MODERNIZATION AND UPGRADING OF EXISTING PLANTS – A DECISIVE FACTOR IN THE FIELDS OF HOT STRIP MILLS[1]

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Abstract
A new hot strip mill has a lifetime of several decades. During this time the hot strip mill must be able to meet the market demands for a wide range of steel grades especially for high-strength steel and advanced steel grades with superior strip quality. And also during this time the hot strip mill will see good economic times, when availability and maximum productivity are most important, and bad economic times, when the reduction of operating cost and the development of new products and materials is the target. This paper is about ways to reduce operation costs and ways to implement technological features which allow new, more attractive market niches to be entered. Based on the extensive experience in the equipment and process modernization of hot strip mills, Siemens VAI has established a number of modernization packages which can reduce production cost and improve product quality performance. Examples of these modernization packages across the whole productions route are shown in this paper.
Key words: Hot strip mills; Modernization; Cost reduction.

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Introduction

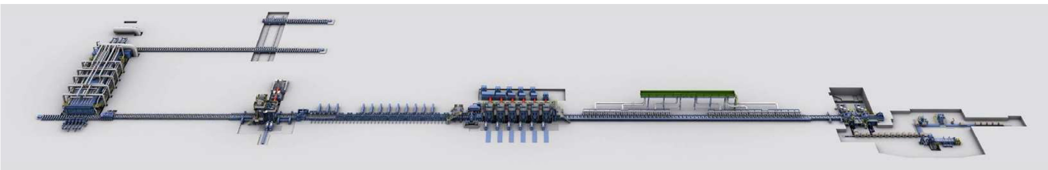
Siemens VAI has developed several technology packages especially dedicated to the modernization of existing mills. It is essential to shorten the downtimes of the mill when installing the new equipment. This can be achieved by offline assembly and pre-testing of the components in the workshops. The components and line concepts for hot-rolling mills follow standardized modules that are optimized in terms of delivery time, functionality and complexity. The packages comprise know-how and expertise in process technology, layout competence, mechanical equipment, electronics, hydraulics, drives and automation systems as well as turnkey competence from Siemens VAI’s in-house resources.

SIROLL^{CIS} HM modernization packages

The SIROLL^{CIS} HM modernization packages are classified according to the targets into

1. Improvement of product quality
2. Extension of product mix
3. Reduction of conversion costs

An example of an efficient package for reduction of conversion costs is reheating furnace optimization and furnace/mill pacing. It is also an example of a “green solution” that drives hot strip mills towards a responsible utilization of resources.
Also “green” is the work-roll lubrication package, which is useful for the improvement of product quality and product mix as well as for the reduction of conversion costs.
Safety, which is becoming more and more important in the steel industry, can be improved with modernization packages, leading also to a reduction of conversion costs in most cases. An example is the pinch-roll polisher package, a new development of Siemens VAI.
These three packages are discussed in this paper.



Furnace Area, Roughing, Transfer table	Finishing Mill	Laminar cooling, coiler and transport
▪ Reheat furnace optimization ▪ Hydr. controlled side guides RM ▪ Encopanels ▪ Coilbox	▪ Upgrade of crop shear (e.g. crank type) ▪ Booster AGC for roll-force increase ▪ Work roll barrel lubrication ▪ Hydraulic AWC incl. controls and models ▪ Hydraulic AGC incl. controls and models ▪ Shifting & bending (SmartCrown, L-block) ▪ Work roll cooling	▪ Upgrade laminar cooling & water system ▪ Cooling models; micro-structure monitor ▪ Pinch roll polisher ▪ Hydr. controlled side guides DC ▪ SIAS surface inspection ▪ Power Coiler ▪ Coil transport ▪ Sample taking station
▪ Advanced rolling models ▪ Strengthen of drive system (motor, gears, etc.) ▪ Fast actuators and advanced automation ▪ Plant safety		▪ Frequency controlled pumps ▪ Energy management system ▪ Consultancy ; level 3 systems

Figure 1: Overview of SIROLL^{CIS} HM modernization packages for hot strip mills

Reheat furnace optimization and furnace/mill pacing

Hot strip mill operations require high-quality reheated slabs at the lowest possible cost at the mill's optimal production rate. The heating strategy has a major influence on both the quality of reheated pieces and on the amount of fuel used for reheating. A traditional, non-optimized heating strategy may seem sufficient under steady-state conditions but does not provide optimal quality and cost performance when there are interruptions in production, variations in product grades or dimensions, or variations in target dropout temperatures. Therefore, a solution is needed to deliver the highest-quality and lowest-cost heating under all conditions with minimal impact on the environment.

