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EFFICIENT SOLUTIONS FOR MODERNIZATIONS AND UPGRADES OF HOT ROLLING MILLS[1]

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Abstract

The recent steel boom was characterized by a steep increase in world wide hot rolling capacity. Still new hot rolling mills are scheduled to start production during the coming years. Existing plants, which may be in operation since decades, have to compete with brand-new equipment and technology in terms of product quality and production efficiency. SMS Siemag have developed and successfully applied overall modernization concepts for hot rolling mills as well as well-defined upgrades, dedicated particularly to the improvement of product quality and the enlargement of product range. This paper describes the general methods of how SMS Siemag approaches hot rolling mill modernization projects for maximum customer benefit and describes examples for overall modernization and upgrade concepts, which have been put into operation during the recent years.
Key words: Hot rolling mill; Modernization; Electric and automation.

SOLUÇÕES EFICIENTES PARA MODERNIZAÇÕES E UPGRADES DE LAMINADORES A QUENTE

Resumo

O recente boom do aço foi caracterizado pelo enorme incremento da capacidade mundial de laminação a quente. Novos laminadores a quente têm sua entrada em operação programada durante os próximos anos. As plantas existentes, que já estão em operação há décadas, têm que competir com equipamentos e tecnologia novíssimos em termos de qualidade do produto e eficiência de produção. A SMS Siemag desenvolveu e aplicou com sucesso conceitos de modernização completa para laminadores a quente, bem como *upgrades* bem-definidos voltados particularmente para a melhoria da qualidade e para a ampliação do leque de produtos. Este trabalho descreve os métodos gerais de abordagem da SMS Siemag em projetos de modernização de laminadores a quente para obter o máximo benefício ao cliente, bem como exemplos de conceitos de modernização completa e de upgrades colocados em prática nos últimos anos.
Palavras-chave: Laminador a quente; Modernização; Sistema elétrico e automação.

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1 INTRODUCTION

The boom of recent years has changed the steel industry fundamentally. Between 2005 and 2010 alone, global raw steel consumption increased from some 1.1 to more than 1.4 million t. That's almost 25%. Most of the increase was accounted for by new plants, above all in China. There were also double-digit growth rates in India, South Korea, and Turkey.
Older plants are in direct or indirect competition with modern plants that are equipped with cutting-edge technology and as a rule can produce the entire range of steel grades more cost-effectively. However, with the right modernization scheme, older plants can meet today's market demands just as well as modern systems, restoring their competitiveness.

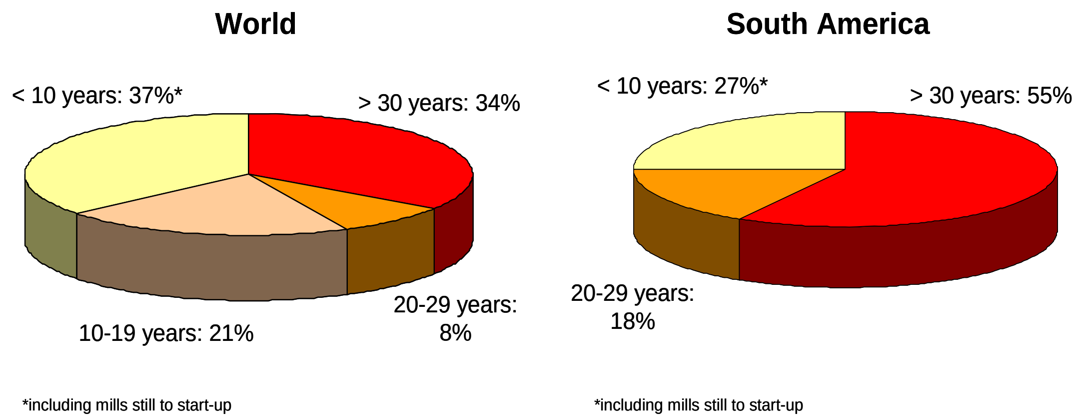

Figure 1. Age group of hot strip mills worldwide and in South America *(Source: Plantfacts VDEh)*.

Besides boosting output, modernizations essentially pursue two objectives: On the one hand an improvement of the market situation by raising the product quality and extending the product portfolio, on the other hand an increase in competitiveness by reducing production cost. In most cases modernization projects involve a combination of these objectives.

