ISSN 1983-4764

PROCESS MONITORING AND CONTROL: STATE OF THE ART SOLUTIONS FOR MODERN ROLL SHOPS[1]

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Abstract
As the present time is characterized by increasing automation and faster production cycles, automatic technical processes becomes more and more important. The quality demands and the productivity are increasing, simultaneously. Due to this conflict of aims, it is necessary that also overall organization and logistic features – today often carried out manually – become integrated in the widely automated production process in “state of the art roll shops”. This affects the processes in modern roll shops and service centers as well. Today’s production technology respectively today’s demands on quality and productivity requires fast, precise and repeatable production steps. An important target of an innovative roll shop is the correct planning and optimization prior to the purchasing of the equipment. A verified capacity study should be the qualification for the design of “a new roll shop”. Not only the machine concept is responsible for a fluent sequence in the steel mill, the quality of the roll shop equipment and the right choice of components has a major influence on the planned results in the rolling mill.
Key words: Roll shop; Automation; Planning; Capacity study.

[1] *Technical contribution to the 47th Rolling Seminar – Processes, Rolled and Coated Products, October, 26th-29th, 2010, Belo Horizonte, MG, Brazil.*

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OPTIMIZATION OF ROLL SHOPS

To guarantee the high quality, the production capacity as well as the overall organization new roll shops have to be planed considering all the needs to the maintenance of rolls, chocks and bearings related to the necessary roll assemblies for the production in the mills. As this scope of duties is very manifold, an exact planning has to meet the requirements of the production target in the roll shop.

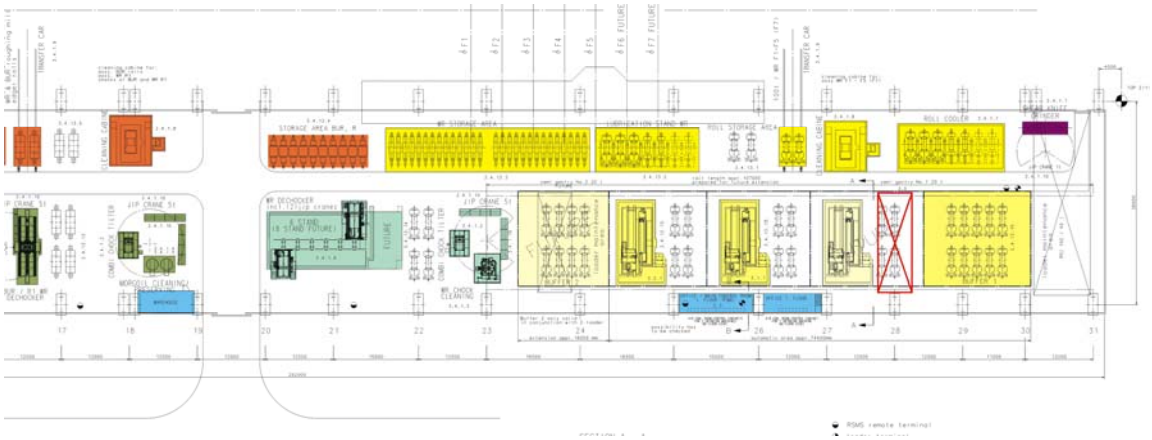

Figure 1: Example of a hot rolling mill roll shop layout.

The following issues have to be considered to avoid any planning mistakes in the preliminary layouts for a new roll shop.

- Minimized number of rolls in production
- Minimized capital investment
- Minimized man power
- Optimized production results
- Optimized floor space
- Optimized overall logistic.

Today's roll grinders are more and more operated in automatic roll shops. The automation includes the roll transportation system, the roll cleaning system, the roll storage system as well as loading and unloading devices for the roll grinders and the roll grinding process itself. Consequently, the whole material flow from the roll stand to the roll shop and back can be automated (Figure 1 and 2).

To optimize these tasks to the above mentioned issues, virtual tools for exact capacity calculations are very helpful. Simulations of the different scenarios can support the planning teams by investigating the right scope of equipment for new roll shops.

As we are talking about very complex systems with individual dynamic including bottlenecks created by production peaks, it is not possible anymore to do exact capacity planning's without any help from simulation software.

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Figure 2: Example for an automated roll shop.

Recently roll shops are more and more operated as independent or integrated service centers. Particularly the capacity of the roll shops is a critical part but for customers an important part of the overall calculation for the production process in the roll shops.

