shaped support with cutter-holder spindle and tool changer. In addition, the cutter-holder spindles can pivot on a CNC axis (A axis) to allow horizontal machining of parts, even at full power. Under the cutter-holder spindles are vector axes (C axes) that include bevel gears used in particular for

3D cutting with flexible saws. Components for standard machining jobs on wooden garden sheds are mounted on the second gantry and its Y supports.

Transportation of boards is achieved via clamping units (Wiesel) which have their own CNC drive. There can be up to four clamping units per work path. These are controlled by the Num Power 1080 CNC – and at very high speed. The low weight of these units allows high accelerations and traverse rates of up to 150 m/min.

The clamping units themselves can be repositioned during machining to permit working in a previously clamped zone. This is done by a special function of the Num CNC. It uncouples the axes during machining, modifies the position, then recouples to axes to continue the program. The additional flexibility afforded by this new machining center is especially appreciated by Valcke. "In the near future, we will also be able to make the doors and windows that we used to have to buy," exclaims Luc Valcke, CEO of the company. "The line will operate in three shifts." A good way of rapidly achieving returns on investment!
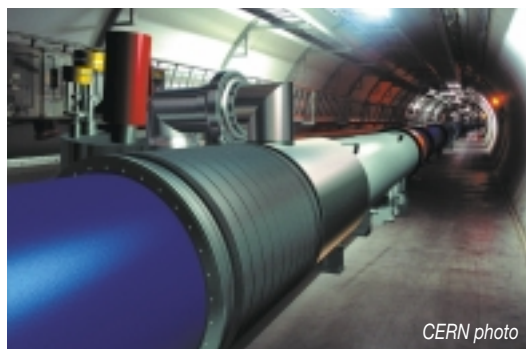
The CNC of Torwegge-Hüllhorst's (IMA group) new machining center is a Num Power 1080 CNC.

Special Machine

Coil head

CERN photo

The LHC is a 27-km circumference tunnel, in which two proton beams travel in opposite directions

For Guiding Protons at 300,000 km/s, JEUMONT Choose Num!

The Large Hadron Collider at the CERN (European Laboratory for Particle Physics), a prestigious project for the beginning of this century, will begin operating in 2007. Meanwhile, a large number of the superconducting coils designed to guide the protons injected at nearly the speed of light (300,000 km/s) are being produced by Jeumont SA using Num CNC systems.

After a development period which has lasted around 8 years, the Large Hadron Collider is now in the production phase. Contrary to its predecessor, the Large Electron Positron Collider (LEP), the LHC accelerates protons instead of electrons. Protons are around 2000 times heavier than electrons, giving an idea of the engineering challenges that had to be met to achieve the required performance capabilities: guide two proton beams traveling at nearly 300,000 km/s in opposite directions along their path through a ring with a circumference of 27 kilometers. The goal is simple: artificially recreate the Big Bang. The shock of the resulting collision will generate particles that do not exist naturally.

One of the main requirements of the project is to guide the proton beams exactly around the center of the tunnel to produce head on collisions at specific insertion points. Extremely powerful magnets are required to guide the proton beams correctly. The electromagnetic forces developed in the coils of these magnets are around 400 metric tons per meter!

A Coil for 9 Teslas!

The CERN engineers decided to use superconducting magnets. Superconducting materials were a necessity considering the required characteristics. It should be noted that a magnetic field of 9 teslas is nearly 10 times higher than the highest values used to date. It is also easy to imagine the technical prowess required to design and manufacture such coils, whose magnetic properties are directly related to the quality of their geometry.

Jeumont, a subsidiary of Framatome ANP, was chosen to build the coils in collaboration with Alstom. The LHC represents a totally successful diversification for this French company, since Jeumont was the first manufacturer chosen on the project to start regular production.

Jeumont moreover invested in a new 5-axis machine developed by SD Industrie and controlled by a Num Power 1050 CNC.

Flawless Geometry

This machine winds a niobium-titanium flat superconducting cable onto a 15-meter core. The cable drum is mounted on a gantry straddling the core. The moving core tilts to keep the flat cable constantly in the correct position while winding it.

The CNC system guarantees the wire path over the 15-meter length. It controls (see photo 1) its tension (1), the core position (2), and the movements of the drum (3) and gantry (4). Simultaneous control of all the data requires high CPU power in order to optimize production times. "That is the major asset of the Num Power 1050 CNC and the special application developed in Visual Basic by SD Industrie," said Jean-François De Coëne, LHC Project Manager at Jeumont. "It should be noted that the production process was first attemped on another machine equipped with a different CNC. Since the computations are extremely complex, this caused stoppages during winding. Now, with the Num Power 1050, work is continuous." This is a decisive argument, since the ultimate output will be 2.5 magnets a week on two production lines.

