FIT FOR THE FUTURE BY MODERNIZATION LATEST SOLUTIONS FOR TANDEM COLD MIIIS [1]

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Abstract
Following the steady and rapid growth of the world´s steel markets in recent years, a period of consolidation has now begun. Rolling mill owners are well advised to use the time to upgrade their plant and equipment to the state of the art in technology and efficiency in order to meet future demands. The modernization of plant and equipment is an important part in the portfolio of the Cold Rolling Mills Division of SMS Siemag. Customers profit from the vast experience which SMS Siemag has gained in this field. More than 40 revamping projects carried out during the past ten years give proof of that. The main challenges of a revamp lie in installing and commissioning the highest-quality equipment within the shortest possible downtime. The paper describes the benefits achieved by our customers through the use of X-Roll® solutions for higher availability, reduced maintenance cost and more efficient operation, including, e.g., T-Roll® for a detailed analysis of the process and its tribology, the products of SMS Lubrication, T-Clean, a new lubrication and cleaning approach, as well as the most modern design feature of our equipment.
Key words: SMS Siemag AG; Tandem cold mills; Modernization; SMS Lubrication T-roll®; X-Roll® Design;, T-Clean; Laser welding machine.

PREPARADO PARA O FUTURO ATRAVÉS DA MODERNIZAÇÃO SOLUÇÕES DE ÚLTIMA GERAÇÃO PARA LAMINADORES TANDEM A FRIO

Resumo
Após o rápido crescimento contínuo dos mercados de aço mundiaIs nos últimos anos, inicia-se agora um período de consolidação. Os proprietários de laminadores estão bem orientados ao utilizar esse tempo e atualizar as suas plantas e equipamentos com as tecnologias mais modernas e eficientes, de forma a atender futuras demandas. A modernização da planta e equipamentos é uma parte importante no portfolio da divisão de laminação a frio da SMS Siemag. Os clientes se beneficiam da vasta experiência que a SMS Siemag adquiriu neste campo. Mais de 40 projetos de modernização realizados durante os últimos dez anos são uma prova disso. Os principais desafios de uma modernização estão em instalar e comissionar equipamentos da mais alta qualidade dentro de um tempo de parada o mais curto possível. O trabalho descreve os benefícios obtidos por nossos clientes através do uso de soluções X-Roll® para maior disponibilidade, custos de manutenção reduzidos e uma operação mais eficiente incluindo, por exemplo, o T-Roll® para a análise detalhada do processo e sua tribologia, os produtos da SMS Lubrication, T-Clean, uma nova abordagem de lubrificação e limpeza, bem como os recursos de projeto mais modernos de nosso equipamento.
Palavras-chave: SMS Siemag AG; Laminadores tandem a frio; ModernizaçãoM SMS LubricationT-roll®; X-Roll® DesignM T-Clean; Máquina de solda a laser.

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INTRODUCTION

In recent years, the steel industry has achieved remarkable growth rates worldwide. However, this time is now over. For the coming year, analysts are expecting a consolidation of demand. This will lead to increased competitive pressure in the steel industry worldwide and a favorable cost structure will then becomes the key success factor in cold rolling.
To achieve such a cost structure in the light of increasing product requirements, including enlarged steel varieties, tighter geometrical tolerances and increased yield strength, efficiency in operation needs to be improved by reduced energy consumption, maintenance effort and personnel costs as well as by enhanced availability.
While new plants are “state-of-the-art” regarding these requirements, existing plants have equipment and technologies that are often far away from being up-to-date. Qualified maintenance and more experienced operation alone will not ensure competitiveness of these facilities over time.
Hence it is important that the process is optimized and the plant is modernized from time to time. The hidden potential of a plant can often be utilized through reasonable investment. As a result, it will meet today’s requirements in the same way as the latest-generation mills, while keeping its capital cost advantage.
Focusing on tandem cold mills (TCM), the most important measures for improving the cost structure under consideration of increasing market demands are:

- Process optimization: Measures increasing the plant efficiency through optimization of the rolling process using available functionality;
- Enlargement of the product spectrum and improvement of quality: by reinforcement of the actuators or implementation of new ones, bottlenecks in rolling should be overcome and the product spectrum as well as the product quality should be increased. This kind of modernization aims, for example, at features for flatness control, edge drop control, surface quality and ~~for~~ the rolling of higher-strength steel.
- General revamp of tandem cold mills: without changing the configuration of the production line after many years of operation, worn-out mechanical and hydraulic systems and outdated electrical and automation systems need to be revamped or exchanged. The main target is to reduce the conversion cost by increasing the availability and reducing the maintenance and personnel costs.
- Change of operating mode: depending on where producers see their market, the change from batch to continuous operating mode, such as a linked Pickling Line/Tandem Cold Mill (PL/TCM), is needed. Today most new tandem cold mills are built as PL/TCM from the very beginning. The main target here is to increase the throughput and to benefit from the concept in the same way as their competitors.

