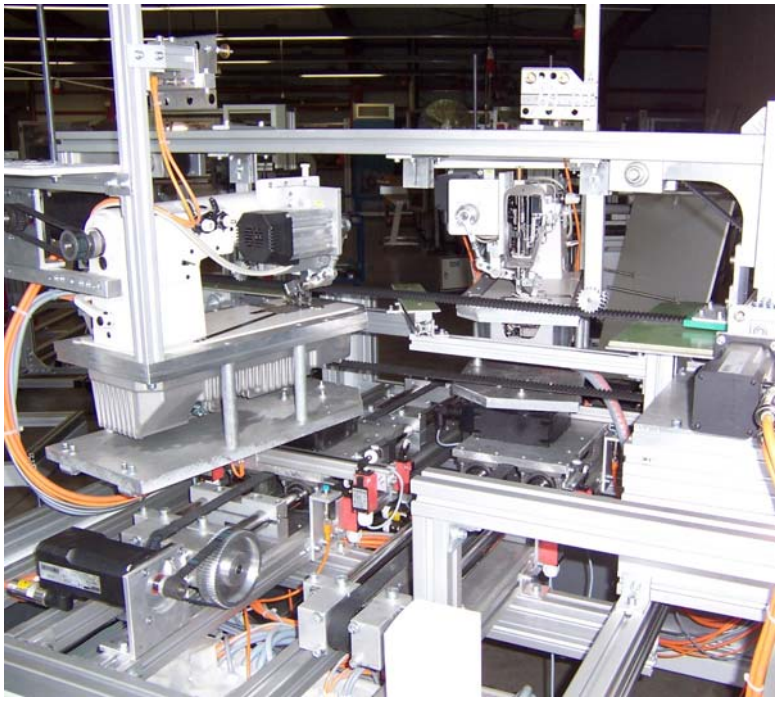
8 axes for sewing a sausage casing

CANopen-based motion control solution for a sausage casing sewing machine

A sewing machine for sausage casings is not immediately associated with high tech. However, the development of an automatic sewing machine manufactured by Beckmann Maschinenbau GmbH for a sausage producing customer posed quite some control technological challenges. After all, a motion control solution had to be devised for seven real axes and one imaginary axis. And the complexity of the motions with resect to the axes is comparable to that typical of CNC path control systems.



The sausage casing sewing machine of Beckmann Maschinenbau GmbH

The task and the method of the sewing machine are relatively easy to describe: the starting product is a fabric tape (textile casing) of 200mm width, which is folded to form a two-layer tape of 100mm width and conveyed close to the two sewing heads by means of a toothed belt. The task of the sewing heads is to sew the contours of various sausage models into the tape according to given geometric data. In this way an endless tape of sewed sausage casings is produced, which are separated from one another in the subsequent course of processing.

<u>Demanding 8-axes motion control application</u>
Each of the two sewing heads has three axes: 1. the needle stroke, 2. the linear motion along the x-axis perpendicular to the direction in which the fabric tape is conveyed, and 3. the tangential slaving of the heads during the process of sewing and, in particular, separating (cutting). The sewing heads are located at the right and left edge of the fabric tape and they are out of line to ensure freedom of motion. The seventh axis is associated with the control of the speed of the material conveyor belt.

From a control technological point of view, this is a typical motion control application. The relation between the three axes of each sewing head is well defined so as to coordinate the respective motions. In addition, the two groups of axes have to be coordinated with the motion of the conveyor belt (7^{th} axis). A

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virtual (8th) axis is used to implement a look-ahead function for speed monitoring. Moreover, typical PLC functions are required, for example, the optical thread break detector, emergency stop buttons, light barriers ….

The end users from food production imposed very high productivity and quality requirements. In order to meet these, the control solutions had to provide sufficient computing power and comprehensive programmability. Beckmann Maschinenbau GmbH chose the ExC55 embedded controller from ECKELMANN AG, Wiesbaden, Germany, as a hardware platform. This top-hat rail device is equipped with the powerful MPC555 32-bit controller.

