

Herkules: control expertise for roll grinders packed into software

TwinCAT ensures the perfect finish

→ The Herkules machine factory in Siegen, Germany, has been developing and manufacturing roll grinders for almost 100 years and is regarded as the worldwide market leader in this important supply segment for the steel industry. Since the year 2000, Herkules has been using Beckhoff control technology and automation components, which are programmed and implemented by its subsidiary HCC KPM Electronics for various types of plants and machinery.



Grinding support: Due to the extreme stresses on the rollers during the rolling process, the demands on a roll grinder are extraordinarily high with regard to grinding accuracy and uptime. They are among the most demanding tasks in the steel and smelting industry.

Herkules implemented a particularly demanding project last year with the delivery of a complete rolling workshop for the Chinese steel company Wuhan Iron and Steel (Group) Corporation (WISCO). The rolling workshop, also known as a roll shop, consists of a total of four roll grinders, two semiportal cranes for loading and unloading the roll grinders (loader) as well as the Roll Shop Management System (RSMS). In the rolling mill, sheet metal which has already been roughed down is rolled to the final thickness and quality. The end product is silicone steel or transformer sheet steel which is used for the manufacture of transformers and motors, for example.

Within a rolling mill, the roll shop provides the mainstay for the quality of the sheet metal to be rolled. Due to the extreme stresses on the rollers during the rolling process, the demands on a roll grinder are extraordinarily high with regard to grinding accuracy and uptime. These are among the most demanding tasks in the steel and smelting industry. The roll shop has to guarantee a work output of approx. 70 working and back-up rollers per day in a three-shift operation, with 97 percent availability.

Giant rollers still need intricate precision

A roll grinder has little in common with a precision tool at first glance. This is due on one hand to its dimensions – the rollers for machining can be up to 400 tons, dead weight and up to 10 m in length – and on the other hand due to the surroundings of the rolling mill where thousands of tons of steel are being maneuvered and processed. However, a second look reveals the high-precision character of such a machine: in addition to several measuring axes, a grinding machine has at least four machining axes, which are implemented by means of Servo Drives:

- | W-axis: Spindle head turns the roller which is clamped centrally in a steady rest.
- | X-axis: Grinding wheel feeds vertical to the roller.
- | Z-axis: Grinding wheel traverses parallel to the roller.
- | C-axis: Grinding wheel microfeeds via a tilting axis.

The roller to be ground is clamped in the spindle head and is driven by it. A high-precision incremental measuring instrument with two tactile measuring sensors traces the turning roller and determines the current form and diameter as well as detects any possible damage on the surface of the roller. The machine operator sets the parameters for cylindricity, final diameter, surface quality and structure or abrasion, depending on the required result. The control system calculates the

HCC KPM measurement and inspection system "on the fly". The high precision, incremental measuring instrument with two tactile measuring probes travels along the rotating roller and determines its current shape and diameter as well as any damage to the surface of the roller.



Herkules roll grinder type WS 450 L Monolit™

grinding process from these parameters. Continuous measuring is carried out simultaneously in order to record the results of the grinding process and determine or correct the required values for the next travel.

Certain manufacturing processes in the steel and paper industries require a precisely defined roller form. These can be conical or spherical or – looked at from the longitudinal axis – display a sinusoidal or bottleneck form (CVC). These variations of form are not visible to the naked eye, as they are on the order of millimeters. The automotive industry, for example, has specific requirements for the

surface structure of the sheet metal in order to have shine and reflective properties in the sprayed bodywork, which could not be achieved by spraying alone. The necessary grinding precision goes down to 1/1000 mm in concentricity and the same in geometrical accuracy.

In order to do justice to this complex task, HCC KPM Electronics has produced a control system which can be applied with only minor adaptations to all kinds of machines – all on the PLC and Motion Control solution, TwinCAT PTP and NC I/CNC software.

Control Panel with customized design

The input to the machine is made via a Control Panel, which was designed and planned jointly with Herkules in line with their particular needs. All hardware operating elements integrated in the panel are linked to the control PC via Lightbus. This compact and highly integrated operating design enables stationary machine management and the implementation of the mobile support control station. The HCC Graphical User Interface (GUI), with which the operator adjusts and operates the complex machine, is visualized on the panel. The operator obtains all the information about the roller and the current grinding status via the GUI. The link from TwinCAT to the multilingual GUI takes place via ADS-DLL, the versatile communication interface from Beckhoff.