The LHC includes 1248 coils of this type and everything must be operative by 2007. Under these conditions, there is no room for error.

J-F De Coëne, LHC Project Manager: "The most sensitive part is the coil head, which is where geometric accuracy is the most difficult to achieve."
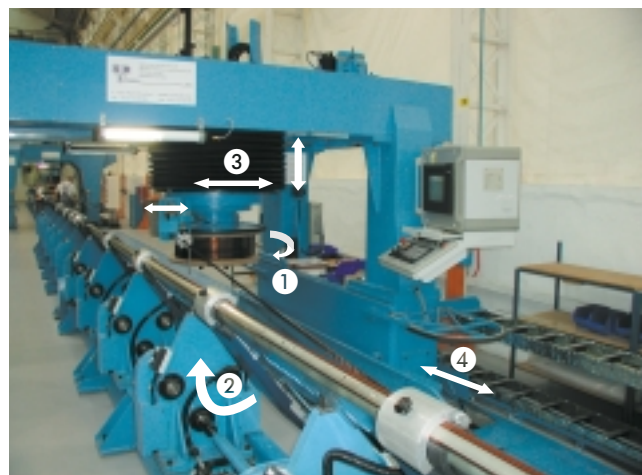
Located in the North of France, SD Industrie specialize in the design and development of special automated and robotized machines and the re-engineering of machine tools.

Expertise: *A Major Asset*

Num provides both reliable high-tech CNC systems and high level consulting expertise. That is why Soudronic, a leader in butt welding machines, decided to call on Num for its new machine.

"We increasingly need to make V-butt welds on blanks instead of just straight welds."
- Daniel Stäubli, in charge of control system software engineering at Soudronic.

Soudronic is a Swiss company located in Neftenbach. Soudronic's new welding machine, Soutrac, is capable of butt welding sheets of different thicknesses in a single operation with nonlinear weld beads.

To achieve this engineering feat, Daniel Stäubli, in charge of control system software engineering at Soudronic, chose Num after evaluating several suppliers. Num was chosen as a partner for both the motor-drive systems and for the CNCs. The CNC selected was the Num Power 1050 system, on which the total number of axes can be extended to 16. This choice was not just made on technical criteria. "The level of expertise of Num teams," explained Daniel Stäubli, "is one of Num's major assets. For our needs in particular, Num have people who know all about motor-drive system techniques, from electronics to mechanics. That is not the case of all its competitors. For the Soutrac project, it was an essential element."

Filling Gaps from 0.3 mm to 3 mm!

Creating harmony between the mechanics and electronics was no easy job for this 10-meter-long system. It had to achieve a traverse rate of 120 m/min as well as an accuracy of 0.01 mm when machining at a work rate of 12 m/min. Another difficulty was to connect a completely innovative system that calculates and controls the filling of possible gaps (up to 0.3 mm) between the two blanks with a filler wire. Like the laser, this system, called Souvis 5000, is located within the welding head, which therefore includes three functional units. The first functional unit is a monitoring system that first accurately establishes the weld bead position and determines the amount of filler required. The second functional unit is the laser with the automatic wire feed system. The third functional unit is the camera located downstream which measures the contour by triangulation and checks the condition of the weld bead.

At least two pivot axes and three rotation axes are required to follow a contour with the weld head. In addition, each element must always be perpendicular to the weld bead. Three other axes are provided for adjusting the height of each element for focusing. A further axis is required to place the laser in the measured position. With the wire feed axis, this makes a total of 10 axes housed in the welding head. All the axes except the focusing axes must be controlled simultaneously. To these are added the X axis and Y axis of the machine table weighing four metric tons. Num was responsible for programming the CNC and PLC axes, designing the controllers and dimensioning the system, with everything that that involves. Another important task was to optimize the servodrive and machine associations, since the precision requirements were very severe. Daniel Stäubli was very impressed by the expertise demonstrated by the Num team in performing its task: "Num gave us very good advice for the electrical aspects and also for the mechanical details. We were able to achieve the required accuracy on the very first prototype. We are very satisfied with this collaboration. Everything went as planned. We definitely chose the right partner."

Daniel Stäubli: "Num gave us very good advice for the electrical aspects and also for the mechanical details. Everything went as planned. We definitely chose the right partner." Behind him, you can see the welding head, central component of the Soutrac system, which includes the laser with the wire feed system and the Souvis 5000 quality control system.