PROZESS OPTIMIZATION

For optimizing the cold rolling process and for an improved product quality, SMS Demag has developed T-Roll®, a physically-based model which considers the complete mechanical and thermal description of the roll gap and, in a unique way, the tribology and the roughness transfer between the work roll and the material being rolled. In addition to the dependence upon the rolling speed, the tribological model takes into account the type and composition of the lubricant, the roughness of rolls

and strip, the thickness of the oil film on the strip and the general pass-schedule parameters.

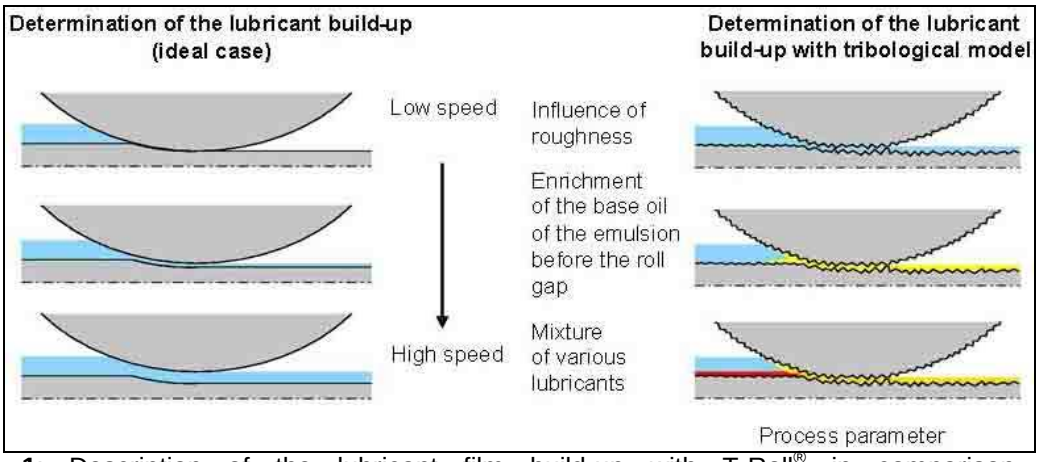

Figure 1: Description of the lubricant film build-up with T-Roll® in comparison to the conventional ideal case approach.

T-Roll® thus helps to determine essential requirements of the lubricant. Together with lab tests, this allows the lubricant to be adjusted to the particular process conditions. This optimization, which is carried out in close cooperation with SMS Lubrication, the supplier of lubricants and latest filter technology within the SMS group, opens up a number of opportunities for improving the process, the quality of products and therefore the performance of the plant. Examples are prevention of chattering, enhancement of reduction, increasing of rolling speed and improvement of surface quality.
Moreover, optimized lubricants help to reduce energy consumption of the mill. In times of rising energy costs, this is an aspect of major interest.

References

References for detailed process analyses in form of a technical study were made, for example, for Ekostahl, Eisenhüttenstadt/Germany and SSAB in Borlänge/Sweden.
Ekostahl wanted to couple its five-stand tandem cold mill to a pickling line. The customer had doubts about the dimension of the emulsion system for continuous operation in the future. SMS Siemag proved, through its detailed analysis, that the emulsion system had hidden potential to cope with the challenge.
In an ongoing study for SSAB we are investigating the further improvement of strip quality safety issues as well as the application of our T-Clean system. T-Clean is a new lubrication and cleaning concept, based on the combination of low-quantity lubrication and the use of liquid nitrogen. Originally it was developed in cooperation with our partners for skin pass mills. In tandem cold mills the system can be applied to the last stand.

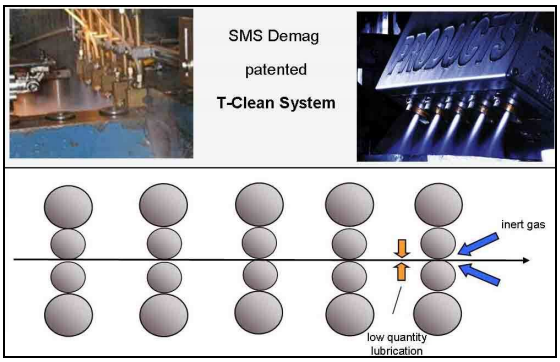

Figure 2: Basic principle of the T-Clean system.

