The eXtended Transport System (XTS) from Beckhoff opens up new solutions to realize compact, highly dynamic machine concepts. Even motion tasks that are nearly impossible to solve with mechanical engineering, or only achieved with considerable effort, can be conveniently and flexibly realized via software. Innovation potential thrives where creativity and machine design come together – be it in the simple linear motion of a “carriage mover”, or as an intelligent transport system within an Industry 4.0 application. The great variety of application possibilities are described below and illustrated based on current Beckhoff tradeshow exhibits.

The innovation potential of XTS is by no means limited to solving highly complex motion challenges. The system offers finely scalable customization options in terms of application requirements, e.g. relating to geometry, number of movers and functionality. It starts with simple applications, such as the purely linear movement of a carriage mover or the extension with a second mover to an XY table. The closing of the modular geometry, consisting of motor modules and guide rails, results in a continuous linear system with a number of movers that can be adapted to individual requirements. The full range of functions can be increased further by combining several XTS systems, using comprehensive TwinCAT function blocks and integrated robotics. If all these features are consistently leveraged in conjunction with condition monitoring and object-oriented programming, the result is a highly intelligent machine or production module, as envisioned by Industry 4.0 initiatives (Figure 1).

Figure 1: The Industry 4.0 XTS demo illustrates an innovative manufacturing process. The captured condition monitoring and energy data are stored in the Cloud, together with data acquired by a second pilot system.
Simple carriage mover and XY table functionality

Even for simple linear movements, XTS offers numerous advantages, thanks to its dynamic movement possibilities in combination with the replacement of mechanical functions through software. It deals with the tasks of a conventional linear motor with a movable carriage, although it is much easier to adapt to the respective application: with one or more motor modules, a suitable length can be selected with little effort. Furthermore, several of the wireless movers can be used if necessary, which greatly improves the flexibility in the application.

One example of how the ability to implement highly dynamic movements can be further increased with minimal mechanical effort is the functionality of an XY table (Figure 2). To this end, the carriage mover is simply equipped with a conventional linear bearing and supplemented by a second mover with a linear guide that is turned by 45°. The required motion in X direction can now be realized with jointly and similarly moving movers. The motion of the movers, relative to each other, creates the required Y motion via the two linear guides. In this way it is possible to realize any movement, including circular movements, e.g. for applying adhesives.

Figure 2: Using two movers with differently positioned linear guides, it is relatively easy to construct an XY positioning table based on the movement of the movers relative to each other, as shown in this demo with manual (foreground) and automatically following positioning table.

Here the system-related benefits of XTS come to fruition: the transport system is ready for use immediately after installation. Since power electronics and displacement measurement are included in the XTS motor modules, and the movers are completely passive, the measuring system does not have to be calibrated and the drag chains needed for conventional XY tables are no longer required. The result is an extremely compact, durable, and highly dynamic XY system. XYZ movements can be realized in a similar way with additional movers and corresponding kinematics.

Continuous linear drive with modular geometry

Due to the modular structure of XTS, it is not only possible to easily adapt the length to the respective application, but also to build a closed, continuous linear system using 180° curve modules. In addition, various curved motor modules are available, 22.5° inside or outside curve, plus 45° outside curve, which can be used to construct virtually any path shape. Examples include an S-shaped track (Figure 3) and a full circle (Figure 4).

Even during cornering, the movers remain under full control of the control computer, making controlled movements, i.e. defined process sequences, possible even at the deflection points. In this way, the transport system can be optimally adapted to the machine design. The XY table principle explained above works in this type of continuous section. The application benefits from mobile positioning tables, which can move continuously from one machining station to the other, in order to enable processes that apply adhesives or press on packaging lids, for example.

Rotary transfer machines are one of the many application possibilities of a circular XTS system. Currently available motor modules can be used to implement a full circle with a diameter of approx. 1.60 m (22.5° modules) or 70 cm (45° modules). Alternative guide rails are available for applications involving heavier weights, as shown in Figure 4. Furthermore, the motor modules can deliver their impressive dynamics with high forces up to 100 N. The range of XTS applications can be further extended with special guide rails from third-party suppliers, e.g. for high temperatures, aggressive agents, or heavy contaminants.