Herkules roll grinder type WS 600. The rollers to be machined can weigh up to 400 tons and measure up to 10 meters in length.



Inputs to the machine are made via a Control Panel that was designed in cooperation with Herkules in accordance to their special requirements.

Synergy from customer expertise and an intelligent control concept

In order to utilize the benefits of a central control concept in terms of commissioning, maintenance and performance, the electrical design engineers at Herkules aimed to run as many functions as possible in software and decided in favor of TwinCAT. The open software structure and the dynamic functions for controlling axis movement that TwinCAT provides enabled Herkules to integrate the expertise acquired over many years of developing their own control system into the software PLC and create the "HCC/KPM 10" roll grinder control system.

Almost all the functionalities provided by TwinCAT are used:

- | 3 PLC tasks in one run-time system with 1 or 10 ms interval time
- | 1 NC task with up to 10 axes with 2 ms interval time
- | almost all programming languages (IL, FBD, ST, SFC) in the PLC projects
- | application of PTP axis functions and complex multi-table coupling for the grinding processes with correction parameters from the grinding current, grinding wheel wear and measured deviations from the required form to the actual form of the roller
- | communication with integrated visualization based on Visual Basic and operating guidance through the ADS DLL communication interfaces
- | TwinCAT NC I for interpolating functions e.g. to mill concentric grooves in the surface of the roller

Lightbus is used as the fieldbus to incorporate the peripheral Beckhoff Bus Terminals within the machine. For communication with the Servo Drives, the Ethernet-based EtherCAT bus system is predominantly used. A major benefit of EtherCAT on one hand is its real-time capability and high data throughput – with

bus cycle times of less than 1 ms – and, on the other, simple handling using TwinCAT. Only one free network port is necessary in the control PC. The Servo Drives are connected via standard network cables.

Transport tasks controlled by software

The large-scale WISCO project offers not only four roll grinders, but also includes two automatic semiportal cranes for loading and unloading the roll grinder (Loader). The Roll Shop Management System RSMS manages the grinding tasks and the rollers – another core competency of the Herkules Group. The software plans the production process and allocates the transport tasks to the loader or the machining tasks to the grinding machines. The loader transports the rollers to be machined to the grinding machines and the finished rollers back to the storage locations. TwinCAT NC I running on the control PC of the loader takes care of the transport and the exact positioning of the rollers in the infeed of the grinding machines. The transport of the rollers into or out of the automated zone is carried out by an overhead crane.

TwinSAFE guarantees safety of personnel

The automated zone, in which the grinding machines and loader operate, is divided into different safety areas. Security doors with guard locking prevent people entering the danger zone. All security-related signal preprocessing and control is implemented using the Beckhoff TwinSAFE system.

The status of the following is monitored:

- | 9 security doors
- | 6 light barriers
- | 14 emergency stop keys
- | 2 laser scanners (protection for loaders from collision with each other)
- | 8 laser scanners using secure radio (protection from collision for the loader with the overhead cranes)
- | safety relay for the drives (safety circuit breaker for drives)
- | 12 key switches (bridging options, number of operating modes)