The lubricant is atomized at the entry side using an amount which will be consumed in the roll gap. The liquid nitrogen is applied at the exit side and covers both strip and roll surface. The benefits of this technology are:

- Improved surface quality and flatness
- Extended work-roll service life
- Lower work effort on the strip afterwards, and
- Separate emulsion system for the last stand is not required

ENLARGEMENT OF PRODUCT SPEKTRUM AND IMPROVEMENT OF QUALITY

Steel is multifunctional, efficient and undergoes continuous further development and refinement. The refinement objectives are further reduction of strip thickness, increasing of yield strength and improvement of formability. The results of this are special requirements for the cold rolling mills and, of course for tandem cold mills.
In order to ensure a constantly perfect product quality over an even wider product spectrum, SMS Siemag has developed a large number of special systems which can be applied independently of the age of a TCM.

CVC®plus and flatness control

For excellent strip flatness we offer our CVC®plus technology, which summarizes the experience gathered in more than 200 applications of our CVC® technology in the last 20 years. Besides minimizing the axial forces, CVC®plus has an extended roll-gap setting range by means of a special roll contour. That allows rolling of even wider product ranges in terms of material strength and strip dimensions.
In addition to CVC®plus, flatness defects of higher order – symmetrical or non-symmetrical – are treated by selective multi-zone cooling through cooling of particular areas of the roll surface.

Edge Drop Control

Edge drop is a phenomenon during cold rolling that leads to an undesired fall in strip thickness at both edges. These parts of the strip must be considered as scrap and be removed by side trimming. SMS Siemag has developed an Edge Drop Control System (EDC®) to compensate the edge drop by shifting a specially designed work-roll barrel contour close to the strip edge in closed-loop control.

Table 1: EDC® references

Customer	Year of contract	Mill type	Edge Drop Control		
			Provisions for later installation	Mechanical equipment	Closed loop control
Shougang JT, Caofeidian/China	2008	PL/TCM	●		
Handan Iron & Steel, Handan/China	2008	TCM	●		
Tianjin, Tiantie/China	2006	PL/TCM	●		
Shougang, Beijing/China	2005	PL/TCM	●		
Baosteel, Shanghai/China	2005	PL/TCM	●		
Wisco, Wuhan/China	2003	PL/TCM		●	
Baotou Steel, Baotou/China	2003	PL/TCM	●		
Handan Steel, Handan/China	2002	PL/TCM	●		
ThyssenKrupp Steel, Germany	1999	PL/TCM		●	●

Rolling of higher-strength steel

Cold rolling of high-strength steel can be performed to some extent by increasing the rolling force and the rolling torque. However, if thinner final strip thickness is required, typical 4-high and 6-high mill stand configurations reach their limit. In this case, for economical production, work rolls with smaller diameters and lateral support are necessary.

Therefore SMS Siemag developed the CVC®plus 18 High stand type which combines the advantages of Z-High technology with CVC®plus and horizontal stabilization HS. As multipurpose mill with this technology it is possible to change from a CVC®plus 4 High to a CVC®plus 18 High configuration within the normal roll change time. This improves significantly the flexibility of a tandem cold mill regarding the product spectrum and the final thickness.

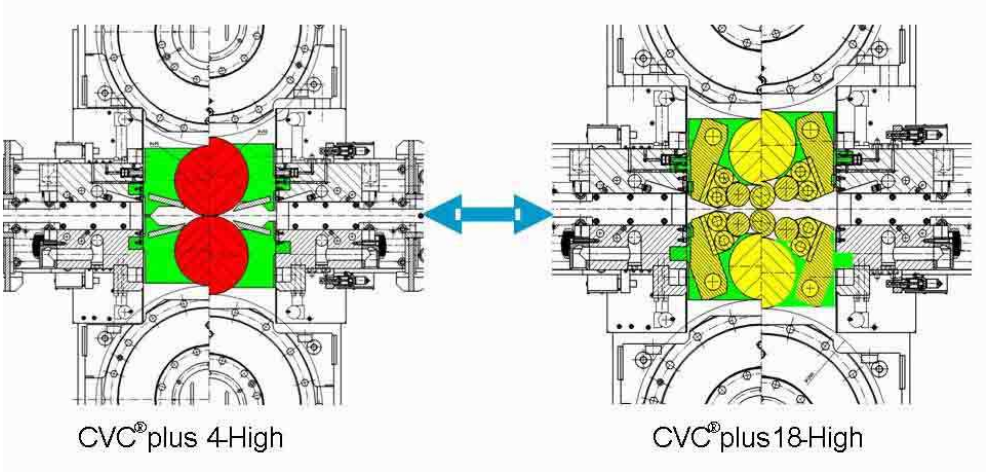

Figure 3: Changeable mill stand configuration.

