Advanced measurement data processing with TwinCAT 3

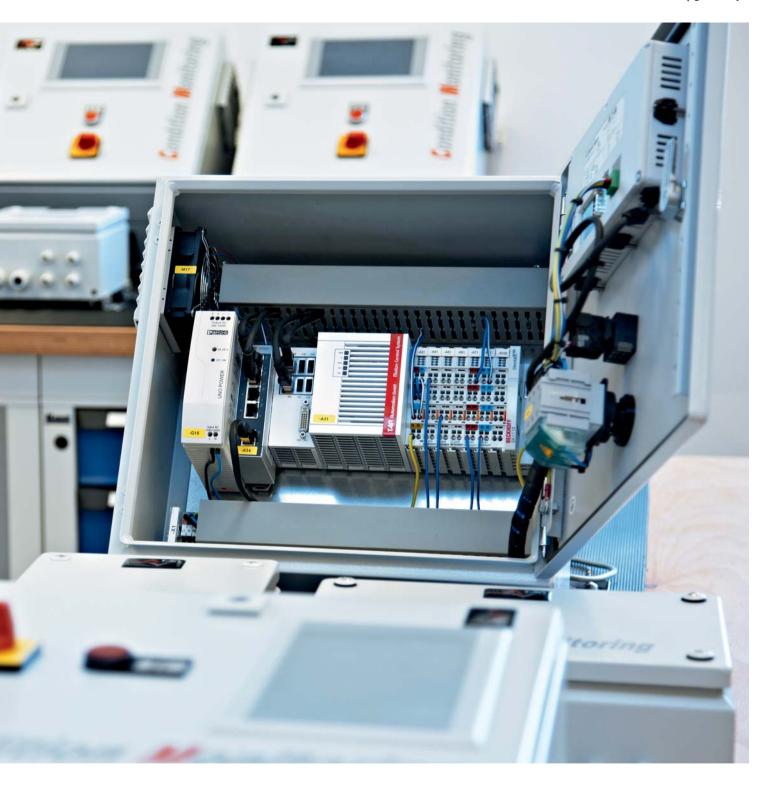# Process optimization through integrated condition monitoring

TAR Automation specializes in high-quality automation technology, supporting manufacturing companies through the integration of innovative control solutions. In addition to the design and implementation of new systems, as well as modernization of existing production machines, TAR develops system solutions in the areas of motion control and condition monitoring. The company, which is based in Dinslaken, Germany, recently developed an efficient condition monitoring system (CMS) for production equipment, based on integrated automation solutions from Beckhoff.

The TAR 9964 condition monitoring system is based on a CX5140 Embedded PC with TwinCAT 3 software, the TwinCAT Condition Monitoring library and EtherCAT Terminals as the control platform.

"In the early days of our enterprise, we used conventional PLC and SCADA products almost exclusively. Today, we increasingly employ PC-based automation solutions from Beckhoff," Alfred Rachner, Managing Director of TAR Automation, explains. "The multi-functional TwinCAT 3 automation platform provides an efficient development environment for our engineers to create software components. It is modularly structured, but nevertheless integrated. The finely scaled series of Embedded PCs provides the ideal hardware platform for the performance requirements of any task at hand."

Highly precise and customizable: Seamlessly integrated condition monitoring system

"The PC-based control solution enables us to integrate numerous new functions in automation technology, which in the past could only be realized using dedicated 'black-box devices'. Condition monitoring for production equipment is a good example," says Alfred Rachner. A conventional CMS is usually installed as a separate subsystem within the overall system. It consists of special hardware for data sampling and evaluation, has a fixed number of channels and a defined functionality. This makes such stand-alone solutions very inflexi-

ble: the user is unable to respond to changing needs, and condition monitoring functions become difficult to integrate, as well as very expensive.

