

Interview with GF Machining solutions about TwinCAT as powerful CNC solution for wire EDM machines

Open CNC improves flexibility and integrates intellectual property protection

TwinCAT offers CNC functionality that is seamlessly integrated with standard control technology. In addition, it provides open integration of customer-specific solutions via TcCOM (TwinCAT Component Object Model) modules. Orio Sargenti, Head of Platform Engineering, Conformity and Norms at GF Machining Solutions SA, based in Losone, Switzerland, explains how the company benefits from the new generation of wire EDM (electrical discharge machining) machines in terms of flexibility, intellectual property protection and reduced engineering effort.





Orio Sargenti, Head of Platform Engineering, Conformity and Norms at GF Machining Solutions SA, Losone, Switzerland: "The advantage of the open Beckhoff technology lies in the great freedom to choose the necessary automation components, as well as in the simple integration of our process-specific expertise in the CNC."

How did the collaboration with Beckhoff come about in the development of the new generation of wire EDM machines, and what technological benefits does PC-based control offer from your point of view?

Orio Sargenti: The aim of GF Machining Solutions was to achieve an integrated control platform, in order to standardize the electronics of the wire EDM machines previously developed by our experts at different company sites. An important requirement was that products from third-party manufacturers, such as drives, should be easy to integrate. In addition, the communication structure needed to enable implementation of the 1 ms control loop for the cutting wire controller. This is where we first became aware of EtherCAT, a very widespread and powerful communication system, as well as Beckhoff, the inventor of EtherCAT, and their wide range of products. What ultimately became the deciding factor to initiate the cooperation with Beckhoff was the fact that they not only offer a PC-based control system but, unlike conventional CNC manufacturers, also a truly open CNC solution.

What does the openness and continuity of PC-based control mean for you as a machine builder?

Orio Sargenti: The advantage of the open Beckhoff technology lies in the great freedom for choosing components, such as I/Os. Here, traditional CNC providers are clearly limited. In terms of numerical control, we require a superior CNC kernel, into which our special process knowledge can be integrated as easily as possible. From our point of view, we use standard components from Beckhoff, while from a software point of view, it is our own CNC. In addition, the TwinCAT software suite offers an open framework, where capabilities for the complex communication between the individual components and integrated safety components, for example, are already implemented. TwinCAT is very open and user-friendly in this regard, and it offers much greater functionality when compared with PLCs integrated in conventional CNCs. One of the biggest advantages is that PC-based control enables us to make all the benefits from the automation world available in numerical control.

What are the special requirements on CNC technology from the wire-cutting EDM process?

Orio Sargenti: With conventional machine tools, the tool can be described precisely by one point in space in an ideal case. In contrast, wire-cutting EDM requires more complex control functions, in order to use the wire as a precision cutting tool. For example, the CNC controls the wire guides that are placed above and below the workpiece through a total of five servo axes. In addition, the entire movement of the wire, including its velocity and force, must be precisely specified. Another complicated aspect of numerical control is that the wire is bent and does not enter the working area in a straight line. This is because the wire tends to move away from the working point, depending on the electrical parameters and the force acting on it. Our core expertise is based on our ability to optimally correct these influences. Here, we benefit from the high computing power of the Beckhoff CNC, since it eliminates the need for stopping and adjusting the wire, previously required for compensation, and enables the execution of curved shapes at maximum velocity.



Orio Sargenti: "The TcCOM modules are the right tool to protect our own intellectual property in the wire EDM process."

Latest generation of wire EDM solutions

GF Machining Solutions uses PC-based control technology from Beckhoff for the new AgieCharmilles CUT C, CUT E and CUT P series. The individual machine types are designed for different requirements with regard to machining accuracy. CUT C and CUT E are aimed at price-sensitive markets and still offer high accuracy of 3 to 5 μm . The CUT P series, with up to $\pm 2 \mu\text{m}$ contour accuracy and up to 0.08 μm surface roughness, is designed for high-precision applications. The main differences between the model series are in their mechanics. However, from a control technology perspective, they are identical – in the spirit of the GF Machining Solutions platform philosophy. According to Orio Sargenti of GF Machining Solutions, a great advantage in this context is the high scalability of PC-based control. With the same control hardware, the shorter response time and higher performance required for the CUT P was achieved by simply upgrading the Intel® Core™ i5 processor used in the standard C6920 control cabinet IPC with an i7 CPU.

Why was a dedicated development project initiated to implement these requirements?

Orio Sargenti: The development of the new control platform was, and remains, an important step and a significant investment in the future of GF Machining Solutions. In order to access as much expertise as possible, we signed a cooperation agreement with Beckhoff in April 2012. As part of the development project, additional support was provided by ISG Industrielle Steuerungstechnik GmbH, based in Stuttgart, Germany, particularly for the integration of the process-relevant functions into the numerical controller. The first machine to enter series production at the end of 2014 was the CUT E. Meanwhile, development work for more efficient control of the wire EDM process has been completed. In order to cover further areas of technology, the project will continue until 2020.

What experiences have you had in the development project with regard to the partnership and cooperation?

Orio Sargenti: The cooperation works very well. On the one hand, this applies to the Beckhoff products and the associated support, especially since Beckhoff has an office in Losone as a base for local contacts. On the other hand, the very open communication and discussion among the project partners has been very successful. In addition, all parties involved have essentially the same level of expertise. This is very important because, when implementing highly specific erosion functions, you not only have to know what needs to be implemented, but also why this is the case from a process perspective.