Furthermore, the rolling of high-strength material also requires stronger shears. Our drum shear model 550 is especially designed to cut high-strength material. The shearing capability allows cutting of material with a strength of up to 1800 N/mm^2 and widths ranging from 600 mm to 2100 mm. The compact cassette design of the shear is easy to change and very maintenance-friendly.

Figure 4: Drum shear model 550.

Improving surface quality

The implementation of the Dry Strip (DS) System, characterized by low pressed air consumption and noise level, reduces costs in the downstream processes since certain cleaning treatments can be omitted. The DS System will always be installed on the exit side, efficiently blowing the rolling agent from the top and bottom sides of the strip and sucking away the remaining agent at the edges, which results in the production of spot-free and dry strip.

Reference modernization of the semi-continuous five-stand pickling line/tandem mill, ThyssenKrupp Steel, Dortmund, Germany

ThyssenKrupp Steel decided in 2002 to modernize their five-stand pickling line/tandem mill in Dortmund. The modernization objectives were the improvement of product quality and the increasing of production by continuous operation mode from 1,980,000t to 2,300,000t per year. The modernization work mainly took place while production was running, with only two shutdowns being needed.
SMS Siemag delivered and commissioned:

- Hydraulic adjustment systems in stands 1 to 5, a multi-zone cooling and a dry strip system at the last stand
- A new double-reel unit in the exit section of the tandem mill, with coil car and shuttle car
- Inline inspection in the exit section of the tandem mill

The delivery was rounded off by the completion and adaption of the media systems.
Just to describe it in more detail: The exit section comprises a drum shear with two pinch-roll units, strip tensiometer and flatness measuring rolls, two tension reels with belt wrappers and coil lifting cars for transferring the rolled coils onto a coil transfer car. Two direct-driven tension reels in cassette-type design for a maximum coil weight of 52 t. An essential feature of the modernized pickling line/tandem mill is the new inline inspection “Rotary Inspect”. This is arranged downstream of the second reel. “Rotary Inspect” is the new ergonomic, easy and save way for reliable inspection of both strip surfaces. Especially for surface sensitive products, like exposed automotive application, the required high inspection frequency will be achieved.


Figure 5: Inline Inspection

The final revamping took place during a shutdown of only 34 days. An important precondition for achieving the time schedule was the complete pre-assembly of the media platforms inclusive of piping and the exit section in our Hilchenbach workshops.

GENERAL REVAMP OF TANDEM COLD MILLS

Worldwide 257 tandem mills are in operation today. More than 140 mills are over 20 years old. Statistics show that most of them are revamped after 25 to 35 years of operation. After such a long period a mill needs a general revamp including, besides new actuators, the hydraulic system, possibly the entry and exit section, and more reliable interstand equipment, the exhaust system, and possibly a new cladding. Furthermore, large parts of the electrical installation should be changed, such as the main drives. After adding single functions to the automation system over the years, a general revamp allows such mills to take the opportunity to install a consistent digital automation system.
The main objective of such revamps is to reduce the conversion cost by reducing the maintenance effort, raising availability and increasing the automation rate.
As supplier of integrated solutions, SMS Siemag has developed its mechanical, hydraulic and electrical and automation system further for sustainable improvement of operation and product quality.
On looking at a mill stand, independently of the mill stand type, important mechanical components to be revamped or exchanged are:

- Hydraulic screw-down system with improved maintainability by allowing full access to the position transducer without disassembling the HGC Cylinder
- Bending system using our well-proven cartridge design with a minimum number of hydraulic cylinders.
- Shifting system which is the prerequisite for using our CVC technology to improve strip flatness
- Wedge adjustment system allowing full automatic adjustment of the pass line to ensure constant rolling conditions and increase the reproduction of the product quality.

Besides the internal components adapted to the situation in the particular mill stand, other efficient solutions of SMS Siemag are, e.g. the modular hydraulic system as well as our revamp concept for the electrical and automation system.

Modular hydraulic system

In general SMS Siemag has implemented the modular design approach to cold rolling mills and their auxiliary facilities in order to improve the economic efficiency in any phase of a plant life-cycle. With this concept we are able to cut the investment

costs and speed up commissioning as well as reduce shutdown times during modernizations and simplify sustainable maintenance.
Regarding the hydraulic systems, the results of modularization are that all hydraulic valves are located on a media platform on the top of each mill stand. Hydraulic functions, e.g. hydraulic gap adjustment or work roll bending are implemented in dedicated modules. These modules are combined in a compact column design.


