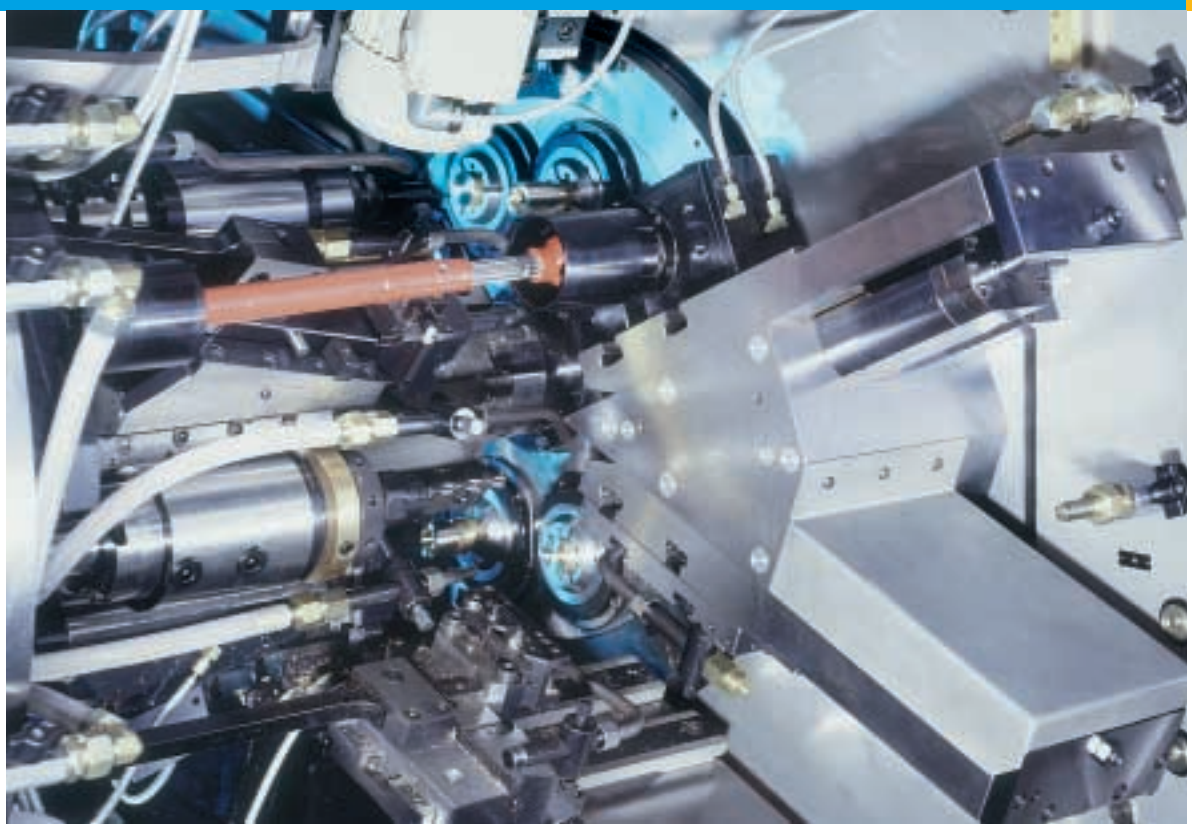
Hydraulic controller ensures precise positioning

Industrial PC solution manages highly dynamic multi-spindle automatic machines

The company Alfred H. Schütte GmbH & Co. KG complements its PC product line with the A 36 PC CNC controlled multi spindle automatic machine. The A 36 PC is an 8-spindle automatic bar machine for the production of mass-produced turned parts or precision turned parts with a high degree of complexity. The machine is managed by Beckhoff control technology, i.e. an Industrial PC with a robust Control Panel, offering the TwinCAT NC I automation software and the newly developed AH2000 hydraulic controller with extremely small positioning tolerances.



The use of up to 20 tool slides, 12 possible compound slide supports or 30 controllable slide axes and up to 12 spindle axes is an indication of the performance of the new 8-spindle machine.