2 FOUR STEPS FOR SUCCESSFUL MODERNIZATIONS

In the last 15 years alone, SMS Siemag has carried out modernization projects in around 50 hot strip mills. It is our philosophy to develop and implement for every project in an interactive process with the customer a cost-optimized modernization concept that is tailored to his specific facility and objectives.
Essentially, four steps determine the success of a modernization:

- systematic investigation and evaluation of plant condition and process requirements. This reveals the need and scope for modernization;
- development of an intelligent modernization strategy, tailored to the customer's demands as well as to conditions on site;
- in-depth preparation, taking into account a minimum number and duration of shutdowns;
- installation of powerful equipment to secure the sustained success of the modernization.

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2.1 Systematic Identification of the Need for Modernization

Each project starts with the determination of the modernization needs. Some owners use their own analyses to define which components of a mill are to be replaced, added or improved. Others specify their objectives and leave it up to the plant builder to analyse which components need to be upgraded or replaced for this purpose. As a first step we can draw on experience from similar projects here. However a thoroughly investigation of the modernization needs and potential on the basis of a study is often indispensable.
Fact-finding of the existing mill is the main factor of a study. Analyses of the product portfolio and production process yield findings on the requirements which mill components must satisfy and on bottlenecks in the production chain. With the help of strength analyses, the static and dynamic loads of critical components are assessed and checked for being able to withstand higher loads. Dynamic simulations, for example, of adjusting systems and drive trains make sure that a proper control behaviour is maintained when new components are installed (Figure 2).

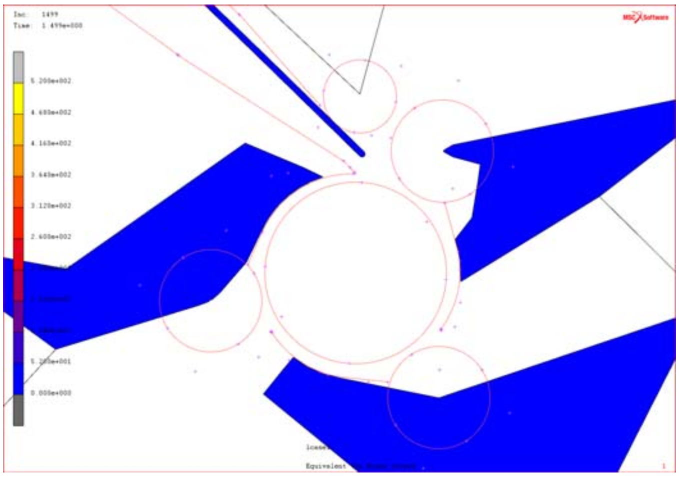

Figure 2. Dynamic simulation for analysis of loads on downcoiler for development of UNI plus Coiler.

2.2 Development of an Intelligent Modernization Concept

Based on the analysis of demands and current condition, we work closely with the customer to develop the best modernization concept. Comparing different modernization options and their costs creates a firm basis for decisions.
Planning of the revamp is thoroughly tailored to customers' needs. Important boundary conditions are, for example, customers' delivery obligations, revamps in upstream and downstream processes or the maintenance cycles. Virtual Engineering is a special method of developing modernization strategies. It can be used to represent individual revamp steps. Visualization of the plant makes it easier to evaluate complex processes together with the customer, and to check that goals will be achieved. That’s how Virtual Engineering makes planning more reliable and creates common understanding between everybody involved (Figure 3).

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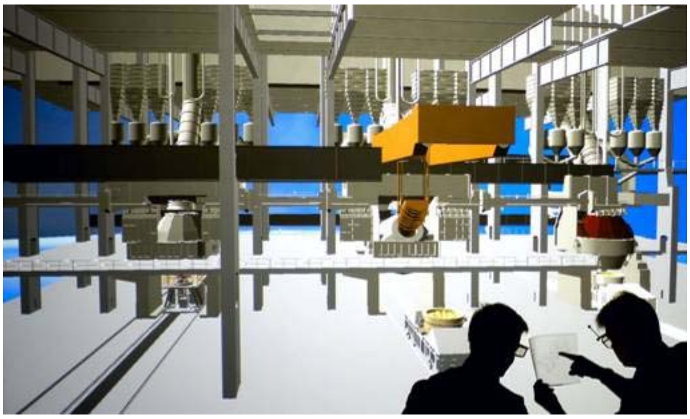

Figure 3. 3D-visualization of a steelwork.