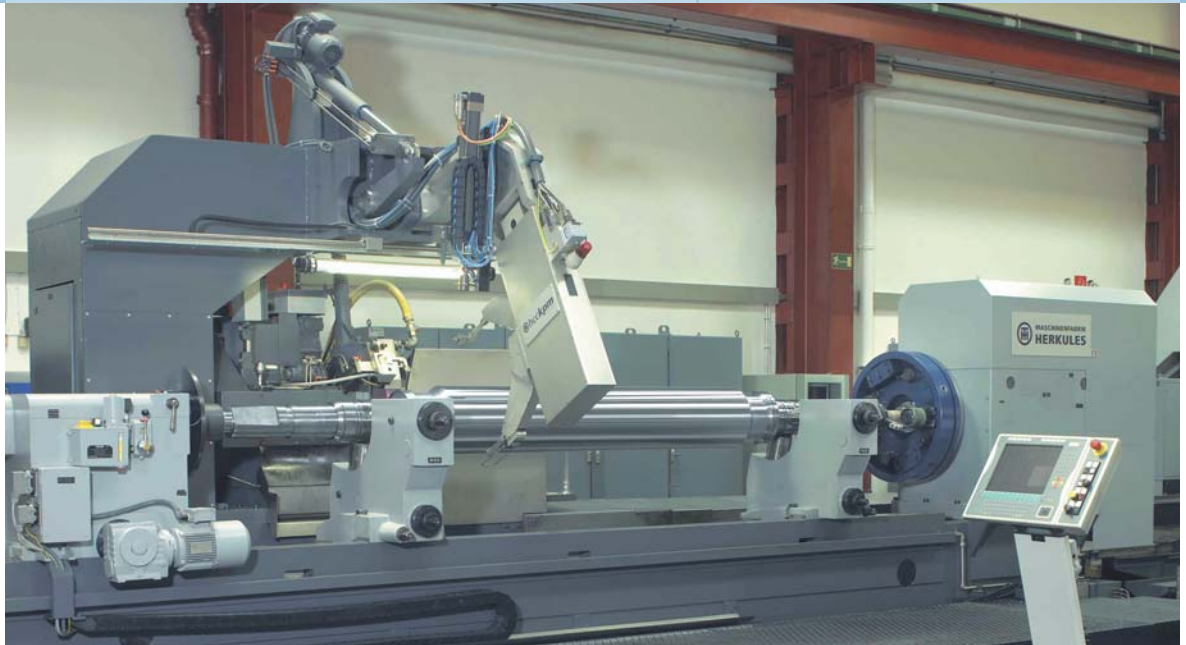
The roll shop for the Wuhan Iron and Steel Group is made up of the following components:

- | 3 roll grinders Type "WS 450-6 x 5000 CNC Monolith™" for grinding work rollers and intermediate rollers
- | 1 roll grinder Type "WS 600 x 5000 CNC Monolith™" for grinding work rollers, intermediate rollers and back-up rollers
- | 2 automatic semiportal cranes (loader) for transporting the rollers from or to the machines
- | 1 Roll Shop Management System (RSMS) for managing the roller and storage data as well as for controlling the production process

Beckhoff components used:

- | 8 control cabinet Industrial PCs C5102-0010
- | 4 Control Panels CP7832-1050
- | 24 Lightbus Bus Couplers BK2000/BK2020
- | 12 EtherCAT Bus Couplers BK1120
- | approx. 1,100 Bus Terminals
- | Bus systems used:
 - Lightbus
 - PROFIBUS
 - EtherCAT
 - Real-time Ethernet

Herkules roll grinder WS 450 Monolit™ for grinding work and intermediate rollers



Additional functionalities

- | release for the 9 security doors
- | detection and monitoring of the loader position (in relation to safety zones)
- | establishing the emergency stop connection with the (4) grinding machines (dependent on the position of the loader)
- | controlling the safety relay of the drives

TwinSAFE safety technology includes checking of the emergency stop keys and the emergency stop requirement for the machines and relays these to the loading installations. In addition, the status of the safety zones is monitored and – dependent on status – a decision is made as to whether the loading installation is allowed to drive into the zone. Release of the security doors using TwinSAFE outputs depends on the positions and operation modes of the loader. The operation modes can also be selected via key switches if desired: in MANUAL, a secure radio remote control with an additional emergency stop is connected.

The status of the drives is also monitored with TwinSAFE. The merged emergency stop signals to the loader can stop the drives via the secure bus terminal outputs. The signals from the loaders' collision monitoring and those from the loader with

the overhead cranes lead to an emergency stop.

In order to implement these safety functions, a total of 19 TwinSAFE Logic Bus Terminals and 51 secure KL1904 input terminals were integrated in a safety network. All safety functions are implemented in two channels.

The TwinSAFE signals are integrated in the grinding machines via Lightbus, the individual Logic Terminals communicate with one another via real-time Ethernet using network variables. In total, this results in an average of six communication connections per machine control system to the I/O level, the servo converter, the central control, the RSMS and the loader. In this design PROFIBUS, via which an ultrasound crack testing system is networked, functions like "the odd fieldbus out."

"This is where the exceptional character of the TwinCAT controller is so impressive, in that it deals with both the PLC and NC functionalities in real time and allows a diverse range of fieldbuses to communicate faultlessly," observed HCC software engineer Oliver Kettner who has been responsible for commissioning the plant. The control and automation concept described here has been implemented with custom modifications in approx. 250 machines so far.

→ Herkules www.herkules-group.de