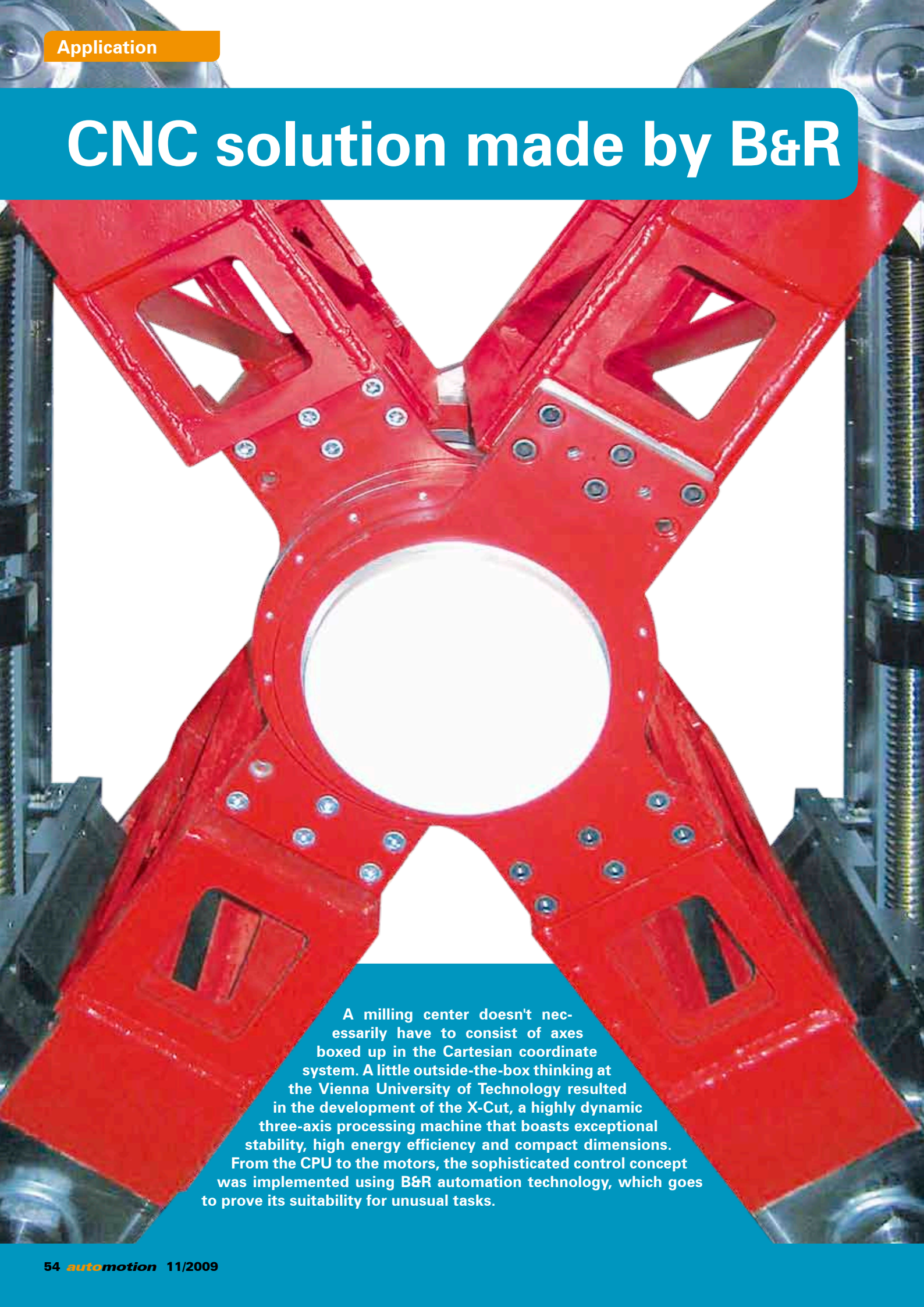


# CNC solution made by B&R



A milling center doesn't necessarily have to consist of axes boxed up in the Cartesian coordinate system. A little outside-the-box thinking at the Vienna University of Technology resulted in the development of the X-Cut, a highly dynamic three-axis processing machine that boasts exceptional stability, high energy efficiency and compact dimensions. From the CPU to the motors, the sophisticated control concept was implemented using B&R automation technology, which goes to prove its suitability for unusual tasks.