2.3 In-Depth Preparation and Efficient Implementation

Implementing a modernization project requires a high level of experience in this field as well as close collaboration with the customer. A consistent project management ensures adherence to the time schedule, the cost and high quality of the various components.

One factor for adhering to the time and cost frame is pre-commissioning of the mechanical components and automation systems. For instance the valve units in hydraulic systems are checked in own test stands. Drives manufactured in the SMS Siemag workshop are installed and the tooth contact pattern set. We are also able to pre-assemble and test entire mill stands.

Before installation at the customer's, automation systems go through the Plug & Work test routine. This involves testing and optimizing the automation system during real-time simulation of the production process.

An additional step is "shadow operation". This requires the mechanical equipment and automation system to be installed in parallel to the existing facility and to be synchronously operated with the latter. This allows all functions of the automation system to be checked before hot commissioning.

If large parts or the complete automation is modernized, a good way of minimizing risk is to use switch-over mode. This means functions or controls can be fully or partly switched on, tested, and optimized. The old automation equipment is only dismantled and the new solution brought on stream when all functions and the system itself have been sufficiently tested and optimized (Figure 4).

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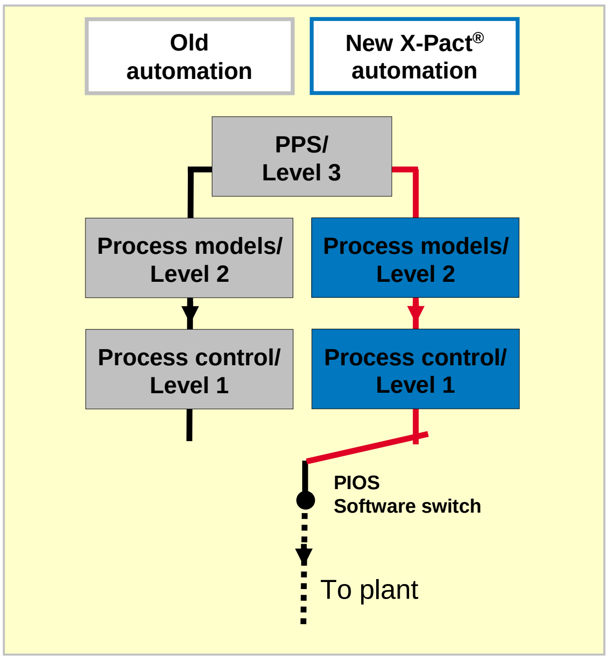

Figure 4. Switch-over mode (example).

2.4 Installation of Effective Equipment

Ultimately, the sustained success of a modernization depends on the performance of the equipment installed. We supply highly developed machines and components for all plant areas. These have proved their effectiveness after retrofitting into many existing plants. By specifically improving our competence in the field of electrical equipment and automation systems we are today capable of offering integrated solutions encompassing mechanical equipment, electrical equipment, automation systems and process technology. This allows us to supply our customers with optimally integrated systems.

3 RECENT MODERNIZATIONS

3.1 Aleris Koblenz

The revamp of the hot rolling mill of Aleris Aluminum Koblenz (Germany) was one of the most spectacular modernizations in recent years. Aleris Aluminum Koblenz is one of the world's largest suppliers of aluminium products for the aerospace industry. To safeguard their position and to be able to produce thicker, wider and longer plates Aleris Aluminum decided to replace the old 148" facility by a new 160" stand with a new drive system. The complete revamp was realized within two modernization phases of only 18 and 20 days. This was achieved by using the most modern methods for the preparation and the execution of the revamp.

3.1.1 Modernization concept

In working out the time schedule, two requirements from Aleris Koblenz had priority: First, production losses had to be minimized due to the customer's delivery obligations. Second, the main work operations had to take place during the annual Christmas shutdowns. Therefore the new equipment was installed and pre-commissioned almost completely in parallel to the existing line, so that during the

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revamp shutdowns, the new equipment only had to be shifted to its position. To be able to cope with these tasks in terms of organization and logistics, the modernization concept provided the replacement of the roughing mill in two phases.
In the first revamping phase in 2006, the new drive system with the motors and gear unit was installed. In addition, preparatory work for the installation of the stand was carried out. During the second phase in 2007, the stand was replaced.