Figure 6: hydraulic systems in modular design

The connection to the hydraulic actuators is made by using pre-fabricated pipe side walls. All these modules are tested in our workshop, which reduces malfunctions on site and erection time.
Also the hydraulic station itself is modularized. It is equipped with speed-controlled pumps which help to reduce the power consumption of the mill.
The modular hydraulic system is thus a very economical solution for today and offers convenient opportunities for adaptation and extension in the future.

Electrical and automation system

Regarding the electrical and automation system, SMS Siemag can look back on a long history. Already at the end of the seventies, SMS Siemag developed control systems to fully utilize the equipment delivered and to optimize the process. Examples are: the highly dynamic and accurate thickness control, utilizing our hydraulic gap cylinder design, or our Level 2 process models developed from our tools for mill dimensioning
Today we provide the complete electrical and automation system for all our equipment. The unique features of our electrical and automation revamp concept are our Plug & Work test and our PIOS solution, which allows parallel operation and step-by-step conversion of the automation system.
Plug & Work is a tool developed by SMS Siemag that significantly accelerates commissioning both in modernization and in new plant projects, as well as offering much better operational reliability. In this test, the new hardware and software, just before they are delivered to the site, are checked against the simulated equipment and process behavior of the particular plant. The benefits of doing so are a tested and pre-optimized automation system, shorter commissioning time and the opportunity to train the customer's operators already using the equipment which they will find on site.

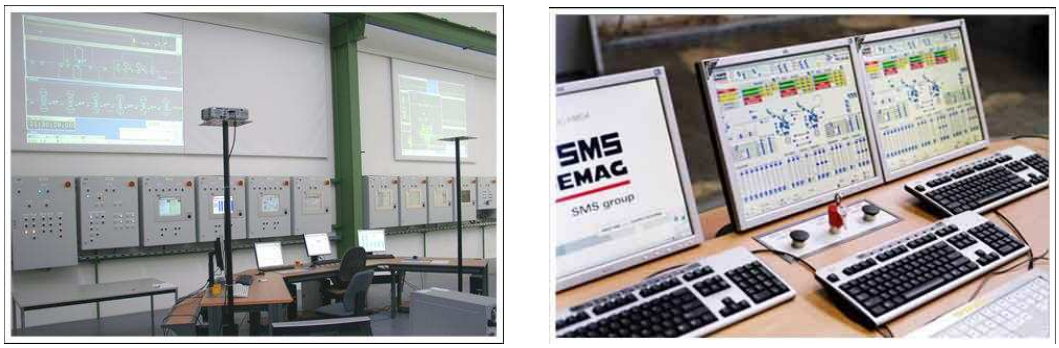

Figure 7: Plug and Work

The PIOS (Process IO server) represents an electronic marshaling panel and acts like a software switch. Using input/output modules, the signal flow of the plant is routed through a new bus connection and via the PIOS in parallel with the existing cabling. This makes it possible to access the actual values for plausibility and to set up a “shadow mode” for the new controls and process models. The advantage of PIOS during commissioning is that if any defects should be found in the new automation system, the “software switch” is simply reset to the existing (old) automation system. Production is not affected and is maintained.

Latest References

Revamp of Tandem Cold Mill at Bielstein GmbH & Co, Germany

Supplied by SMS Siemag in 1969, the four-stand batch tandem cold mill for narrow material is the central key plant for the complete cold strip production at Bilstein. The mill rolls a wide spectrum of steel grades, including structural steel, spring steel, micro-alloyed and high-strength steels.
The annual production was approximately 400,000 t. The modernization mainly aims at enhancing the plant’s availability, boosting production by 60,000 tpy, improving product quality and increasing the degree of automation. For the revamp, SMS Siemag has supplied the mechanical and electrical equipment as well as the automation system from one single source.
At the entry of the tandem mill, a new pinch roll unit has been installed. All mill stands have been equipped with hydraulic screwdown cylinders and the drive trains have been given new gear sets. A dry strip system is arranged after the last stand. The exit side has been completed with a swiveling bridle S-roll set. New synchronous motors for mill stands and tension reel boost the rolling speed of each stand. The installation of new Level 1 and Level 2 with highly accurate process models completes the revamp project.