For a long time, hydraulic systems were somewhat frowned upon among machine tool manufacturers, but they are becoming increasingly acceptable again. For Detlef Langer, chief designer for multi-spindle automatic lathes at the machine manufacturer Schütte, they are more than just another automation option. He has concrete data that confirms the dynamics that can currently be realized with hydraulics and sophisticated electrical control technology: "For accelerating an axis to its absolute operating velocity in our new PC series 8-spindle machines, during thread cutting we often only have a path of 1.5 mm and a time of 20 ms available. Furthermore, our hydraulic axes operate with a positioning tolerance of less than 1 µm." In his machines, the engineer with a doctorate realizes all linear movements hydraulically, while all rotating movements are realized with electrical drives. In order to reconcile the two different systems, Detlef Langer uses the principle of the virtual control shaft: "It resembles a running time axis, to which all movements can be referred to. Unlike with an interpolator, all axes always operate synchronously."

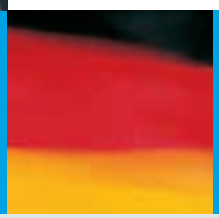
The virtual control shaft used by Schütte in the automatic CNC lathes utilizes the PC-based TwinCAT NC I control software from Beckhoff. The mechanical engineering company has thus realized an ambitious concept, whereby TwinCAT is used as a software kit

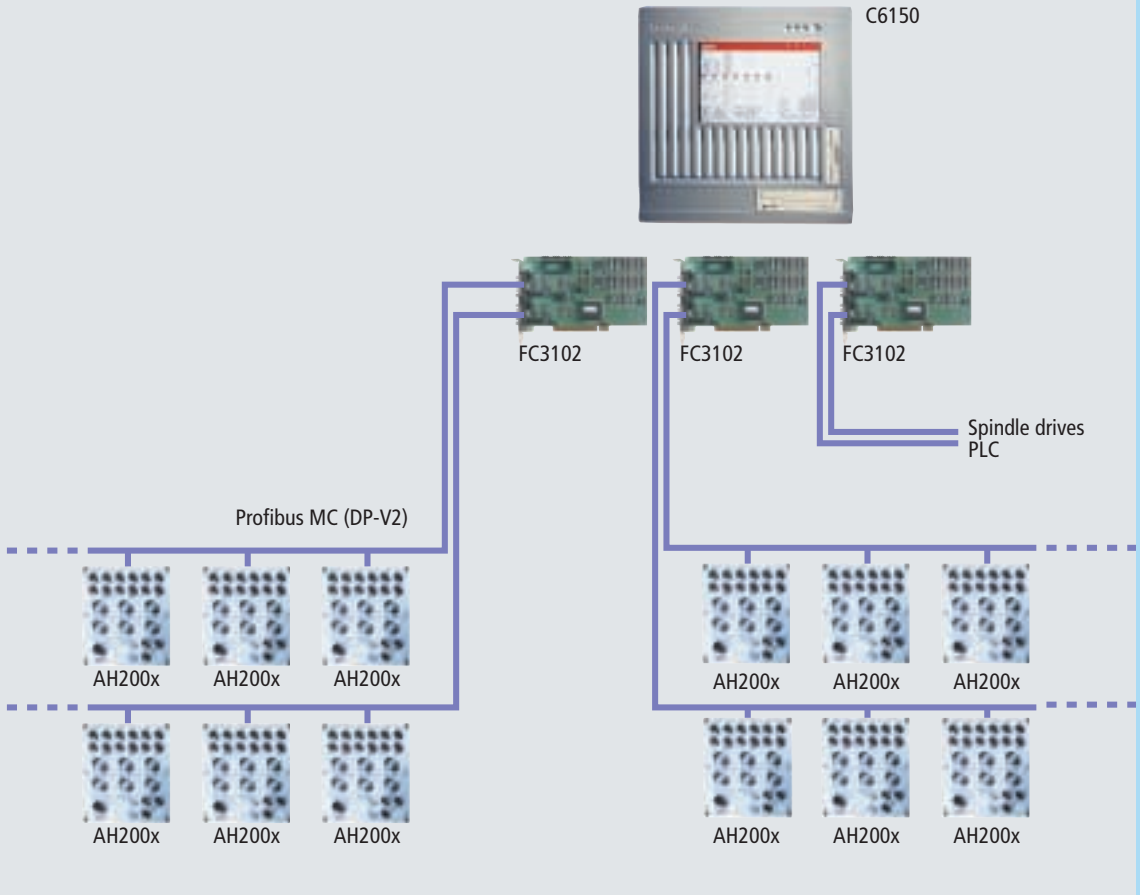
that was complemented with customized additional components. They include a converter that implements the NC program for a cam plate module. Its virtual control shaft controls all movements of the Schütte machines. "This," explains Detlef Langer, "enables us to produce very complex parts on our automatic CNC machines."