3.1.2 Implementation of concept: phase 1

To be able to realize the required high pass reductions at low rolling speeds, a twin drive unit with a power of 2 x 7,000 kW and two reduction gears arranged in one housing was installed. The motors and gear unit were set up in a foundation trough on a shiftable foundation block behind the existing drive unit. Production thus went on untroubled throughout the whole erection and installation period and during the subsequent shadow operation of the new drive unit.
During the Christmas shutdown 2006 the old drive train was then dismantled, the foundation adapted and the foundation block with the motors and gear unit (total weight: 1,200 tonnes) shifted into position. After setting up the spindle carrier and the spindles, the new drive unit could be started up together with the old millstand after 18 days, as scheduled (Figure 5).

Figure 5. New drive behind existing drive unit (drawing, left), installation of gear unit (middle), shifting of foundation block (right).

Concurrently with work on the drive unit, the foundation was adapted to take up the new, heavier millstand. Also new roller tables and new side guides were installed.

3.1.3 Implementation of concept: phase 2

During the summer 2007, the roughing stand was completely assembled in SMS Siemag's workshop, piped and movements tested. Then the millstand was taken apart into transportable units, transported to the customer and set up there in the assembly pit next to the rolling line. In order to ensure 100-percent that the new mill stand would go into operation smoothly, it was tested in “shadow operation” synchronously with the existing stand, always using the signals from the existing automation system. Also the electrical and automation system which had already passed the Plug & Work tests at SMS Siemag was completely installed parallel to existing facilities.
During the 2007 Christmas shutdown, first the old 148" millstand was dismantled into its pieces. Then the central foundation area to take up the new millstand was enlarged and the new base plates to hold the mill housings set up and grouted together with the millstand pan. Using special crane and transport systems, the completely assembled 160" stand with a total weight of 1,250 tonnes was raised by 2.50 m and taken to its position over a distance of 20 m (Figure 6).

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Figure 6. Pre-assembly of 160" millstand at SMS Siemag workshop (left), shifting to the final position at Aleris Aluminum Koblenz (middle), millstand in production (right).

After a 20-day shutdown and thus one day earlier than planned, the new millstand was rolling the first plates. During the subsequent run-up of the line the scheduled production figures were then quickly attained and quality requirements even exceeded.

3.2 Tata Steel

The modernization of the hot strip mill at Tata Steel (India) is an example of a production increase and a quality improvement by reinforcement of existing mill components. The modernization took place in two phases in 2008 and 2009.

3.2.1 Production study

Tata Steel's hot strip mill went in operation in 1993 and is designed as a compact-type hot strip mill with one four-high reversing roughing mill, a coilbox, a 6-stand finishing mill and two downcoilers. As part of planning the production capacity increase at their Jamshedpur works, Tata Steel in 2006 placed an order with us for investigating the potential for raising the hot strip mill capacity from 3.1 to around 3.5 million tonnes per year.

A study of SMS Siemag showed that production could not be raised by increasing the furnace capacity alone. The bottleneck here was just shifted into the roughing mill. A reduction of the number of passes from seven to five for part of the products and the reduction of off periods as a result of the high thermal loads of the motors above all during rolling wider strip required a 25% increase in drive power and a higher roll force. In addition it was shown that a higher transfer bar thickness required a 10% increase in the drive power in the finishing line. All in all, these actions would allow a production of 3.55 million tonnes per year (Figure 7).

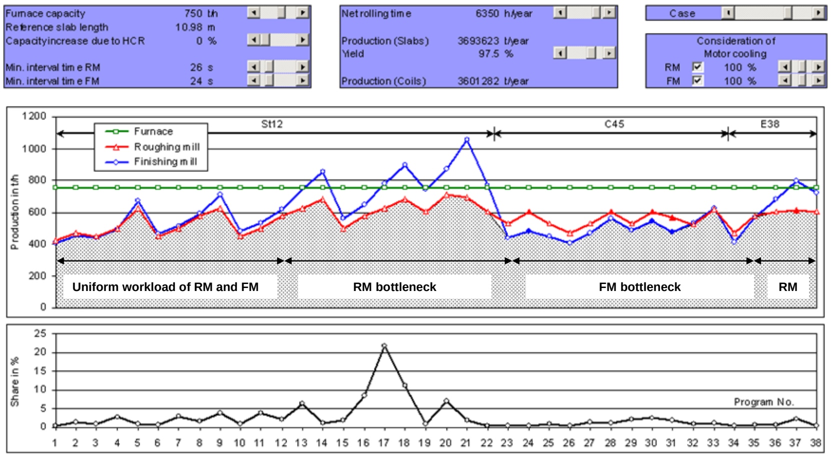

Figure 7. Bottleneck analysis for additional furnace and modernization of RM and FM.