SIROLL^{CIS} Furnace Optimization is a complete hardware and software solution that provides the latest technology in supervisory control of the reheat furnace. The system calculates and tracks the thermal condition of individual pieces inside the furnace, including hot-charged pieces. Based on this information, optimal zone temperature setpoints and furnace production rates are determined. The system takes into account both planned and unplanned delays in rolling production—minimizing fuel consumption during idle times and optimizing the ramp-up of setpoints in anticipation of continued production. Therefore, information from the mill pacing that provides the expected run times for slabs at furnace entry is used, if available. The optimized heating strategy results in accurate discharge temperatures, minimal surface scale formation, minimal decarburization, minimal fuel consumption, and minimal CO_2 emissions – all while respecting the desired piece-to-piece dropout rate and maximum temperature gradient within each piece. The system is well-proven in many applications for reheating furnaces with various configurations, including walking beam, pusher, multiple furnaces, multiple rows per furnace, etc.

The major components included in the SIROLL^{CIS} furnace optimization system are:

- An on-line, multi-dimensional thermal model calculates piece temperatures and gradients while accounting for changing product dimensions, varying initial temperatures (including hot charging), skid marks, and material grades. The model is used to predict the heating of every piece in the furnace. Modeled sections and heat transfer control paths are configured based on product type (see Figure 2 and Figure 3).

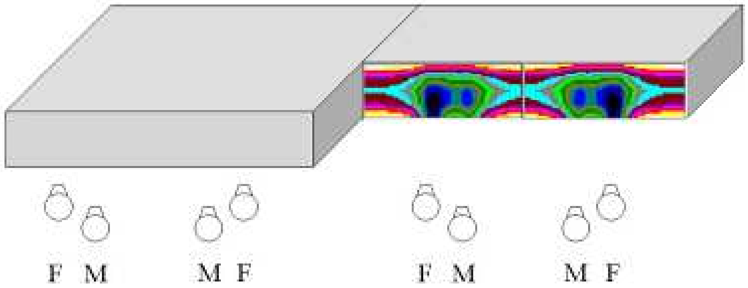


Figure 2: Modeled section of a slab

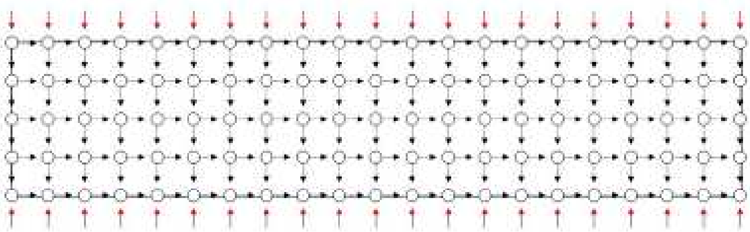


Figure 3: Heat transfer control path configuration for a slab

- Furnace control software strategies provide optimized zone temperature and production rate setpoints to consistently produce properly heated pieces.
- Delay management software adjusts zone temperatures to maintain the proper product temperature during delay conditions, to permit resumption of production at the end of the delay while minimizing fuel consumption and achieving quality goals.
- Furnace and mill pacing software maximizes production while accounting for the requested discharge interval and the available heat input of the furnace. The system uses minimum piece-to-piece discharge intervals and a rolling schedule to calculate residence profiles (location/time profiles) for all pieces in the furnace. The rolling schedule comes typically from a superimposed production planning system. With this information, the mill pacing system requests the predicted run times from the model setup calculation and calculates the total run times while respecting the requested minimum distances and times in the plant. After discharge, the mill pacing system tracks the slabs and updates the run times. From this data, the mill pacing system calculates the optimum discharge time for the next slab, which is then sent to the furnace optimization system. Based on the calculated residence profiles, an optimized heating strategy is determined. If the facility throughput is furnace-limited, the optimization system aims to provide properly heated pieces to the mill as quickly as possible without violating the heating requirements. If the facility throughput is mill-limited, the optimization system seeks to provide properly heated pieces to the mill "just-in-time" by decreasing the furnace zone temperature setpoints to minimize fuel consumption (see Figure 4).