Based on proven hardware and software standards

The ExC55 has, as a standard, an Ethernet interface, an RS232 interface for loading the application software and 2 CANbus interfaces. ECKELMANN AG has preferred CANbus as a standard for field communication for a long time. All controllers developed in-house, but also components of the E•FBM fieldbus modules have CANbus interfaces. For all of these products specifications are defined according to the CANopen communication protocol. Controller ExC5x: CiA 401, 402, 405. Fieldbus modules E•FBM: CiA 401.

Equipped with the ECKELMANN Motion Control Library, the ExC55 controller forms a complete solution which provides all performance features required for coping with the control task to be managed. The Motion Control Library just mentioned contains various PLC function blocks conforming IEC-61131-3, which enable multi-axis positioning form a PLC program. With the aid of the Motion Control Library, complex motion control and simple motion-related PLC functions such as linking input signals and computing and setting output signals can be realised in the same system.

Thus the EMC55 control system, which is provided with this library, can also be used in machines where the control of complex, fast and precise movements plays a decisive role. The use of the PLC platform has the advantage that the PLC and NC functionalities are present in a uniform programming environment, which, apart from common PLC actions, enables several movements to be coordinated, driven in parallel and even superimposed. The library contains all motion control function blocks according to the PLCopen standard version 1.

At the request of the manufacturer Beckmann, a touchscreen panel from Sütron Electronic GmbH was chosen as operator unit. Sütron, which is the in-house standard at Beckmann, also supports CANopen. However, the interface was programmed anew for the final application in order to achieve pure slave operation of the operator unit. The external inputs and outputs have been realised with CANopen conforming modules from the above-mentioned E•FBM series.

Application programming for CANopen

The application software for the sewing machine was created by VDM-TEC in cooperation with developers from ECKELMANN AG. “Programming this application was very demanding,” says Olaf van der Most, managing director of VDM-TEC. “Particularly as the solution required high precision, speed and user convenience

and, at the same time, most economical utilization of the hardware capacity (CPU power and storage)."

First of all, the geometry of the seams had to be incorporated for the drives of the sewing head axes. The contours of the right and left sides of the different shapes of sausage casings were scanned and converted into a table of interpolation points. For the coordination of the sewing head axes, MC function blocks for axis coupling were used. The synchronised movement of the three axes is realised via a so-called CAM table. As the coupling of master and slave cannot be described analytically in this case, this table has to be represented numerically. At the same time, the synchronisation with the drive of the fabric conveyor belt is computed as a coupling which can be expressed as a mathematical function.

The operator can choose the maximum values for the motion of the axes and the absolute stitch depth as further parameters that determine the actual motion of the sewing head axes. Depending on these parameters, the control system computes the positions of all axes on the basis of the above-mentioned CAN tables with a minimum interpolation cycle of 4ms. In order to achieve a reliable spline function for the path interpolation, the variables of the CAN tables had to be stored in the real format. Only with this format could the required derivatives of the trajectory for the 3rd and 5th order spline be determined with a sufficient accuracy.

An optical control and correction function was also implemented so as to be optimally adapted to the specifics of the complex motion control solution. The textile casing is marked with logos, which have to be always placed in the centre of the sewed sausage casing with low tolerance. For this purpose, a photosensor checks an imprinted mark before each sewing sequence thus determining the position of the logo on the tape. If the position is within the desired deviation, the control system computes a suitable linear stretching of the sewed image (in the order of magnitude of 1% at maximum) so that the continuous manufacturing process can be continued without interruption. If the control mark is missing, the control system can access the positions of the previous marks in a circular buffer to calculate a mean value as a substitute.

<u>Safety and convenience for the operator</u>
The visualisation and operation was customised by VDM-TEC. In particular, a sophisticated manual operation mode was programmed. All seven axes can be driven manually via dedicated screens (and external typing keys). However, to ensure safety, an automatic positioning control is superimposed to the manual operation so that no operating errors can occur in this mode (travel limitation, …). Unnoticed by the operator, all movements are profiled via a look-ahead function in automatic operation. For this the control system creates a virtual 8th axis, which computes the speed profiles of all coordinated axes.

The possibilities offered by CANopen fully met all technical requirements of this application. The solution chosen provided maximum economical advantages as the CANopen interface is contained in the standard scope of supply of the drives from Seidel Servo Drives used.