Advanced technologies for fully automated roll shops

The use of modern digital technology and IT systems coupled with innovative solutions, has enabled the creation of the fully automatic roll shop, including roll grinding, roll shop to mill transport and information systems, which are available on both green field sites and mill upgrades.

Francesco Auteri, Paolo Gaboardi and Claudio Trevisan
Techint Compagnia Tecnica Internazionale S.p.A.
Pomini Roll Grinders Division

● **Figure 1** ***USS automatic roll shop (1989)***

The reduction of costs is a key issue for steel producers and roll shop design has been transformed in recent years by this need; involving increased use of automation and information technology. Since the end of the 1980s, a general trend in the world steel industry towards greater focus on the so-called 'core business' has included minimising auxiliary technical services such that, for instance, the equipment supplier for the steel industry is required to coordinate the technical execution of the contract, while simultaneously increasing equipment productivity.

The equipment supplier has to address these two factors by widening his technical and logistical capability to take care of supervision of construction and supply of equipment and also by developing modern technologies for full equipment automation.

The automation of roll grinders has been typically high, thanks to the use of last generation numerical controls (NC) and to the integration of geometrical and surface measurement data into the grinding process. However, the automation of loading and unloading operations of the rolls onto the roll grinder offers a huge productivity improvement and a significant rationalisation of the work force. The automatic roll loader, resulting from the combination of a sturdy lifting machine – designed to keep the necessary stiffness under high accelerations and decelerations – and NC, meets the necessary requirements of speed, precision, safety and durability. The use of NC instead of a dedicated PLC simplifies the use of complex algorithms and offers a friendly machine interface for the operator. It is also possible to better archive operations data, link with higher-level databases and achieve more efficient control of both preventative maintenance and troubleshooting.

Automatic loader – US Steel, 1988

The first application using roll grinding machines integrated with roll loaders was at US Steel, Gary, Indiana, USA, in 1988 at both cold and hot mills (see *Figure 1*). Four fully automatic roll grinders are served by a single 3-axis roll loader, and the entire roll shop, including the roll cooling system, is controlled by a single operator (see *Figure 2*). This level of centralisation and optimisation of each roll grinder has enabled these roll shops to remain among the most competitive in the world even 15 years after construction. One of the factors that helps to classify equipment capability is the ability to control an automatic machine from a remote station. Even if the operator cannot see the machine directly, it is possible to reach such a goal by means of suitable automation software and appropriate sensors.

At this time, as well as the use of CNC and PLC, industrial PCs appeared that enabled the grinding results, profiles, tolerances, statistical data and operation scheduling to be displayed to the operator in a remote pulpit and stored on the PC for possible future analysis. Each computer installed in the remote pulpit of each machine was connected

through serial interface RS232 with the mill computer level 2 system, which enabled the mill to receive, in real time, the updated status of the rolls in the roll shop area. This approach was further developed in the subsequent years as new technologies became available.

The automation of roll handling within the roll shop requires the application of further safety measures in order to bar personnel from those areas where operations are carried out automatically, and therefore not directly supervised by personnel. This was the first application at a US Steel plant where safety barriers were introduced to mark the limits of the working area of the automatic loader and allow access only for maintenance or emergency purposes.

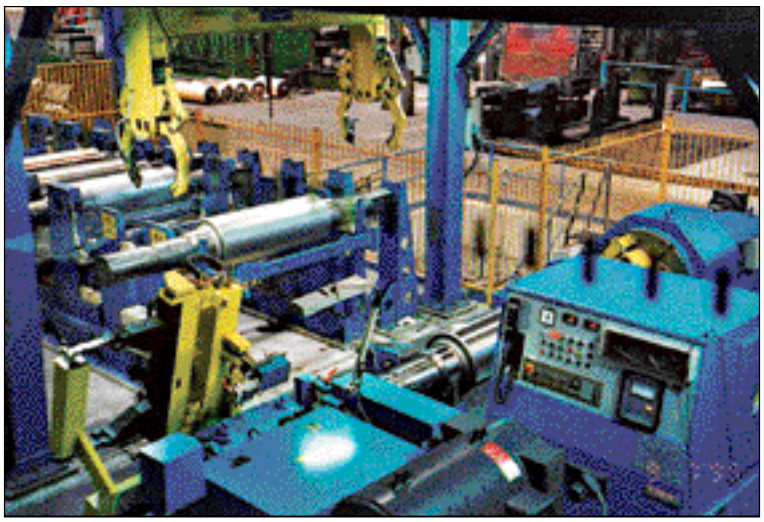
The necessity of assuring the operators' safety in the roll shop required Techint Pomini to develop the necessary safety knowledge in order to be able to interface with the national and business safety norms.

