Cart Track 4.0

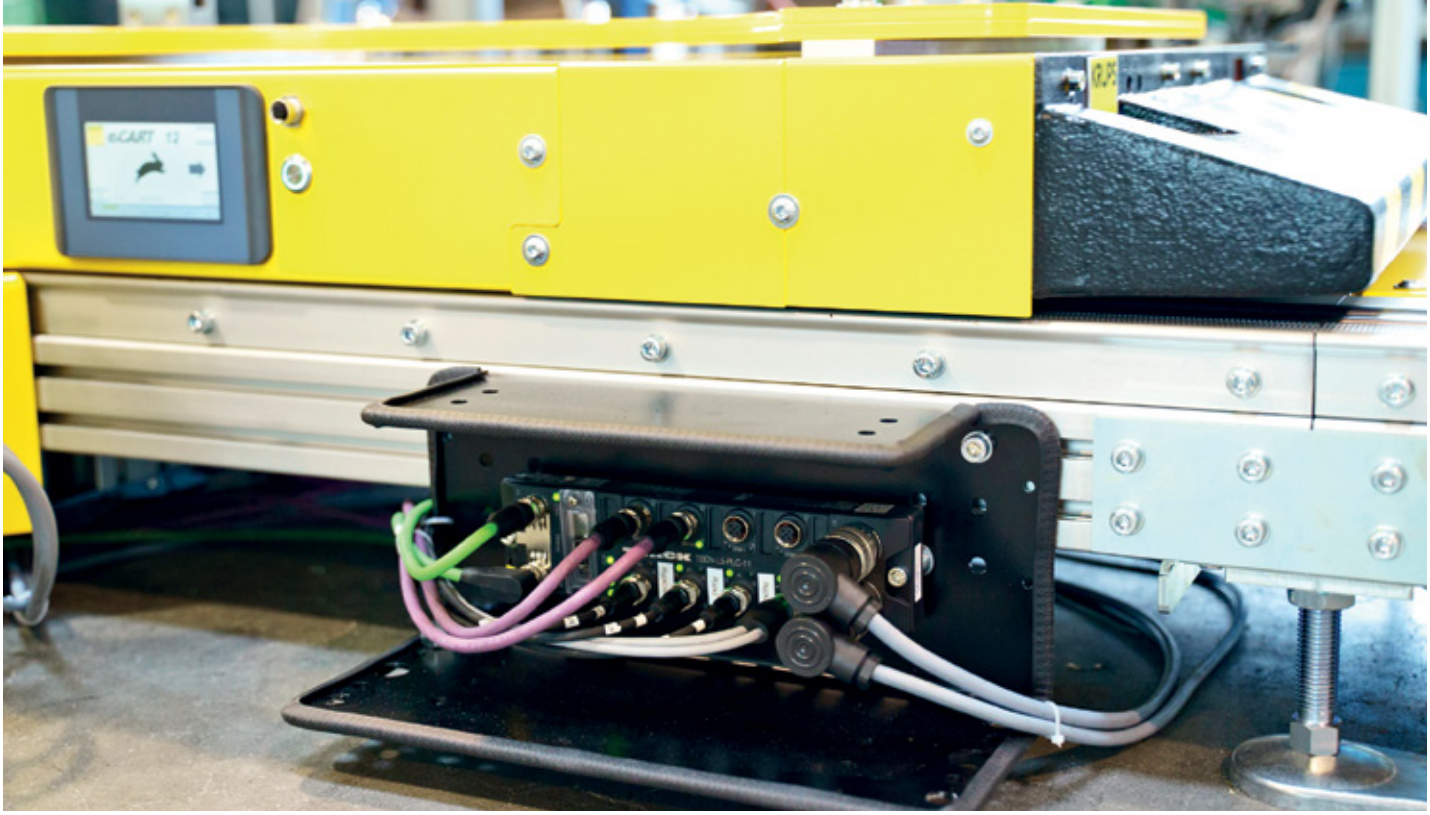
Self-driven, electric e-Carts from Krups Fördersysteme optimize the assembly and testing track in the battery pack production of a German car manufacturer; Turck's robust IP67 PLCs provide the decentralized operation control of the individual conveyor modules

In many places, the production halls of automobile manufacturers or tier-1 suppliers very much resemble a clockwork mechanism. The operating steps of robots and co-workers at the individual stations are closely synchronized so that the treated object can then be returned to the process flow. However, if one cog sticks, particularly if this cog is the production conveyor system, the entire plant gets out of step.