VIRTUAL ROLL SHOPS

WALDRICH SIEGEN has introduced and developed a software package to develop a digital roll shop (Figure 3). It enables us to support our customers competently when planning the roll shop. All data of a simulation study can be used to specify machine and equipment.
With this simulation package all logistics, machining and auxiliary times within a roll shop can be simulated. Detailed simulations for any period (1 day, 6 month or even years) are possible. All production demands can be considered. Comparisons between different scenarios are easy to calculate by using editable Excel spreadsheets. A simulation of the complex issues in a roll shop minimizes the risk of planning mistakes and the solution will be an optimized roll shop reflecting all demands of the production target.

Figure 3: Virtual roll shop showing a fully automated work cell.

Using complex simulations, we demonstrate logical connections:

- between machines,
- roll shop equipment,

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- transport equipment,
- with regard to personnel planning.

A simulation model can:

- display exceptional situations,
- detect bottlenecks,
- offer an overview of solutions.

Target projects for roll shop simulations can be either:

- New roll shops for new rolling mills → define the best solution, regarding no. of machines, no. of rolls in process, roll shop equipment and man power.
- For existing roll shops → find solutions for modernizations, optimizations and relocations.

MACHINE CONCEPT

As the load factor on today's equipment is rather high, issues like availability, maintenance-friendly systems and standard components on the machines and equipment are becoming more and more important (Figure 4). Especially the high tech grinding machines need to be service-friendly. This can be realized by using standard components on the grinders to the highest possible degree.
As a result of a machine concept based on standard components the customer has also advantages in regard to the storage of critical spare parts.

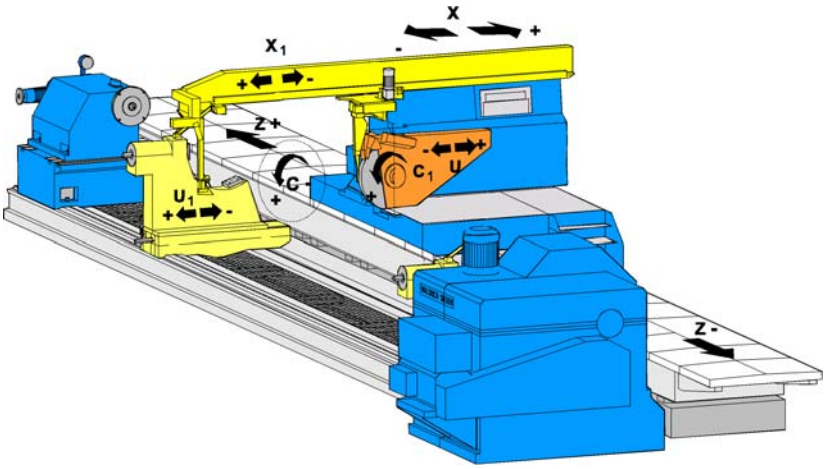

Figure 4: Grinding machine with standard components.

The following components on grinding machines can be standardized:

- work piece bed,
- support bed (bed for the wheel head),
- grinding support (wheel head),
- tailstock,
- measuring caliber,
- machine oil supply → energy box (hydraulic / hydrostatic unit),
- coolant filter,
- electric cabinets,
- drives (as far as possible),
- CNC control.

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Different components respectively set-ups in regard to the different application (work roll grinding machine or universal roll grinder - Figure 5):

- headstock,
- steady rests (for back up rolls),
- centre high for the work piece side (set up),
- distance between work piece bed and support bed (set up).
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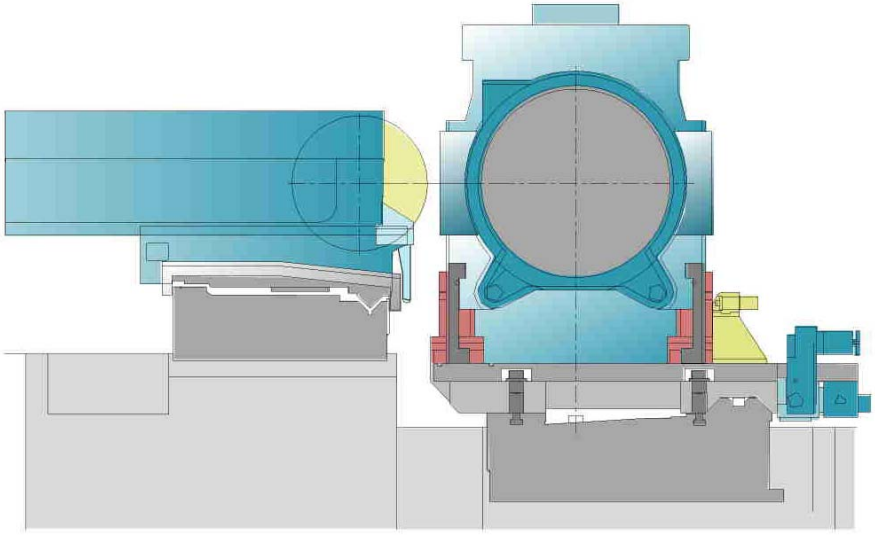

Figure 5: Set up for work piece side on universal roll grinding machine.