Data management – BHP Steel, 1994-5

Up to the start of the 1990s, with the exception of the US Steel roll shop, the market was orientated towards achieving a loader that was dedicated to a single machine. The maximum synergy of this kind of architecture was achieved in 1994/5 at the cold rolling mill of BHP Steel, Port Kembla, Australia, where two completely automatic roll grinders are located. Each of them is equipped with a 2-axis loader monitored by the NC of the roll grinder (see *Figure 3*). Controlling a roll grinding machine and automatic loader from a remote station was historically seen as an unattainable task, particularly in a cold mill where surface finishing has always been visually controlled by an operator. Since 1995, this has been possible thanks to the machine capability of storing and repeating the performances on the same kind of rolls. The NC must always be well synchronised with the grinding machine and loading system and the Techint solution uses, in this case, a single CNC and PLC for the movement of both the machine and the loader.

The demand for increased data on the features of the ground rolls – roughness and hardness data, and surface checks to exclude the presence of critical defects such as cracks and bruises – has led to the creation of a system based on a database with the function of a roll management system, called Roll Shop Computer (RSC). This has been possible due to the availability of PCs with ever increasing performance and hard disk capacity, the availability of dedicated software to work on databases in an easy and reliable way and the lower costs of the servers, where it is possible to host the main database to store the data received from the devices used in the roll shop. This software is able to collect data, compare information with level 2, and carry out

● **Figure 2** ***Grinder control room***



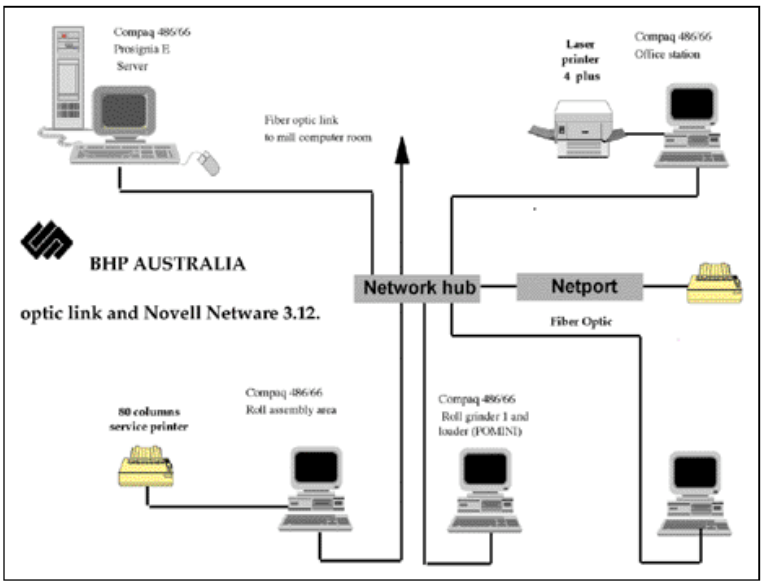
● **Figure 3** ***BHP automatic loader in cold mill***

statistical data analysis focused on optimisation of performances and cost reduction.

Figure 4 shows a flow chart of the roll shop computer software package supplied to BHP Port Kembla.

The quality of ground rolls is preserved by the care, precision and cleanliness of the automatic loader. These features and the repeatability of the roll grinder have completely fulfilled the requirements of BHP by showing that the automation of the grinding operation and the automatic handling of the rolls could be used at an industrial level and on a daily basis in a high-capacity, high-quality cold mill.

From this application the growing integration of roll grinder and loader led to a design effort aimed at the optimisation of the auxiliary racks inside the automatic area. This is correlated with the capacity of the productive unit roll grinder-loader, the productive mix required by the layout, and by the different mills of the customer.



● **Figure 4** ***RSC***

● **Figure 5** ***AST transfer car***

Integration with mill – Acciai Speciali Terni (AST), 1998

By the end of the 1990s the possibilities revealed by the advances in technology allowed the full integration between rolling mill and roll shop to become a reality. The advantages for the customer are the optimisation and automation of roll transportation between roll shop and mill, increasing the processing speed of the roll shop and rationalisation of manpower. This enables a faster reaction to production changes and a decrease in roll stock.

The first application of this new principle was carried out in 1998 at AST (part of the ThyssenKrupp group) based in Italy, during a modernisation and mill automation programme for the direct rolling of stainless steel: a world first (see *Figure 5*). For this roll shop Techint supplied the automatic transfer car between the roll shop and mill, so reducing the handling lead times. The increased use of digital technology enabled the addition of roll surface temperature, measured during handling, to the checked parameters, so providing the necessary feedback to optimise the cooling of the rolls (carried out inside the automatic area and handled by the loader software), and therefore avoiding grinding rolls with excessive surface temperature.