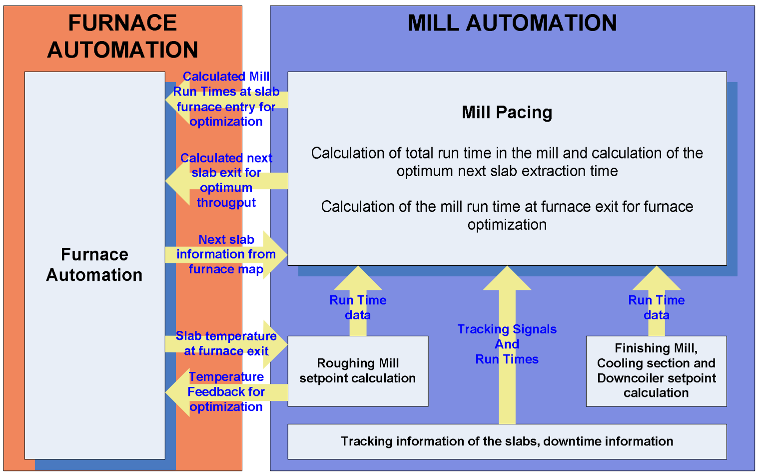


Figure 4: Overview of the interaction of the furnace automation and the mill pacing

- Operator interface hardware and software display information to the plant operators and provide operator input functions (see Figure 5).

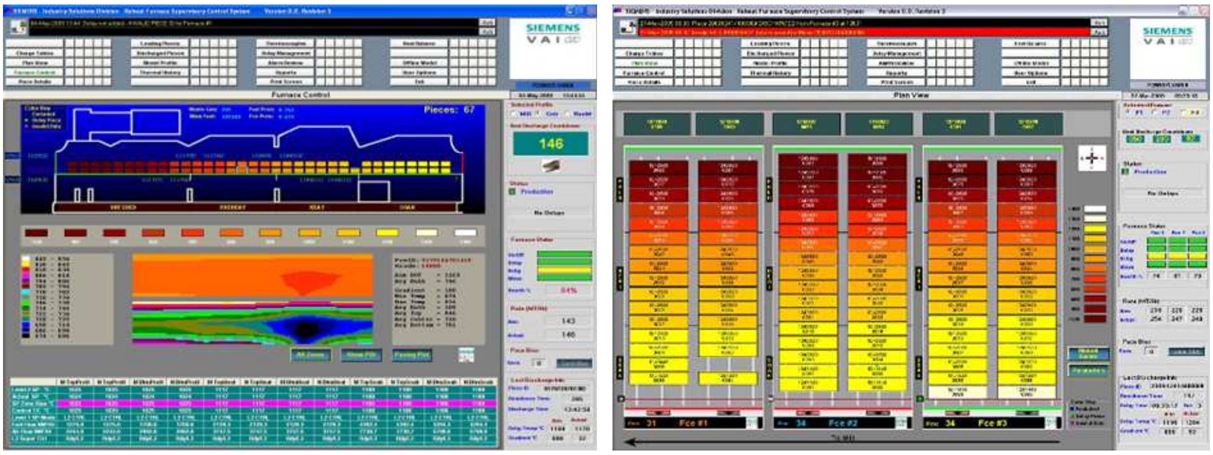


Figure 5 : Typical operator interface screens

- Adaptive feedback software biases the target discharge temperatures according to the mill temperature feedback and typical rolling practice.
- Data acquisition software collects furnace and product information for accurate piece tracking, production and quality reports, operator interface screens, and any desired data transfer to higher-level computers.
- An off-line model,a design and analysis tool, brings flexibility to a system that is expected to handle new product grades and sizes that might be added to production in the future. The off-line model uses the same heat transfer calculation subroutines as the on-line model. It allows the user to input different product data and furnace conditions in order to generate desired “what if” types of scenarios and calculates the results under those conditions. The off-line model proves to be a very useful design tool at all stages of system development, commissioning, tuning and on-going usage.