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3.2.2 Revamping concept

Tata Steel decided to follow the recommendations of the study and ordered us to perform the revamp in two phases. The background here was mainly the long delivery times of unmachined parts for gearwheel fabrication that existed at the time of order placement. For this reason, the first step included the revamp of the roughing stand in 2008, which allowed Tata Steel to already realize a large part of the capacity increase. The finishing mill drive units were revamped in 2009.
To transmit the higher rolling torques, work rolls with a larger diameter were installed in the roughing stand. The roll force was increased from 30 MN to 40 MN by installing a hydraulic adjustment system. An FE analysis showed that even at the higher roll forces, the maximum load of the mill housing was still within the tolerances. To absorb the higher roll forces, we installed Morgoil® bearings of the KLX®series with a higher load-bearing capacity.
In the finishing line the modernization project provided the replacement of the main gear units on stands F1 to F4 and of the mill pinion gear units from F1 to F5. On two main and two mill pinion gear units it was possible to raise the torque by installing new gearwheel sets, whereas the other 5 gear units were replaced by new ones with a higher load-bearing capacity. Moreover, the first two finishing stands were equipped with Sieflex® gear-type self-aligning spindles (Figure 8).

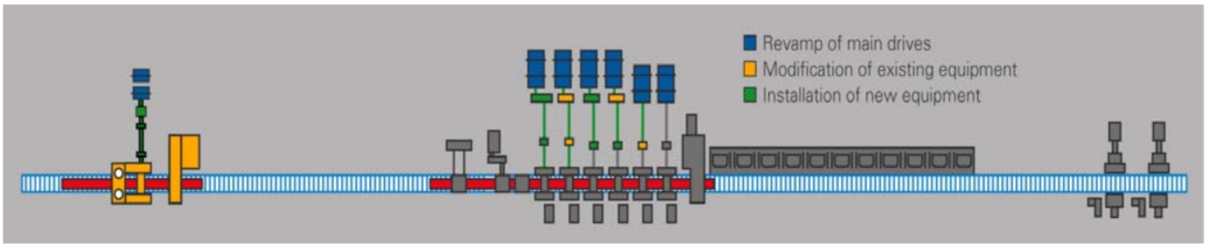

Figure 8. Overview of revamp actions at Tata Steel hot strip mill.

3.2.3 Implementation of revamp

The roughing stand was revamped in November 2008. The drive motors were replaced and the new slipper-type spindles installed. To take up the larger work rolls, the mill housings were machined. For this purpose a special portable milling machine was taken from Germany to the jobsite to ensure the exact adaptation of the housing contour. After the scheduled 18-day shutdown the mill could be restarted and immediately achieved the new production level.
The finishing mill was modernized in September 2009. The new gear units were manufactured in the SMS Siemag workshop and delivered to the Tata site ready for installation and with preset optimal tooth contact pattern. As a result, this stage of the revamp could be finalized after a shutdown period of just 10 days.

3.2.4 Results

After the second shutdown period for revamping work, the hot strip mill immediately attained the higher production level and proved that it was able to achieve a production rate of 3.55 million tonnes per year and even more. Moreover, the thickness and width tolerances of the transfer bar were improved, which had a positive effect on the quality of the hot strip and the rolling stability in the finishing mill.

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3.3 Salzgitter Flachstahl

The hot strip mill of Salzgitter Flachstahl (Germany) went in operation in 1963 and is a textbook example of how continuous modernization can maintain a mill state-of-the-art even after almost five decades. In the last ten years, virtually all mechanical equipment and the whole automation system were modernized by SMS Siemag. The revamp of the roughing mill with the installation of a slab sizing press and the replacement of the reversing roughing stand have already been described in detail.(1)

3.3.1 Modernization concept

During the current modernization phase (2009-2011), the focus is on the finishing mill. Salzgitter Flachstahl pursues mainly three objectives:

- to increase output from 3.6 to 4.5 million tonnes per year;
- to increase the finish-strip width from 1,880 mm to 2,000 mm ;
- to extend the product mix (mainly to include higher-strength steels).