Scientists are people who look past the usual answers and ask themselves questions. Questions like: "Why should machine tools always be constructed the same way, just because it's been done that way for decades?". This question was asked by the team led by Professor Friedrich Bleicher at the manufacturing laboratory at the Institute for Manufacturing Technology and High Power Laser Technology at the Vienna University of Technology. "The laboratory takes a scientific approach to solving concrete problems faced in industry," explains Falko Puschtitz, the laboratory's project manager for mechatronics. "This ranges from manufacturing technology and production automation to calculation, construction and even implementation of machine tools." Customers are found in all branches of industry - wherever conventional development methods fall short, because new problems demand a scientific approach. One example is a system used when drilling holes several meters into very tough materials, which allows detection and correction of lateral drill movement.

### New approaches to machine manufacturing

The search for new approaches to machine manufacturing will lead you directly to the X-Cut, a machine whose main spindle has complete freedom of movement on two axes to position itself in the available space. A third and potentially fourth axis can be added by moving the tool carrier laterally on the spindle or by moving the workpiece carrier.



Highly modern ergonomics: Before becoming commercially available, the TU Institute will integrate the B&R CNC Panel including the handheld device.



The X in the name comes from the high level of parallel kinematics, with a parallelization degree of 2 for positioning the spindle. The spindle is located at the apex of a triangle formed by two arms, whose other ends are moved parallel in opposite directions on a common track, moving the spindle in the x and y directions. When this triangle is stretched to an extreme angle (very flat or very sharp) where the two arms become nearly parallel - what scientists call a

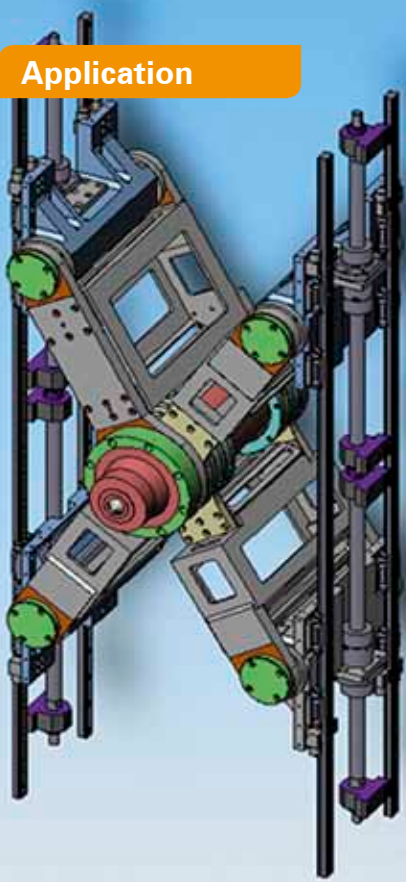
singularity - rigidity is lost in one direction. For this reason a second pair of arms is used to make the triangle into an X (see picture). At any one point, the weakness of one pair of arms is compensated by the strength of the other pair.

This construction has four advantages over a conventional approach: On the one hand, the vertical tracks in which the arms move give the machine a very small footprint, so it takes up less of the valuable floor space in a production hall. On the other, the machine's construction gives it exceptional stability in the z direction, much more than conventional >>>



More space and fewer cables in the switching cabinet: All internal communication between the CPU, the intelligent ACOPOSmulti drive modules (left) and the space saving X20 I/O modules (right) takes place via POWERLINK (the green cable).

## Application



Revolutionary: The over-determined parallel kinematics powered by highly dynamic B&R motors.

solutions. Third, the stability in the x and y directions can be directly controlled by independently moving the two triangles and more or less "wedging" them to achieve extreme rigidity. Finally, compared to machines with a Cartesian axis structure, the kinematic translations of the X-Cut allow accelerations of nearly 2g, thanks to the small amount of mass to be moved, which also increases energy efficiency.

If you wonder why something like this was not invented long ago, Falko Puschitz has an easy answer: "The Institute for Manufacturing Technology and High Power Laser Technology has been working for years on new machine tool concepts, including testing and development of special kinematics such as parallel kinematics. The Quickstep and the Quickstep Neon are two tripod structures that have already been presented at the EMO trade fair together with Krause & Mauser Machine Tools. The highly parallel X-Cut structure utilizes the institute's extensive experience to take a clear step forward in relation to conventional structures."

### Machine control as a mathematical task

The control of the X-Cut's parallel kinematics is therefore a task that goes way beyond sequential programming of individual movement steps. "Rather than programming linear axis movements, it's better to use the mathematical model of the kinematic transformation, and also to use it for all necessary path corrections," explains Falko Puschitz. "This is one of the reasons we decided to use automation technology from B&R, because the B&R development environment, Automation Studio, allows the developer to program these transformations." This seems trivial, but is really not: With most well-known manufacturers of controller hardware, these functions must be programmed into the firmware. The algorithms

are generally programmed into the hardware by the manufacturer. "This would have been unacceptable for us," says Puschitz, "because not only would it delay each step of the project, it would result in our valuable expertise being passed to the controller manufacturer."