To ensure an overall availability in the roll shop it can be a goal for the customer to consider one universal grinder (with above mentioned standard components) for the use of work roll grinding. Just in case the back-up roll grinding machine is out of order, this universal roll grinder can be seen as insurance to continue regrinding of back up rolls in all cases.
Further appliances for automation and quality control are automatic inspection systems (roll shop inspection system: RSIS). With such automatic inspection systems the operator specific variations are minimized and quality control is kept stable and independent.

ROLL SHOP EQUIPMENT

All auxiliary activities in the roll shops, like de- or re-chocking, roll and chock handling, roll storage, roll and chock cleaning as well as roll assembly cleaning, roll transfer cars, roll cooling units and fully automated roll loading systems are becoming more and more important to guarantee the overall performance on roll assemblies for the mills.
As this equipment is directly related to the quality and production of the roll grinding machines itself, more and more customers are purchasing roll shop equipment directly from the grinding machine supplier.
To give an overview about the technology level of such components, the key components which can be offered are listed below.

Roll cooling device

In the cooling device (Figure 6) the work roll will be cooled down from its operation temperature in the mill to the ambient temperature in the roll shop. This minimizes

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the time frame between removal of the roll from the mill and the start of machining on the machine.
The work rolls will be put in storage positions of the cooling device one by one. After start, fresh coolant will be pumped from storage tanks via a tube system to the spray nozzles. Each cooling rack can be switched on or off manually. After the coolant is sprayed on the rolls and absorbed the heat energy of the roll, it flows into the sump and into the collector tank. From there the used coolant will be conveyed for treatment.

Figure 6: Roll cooling device.

Roll dechocking

In order to facilitate the maintenance of the chocks and to enable the grinding of rolls without chocks, the chocks will be dismounted and mounted off the roll with this device.
The roll will be put in the deposit prism with the help of the hall crane. The extracting slide with the lifting device will be positioned below the component by the operator. After the operator has opened the locking mechanism of the roll bearing and removed it with the help of a crane, the component will be discharged by lifting of the lifting device. Through a backward movement of the extracting slide the component will be pulled off the roll neck. The mounting and dismounting will be done independently from each other for both sides (Figure 7 and 8).

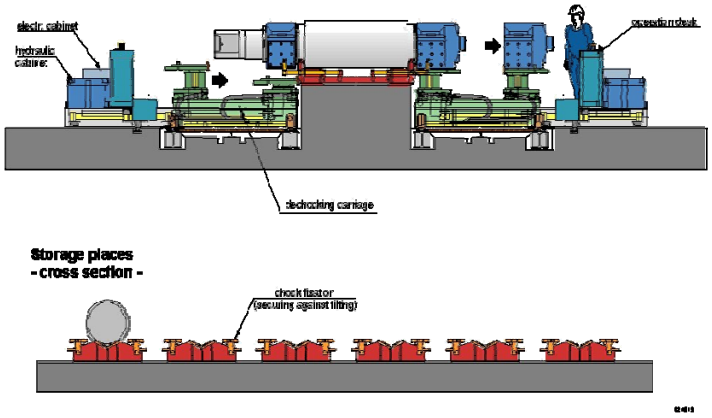

Figure 7: Work roll dechocker.

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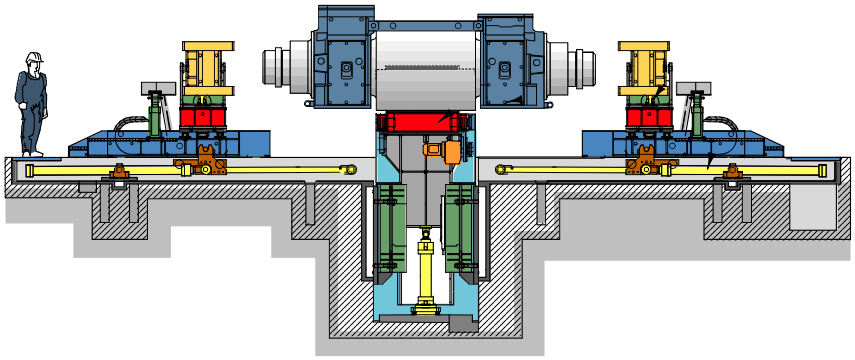

Figure 8: Back up roll dechocker.

