Hayes-Lemmerz has the most advanced wheel production facility in the world

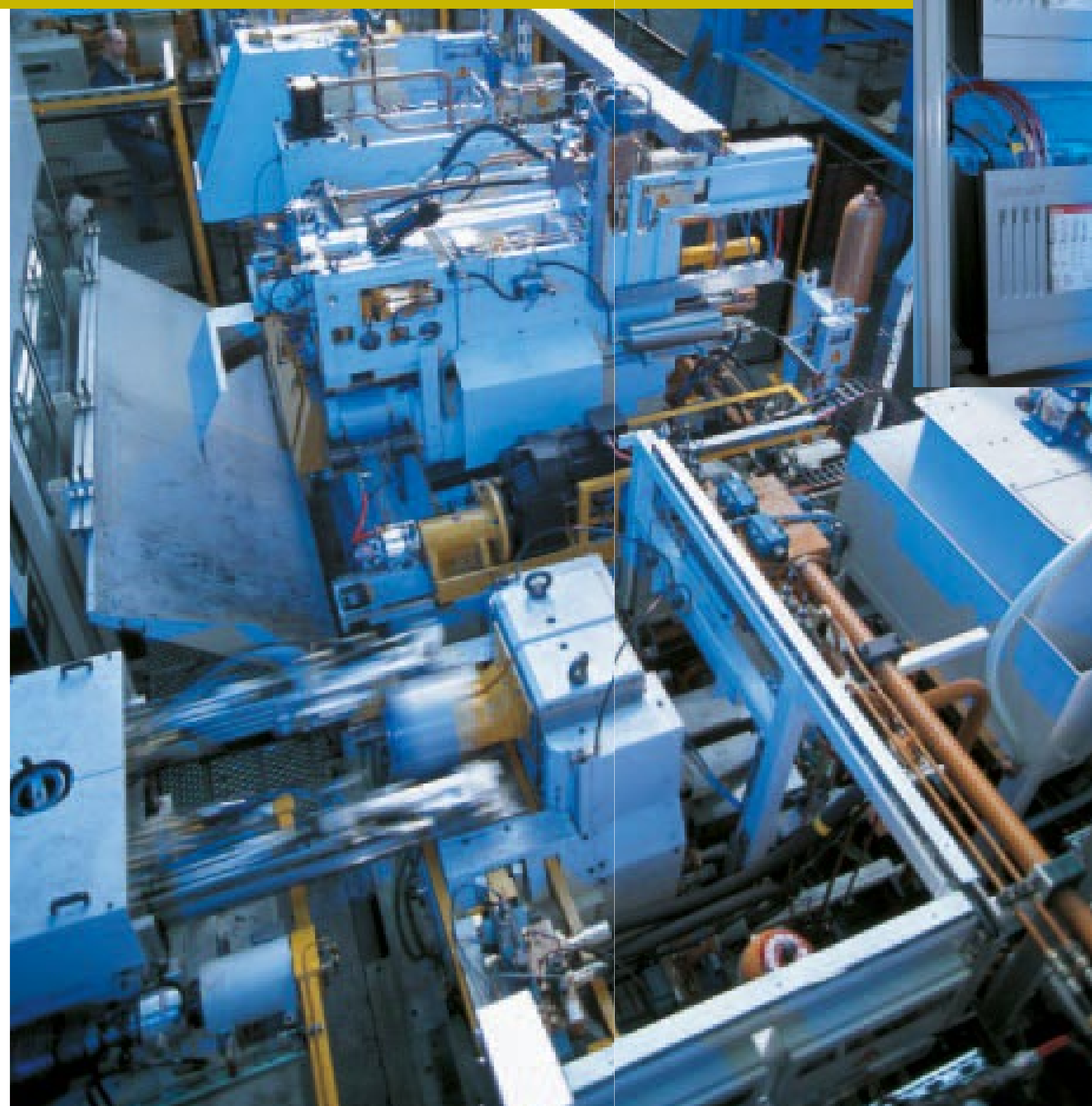
Hayes-Lemmerz produces car wheels. In North America, Hayes produced wheels for the legendary Ford model T since the beginning of the 20th century. In Germany, the Lemmerz family started producing wheels after World War I. In 1997, the biggest North American and European producers merged to form Hayes-Lemmerz AG, the largest supplier of car wheels in the world. Hayes-Lemmerz supplies the complete automotive industry from Mercedes to Plymouth. The main products are steel wheels for cars and lorries. Hayes-Lemmerz currently produce 10 million wheels per year.