The installation at AST was the first to have a completely digital control (Siemens 840D). Among the advantages offered by this technology is access to the data via a network enabling the development of a modular system, whereby each single element can receive and send information from and to the outside. For example, the roll number is fixed when the roll set is extracted from the mill and taken through the dedicated transfer cars in the roll shop area; and this number follows the roll through all handling operations. The roll data are not lost, even in a power failure since they are stored in 'memory areas' of the PLC using a battery-powered buffer.

The automation level of the AST plant enables it to handle the de-coupling and re-coupling of each set of 'mate' rolls by means of the two loaders, in a completely automatic way. The operator inserts the destination of each roll as a map reference and the handling, control and cooling time are then determined automatically. Although each machine is served by one dedicated loader, it can be used for either machine during maintenance. A further feature of this roll shop is the replacement of four existing roll grinders with two new machines, without decreasing the performance of the mill. In order to achieve this Techint/Pomini developed all the necessary technology and skills to better coordinate the several necessary activities.

Integration with production – Corus (Hoogovens Staal), 1999

The principle of roll shop integration in the production system of a mill was maximised in 1999 in the direct rolling plant of Corus (formerly Hoogovens Staal) at Ijmuiden, The Netherlands. The roll shop is integrated with the mill, both physically via automatic roll handling, and electronically via data exchange for production. In this plant the concept of the roll handler (RH) software package was introduced for the first time which handles rolls in the roll shop area on the basis of production requirements, in order to provide the mill with the necessary rolls in due time. This was a very complex task that was required to allow the production department to plan the handling of rolls, instead of the operators. Each piece of equipment is controlled

by the RH, even the main overhead crane. (see *Figure 6*).

Setting up such a plant required several months of preparation and testing and maximum flexibility to meet the ever-changing requirements during the startup of the mill. The use of RSC and RH mark the Corus roll shop as a state-of-the-art installation.

This particular plant layout, determined by demanding requirements, led Techint Pomini to introduce a completely new concept for roll shops: the exchange area (see *Figure 7*). The exchange area is the interface between the automatic part of the roll shop and the manual one, or the interface between two different automatic areas. It prevents bottlenecks due to the difficult task of co-ordination between two different machines or parts of the plant working on the same rolls.

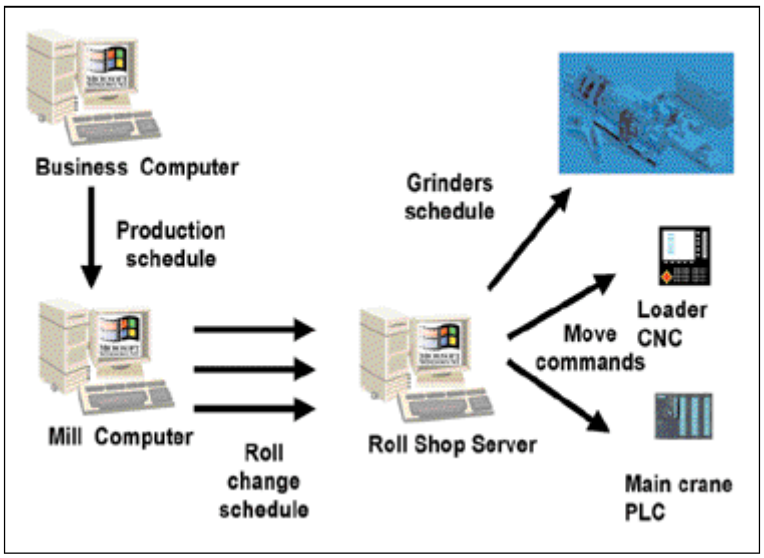
The exchange area of the Corus roll shop is particularly sensitive since the supply of ground work rolls to the mill directly affects its smooth operation. It represents the interface between the high-speed automatic loader and the automated overhead crane that moves the roll sets to and from the transfer cars and shifting tables. The coordination of the exchange area is carried out initially through the RH software, which determines the 'rights of way' in the automatic area in a continuous and flexible way in accordance with the given priorities, the position signals for loader and crane, and the feedback of the anti-collision devices.

Avesta Polarit, 2001

Since the beginning of this new decade there has been a trend of appointing to the supplier the task of technical coordination and global supply. Additionally, increased competition in the steel market and limitations on investment have required customers to reduce the scope and cost of new installations without losing flexibility and low operation costs.

The first example of this new trend was the roll shop for the hot mill of Avesta Polarit in Tornio, Finland. This shop, commissioned at the end of 2002, allows the same automatic operation level as implemented at Corus, but is installed in an existing mill and therefore has a more compact layout. This facility represents the union between the efficiency of automatic, direct roll transportation into the roll shop area, as at AST Terni, and the highest automation level, as at Corus. The exchange area consists of a transfer car, which transports intermediate, work and back-up rolls. The quantity and type of the rolls are identified by means of sensors at the entrance to the shop.