Universal chock tilter

In order to ease the maintenance of the chocks, these will be turned by 90° into a horizontal position after pulling them off of the roll necks.

After the maintenance, chock will be put on the tilter in horizontal position with the help of the shop crane. Through an electrically operated system the tilter will be turned by 90°. By this the chock will be taken up from the tilting device in its vertical position. The erection of chocks will be done in reversed order.

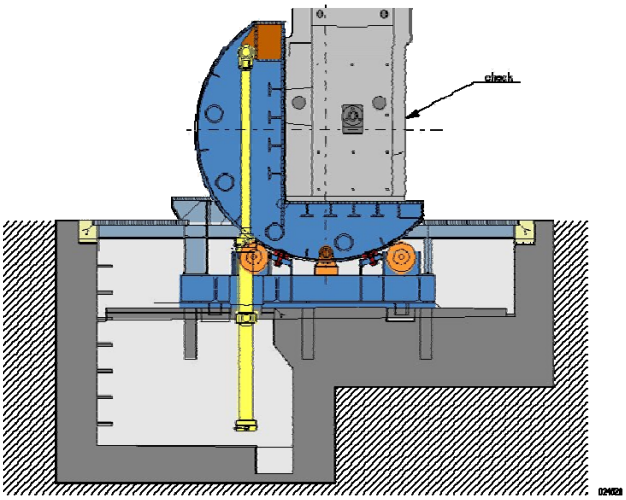

Figure 9: Universal chock tilter.

Roll and chock cleaning

The roll cleaning system is operated in manual mode only (automatic systems are available). The rolls are put on the base by overhead crane. There, they are subsequently cleaned by the pressure washer with hand spray gun to remove all grease, oil and other dirt.

For chock and bearings as well as for other smaller parts this manual unit consists of a cleaning tank which is open on top (automatic systems are available). The parts to be cleaned will be placed on a grating in the tank and will be cleaned manually with a brush which is connected to the cleaning tank with a tube. Via electric foot pedal the cleaning fluid will be supplied to the brush.

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Figure 10 to 12: Cleaning equipment.

Roll storage racks

Different concepts for different roll types are available. For two high racks the loading and unloading technique is as follows. When loading the first level of roll storages the opened setting levers swivel back and will be positioned in a way that its support side turns the second level receptive. As a result the setting lever swivel until they touch the buffer.
Storage racks in automatic zones will be controlled by sensor systems.

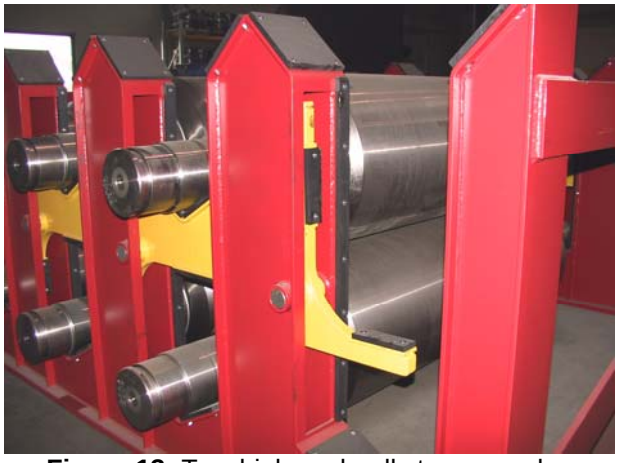

Figure 13: Two high work roll storage racks.

Roll transfer cars

For roll transport between mill bay and roll shop. Systems are available in manual as well as in automatic mode. Loads above 200 metric tones can be realized.
Loading and unloading of the transfer car with rolls is done with the hall crane. The work rolls are to be put on the car in pairs with chocks. Back-up rolls will be put onto the car separately with chocks. The car is controlled by the operator from one of two operator panels after coming into sight. These are located on the lateral sides on the car.

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Figure 14: Roll transfer car.

Automatic roll loaders

Roll handling equipment for all types of rolls for safe handling. From fully automatic systems through to manual lifting beams are available.

Automatic semi-gantry cranes can be used for loading and unloading of the machines with rolls.

The roll racks in front of the machine will be installed as „roll fields“. The sides of the roll fields serve as „transfer buffer”. The operator loads the un-ground work rolls and intermediate rolls from the buffer and the roll fields to the machines and back after machining. Finally the operator will transport the finish ground rolls to the racks by means of the electric overhead traveling (EOT) crane.

The system is designed for manual and semi-automatic loading and unloading of rolls. A fully automatic operation is only possible in case of an interface to a roll shop management system (RSMS) that should then be part of the scope of supply.

Figure 15: Automatic roll loader.