What are the special advantages offered by the openness of the TwinCAT CNC software?

Orio Sargenti: TwinCAT CNC offers TcCOM, an open interface for the numerical

controller. This is the key to make optimum use of our own process-specific knowledge as a core competence. The TcCOM modules enable us to use standard control technology and at the same time integrate our own special functionalities. This makes it very easy for our experts to focus on their core competences.

What are the main advantages of the TcCOM modules?

Orio Sargenti: What is crucial is that our intellectual property regarding wire EDM remains in our hands and does not have to be passed on to the control system provider for implementation. The TcCOM modules are the right tool for this and offer integrated, user-friendly intellectual property protection for our own expertise. In addition, we benefit from PC-based control as a forward-looking technology that is continuously developed, and from the high innovation capacity of Beckhoff. Because of the TcCOM modules, the innovation cycles on both sides can be decoupled – there is no need for complex synchronization if one side implements new features.

Which functions have been implemented via the TcCOM modules?

Orio Sargenti: Wire electrical discharge machining requires a control technology where the entire application is governed by the traditional control loops for torque/force, velocity and position with an additional loop for process control. As a consequence, the required velocity is not a fixed value, but rather is provided by the EDM process control module and has to be continuously applied in real-time. It is worth bearing in mind that the spark generator may also operate too fast with respect to the workpiece, so that the interpolation not only has to work in forward direction, but also backwards. This further increases the control complexity, not to mention the need for on-the-fly compensation of the cutting wire deflection and the spark lengths. From the perspective of the



Orio Sargenti, Head of Platform Engineering, Conformity and Norms at GF Machining Solutions, and Gerhard Meier, Key Account Management and Member of the Executive Board of Beckhoff Switzerland, at the customized CP3919 Control Panel on the new CUT P 350 wire EDM machine (from right to left)

The largest wire EDM machine of the new generation is the CUT P 1250, which can process workpieces with a length of up to 1.25 m.





GF Machining Solutions R&D Strategy Statement

"Our collaboration with Beckhoff on the new CNC development was a very positive experience both technically and in terms of teamwork. We also appreciated that the Beckhoff hardware solutions as well TwinCAT and CNC packages displayed good reliability that is critical for GF Machining Solutions as a Swiss company for which the quality of product is a determining factor of success. We look forward to continued development together with Beckhoff and the ISG team as we work to extend the new CNC platform to cover a broader range of GF Machining Solutions products."

Dr. Sergei Schurov, GF Machining Solutions Head of R&D Strategy

At its Losone facility, GF Machining Solutions produces around 100 machines per month (the image shows final inspection of several CUT P 350 units).





Orio Sargenti: "The EtherCAT plug-in modules reduce wiring effort in control cabinet construction by almost 40 percent while reducing the error rate."



The EtherCAT plug-in modules from the EJ series with the customized signal distribution board (on the right), as well as the C6920 control cabinet IPC and the EP6224 IO-Link module with IP 67 protection.



Wire EDM (electrical discharge machining) can be used to produce complex geometries.

CNC, we change the tool-radius compensation dynamically. All this is realized through four TcCOM modules as interfaces to the CNC kernel: wire bending correction, dynamic tool-radius compensation, corner pre-control and surface speed regulation.

What is the significance of the openness of TwinCAT as an engineering tool?

Orio Sargenti: The integration of TwinCAT in Visual Studio makes work easier for the developers, because they can use a known framework. The implementation of high-level languages is very important for the development the TcCOM modules, which are all programmed in C/C++. One feature, which GF Machining Solutions uses extensively, is MATLAB®/Simulink® integration. We use this heavily for modelling in order to define the best path for the required machine processes, based on an object model.

Why do you use a customized version of the CP3919 Control Panel for machine operation?

Orio Sargenti: The main reason is the design aspect, which ensures clear differentiation of GF Machining Solutions machines. On top of that, it provides easy operation and suitability for practical application, which has been optimized in collaboration with Beckhoff. For example, special requirements are imposed on the suspension of the Control Panel, since machine operators are accustomed to leaning on its push-button extension.

The I/O system is implemented using a customer-specific signal distribution board and the EtherCAT plug-in modules from the EJ series. What were the reasons for this decision?

Orio Sargenti: The traditional electrical distribution in our control cabinets was installed on DIN rails. GF Machining Solutions started to design control cabinets with signal distribution boards in the late '90s and the EtherCAT plug-in modules represent the ideal solution for us. This primarily provides two advantages: the error rate is significantly reduced compared to individual wiring, and the EtherCAT plug-in modules reduce the wiring effort by almost 40 percent, resulting in significant cost savings. Building a conventional control cabinet with equipment installed on DIN rails requires about 20 hours of work. With the EtherCAT plug-in modules, it only takes 10 to 12 hours. This is a significant time and cost savings factor. A further advantage is the high number of control cabinet units for the new machine generation, since, according to the platform concept, all wire EDM machines should be equipped with the same control cabinet. The different requirements can then be met effortlessly with the chosen EJ modules and possibly a modified board variant.

The interview was conducted by Stefan Ziegler, Marketing Communications, Beckhoff

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