The optimum solution for time-controlled set value specification

In order to be able to control the hydraulic actuators, at Schütte's suggestion Beckhoff developed a decentralized hydraulic controller, the AH2000. It is considered to be the only module on the market that is addressable by controllers via fieldbus in the required way. Detlef Langer is therefore convinced: "There is currently no other approach that covers time-controlled set value specification in such an ideal way. Other systems only operate with a command interface or with a less highly clocked set value interface."

What servoamplifiers do for electric drive technology, the AH2000 series hydraulic controllers do for hydraulic axes. Together with a sensor for the position, a proportional valve, a hydraulic cylinder, pressure sensors, digital inputs and outputs and the TwinCAT automation software, complete axis drives can be built. The controllers control the velocity and position of the cylinders. Interfacing of the drives is achieved in the Schütte machine through 5 of the 6 fieldbus branches (see system overview) via Profibus MC (DP-V2). The 2-channel PC fieldbus cards FC3102 from Beckhoff are used as control interface. Depending on the configuration, for example 24 of the maximum 48 axes may be connected to up to 16

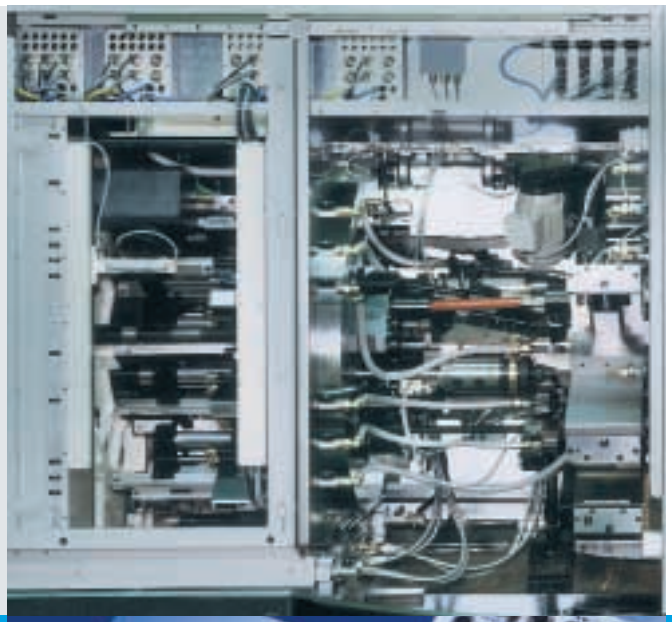




The advantages at a glance

- The set value specification is transmitted to the individual decentralized hydraulic controllers via a Profibus network.
- The AH2000 hydraulic controllers now deal with position control and velocity control.
- The control modules are combined with a direct position sensor system with a resolution of < 0.1 µm.
- The very high pulsing of the control modules, representing a synchronous multiple of the fieldbus clock rate, enables accurate control with regard to path characteristics, positioning accuracy, acceleration and dynamics.

Dr.-Ing. Detlef Langer, chief designer for multi-spindle automatic lathes: "There is currently no alternative to the AH2000 solution, because it deals with time-controlled set value specification so directly and processes it so accurately."



AH200x drive controllers. In this case, the AH2003 hydraulic controllers deal with the position control. The solution is suitable both for metal cutting machine tools and for positioning technology tasks.

Short cycle times for quick velocity control

The AH2000 range comprises two different versions: the AH2001 variant has one controller, the AH2003 variant has three controllers. The hydraulic controllers with integrated Profibus interface contain a powerful PC-based computer core. A 266 MHz Pentium I processor provides the necessary computing power. The control functions are realized via the TwinCAT automation software under the operating system Windows NT Embedded. Due to their extremely short cycle time of 250 µs, they also manage to deal with velocity control for very fast control valves. Depending on the application, either a central control or the hydraulic controller itself deals with position control.