From sheet metal to wheel

Over the last 2 years, the most advanced wheel production facility in the world was built at the site of the former Lemmerz factories in Königswinter, Germany. For automation purposes, Beckhoff technology is used exclusively: PC-based TwinCAT PLC and positioning controllers, Industrial PC as well as Beckhoff Lightbus for I/O communication.
It’s a long way from sheet metal to the finished wheel. Initially, the wheel disk and wheel rim are produced in separate production processes and subsequently welded together in an assembly line. The wheel disk is produced from coil stock in a deep-drawing process using a progressive press (shaping and punching). The associated wheel rim is produced in the wheel rim line. Here too, the basic product is a sheet metal coil. The coil is unwound and cut to length, and subsequently pre-bent (round bending) and welded into a circular blank. This circular blank is then profiled via roll stands and is shaped into the typical wheel rim profile. In the assembly line the disk is pressed into the wheel rim, welded, checked and subsequently dip-primed. A new wheel is ready every 6 seconds. What may sound relatively easy here in reality involves the integration of a variety of process technologies and their interlinking into an approximately 200 m long production line.

The welding process
The complex control process starts with welding of the circular blank in the wheel rim line. This procedure is technologically very demanding and consists of the following steps:

1. The two ends of the round-bent sheet are brought together via a hydraulic axis until they are in contact.
2. Once they are in contact, they are heated by applying a controlled current. The round-bent pieces are then welded together, with the material being upset during the welding process. During this process, in addition to the current and the pressure, the position of the hydraulic axes involved is also monitored.



Overview of the Hayes-Lemmerz wheel rim line consisting of reeling, welding and profiling units.

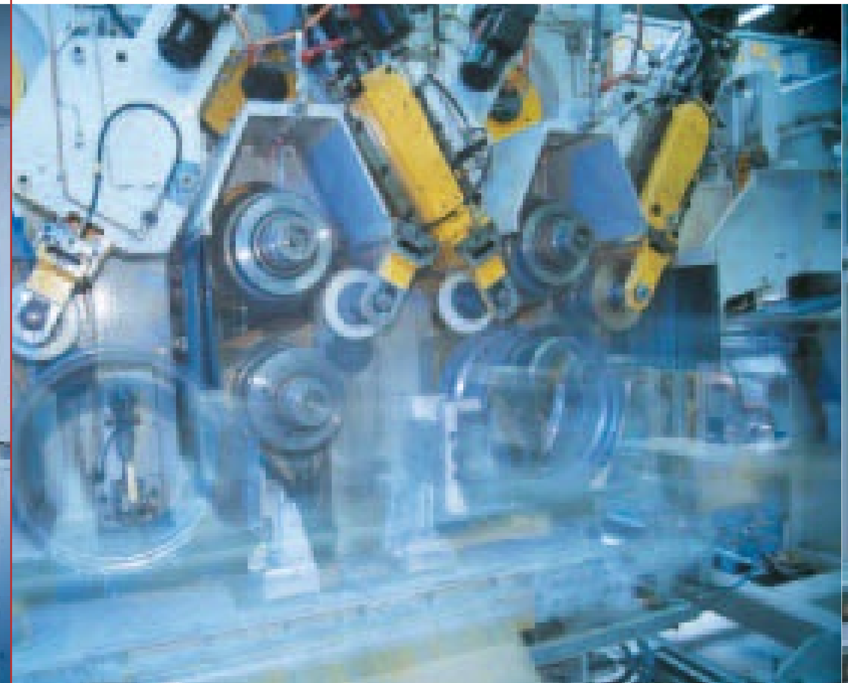
Beckhoff Industrial PC C6140 at the assembly machine with integrated Software PLC/NC TwinCAT.

Therefore, several processes correlate with each other, i.e. the pressure and the position control for upsetting the sheet metal and the control of the welding current.
Until now, the welding process used a proprietary control and a PC-based system for generating, managing and downloading the welding programs and for generating the set values. The wheel rim line manufacturer, Fontijne, combines both processes via a Beckhoff TwinCAT control system, thus demonstrating its performance and flexibility, particularly for the realization of technological control processes.

Profiling of the wheel rim blank
The next production step is the profiling of the wheel rim blank in three successive roll stands. This process is also more demanding than it may appear at first glance. The blank is transported step-wise into the roll stands. The upper and lower rolls close in a controlled way to generate the profile. At the start of each manufacturing stage, the peripheral speed of the two rolls is adjusted to the mean radius of the wheel rim blank. Once a frictional connection between the two rolls has been established via the wheel rim material, the process control is changed to moment control. Here too, high computing capacity and deterministic machining at short cycles is required. Due to its nearly inexhaustible reserve capacity, a TwinCAT PC control is able to meet these two requirements extremely well.