Despite all these features, XTS is by no means too costly or complex, even for essentially simple rotary table applications. If one of the processing steps takes significantly longer than the others, one could simply provide multiple instances of the respective station and integrate them into the process via software, thereby significantly increasing machine throughput with little effort. Other tangible
benefits arise from the high dynamics of XTS. Historically, conventional rotary tables are too expensive when the diameter exceeds 70 cm in applications with a desired cycle time of one second. Further benefits of XTS result from the lower weights that have to be moved, which reduces the number of required mechanical components as well as energy use.

Complex geometries and movements
Other ways to increase functionality, in the quest to solve challenging machine tasks, include combining several transport systems, whereby the installation position of each XTS can be freely selected. Figure 5 shows a product demo with a continuous XTS system and two linear XTS systems positioned at right angles to it. Each individual mover is represented as a servo axis, and a single Beckhoff Industrial PC with TwinCAT controls them all. Such a system is very efficient for sorting products, for example, and product changeovers are very flexible and quick to implement.

The motion functions that can be realized with XTS can go far beyond simple "Move from A to B" instructions, and not just in conjunction with complex geometries of the type described above. Additional features include automatic reversal of several movers for collision and jerk avoidance, mutual synchronization for holding or shaking processes in packaging applications, or for the XY function referred to above. This and other application-specific movement functions can be easily implemented with TwinCAT, using ready-made motion modules, resulting in a high degree of engineering efficiency. Virtually every mover is instantiated as an object-oriented program part, which reduces basic functions such as "dynamic backup with distance control" to simple parameterization, providing faster machine cycles through efficient program sequences.

Seamless integration of robotics
For applications requiring even more complex machining operations, XTS can be seamlessly integrated with robotics (Figure 6). TwinCAT Kinematic Transformation offers four different levels for this purpose, up to Level 4 with serial 6-axis kinematics, hexapod, and 5D kinematics. Using the mxAutomation library, commands can be sent directly from the PLC to a KUKA robot equipped with the KR C4 control system. Stäubli robots are also easy to integrate in TwinCAT.

The system benefits from the highly and appropriately scalable computing power of Beckhoff Industrial PCs, which can process XTS movements as well as robot kinematics on one CPU. This simplifies program handling and synchronization of subprocesses. Plus, the usual interfaces between the standard controller and the robot control are no longer required, which simplifies the exchange of variables.

Individualized product transport with XTS as an intelligent Industry 4.0 module
Offering high innovation potential, XTS seeks to make production processes more efficient and, above all, flexible. For this reason alone, it is ideal as a modern machine element from an Industry 4.0 perspective (Figure 7). A closer look makes this even clearer: in a traditional packaging or assembly process, the product is moved by a transport system and has to be repeatedly recognized, gripped, and possibly analyzed. In sensitive areas, such as medical and food technology, this results in a large number of mechanical components and sensors. In contrast, XTS enables the product to only be picked up once and then transported through the entire process with the same mover. Accordingly, the control program always "knows" where the product is and in what state.

This is supported by the object-oriented programming approach of TwinCAT, whereby each mover is mapped as a software module. Based on this direct
mapping of mover images and products, the “intelligent and self-organizing product”, defined by Industry 4.0 as a vision of the future, can essentially already be implemented today. With each mover implemented as a software instance, it is quite easy to “carry through” or track and document not only the current process steps, but also quality data and error messages, for example. This information can be used directly in the production process. If, for example, an error occurs in the sterilization of food packaging, the affected pack, which is uniquely defined via the mover, can be taken through the entire process without printing or filling. At the end, the empty pack is simply discarded as a reject, without wasting additional material or filling content. The process cycle is controlled independently by each mover program, e.g. by automatically activating the next processing station, as soon as the previous mover has left this location.

A wide range of additional system data are already integrated into XTS, which can be used for efficient process management. For example, the speed-control demo shown in Figure 3 continuously monitors the distance between the sensor flag of movers and the motor module. Based on this value, the software detects whether the weight of the mover has changed, i.e. whether the ball has fallen out of the bowl due to excessive speed. This information can be utilized in many ways: is the product to be processed still in the workpiece carrier? Is the weight correct after processing? Was too much or too little adhesive applied? Typical condition monitoring also benefits from the information, for example, by making it possible to detect contamination on the guide rail or damage to bearings or rollers.

Further information:
www.beckhoff.com/XTS

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