In terms of the Schütte solution this means: The AH2000 hydraulic controller receives the set values from the PC control via Profibus and the actual values from the process periphery, i.e. directly from the valves and the encoders. This information is converted into a control loop and forms the control value and actual value information. Via Profibus, the values flow back to the central controller as directly usable actual values. In the previous solution, the sensors were directly linked to

Hydraulic controller AH2000

Since production machines like the Schütte machine are in regular use for years, robustness was an important factor during the development of the AH2000. The use of a fan or other movable elements was avoided. All parameters and even the control software can be accessed via the fieldbus. A flash file system serves as data backup and replaces the hard disk. The enclosed design and suitable connectors ensure protection class IP 65. The AH2000 is located in a compact aluminum housing with the dimensions of 174 x 200 x 80 mm and a weight of approx. 3.5 kg.

The hydraulic controllers offer comprehensive peripheral connection options. Hydraulic valves from Rexroth or Bosch with 12-pin connectors or a variety of valves from other manufacturers may be connected with appropriate cable sets. The controller deals with the power supply and the monitoring function for the valve. Incremental encoders with sine/cosine signals (1 V_{SS}) or TTL signals, e. g. from Heidenhain, may be used as position sensors. Furthermore, analog displacement sensors with 4 – 20 mA signals, e.g. from Balluff, may be used.

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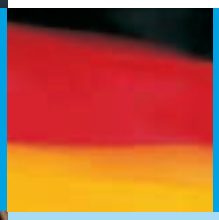
the fieldbus, and had to be retrieved and processed by the central controller. All this is now much more direct and thus more dynamic.

This leads to more dynamic controller structures, as Detlef Langer attests: "At a velocity of more than 7 m/min, for example, an axis remains within a following tolerance precision window of 2/100th of a millimeter over the whole turning length. For the chasing of threads this is an advantage that should not be underestimated." And a further special feature exemplifies the benefits of the Schütte solution: Analog sine/cosine encoders from Heidenhain are used instead of purely digital encoders. "This," says the chief designer, "provides significantly better path resolution via intermediate interpolation and achieves 10-fold improvements in terms of path accuracy." The automatic machines become more dynamic, resulting in shorter production times.
Non-productive times are also shortened, since rapid traverses are reached with higher accelerations. Switching from position to force, e.g. for stamping processes using curling tools, is a further advantage. For Detlef Langer, hydraulic systems are particularly strong for this type of process. Because only a hydraulic axis can generate a standing force with unrivalled ease.

Power pack in the control cabinet

The hardware platform of the central controller is an Industrial PC C6150, optimized for installation in a control cabinet. One of the reasons why machine manufacturer Schütte uses the Industrial PC for automating his CNC lathes is the fact that the drive profiles cannot be generated in the actuator. The axis interrelationships are generated centrally for all axes via software in the PC. The fact that the machine operator can continue to program the workpiece in the familiar DIN syntax of his CNC station is an advantage that should not be underestimated. This DIN program is converted into a cam plate that takes effect at run-time. For the user this means that he can simultaneously take advantage of the DIN programmability of a CNC machine and the continuous and complete synchronicity of a cam plate. Apart from the common options such as creation of a customized user interface, networking and remote diagnostics, Langer also uses the Industrial PC and the TwinCAT automation software for monitoring the machine for tool breakage. Heat conduction compensation, a typical task for high-precision machine tools, is in preparation. The software will then compensate the thermal influences on the machines and any thermal expansion of the construction.



Wilfried Osterfeld, specialist for motion control and hydraulic drive technology at Beckhoff.

Today, most motion tasks can no doubt be solved electromechanically. During the last 25 years, this has shifted the relative shares of the drive technologies at the expense of hydraulics. However, the reputation of hydraulics as being "old-fashioned" is unjustified, because even today there is a comprehensive range of applications where its specific mix of characteristics matches the requirements very well. It should not be overlooked that hydraulics too was able to benefit from progress, be it in production engineering, electronics or computer science. Beckhoff will continue to actively support hydraulic motion technology. In this context, the AH2000 has to be seen as the high-end product. In addition, wide-ranging support is being established within the product range, which is recognized as being modern, in open concepts with a high degree of integration.