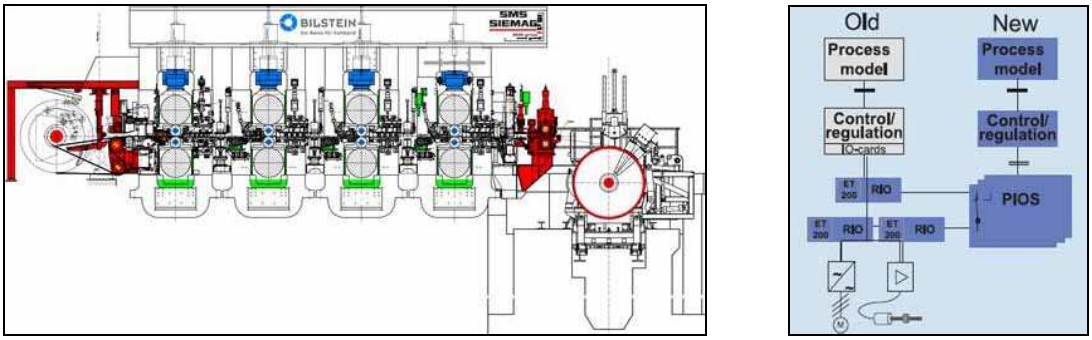

Figure 8: Modernization concept of the TCM at Bielstein (l) and Switch of automation system by PIOS (r)

Revamp of a five-stand tandem cold mill, TKS Rasselstein, Andernach, Germany

The main objective of Rasselstein, with the modernization of its five-stand batch tandem cold mill, was to increase the availability, to reduce maintenance costs and to make the performance equal to that of the second tandem mill in use.

Figure 9: TCM Rasselstein after revamp with new cladding (l) and new service platform (r)

The modernization included a new entry section, hydraulic screw-down system for all mill stands, new mill-stand service and media platform, fume exhaust system, new mill cladding, high and low-pressure hydraulic systems and piping.
In close coordination with the customer, comprehensive preassembly and functional tests were carried out for the hydraulic gap-adjusting system, mill-stand service platform and the new entry section.
Thanks to the measures described above, well-coordinated processes and committed project teams, the production downtime could be limited to four weeks. At the end of September 2008 the production started again on time. The FAC was awarded successfully in December 2008.

CHANGE OF OPERATION MODE

More than 40 % of the tandem cold mills in operation worldwide are either coupled to a pickling line or are run in a fully continuous mode. The number keeps growing because it is a fact that continuous operation as a linked pickling line/tandem cold mill is the most economical configuration for producing large amounts of cold strip.
The advantages regarding the conversion cost of the continuously operated tandem cold mills relate to energy, consumables and personnel.

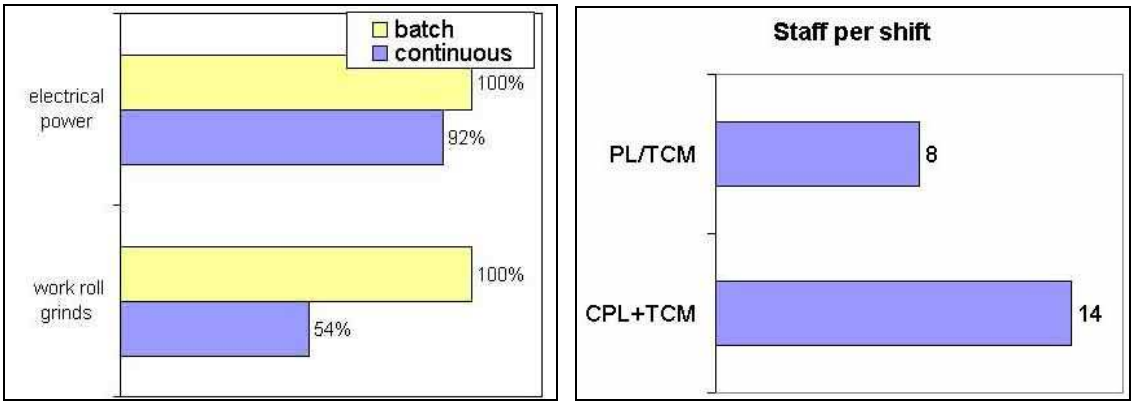

Figure 10: Comparison of electric power consumption and work roll grinds and personal per shift for TCM in continuous and batch mode

The energy costs are reduced by the smoother operation. The savings in consumables costs relate to the work roll consumption. Due to the fact that threading in and out is no longer needed, marking of the rolls is avoided and the number of coil breaks is reduced. All these facts plus the reduced roughness requirements nearly double the life-time of the work rolls.
Furthermore, the off-gauge length is significantly reduced and damage relating to coil conveyance and handling between the pickling line and the tandem mill is avoided. Moreover, the smooth operation improves the performance of the control systems and consequently the quality of the strip.
With regard to the PL/TCM, the reduced number of staff for operating the line is another significant factor which lowers conversion costs.
For continuous operation as PL/TCM the following areas have to be modified or to be added:

- Strip feeding and welding section
- Strip accumulator, side trimmer, twist rolls
- Entry and exit section of the tandem cold mill

Strip feeding and welding section

To ensure performance of the coupled line, the strip feeding and welding section is of essential importance. SMS Siemag offers different solutions for strip feeding based on one, one and an auxiliary or two pay-off reels, depending on the production capacity of the line .
Based on experiences gained from many projects, we developed the new laser welding machine called Laser-tec. It allows welding of thinner strips, strips having higher amounts of alloys and is cheaper than flash-butt welders and very compact in design.