Based on a study of SMS Siemag, Salzgitter Flachstahl decided to realize a concept which mainly concentrated on these activities:

- wider opening dimensions in the entire plant;
- installation of CVC® plus in stand F1;
- replacement of the entire drive technology in the finishing mill;
- replacement of the entire intermediate stand equipment from F1 to F7;
- installation of a 3rd down coiler;
- new coil transport system;
- new electrics and automation for the down coiler and coil transport.

3.3.2 Revamp planning

Because the upstream and downstream process stages at Salzgitter Flachstahl depend on the hot strip mill, it was essential to implement the revamp with minimal shutdown times. In close cooperation, SZFG and SMS Siemag drew up a strategy that involved five shutdowns between 2009 and 2011, each for a duration of eight to ten days.

3.3.3 Powerful components

The drive units of the finishing stands were already highly loaded before the modernization, so that a replacement of the motors was absolutely necessary to increase the output. All stands received high-performance motors with a power of up to 15,000 kW.

To achieve minimum shutdown times, the existing foundations were re-used. SMS Siemag installed the new gears before the shutdown in the motor hall and adjusted the tooth contact pattern. During the shutdown, after the old units were dismantled and the foundations prepared, the overhead crane moved the up to 150-t gears as complete units into position. Then the motors were installed, and the plant resumed production (Figure 9).

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Figure 9. Insertion of finish-assembled F1 main gear unit.

The retrofitting of CVC® plus in the finishing line has already been under way step by step since 1996. In this modernization phase, also F1 as the last mill stand was equipped with CVC® plus. After the introduction of CVC® plus in F2 to F5 in 2003 the strip quality was evaluated. It shows a considerable improvement of the results (Figure 10).

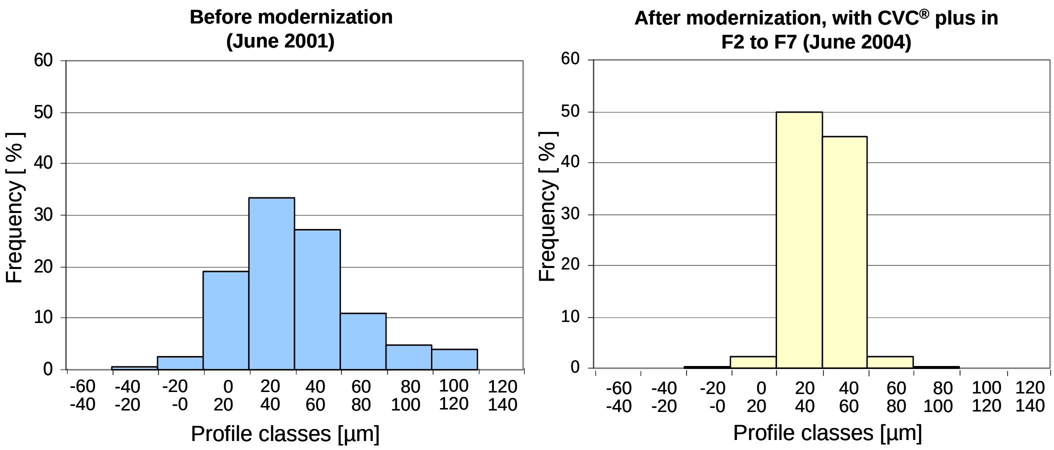

Figure 10. Profile classes C40 at Salzgitter Flachstahl before and after modernization.

The hot strip mill of Salzgitter Flachstahl is the world's first with a finishing train equipped completely with differential-tension loopers. Here all finishing stands feature differential tension loopers so that a fully automatic leveling can be realized for the complete mill. This releases the operators from this task and safeguards a stable rolling process for all grades and dimensions.

To be able to coil high-strength strip up to 2,000 mm width and 25.4 mm thickness, Salzgitter Flachstahl decided to use an UNI plus coiler as their third coiler. The UNI plus coiler was developed by SMS Siemag especially for very thick high-strength strip.(2)

The UNI plus coiler was installed downstream the two existing coilers. The coiling unit arrived at the Salzgitter works preassembled and was inserted directly into the coiler pit. Finish assembly and cold commissioning took place with on-going production. During the second revamp shutdown the UNI plus coiler was connected to the two remaining coilers by a carry-over table and was then started. For the changeover of the automation on the already existing coilers 1 and 2, a switch-over mode was used to ensure availability and full productivity over the entire period. The

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coiling strategies that have proved so efficient in recent years for the specific product range were adopted in the new automation system.

