

PC-based control technology for welding of fuel element spacers

→ Assembly and micro-assembly technology supplier, Rohwedder AG was commissioned by ANF to build a welding plant for steel grids that are used as spacers for fuel rods in BWR or PWR nuclear reactors. The critical requirements for the plant were high precision and accuracy coupled with high speed. During the high-precision welding process, each weld point up to 8,000 parameters are transferred at a cycle time of less than 1 second. The process requires extremely sophisticated control technology. Rohwedder chose the PC-based PLC and motion control solution from Beckhoff for handling this complex process.

The Karlstein-based company Advanced Nuclear Fuels (ANF) GmbH is a wholly owned subsidiary of Framatome ANP GmbH Germany and produces fuel rods for the German and European markets. Since operations started in 1979, it has produced more than 20,000 fuel elements containing more than 3.4 million fuel rods. Within the fuel elements, precisely manufactured spacers ensure that the fuel rods, which can be up to 4 m long, are safely guided or held in position. Peter Blomberg, control technology manager for Rohwedder AG at Bermatingen (Germany), explained, "Our task was to develop and realize a plant for finishing the spacers with high precision, coupled with high throughput." The requirements in the nuclear energy sector are known to be some of the most stringent in the world. Errors or inaccuracies are simply unthinkable.

Peter Blomberg explained why the order was placed with Rohwedder, "High quality and reliability at all steps of the manufacturing process are of paramount importance for ANF. Since we already had a wealth of experience in design, development and implementation of special machines, ANF approached us with this order. We are known for our quality and also for the fact that we only use components from reliable partners." The special purpose machine manufacturer described the close cooperation with Beckhoff, "Beckhoff is our automation partner for this project. We have been using Beckhoff products and solutions since 1996 for successful project implementations. From Beckhoff we get more than 'off-the-shelf products' – we also like to explore new ideas together."



Overview of the plant: Both welding chambers are equipped with a welding laser, a camera system and a visualization PC at the control unit. A Kuka robot handles the steel grids.

The plant in detail

ANF's task was to realize a welding plant for joining an initially loose construct of longitudinal and lateral bars via laser spot welding to form a rigid steel grid. The plant realized by Rohwedder consists of two welding chambers, each equipped with a laser for the actual welding, a camera system and a visualization PC at the control unit. A Kuka robot is used for handling the components of the steel grid.

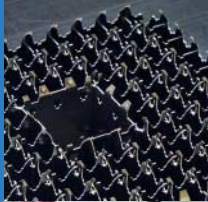
In the first step, the parts are mounted on a workpiece carrier. Via a conveyor belt it is transferred into the welding chamber and positioned by the robot. Peter Blomberg explained: "The components are made of a zircon alloy and the material has to be welded in an argon gas chamber since in a normal atmosphere it would catch fire." Once the workpiece is positioned in the welding cell, the cell is closed and a vacuum is generated. The chamber is then flooded with argon. "This is a complex and comparatively expensive process, but in this case the material used makes it unavoidable," explained Peter Blomberg.

The specifications for the welding process itself are also very demanding. Highly dynamic linear drives are used for moving the laser to the individual contact points. Here, the laser melts the material with high precision, creating the required weld quality. "The welding process is impressive. Speed and precision go hand in hand here," said the control specialist. A camera mounted in the cell monitors the complete welding process. Defective welds are visualized immediately and automatically re-welded. Furthermore, the camera system surveys the grid before the welding process.

Less than one second processing time per weld point

"The welding process is a high-precision, high-speed process that generates a huge amount of data," said Peter Blomberg. The plant can simultaneously process more than 50 steel grids, 26 of those can be of differing types. The individual grids are asymmetric – some have cut-outs. "This means that the system has to man-

The Beckhoff Control Panels are used for process visualization.



age more than 50 component variations. Positions, travel paths, laser control, NC and camera programs have to be 'parameterizable,'" said Peter Blomberg. Regarding the data volume, each spacer requires up to 1,000 welds, each with a cycle time of less than 1 s. During this time, the following steps are executed:

- | positioning according to recipe (100 kg/mass)
- | correction via camera
- | laser welding according to recipe parameters (manual, via NC program, or spot welding)
- | weld point analysis.

The high-precision welding process with a positioning accuracy of < 0.02 mm requires eight parameters for each weld point, resulting in up to 8,000 parameters for each spacer.

PC-based control: Database connection included

Due to the exacting requirements in terms of drive and control technology and visualization, Rohwedder relies on PC-based control technology from Beckhoff using version 2.9 of the TwinCAT NC I automation software and a 19" C5102 slide-in 2.4 GHz PC as the control PC. "With TwinCAT we have decided to use an open PC solution instead of conventional axis modules and CNC controls. Exact positioning, fast motion, high data volume and measuring tasks necessitate the use of a PC-based controller such as this. We would not have been able to realize the complex control tasks using a conventional controller," said the control specialist.

"One of the advantages of the PC platform is that standard Office files such as Excel can be used and ActiveX components can be integrated," said Blomberg and continued: "Measured values can be stored in a database and subsequently printed on a network printer via Ethernet. In addition to these positive effects, the software solution is significantly more cost-effective than a comparable solution

using traditional hardware components. The PC also offers significant advantages with regard to remote maintenance."