Smart Servo Balance Function

How to Align Following Errors *Intelligently!*

"Work fast and well!" That is the aim of every Production Manager. And that is the reason for the extensive research on algorithms for CNC systems. With the Smart Servo Balance function, Num once again demonstrates its determination to develop clever, innovative solutions.

On a machine tool (diagram 1), it is essential to align following errors to achieve high accuracy. It is necessary to align all the axes which, since interpolated, will work simultaneously and interdependently (diagram 2). Alignment was
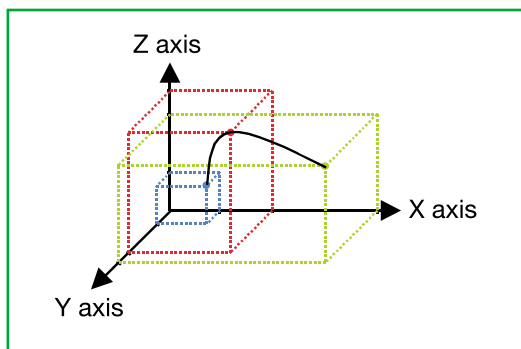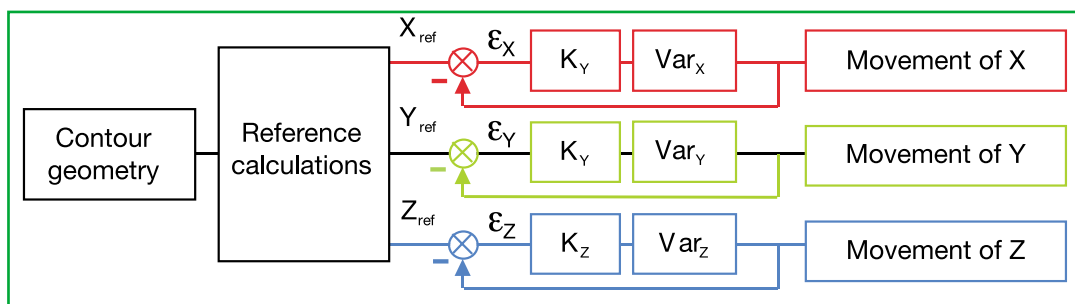
2 – Interpolation on several axes. It is easy to see how the least synchronization error between the axes can cause a contour error.

achieved long ago by setting the same gain on all the axes. More recently, it was attempted to eliminate following errors instead of aligning them.
Both methods have serious drawbacks, which is why Num introduced its new Smart Servo Balance function.

Conventional Method: Gain Alignment
This method, which has been used since the start

of numerical control, works OK on straight lines because the user is sure to follow the required contour accurately. However, for circles, although the demanded tool path accurately describes a circle, the produced radius is slightly smaller than the one programmed (diagram 3).
Aligning the gains can have some other drawbacks. In effect, to obtain the same following error on all the interpolated axes, the same gain is set on all the feedback loops. But this amounts to aligning all the axes to the one with the lowest gain.
It is easy to understand the penalties of this method. It degrades the performance of certain axes. Moreover, for this very

reason, it is not always feasible. When the interpolated axes have very different inertias, it is sometimes impossible to apply the same gain to both.
For instance, imagine a machine on which an axis carrying a heavy workpiece is slaved to another axis moving a light tool. The two axes have very different inertias because of their respective masses. The axis moving the workpiece will have a much lower gain than the axis carrying the tool. When the gain of the light axis is decreased to match the heavy one, the axis may loose its responsiveness and become

sensitive to perturbations. Under such conditions, it is may be impossible to align the gains!

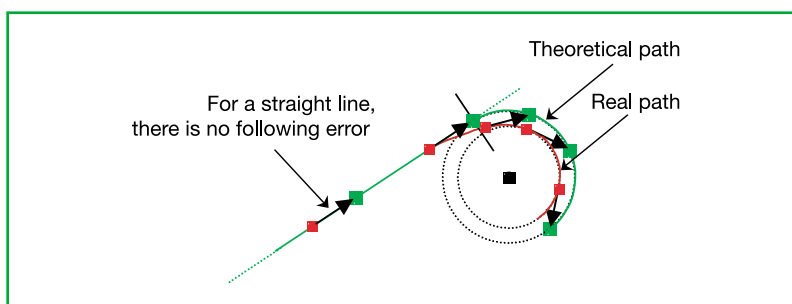**Partial or Total Anticipation**
Another way of aligning the following errors consists of combining feedback control and feedforward control. The principle is simple: since the axis lags behind the control signal, why not increase the control signal to "anticipate" this error (diagram 4)? This is called partial or total anticipation, according to how much the control signal is increased.
This method has the advantage of improving the accuracy on a circular