Maximum availability and flexibility are top of the list of customer requirements. This puts conveyor system manufacturers under pressure to innovate. They are required here to provide maintenance-free and more flexible conveyor systems that are simpler and faster to integrate, which are less expensive and available faster than alternative solutions once all direct and inidirect costs have been offset.
Krups, a company with its main plant in Dernbach Rhineland-Pfalz, is one of the market leaders in assembly and test automation. The company specializes in automation systems for the efficient linking of assembly and testing stations. The new e-Cart system provides actively powered, intelligent workpiece carriers, which are able to rotate, lift, clamp or tilt workpieces.

Krups latest device is a highly available conveyor system which is breaking (or making) new ground. Philipp Krups, second generation head of the company, explains the basic idea behind it: “In a conventional roller conveyor system the drive is located in the conveyor track. This involves a lot of mechanical parts in the track, and also the associated amount of wear. With permanently installed systems, maintenance is therefore always a problem. That's why we wanted to turn the system round and remove the maintenance from the track. We therefore developed a passive track that is completely maintenance free. The whole technology and electrical system is now located in the carts, the so-called e-Carts. These electrically driven carts have a self-diagnostic function and can be discharged from operation if required for preventative maintenance. This means that the downtimes are reduced and the track remains operational. It also

The e-Cart system takes the drive and thus also the maintenance away from the conveyor track, thus maximizing its availability



Turck's TBEN-L-PLC controls the Krups conveyor system modules – communication to the periphery is via CAN and to the main controller via Profinet or Ethernet/IP

makes any later expansions to the conveyor line very easy to implement. The e-Cart system furthermore makes it possible to implement more flexible production processes with smaller batch sizes. It could even be said that it is an Industry 4.0 conveyor."

e-Cart revolutionizes materials handling for e-mobility

Krups has launched the new conveyor system under the name "LOGO!MAT e-Cart". And where if not in the automobile industry should one of the first applications of this conveyor system be implemented? The automotive sector is after all the early adopter of industrial automation. This is a home game for Krups since the company does around 95 percent of its sales in the automobile industry. Some of the customers of the company based in the Westerwald are integrators that supply complete systems for automobile manufacturers, or also the integrators of the automobile manufacturers themselves. A major German automobile manufacturer will therefore be using an e-Cart system in future in the battery production facility for electric cars.

Krups uses a modular concept in order not to have to re-invent the wheel. The system consists of a few standard modules: Rotate modules, shuttle modules, stopper modules and indexers. These units are combined in a layout according to individual customer requirements and connected to the onsite control system of the plant. The conveyor system supplies the customer's production system with report data and enables the implementation of bidirectional communication interfaces.

Decentralized control for modular conveyor systems

"Previously there was always a main controller, to which all signals were routed. This partly involved point-to-point wiring, but increasingly more often also decentralized I/O units. The problem here was the programming. A plant programmer normally programs everything in one sequencer. However, if any condition at switchon or after an emergency startup is present that is not represented in this sequencer, the users must move units by hand in order to restore a known situation," explains Christian Mies, control developer at Krups. "A conveyor system has to be programmed

"In the long term we don't just want to be a supplier of mechanical systems but a supplier of plug and play conveyor systems – smart systems that control themselves and only need a higher-level master controller"

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With its e-Cart system Krups Fördersysteme is responding to the increasing requirements of modern assembly and test automation in terms of safety, low maintenance and communication. A zero maintenance track and intelligent self-driven carts, combined with decentralized system components with standard controls ensure the possibility of flexible and safe assembly automation. This increases availability and allows flexible processes for small batch sizes. The individual modules of the track are autonomously controlled by Turck's TBEN-L-PLC. With the multiprotocol-enabled IP67 PLC, Krups can offer standard and optimized control sequences for the individual components. Customers can thus reduce the time required for wiring and commissioning and expand the system easily.

At the stoppers and other function modules the e-Cart system communicates with the carts via NFC

differently in order to eliminate the need for manual interventions. Conditions and appropriate reactions have to be defined that are suitable for all situations." If the modules are controlled in the central controller, customers have to make some changes that interrupt the overall process. If faults later occur, these come back to Krups – even though the company was not responsible for them. This experience taught Krups one thing: Ideally, every module should be autonomously controlled.

Autonomous control increases process safety

Today each module operates externally as a black box, which simply communicates bidirectionally with the central controller in both directions via a bus connection. The module runs its program in order to perform its particular task: Rotating, transferring, traffic monitoring and reporting of module status. Each module is therefore controlled – exactly according to the development – and perfectly implements all possible sequences. A plant controller is installed at the level above this and controls the overall flow. However, the actual positioning sequences and the monitoring of conditions is taken over by each controller at the module.