SIROLL^{CIS} furnace optimization is designed in a client-server configuration with Ethernet communications between a single-server computer and multiple Human-Machine Interface (HMI) client computers (see Figure 6). The server is typically implemented on the Windows platform and is also available on other platforms.

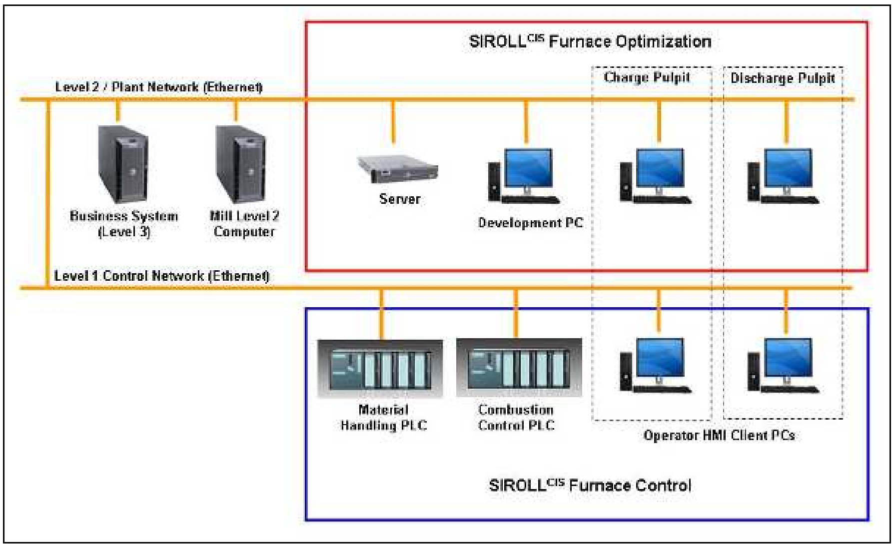


Figure 6: Typical system architecture

The SIROLL^{CIS} furnace optimization system provides optimized setpoints to the SIROLL^{CIS} furnace control system which provides basic automation for material

handling and combustion control equipment. The system can also be integrated with existing basic automation systems, as well as other existing computer systems.
Summary of the benefits of SIROLL^{CIS} furnace optimization:

- Reduced energy costs and CO_2 emissions—fuel consumption reduced by 6 to 15%
- Consistent piece-to-piece discharge temperature performance—average bulk temperature within 1% of target temperature
- Temperature consistency within each piece—variations within the heated piece as low as 1% of the target temperature
- Reduced scale formation and decarburization—surface quality is improved as a result of the optimized heating strategy
- High productivity—quality goals are achieved while respecting the desired production rate. Tighter control of dropout temperature, so no need to overheat pieces to be "safe".
- Optimal furnace pacing based on information from the mill pacing system
- Improved rolling mill gauge performance—temperature consistency from piece to piece and within each piece results in consistent hot rolling stock

Work-roll lubrication

The motivation for installing the barrel lubrication on work rolls is to avoid surface defects due to rolled-in scale and to reduce roll wear, which has a high impact on conversion costs and on the limitation in scheduling. The application of lubrication media onto the work rolls is dedicated to reduce friction.
Most of the equipment used for this application is mounted onboard the finishing-mill stands, close to the work rolls, such as spray nozzles and mixing unit (see Figure 7) Additionally, external equipment such as lubrication unit, electrical control (automation, visualization, data-processing) and supplies of air, water and oil is installed.