Enhanced flexibility and reduced costs drove the TAR engineering team to develop the TAR 9964 condition monitoring system, which is based on a CX5140 Embedded PC with TwinCAT 3 software, the TwinCAT Condition Monitoring library and EtherCAT Terminals as the control platform. EL3632 Condition Monitoring terminals are used to connect IEPE acceleration sensors. The integrated configuration provides numerous benefits:

– The system is freely programmable, enabling the addition of new functions at any time.
– Vibration and analog channels, in addition to temperature measurement or digital I/Os, can be retrofitted at any time using the range of modular EtherCAT Terminal I/O.
– EtherCAT, as a broadband real-time network with high-precision clocks for synchronization, as well as oversampling technology, facilitates sampling rates of up to 100 kHz for analog signals and 50 kHz for acceleration values.

Ralf Stachelhaus, Manager
Beckhoff Sales Office
Rhein/Ruhr, and Alfred Rachner,
Managing Director TAR
Automation (left to right)

– The EL3632 condition monitoring terminal provides connection of IEPE sensors (acceleration, microphones, etc.) and features oversampling technology, parameterizable hardware-based antialiasing filters, digital filters and offset compensation.
– Basic analysis algorithms can be integrated as a PLC library, permitting the modification or expansion of functionality at any time.
– Integration into the customer's system is straightforward – a function of the availability of all common interfaces, including PROFIBUS, PROFINET, EtherNet/IP, CANopen, and Ethernet, among others.

More than condition monitoring: Process optimization of a granulator

The TAR 9964 condition monitoring system provides, as a real-world example, monitoring and process optimization of a shredding machine for recyclable material such as components used in PCBs, cooling units, washing machines, various plastics or tires. The granulator has a 400 kW drive for the cutter shaft and a 12 kW hydraulic unit for the pushing unit and stator adjustment. The cutter shaft features acceleration sensors, whose data are logged via the EL3632. First, software function blocks from the TwinCAT Condition Monitoring library acquire and bundle data in a very fast task. In one or several subsequent tasks, various analysis function blocks are used for additional operations, such as Fourier analysis, limit value monitoring, averaging and classification. The condition monitoring library also ensures correct time correlation of the acquisition and analysis tasks.

The integrated condition monitoring system results in tangible benefits for the operator of the shredding system:
– Bearing monitoring: In the past, bearings were monitored via temperature measurement, so that impending bearing damage was usually detected too late.
– Vibration, limit value and trend analysis: Detect potential bearing damage before costly damage actually occurs.
– Over-lubrication detection: Minimize lubrication waste Optimized system operation: If the working area is not closed properly, the material

"dances" on the cutter shaft and does not shred correctly. The resulting increased vibrations can now be measured, and the feed corrected by applying pressure.
– Automatic V-belt tension detection: Automatic detection and adjustment of loose V-belts Detection of blunt cutters: In the past, the plant was inspected "by ear", requiring personnel to actually listen for changes in equipment and the cutters were sharpened manually when needed. The condition monitoring system supplies reliable measurement readings for detecting blunt cutters and sharpening is carried out automatically.
– Integration into the machine control system: The material feed was historically controlled manually. Previous attempts to control the infeed with optical measuring systems were unsuccessful, because the materials to be shredded differ greatly in size and form. Now, the vibration analysis function of the condition monitoring system enables reliable detection when the granulator is empty, supplying new material automatically. Continuous utilization of the machine increases productivity by up to 50 percent.

New potential for system integrators

"For TAR, integrating condition monitoring into the automation and control system also opens up new opportunities and sales potential," points out Alfred Rachner. "TwinCAT is ideal for us as an integration platform: From simple control tasks to motion control, CNC applications, condition monitoring and safety technology – we can solve any task with a single system. This eliminates costs for training programmers on different platforms, and we only have to install and maintain a single engineering system in our departments. The same savings apply to maintenance procedures at our customers' sites."