1 – On a machine tool, the servo system calculates the difference between control signal and measured feedback value. The difference is multiplied by a gain value to control the servomotor.

contour. The CNC takes the position loop delay into account and calculates a virtual control contour based on the system characteristics to arrive at the desired form (diagram 5). Total anticipation is particularly important for high speed machining, so as to maintain excellent contour accuracy even at high

3 – When the gains are aligned, there are no contour errors on straight lines. However, for circles, the tool path describes a circle whose radius is slightly smaller than required.
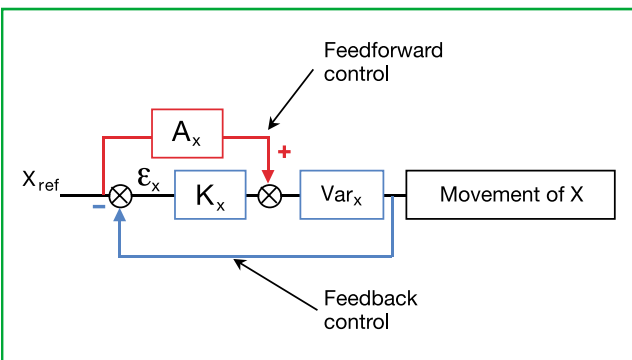
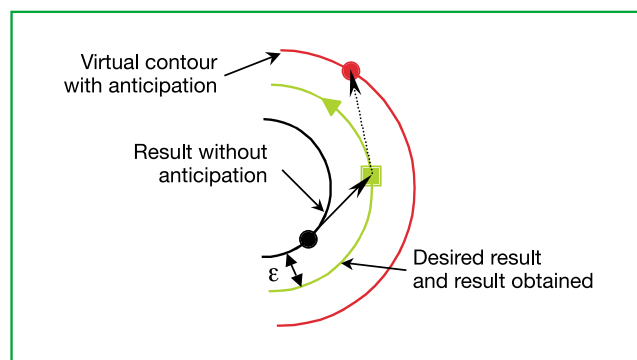**4 – With total or partial anticipation, both feedback and feedforward control are used on the machine.**

filter modulates the anticipation action according to the contours encountered and even cancels it when its action could be harmful. The filter is easily adjusted on a circular path with the integrated Ballbar trace tool. It is then completed by fine-tuning the circularity. This method combines contour accuracy with high productivity and adapts to the specific features of certain types of work. There is no doubt that under these conditions, the function will be imitated.

5 – The CNC calculates a virtual contour to "anticipate" the expected circular path error.

speeds. Unfortunately, this method also has drawbacks. In the case of a sharp discontinuity in the path, such as an angle, both total and partial anticipation can lead to a strong vibration. It is then necessary to considerably reduce the feed rate very far upstream of the point concerned. If the parts to be machined exhibit numerous discontinuities of this type, the tool correctly follows the required path, but the work rate is no longer compatible with production requirements. The variations in work rate may also be prejudicial to certain types of work. For instance, in woodworking, it is especially important to maintain a constant work rate so that the tool doesn't burn the material.

Combining Accuracy and Productivity

Num has developed a "smart" alignment technique to be able to align the axes without having to use total anticipation or align the gains to the least dynamic axis. Called Smart Servo Balance, this function is available on all the Axium Power systems. It consists of using filtered partial anticipation. This additional

Summary Table

	Gain alignment	Total or partial anticipation	Smart Servo Balance
Straight path following	Zero contour error	Zero contour error	Zero contour error
Circular path following	Contour error (the machined circle has a smaller radius than the programmed one) Circularity correct	Controlled or zero contour error Perfect circularity	Controlled contour error Perfect circularity
Machining time	The CNC must decrease its speed to preserve correct accuracy on circles	Optimal on smooth curves Acceptable when the contour exhibits sharp discontinuities	Better tradeoff
Sensitivity to perturbations	High if the axes are asymmetric	Good because each axis can be set independently	Optimal because each axis is totally independent
Precautions	Impossible when the axes have very different inertias	The part program must be adapted for high speed machining (CAM)	None

Num European Metal Machine Builder *Catalogue*

In the Num European Metal Machine Builder Catalogue CD, you will find an overview of machines equipped with Num CNC systems. Although not exhaustive, this document with over a hundred pages clearly demonstrates the scope and variety of applications covered by Num equipment. Each application is described in a short abstract, and all the information required to contact the manufacturer directly is provided.

Two videos illustrate the activities of both Num and its parent company, Schneider Electric, highlighting their harmony. The CD is available on request from: sales@schneider-num.com

The first issue of the Num European Metal Machine Builder Catalogue CD is available on request from sales@schneider-num.com.