Since production of the complex individual components of the machine is expensive and public financing limited, the team at the production technology laboratory at the Vienna University of Technology utilized simulations prior to constructing the prototype. This applies to the machinery construction, where the distribution of forces needed to be tested under all possible load scenarios using finite element analysis. It also applies to the open-loop and closed-loop control logic, which is tested using MATLAB/Simulink before it is allowed on the machine as a program. The new B&R Automation Studio Client for Simulink provides the ability to generate the program code directly from the simulation model and transfer it to the controller. "This saves us valuable time and increases safety," acknowledges Puschitz. "When there are changes, we can have the finished program on the machine only minutes after performing a successful simulation. And we do so without potentially introducing new errors to the simulation result during programming."

### B&R automation technology - The heart and brains of the machine

"A further motivation for our decision to work with B&R was the completely integrated automation solution," reports Puschitz. "From the CPU to the motors, everything comes from the same place and works perfectly together. We don't have to worry about



The machine brought Vienna University of Technology second place in the POWERLINK competition. From left to right: Stefan Schönegger (Product Manager Powerlink, B&R), Wolfgang Seiss MSc. (R&D Powerlink, B&R), DI Falko Puschitz (IFT), DI (FH) Thomas Mikats (research assistant, IFT), Univ.Prof. DI Dr.techn. Friedrich Bleicher (IFT).



Organized, integrated drive technology: B&R ACOPOSmulti

I/O components from B&R's X20 series, and programmed in the same development environment using SafeDESIGNER.

"The internal POWERLINK network has proven itself in several ways," reports Puschitz. "Not only does it require very little

wiring and a small amount of switching cabinet space, it can also handle the high data throughput that results from the high dynamics and precision of the parallel kinematics, and from the fact that feedback and diagnostics data also runs on the same network."

Also connected to the CPU via POWERLINK are the ACOPOSmulti drive components. Compact and powerful, the servo drives provide maximum power with minimum volume. They are also equipped with their own intelligence, which provides extensive diagnostics possibilities and safety functions without any external connection.

This ergonomic combination of operating units, which is equipped with countless function switches and buttons designed for operation in a harsh environment - even by an operator wearing gloves - will not be available on the general market until Fall 2009, but until then it will have a chance to prove itself in its realistic implementation on the X-Cut. ■

internal communication between the components, and we have only one contact person."

The necessary processing power is provided by an APC 620. The adaptable and - thanks to its lack of fans and hard drives - very robust industrial PC is connected to the X20 interface modules via the speedy POWERLINK. (Note: The additional scales are connected directly to the controllers via a second control card.) The X20 modules are required for the machine's switching commands (turn on motor, eventually to switch tools, switch motor spindle, etc.). The machine does not yet have any protective equipment in place, but when the time comes, this can be integrated using the Safe

*"From the CPU to the motors, everything comes from the same place and works perfectly together. We don't have to worry about internal communication between the components, and we have only one contact person."*

**Falko Puschitz**

Project Manager for Mechatronics

Laboratory for manufacturing technology

The automation solution is fully integrated, right down to the motors. The five B&R three-phase synchronous motors from the 8LS series, with 31.6 Nm rated torque and 36.4 Nm stall torque, are permanently excited, electronically commutated synchronous motors for applications that require excellent dynamic characteristics and positioning precision as well as compact size and reduced weight.

**Visions of the future**

During its development, the machine was operated using a B&R Automation Panel 900, but in the summer

of 2009, B&R provided the university with a pre-series CNC Panel with a hand operating device, which had been developed primarily for milling centers. Equipped with operation functions designed specifically for CNC processing, the control elements are customized for the "CNC Sample" user interface, but are also suitable for a visualization application programmed by the customer.

#### Vienna University of Technology:



Vienna University of Technology:

Vienna University of Technology - short description: T.U. Vienna is one of Europe's most successful technical universities. With over 20,000 students and nearly 2,000 researchers, it is Austria's largest applied science - technical research and educational institution.

The Institute for Manufacturing Technology at the Vienna University of Technology covers a broad range of production technology and machine tools. In regard to process development and the associated machine engineering, the institute is considered one of the most important addresses for production technology research.

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