"In addition, TwinCAT supports all common fieldbus interfaces such as PROFIBUS, PROFINET, EtherNet/IP, and CANopen, so that we can easily integrate our solutions into the control environments our customers use – for example, when it comes to modernizing an existing system. The most effective way forward is a fully integrated PLC/NC/CMS solution based on TwinCAT, although this is obviously only possible for new systems."

Condition monitoring with TwinCAT and EtherCAT

EtherCAT eliminates the need for subsystems

In the past, sampling rates of 100 kHz were not possible with fieldbus systems. With EtherCAT, this has changed – its functional principle enables usable data rates far in excess of 90 percent with full-duplex, fast Ethernet and bus cycle times of a few microseconds. Oversampling technology, providing buffering of measured data directly in the EtherCAT slave, enables the increase of sampling rates far beyond the actual bus cycle. Distributed Clocks in the EtherCAT slaves ensure time-synchronized data sampling across the network. The jitter is significantly less than 1 microsecond, usually even less than 100 nanoseconds. This enables the integration of a variety of functions into the control system, which in the past were realized with decentralized, intelligent subsystems to address speed concerns. Now, EtherCAT offers ample speed for the measured data to reach the control system with time to spare.

High-precision measurement technology via EtherCAT Terminals

Beckhoff utilizes EtherCAT functionality for ongoing development of new measurement technology I/Os. Terminals are already available for temperature measurement, load cell analysis, current and voltage logging, vibration monitoring and various analog signals, such as +/-10 V or 0…20 mA.

Condition monitoring integrated seamlessly into the control system

In addition to EtherCAT and high-precision measurement terminals, the continuous performance improvements from PC-based control technology represents a key factor in the ability to operate condition monitoring systems directly, rather than via subsystems. Intel® Core™ i7 quad-core CPUs with 2.1 GHz are used in high-performance devices such as the CX2040 Embedded PC. Even for complex control tasks, this means that ample performance reserves are available for the analysis of measured data.

TwinCAT 3 optimizes data processing

TwinCAT 3 automation software gives users the power to distribute individual program tasks to separate CPU cores. To use computationally intensive algorithms for analyzing measured data, for example, a dedicated analysis task can be defined and executed on a separate CPU core. In addition, TwinCAT 3 offers PLC programmers a Condition Monitoring Library for measurement data processing. It is designed as a software kit, which enables users to choose between basic mathematical algorithms or user-specific modules, depending on the application and level of knowledge: Examples for basic algorithms from the fields of analysis, statistics and classification include blocks for Fast Fourier transformations, Envelope, Kurtosis, Crest Factor, RMS and limit value monitoring. Users have a full range of basic algorithms available for developing their own analysis routines.

User modules serve as another step towards application. These modules comprise basic algorithms and encapsulate the algorithms as required for monitoring roller bearings, for example. In this way, a user can configure the module with individual bearing geometry data and teach-in limit values, without the need for detailed knowledge of the calculations that are carried out internally.

Piezoelectric sensors from IMI Sensors

The vibration sensors used by TAR Automation are based on ICP® technology and have the significant advantage that the measuring signal is transferred as a voltage value with low source impedance, which is immune to interference. This minimizes disturbances through electrical and magnetic fields from adjacent devices. The different versions and types of available sensors facilitate use in virtually any situation, including high-temperature applications or Ex zones.

The condition monitoring system is supplied ready for operation, installed in a compact terminal box.

Industry 4.0: Communication standards for vertical and horizontal networking

The wide range of Embedded PCs are scalable in terms of performance and I/O configuration while offering diverse networking options. This offers many degrees of freedom when implementing control architectures and, as a result, optimum solutions for the tasks at hand. "Whether we are dealing with a small, stand-alone solution, networking of decentralized, intelligent controllers or a high-performance central solution – anything is possible," concludes TAR's Managing Director. "In combination with support for OPC UA as the universal standard for vertical networking, it is also possible to integrate ERP systems, both within a site and across sites."

Further information:
www.tar-automation.de
www.beckhoff.com/Condition-Monitoring