Final assembly of wheel disk and wheel rim
The last operation, i.e. final assembly of wheel disk and wheel rim, is just as complex. A robot positions the wheel disk in front of a camera system, which detects the rotational position. The wheel disk is then placed into a wheel rim positioned on two walking beams. A gripper for clamping the wheel is positioned on each side of the walking beam. Once the gripper engages, a frictional connection is established between the two beams via the fixed wheel. During transport, the beams are synchronized with high precision in order to avoid mechanical damage. The beams are synchronized electronically via TwinCAT through linear master-slave coupling.
The wheel disk is pressed in via a press, creating a firm connection. The height of the burner heads in the subsequent welding stations is adjusted depending on the height of the wheel disk patch. Four weld seams are simultaneously produced. For this purpose, 4 burner heads are symmetrically arranged at each station. Each burner can be individually fine-tuned, i.e. one axis for vertical and radial positioning, one for lifting or for positioning of the wheel under the burner heads, and one rotational axis for rotating the wheel during the welding process are available. Measurement and quality control of the finished wheel are carried out with a specially developed camera and image processing system.
The assembly plant consists of 57 servo axes, of which 42 are synchronized, highly dynamic axes for the production (machine cycle: 6 s), the rest are purely asynchronous feed axes. The servo axes and a further 1500 digital and analog I/Os of this machine are controlled via a single TwinCAT controller. The position controllers cycle time for all 57 servo axes is 3 ms and ensures a real time load of the control system of only 50%. The control system manages a total I/O address space

At the reeling machine, the coil for the wheel rim is unwound and cut to length, and subsequently pre-bent (round bending) and welded into a circular blank.



Profiling of the wheel rims.

of several thousand bytes. The performance capability of a TwinCAT control system could scarcely be documented more impressively.

Flexible visualization via Visual Basic

The visualization of the assembly machine, which was created in-house at Hayes-Lemmerz, is carried out on an additional Industrial PC that is networked with the TwinCAT control system via Ethernet. In house visualization was done because a large number of-the-shelf products are ideally suited for process engineering applications, but are sub-optimal for machine construction. Visualization via Visual Basic is very flexible and cost-efficient, since there are no license costs, and it is optimally adjustable. System care and maintenance can be carried out in-house without problem.

For example, the DXF files of the construction drawings are used and amended with appropriate status indicators. This is not only practical, but it also leads to a very appealing and clear appearance.

Free networking

The networking and communications options are also very effective. Since TwinCAT is a PC-based software solution for PLC and Motion Control, networking is supplied as a matter of course via the PC platform. For internal device communication, e.g. between TwinCAT PLC and visualization, standard interfaces such as ActiveX or OPC are used. This makes access to data within the network for interfacing with MDE or BDE or for remote maintenance very easy. Since the same language is spoken here and in other standard EDP applications, the in-house expertise of the appropriate departments can be utilized.

Convincing overall factory automation concept

According to Michael Glos, Director Electronic Design at Hayes-Lemmerz, the TwinCAT PLC and positioning controller is the optimum solution for wheel production. Due to the tremendously large process images and the extremely exacting demands in terms of computing capacity for PLC and positioning, only a PC-based solution such as TwinCAT offers the opportunity to automate such a machine with a single CPU system and to avoid inadequate (yet costly in programming terms) communication between several PLC CPUs. The conclusive and straightforward integration of the complete Motion Control within the TwinCAT system is ideal. Apart from the simple handling, Michael Glos is also very enthusiastic about the central data management of a drive solution with central intelligence and integration into the PLC programming system: "Normally, I would require different specialists for the PLC, the drive technology and the technological controls. Thanks to the integrated system platform of the TwinCAT control, only one programmer is required for the complete project design and programming of the system".

At the assembly machine, the wheel disk is inserted into the wheel rim.

The final step: the welding of wheel disc and wheel rim.

The automation components are connected with each other via a Lightbus system.

Automation technology at a glance

The following components are used for the automation of the complete wheel assembly line:

Industrial PC:

| 16 C6140 control cabinet PCs (Pentium III, 850 MHz)
| 8 CP7021 Control Panels, 2 CP7022 Control Panels, 2 CP7032 Control Panels

Fieldbus:

| 20 Lightbus FC2001/2 PC fieldbus cards
| 120 Lightbus BK2000 Bus Couplers
| 5,000 digital Bus Terminals, 1,000 analog Bus Terminals

Software:

| TwinCAT PLC cycle time: 9 ms
| TwinCAT NC cycle time: 3 ms with max. 57 servo axes in a single TC control system

Visualization:

| Visual Basic, interfacing via TwinCAT OPC

The central drive intelligence is also advantageous in terms of costs. For a distributed solution, each drive controller would required approximately 500 euros worth of integrated technology cards. Additionally, a further bus system would have been required for the synchronization. The Lightbus, however, is powerful enough to be able to transmit the real time data (set values and current position values of the drives) cyclically and deterministically from and to the central position controller of the TwinCAT PTP positioning system, synchronized with the central position controller. Further hardware costs are thus avoided. At the same time, handling is simplified because the minimum possible number of systems is used. After two years experience with Beckhoff TwinCAT, Michael Glos sums up his experience as follows: "In hindsight, I would take the same decision again any time."