Simple recipe management via Excel table

PC-based control technology also offers obvious advantages in terms of recipe management. All recipe parameters, including NC and laser programs, are handled via Excel. Peter Blomberg explains why the spreadsheet program was chosen, "Given the huge data quantity, it offers the simplest form of data handling. Also, no programming knowledge is required for creating the recipes." The Excel file contains information about the component (steel grid type), such as size, number of weld points, distance of the webs and any cut-outs, and a description of the weld sequence including the parameters for each weld. The document also contains the NC program, the laser and image processing program and associated parameters. "The Excel data are read into the associated PLC data structure. For each component, the PLC creates a data file containing recipe and process parameters, which is also accessed by the higher-level plant management system," explained the Rohwedder manager. "Recipe creation and processing of the different components are determined with the customer, who simulates the procedure using TwinCAT's ScopeView. This enables errors to be detected and rectified in advance, optimizing the process."

Simulation saves time during commissioning

For Peter Blomberg, the main benefits, particularly from TwinCAT, are simple and convenient handling and fast installation on the computer. "Within half an hour we can convert the PC into a real-time PLC and motion control system. Hardware independence is another attractive feature – in theory, we can use any PC as a platform for the software system," he said. "The simulation options also offer significant benefits. We were able to fully model the plant in advance on the PC." This saves time and avoids surprises during commissioning on site. Moreover,



The 19-inch slide-in PC from Beckhoff serves as control PC on which the TwinCAT NC I automation software runs.



Peter Blomberg is control technology manager at Rohwedder AG in Bermatingen.



TwinCAT provides secure investment through PLC programming according to IEC 61131-3: "We appreciate this openness, which represents investment protection for us," said Peter Blomberg.

With TwinCAT NC I, the engineers from Bermatingen decided to use a motion control solution with 3D axis interpolation. "One of ANF's requirements for the NC was 3-axis interpolation with laser power control. As an example," the control technology manager quoted from the design specification, "this means that from position 4 mm to 18 mm, for example, the power has to be controllable between 50 % and 60 %. Furthermore, positioning of the linear axes for standard grids should take less than 300 ms, corresponding to a travel path of 12 mm. With TwinCAT NC I, Beckhoff offers a particularly precise and fast solution, with very cost-effective software-based path control."

TwinCAT and SERCOS form a fast and highly dynamic unit

The plant has a total of twelve highly dynamic, water-cooled linear drives, which are controlled via TwinCAT NC I. In combination with a SERCOS interface drive bus, the result is a highly dynamic drive system that can synchronously move several axes to the target. "High data transmission rates and short cycle times with simultaneous interference immunity are arguments for SERCOS interface," said Blomberg. "In our case, where high speed is a significant factor, fast and smooth data exchange between the motor and controller is obviously also important." Here too, Beckhoff was able to provide a suitable solution in the form of PC fieldbus cards. "We use special cards for the PROFIBUS (FC3101) and SERCOS interface (FC7501) bus systems that were specifically developed for fast controllers and real-time tasks such as drive position control. They perfectly complement the TwinCAT system," he explained.

At the I/O level, Beckhoff Bus Terminals in protection class IP 20 and Fieldbus Box modules in protection class IP 67 with PROFIBUS interface are used. The decisive criteria for using the IP 67 modules were their compact and robust design and

modular expandability through further modules via the IP-Link system. The Coupler Box (IL2301-B318) is used for interfacing with the PROFIBUS network. Further I/Os are integrated via Extension Box modules. The Coupler Box collects the I/O data via the IP-Link optical fiber connection from the extension modules and communicates with the higher-level controller.

Requirements met exceptionally

Rohwedder uses their in-house AMS XP product as a plant management system for central monitoring and management of the process. "Apart from process visualization, AMS also deals with process data archiving, order and type management, and statistical analysis. Particularly noteworthy is the traceability tool, an increasingly important feature in our current era of traceability," said Peter Blomberg. "Any maintenance or non-maintenance is documented. Any errors or reworking, as well as manufacturers or suppliers of third-party products are stored within the program. In the event of subsequent damage, the end user can quickly obtain information about the origins."

Overall, with this project the mechanical engineering specialists from Rohwedder once again demonstrated their competency for providing sophisticated individual solutions. "Our strategy of using familiar and reliable automation technology was once again successful. This enabled us to operate a high-quality and reliable plant that meets the stringent requirements of the nuclear energy sector. We are proud to have met ANF's requirements exceptionally," concludes control expert Peter Blomberg.

→ Rohwedder AG www.rohwedder.com

Rohwedder AG

The company Rohwedder AG with head office in Bermatingen (Germany) supplies complex system solutions for the technology segments of assembly and micro-assembly technology, electronics production and plasma, solar and vacuum coating technology. The portfolio is rounded off with complementary handling, image processing, robot and production engineering technologies. Rohwedder customers come from almost all industry sectors. During the financial year 2003, the Group, with approximately 750 staff, generated a turnover of around 124.1 million euros. Compared with the previous year, this corresponds to a growth of 17.5%. The operating result was 4.6 million euros, the net result 1.5 million euros.

"Automation technology continues to be a growing market", said chairman Joachim Rohwedder. "Having expanded vigorously for years, the Rohwedder Group has now reached a consolidation phase that should be completed in 2004", said the CEO of the Group. According to a VDMA forecast, the robotics and automation sector is expected to grow by another five percent in 2004. By then, sales are expected to have reached almost 7 billion euros.

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