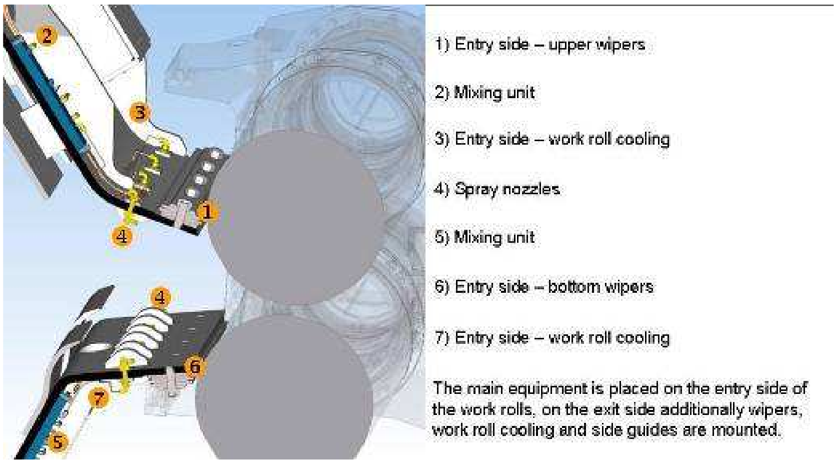


Figure 7: Work-roll lubrication equipment

The core of the work-roll lubrication system is the proper function of the wiper system. The entry wiper design for roll gap lubrication is a special sandwich-composition to get best sealing conditions. The sealed entry roll gap ensures a low consumption of oil, with the entry work roll cooling permanently switched on, which is important for a high throughput of the mill. This design also ensures safe operation for special steel grades such as silicon grade, pipe grade and high-carbon grade.

The lubricant is applied at the entry side of the finishing mill stands, the oil/water mixing unit being located on the top and on the bottom entry wiper in order to produce the required oil/water ratio close to the wiper and work roll surface. A special nozzle arrangement and an optimized nozzle design ensure optimum consumption consumption and distribution of the lubricant. (see Figure 8)

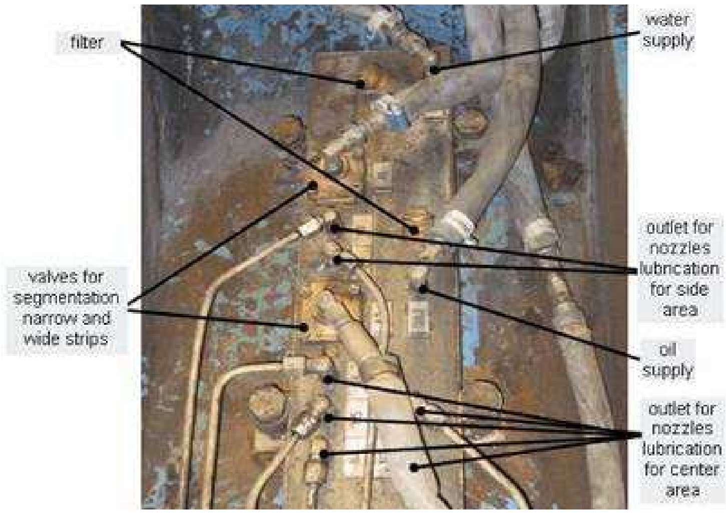


Figure 8: Oil/water mixing process and application

With standardized interfaces and flexible communication options it is easy to integrate the roll gap lubrication into to automation of an existing plant.
The benefits of work roll lubrication include aspects of improvement of product quality, extension of product mix and reduction of conversion costs and can be summarized as follows:

- Improved strip surface quality
- Saving costs
  - Less work roll wear
  - Less demand on electrical energy
  - Low oil consumption (40–80 ml/min per mill stand)
  - Separated arrangement of pipes ensures system availability and ease of maintenance
- Extending mill utilization time
  - Longer rolling campaigns
- Extending mill limits
  - Higher maximum thickness reduction
  - Lower thermal motor load
  - Reduced minimum gauges
- Lower energy consumption
  - Reduction of deformation power by 20%
  - Impact on deformation energy related to a total strip: -13% (reference: 2 mm)

Pinch-roll polisher

The automatic pinch-roll polisher was developed to detect and locate remove surface applications for the upper and lower pinch rolls. The design of a pinch-roll polisher is shown in Figure 9.