Krups then no longer has to intervene in the control of the overall plant, neither does the plant operator have to control the conveyor system modules. Only the communication between the general controller and the modules has to be implemented at base level. In-house, Krups calls these conveyor system modules which have their own intelligence smart modules. The company therefore looked for autonomous controllers ten years ago, which can be installed directly on the modules.

Before – after: The controller built in-house by Krups (left) worked well but, compared to Turck's TBEN-L module (right), was considerably larger and more complicated to install and only worked in Profinet networks

Self-built IP67 controller

"At that time we already looked for compact controllers with IP67 protection. However, there was nothing on the market," Christian Mies reports. Krups therefore helped itself first of all: "We had our own controller built on a board, fitted all M12 plug connectors and placed everything in a housing. This housing had to be provided with drill holes plus a pneumatic system and a display. These were very big units and relatively difficult to manufacture. We had to have the boards built, the housings assembled and everything wired up. Although this was successful, it was a laborious task," senior boss Peter Krups explained the journey towards an in-house module controller.

Since Turck launched its TBEN-L-PLC block controller on the market a few years ago, Krups has been able to save the effort required for a self-build. The company is now using the IP67 controller in many machine models – not only in the e-Cart system. The control system for every conveyor system element was written in Codesys. The communication to the drives or valve blocks and other components of the module is implemented via a bus interface, while the communication to the main controller is mostly implemented via Profinet. "We now have the benefit: The modules can be deployed immediately and without the need for any other field programming device, i.e. replace, insert, data backup. In the ideal situation: the customer just has to connect the 7/8 inch plug connector for 24 volt and the Ethernet connector for the bus connection," Mies explains the benefits for the users. For an international company like Krups even the range of protocols offered by the compact controller pays for itself, according to IT manager Mies: "We can serve the US market with

Ethernet/IP in exactly the same way as the European and Asian market, where the protocols are mixed. We are currently concentrating on Ethernet/IP and Profinet, but Modbus TCP would also be possible in principle if this is required by a customer. The great thing here is also the fact that all the Codesys licenses are contained in the Turck device. The license is there and we can use it, regardless of the fieldbus the customer uses. We can even use them when we sometimes need a small main controller because the master licenses are also available," Mies describes the different scenarios in which the TBEN-L-PLC can be deployed.

e-Cart system saves power in battery production

The specifications of the e-Cart conveyor system in battery production already make it clear that the manufacturer means it with e-mobility. With 130 self-driven carts on a kilometer of conveyor track, the stage of small series production has been left behind. Krups fitted 70 turntables and around 140 stoppers on the track. 10 stoppers use a TBEN-L-PLC jointly as a gateway to the customer's main controller. This considerably reduces the number of bus nodes required for the customer.

To change direction, the carts are moved by transfer units to parallel tracks or their direction is changed by turntables. Unlike most conventional systems it is possible to communicate with the carts of the e-Cart system. NFC (near field communication) units are provided at the stoppers in order to use the TBEN-L-PLC as a gateway to implement communication between the main controller and the carts. In this way, carts can be removed depending on their state or the presence of warning messages. Another benefit: When the carts are waiting, they do not consume any power – unlike the conventional roller conveyor systems in which the drives normally continue running – even if no cartons have to be moved.

BL compact provides additional I/Os via CAN

The sensors and actuators of the modules are connected directly to the TBEN-L-PLC. The block controller provides eight universal channels on four sockets, which can be set automatically to the required configuration as input or output. If other I/Os are required, Krups can expand the number of signals required with the BL compact I/O module via the CAN bus connection. The BL compact modules are likewise designed with IP67 protection and are mounted directly at the units.

IP67 saves wiring

Krups has recognized the work that can be saved with the IP67 technology. "Just routing the 24V cables and signals to the twelve controllers on the stoppers and labeling would be very labor intensive. The price of the TBEN-L-PLC covers this easily," IT manager Christian Mies expresses his appreciation.

The e-Cart system is not only energy-saving and fail-safe, it also enables more flexible processes as outlined in Industry 4.0 model scenarios and also already implemented. Through the communication with the workpiece carriers greater product variance can be achieved, as shown in another application example: Likewise in the automobile industry, the e-Cart conveyor system transports the vehicle axles of two models. There are, however, 140 different types of axles that the carts can move through production. The actively driven workpiece carriers enable different production steps to be activated easily or left out. Wait times are minimized and different speeds can be assigned to the carts at the stations.

The e-Cart system with smart control technology in the field thus helps to ensure the smooth and highly efficient execution of flexible production processes. In view of all this, it becomes clear that the image of production as a highly synchronized clockwork mechanism comes from a different time. Even if production 4.0 requires the meshing of one cog in another, the clocks of production 4.0 have to be flexible like those in Salvador Dali paintings.

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