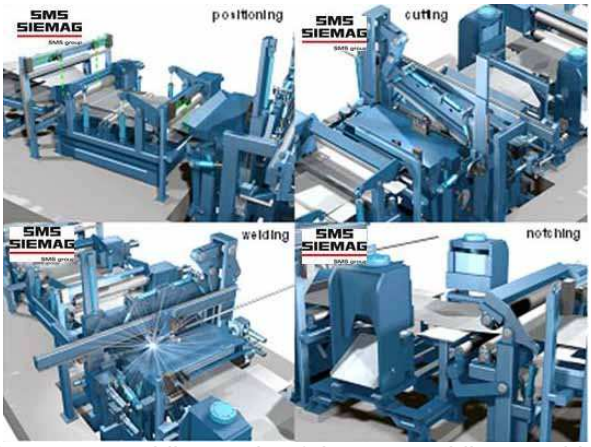

Figure 11: Welding cycle of the new welding machine

Latest references are the continuous pickling line of Salzgitter Flachstahl GmbH with a capacity of 2.5 m t/a. The laser welding machines are also part of the continuous pickling line for Tokyo Steel (capacity 1.8 m t/a) and the PL/TCM for TKS Alabama, which will have a final capacity of 1.6 m t/a.

Strip accumulators, side trimmer, twist roll

With the coupling of the pickling line and the tandem cold mill, strip accumulators are needed. The volume of the looper in the entry of the pickling process section depends on the coil preparation and welding time and on the process speed. In the exit, the accumulator consists usually of two loopers, one for the side trimmer and one to compensate the reduced cutting speed in the mill and the roll change time.

The combined ASC side trimmer and chopper unit is a very time-saving and maintenance-friendly unit. On each side of the line, two trimming shears with associated scrap choppers are mounted on a turntable platform in a 180-degree arrangement. This arrangement allows replacement of the shear within 60 seconds and the safe maintenance of the standby trimmer/scrap chopper unit during production. All settings of the knife gap and knife overlap are performed automatically by maintenance-free eccentrics.

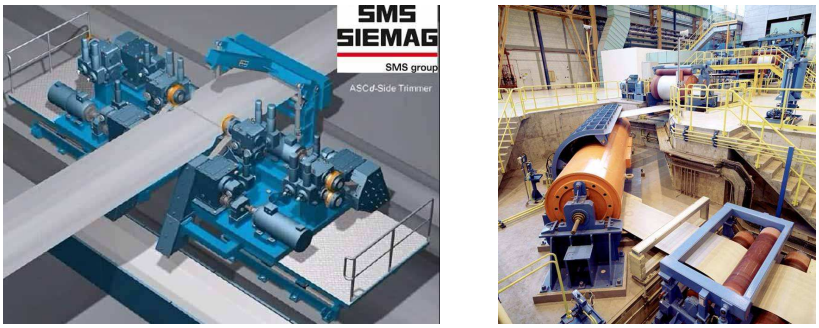

Figure 12: ASD Side trimmer (l), twist roll in the entry section of a PL/TCM (r)

In cases where pickling line and tandem cold mill are not arranged in a line, the strip can be turned by our twist roll. This is characterized by a compact design and is easy to maintain, i.e. the strip can remain in the twist roll during maintenance.

Entry and exit section of the tandem cold mill

To adjust the right tension level for rolling when coupling the pickling line to the tandem cold mill, a bridle will be installed in the entry of the TCM. Moreover, to handle coil breaks in an efficient manner, the entry section will be equipped with a strip clamping device and an emergency shear.

For the exit section, depending on the required production capacity, three coiling options are offered by SMS Siemag. First, only one tension reel is used. Consequently, the line operates in a semi-continuous mode and will stop after each coil for a short time. The second solution is a double reel. It ensures the fastest coil sequences. Finally, the carousel reel should be mentioned. The advantages of this solution are its compact design with only one coil car and its short head and threading distance, which makes it the favorable solution for those producers who wish to roll a large proportion of thin products.