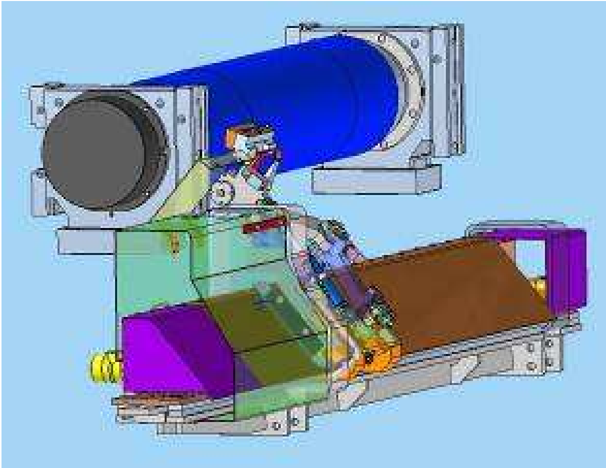


Figure 9: Pinch-roll polisher in 3D design

Material deposited on the surface of pinch rolls during strip coiling on the hot coiler negatively affects the strip surface and must be removed periodically by means of grinding. Line operators have traditionally carried out this dangerous procedure with a hand-held grinder during regular operations. In order to avoid the dangers involved in this procedure, plant managers have long been looking for an automated solution to the problem.

A new development by Siemens VAI is a new generation of pinch-roll polishers which are now in operation at voestalpine in Linz, Austria (Figure 10), and will be installed at Jindal Stainless in India. The development of this pinch-roll polisher was the subject of a research cooperation with voestalpine Stahl.

Figure 10: Pinch-roll polisher installed at voestalpine Stahl, Austria

The innovative technology is based on a grinding system that traverses the rotating pinch roll and automatically recognizes material deposits. By means of oscillating movements, the unit then grinds the deposit only where it occurs until it has been removed. The system also automatically inspects the surface profile and wear condition of the pinch roll in order to determine the optimum time for roll changing (Figure 11).

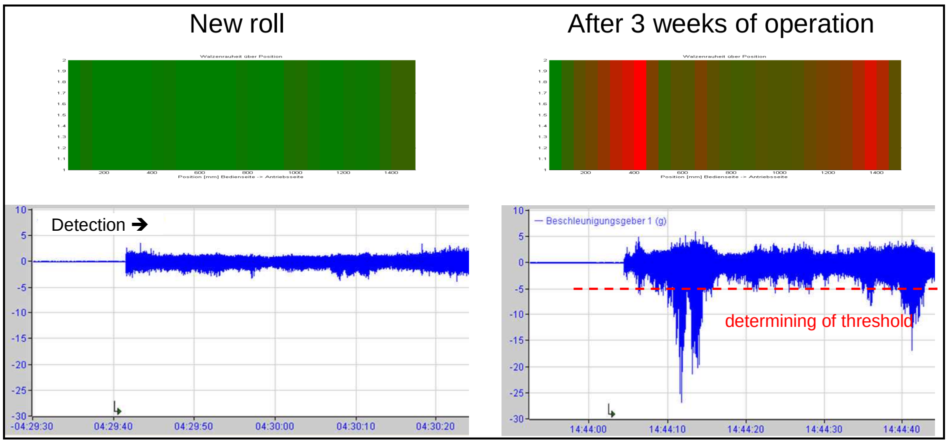


Figure 11: Inspection of surface profile and wear condition of the pinch roll

The principle of detection and removal of stickers is that the grinding head is equipped with vibrations sensors. Areas with deposits cause an increased vibration of the grinding head. If the vibration level reaches a certain limit the position is stored, the grinding head oscillates at stored positions and grinds off deposits. The average duration of a total cycle is only 100 sec, that means pinch-roll polishing can be done during regular operation, so there is no downtime of the hot strip mill.
By installation of the pinch-roll polisher the strip surface quality will be improved, the non-conformity costs will be reduced through permanent detection of pinch-roll surface defects and cleaning of the pinch-roll surface. Due to full automatic function safer work conditions for operators will be provided.

Concluding remarks

The future is made by decisions and actions in the present. Through the application of SIROLL^{CIS} HM modernization packages, plant manager of hot-strip mills can do effective actions for thriving on the crisis.
Therefore Siemens VAI specially provides studies for hot strip mills – enabling for cost reduction to be identified and quality level and productivity to be improved.