The schedule of grinding operations is calculated on the basis of production requirements from the mill and according to management priorities. The roll grinder is able automatically to change the position of



● **Figure 6** ***Corus – automation flow***

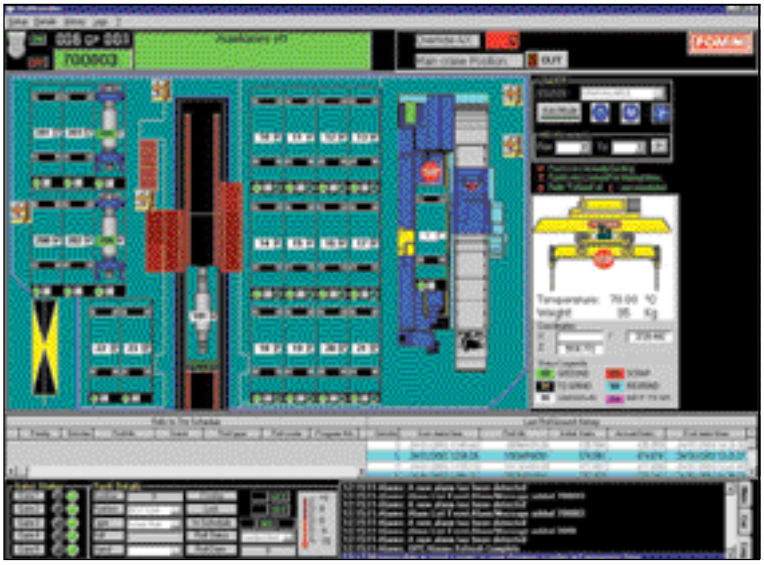
● **Figure 7** ***Corus – exchange area***

the neck rests and footstock according to the dimensions of the rolls to be ground. Only the back-up rolls are ground independently from this automatic process, since the grinding frequency does not justify the investment for a loader that is able to handle back-up rolls with mounted chocks.

Much importance was given to the graphic interface, which must be user-friendly and as realistic as possible. All controls are displayed on screen to allow the operator to focus his attention only on the screen (see *Figure 8*). The same philosophy has been also applied to the roll grinder interface – with great success.

Maximum flexibility – Dofasco, 2003

The second and most recent example of the trend towards automation, but at low cost, is the roll shop



● **Figure 8** ***RH – advanced operator interface***

● **Figure 9** ***New racks: operator interface***

for the cold mill at Dofasco, Canada. The plant consists of an automatic loader, a new roll grinder, a revamped grinder, and a pre-existing one; and features a different level of automatic operation of the loader depending on the capabilities of each of the roll grinders, thus allowing maximum machine output. The different degree of independence of the machines – the new machine is able to automatically change configuration, while the old one needs the constant presence of the operator – set a challenge for Techint Pomini technicians regarding roll shop safety. This is guaranteed by an innovative system of differentiated entry gates, all controlled by RH software.

The IT system also handles different configurations of roll storage, which are based on 2-high or 3-high movable roll racks, in order to transport the rolls to and from the mills. The RH software is not only informed about the number and level of each rack, but also about the type of each roll on the rack and the current location of the rack.

The IT system has been designed to simplify the working environment, facilitate the operator/machine interface and permit personalisation of the software packages according to the requirements of each customer and to the working environment.

It is clear that one should not think of a 'standard' configuration for roll shops, as each customer has different requirements and existing structures. This, however, does not mean that only approximate solutions are possible. Any modern roll shop software must be designed for performance and maximum operator accessibility (see *Figure 9*).

For this reason, the supplier needs specific knowledge of all the elements involved in the project, including the user and his expectations. The necessity of the supplier to take over project coordination, planning and construction of the auxiliary machines for a roll shop has led Techint Pomini to develop the necessary capabilities and relevant technologies to become a supplier for both supervision and auxiliary machinery such as chocking/dechocking, chock tilters, transfer cars and racks for rolls. All these accessories can be included, at different levels and according to opportunity, under the automation of the roll shop.

Conclusions

It has been shown that over time and at different development levels, new IT technologies can be used successfully in the field of roll shop design and construction to meet customer requirements.

As to the future, Techint's goal is always to offer state-of-the-art technology and innovations in order to provide added value roll shops. We can achieve this goal with help from our customers regarding their needs and all those who choose innovative solutions.

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Francesco Auteri is Area Sales Manager, Paolo Gaboardi is Senior Vice President and Claudio Trevisan is Automation Director, all at Techint Compagnia Tecnica Internazionale S. p . A. , Castellanza, Italy.