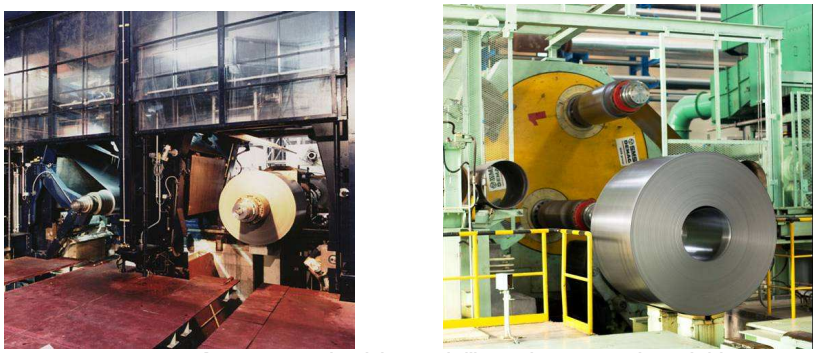

Figure 13: double reel (l) and carousel reel (r)

Latest References

New entry section for the coupled tandem cold mill, ILVA Novi Ligure, Italy

Ilva S.p.A. modernized its coupled pickling line tandem mill (PLTCM) at its Novi Ligure location with a new entry section. The modernization was aimed at boosting annual production to 2.0 million t.
The new entry section was erected in front of the old one. It consists of two payoff reels, a new coil conveyor system and a new laser welding machine with all auxiliaries. The strategy for minimizing production downtimes and the risk of production losses was to bypass the old entry section via a bridge.
With this measure, strip feeding time is reduced and availability of the whole plant is improved. All equipment was installed within eight months.

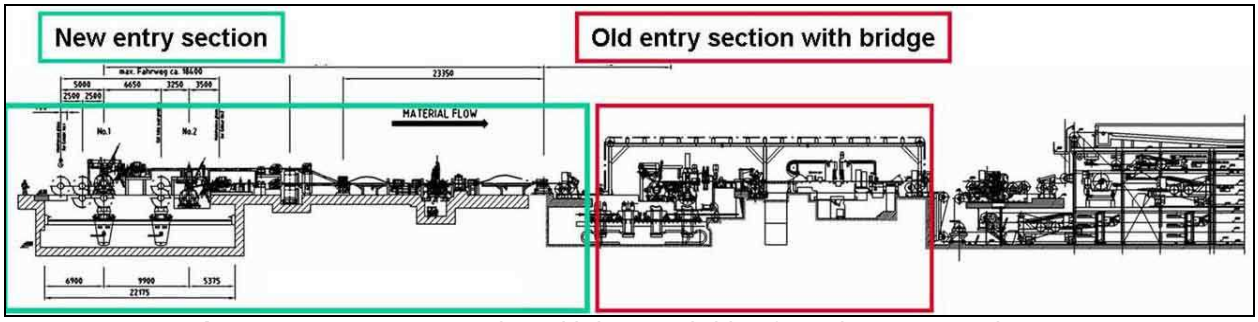

Figure 14: New entry-section with bypass-bridge for strip transportation

Extension of the PL/TCM at ArcelorMittal's “Vega”, São Francisco do Sul, Brazil

The PL/TCM in São Francisco do Sul was set up in 2002 and 2003 by SMS Siemag under a contract from Usinor and the Brazilian CST company – later Arcelor.
With the new order for SMS Siemag, ArcelorMittal Brazil intends to upgrade this semi-continuous line from 900,000 t to 1.4 million tons. This requires fully continuous operation. Therefore, the scope of supply by SMS Siemag includes the second tension reel with its coil conveying system. In addition, a pinch roll unit, drum shear as well as strip carry-over tables, deflector rolls and a belt conveyor will be delivered.

Figure 15: ArcelorMIttal´s “Vega” PLTCM to be be upgraded

Revamping will be completed during a main shutdown period of around two weeks, and the first coil in fully continuous operation will be rolled in October 2010 following an 18-month project term.

From a Batch Tandem Cold Mill to a PLTCM, ILVA Cornigliano, Italy

At the Cornigliano works, ILVA is upgrading one of its 5-stand tandem cold mills to a PL/TCM with a capacity of 1.2 mio. t/a. The upgrade will be performed in two steps by SMS Siemag.
In the first step, a new continuous exit section was installed and commissioned. The new exit section consists of a drum shear with pinch roll units, a carousel tension reel for holding coils up to 45 tons with a diameter of max. 2.5 m, coil car, strapping and marking machine as well as a high-speed coil car for transportation of the finished rolled coils to the yard.
After a project time of only 16 months, the new continuous exit section was erected and commissioned in December 2008.