ROLL SHOP MANAGEMENT SYSTEM (RSMS)

While a Roll Shop Management System (RSMS) prepares roll sets for the mill, rolls and their related components run through several process steps. Some of these steps are done on machines and others are done manually. To ensure a constant

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quality of roll sets, it is necessary to plan and to monitor the process steps and to evaluate resulting data.
On the other hand, costs for each step should be categorized and optimized in order to achieve an overall cost reduction. Data from the RSMS and mills build up the basic information for cost optimization.
The Roll Shop Management System links all roll handling facilities, either for production or for roll preparation, to a complete information network. It is an organization system that constantly provides an overview of registered components and allows the user to derive effective decisions for production, planning, quality and purchasing.
As central information storage the system utilizes an ORACLE database to handle data of all roll shop related components. Typical components are rolls, chocks, bearings, grinding wheels and machines.
Basically the tasks of the RSMS are assorted in two categories: database functions and automation functions.
Database functions take care of gathering information and evaluation of this information while automation functions handle the control and monitoring of automatic roll loading and unloading with an auto-loader. The automation is an RSMS-option and can be implemented only if an auto-loader is available.
As a complementation to a RSMS software for optimization of the roll shop are available (Optimizer). This kind of software is set specifically to customers environment and works with the collected data base, finding optimum values for grinding times, grinding wheel consumptions, and so on.

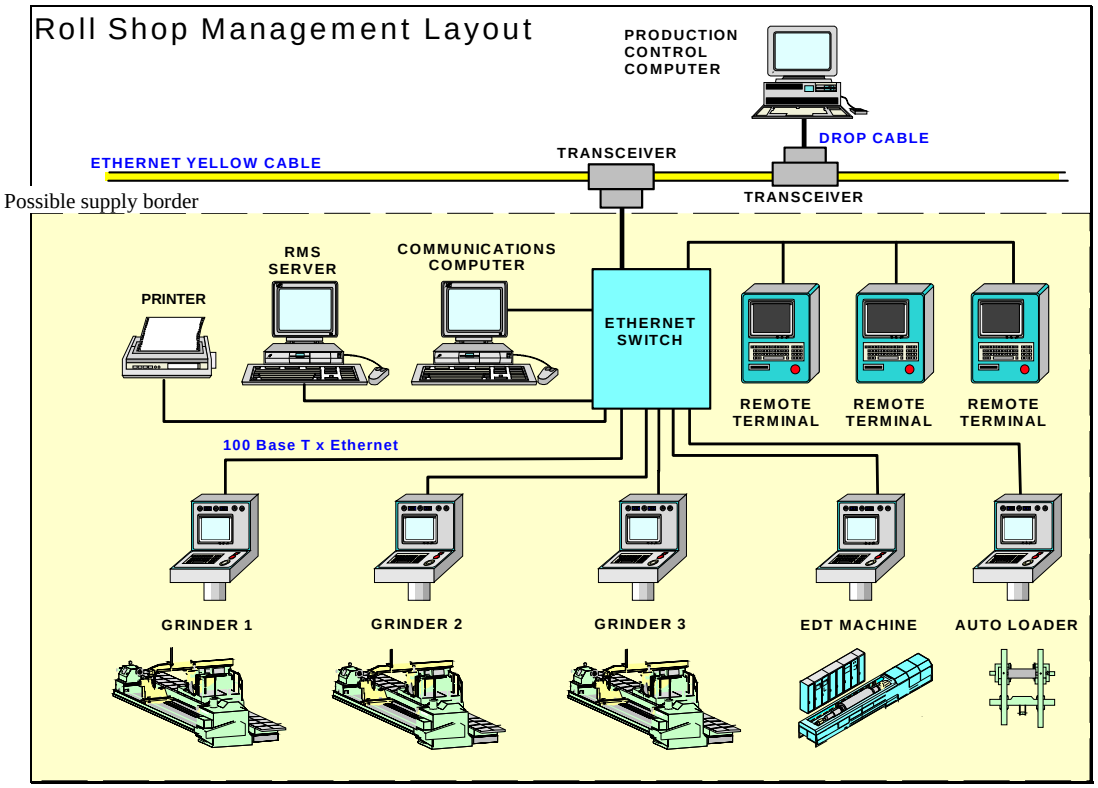

Figure 16: Roll shop management layout.

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SUMMARY

The idea of a fully automated roll shop is not new.
“State of the art technology” allows increasing the productivity and the performance is always on a very equal high level.
This stable and better performance will influence directly the final products.
A detailed investigation of all savings will show that capital investments in a range of 10 to 15 Million US$ have a short return.

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