3.4 ThyssenKrupp Steel

Downcoiler systems are currently at the focus of modernization projects, during the last five years alone SMS Siemag have installed 16 coilers in existing hot strip mills. Among others, the complete coiler group each with three coilers in two hot strip mills of ThyssenKrupp Europe (TKSE), Germany was replaced. A special revamp concept allowed the revamp to be made almost without any restrictions in production.

3.4.1 Revamping concept

TKSE's requirement for the revamping concept was to maintain production as much as possible during the modernization project. SMS Siemag therefore developed a concept with just one shutdown of several days. During the rest of the time (except for five days), two coilers were at all times available to TKSE, so there was no need to cut back production (Figure 11).

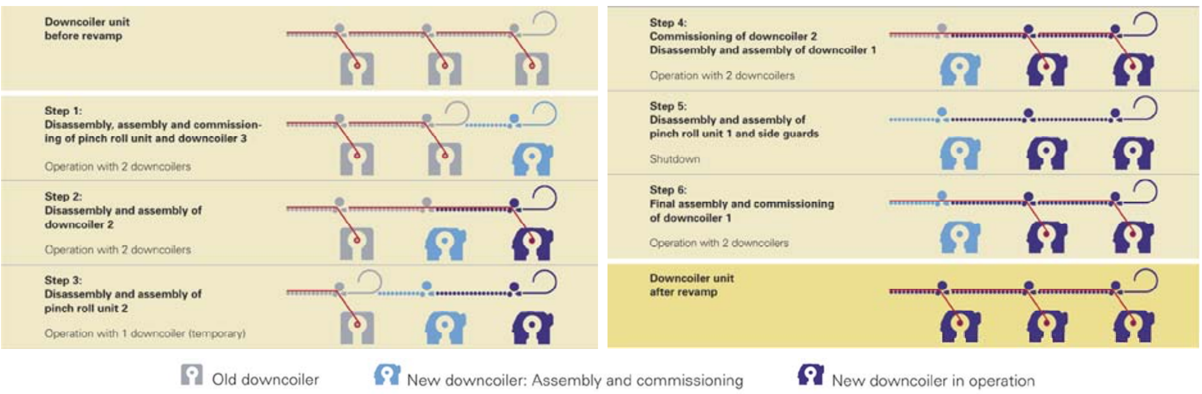

Figure 11. Schematic overview of revamping concept.

3.4.2 Preparation of revamp

The coilers for TKSE's Hot Strip Mill 1 were manufactured in the SMS Siemag workshop. The coiling unit of the coiler with the drive base and gear unit as well as hydraulic equipment were completely assembled and tested prior to delivery. Then the coiler was dismantled into as large as possible finish-assembled modules, taken to the jobsite and placed into the coiler pit directly off the truck.
Before delivery, the coiler automation systems were subjected to the Plug & Work tests. For this purpose the automation system was tested against a real-time simulation of the complete coiling process. The simulation takes into account the coiler's design data, the geometrical data, the kinematic and dynamic behaviour of the coiler and the function of the field instruments, thus reproducing reality as precisely as possible. This way the automation systems could be optimized already before commissioning in the mill.

3.4.3 Implementation of revamp

The revamp started in March 2007 on downcoiler 3, the last one of the downcoiler group. To be able to perform all work safely while production was under way, a temporary catcher was installed downstream downcoiler 2. Then all components of the old downcoiler 3 were dismantled and the new downcoiler with its drive unit and

pinch roll unit installed. After cold commissioning, the new unit was linked to the remaining downcoilers and started up.
After optimizing the third downcoiler with a view to the special product mix of the hot strip mill, the revamp of downcoiler 2 could be started in mid-June 2007. Here the old downcoiler 2 was first dismantled and then assembly of the new unit was started with downcoilers 1 and 3 in production. For the installation of the new pinch roll unit and new carry-over table between downcoilers 1 and 2, downcoiler 3 had to be shut down, with coiling during these five days only possible on downcoiler 1.
After downcoiler 2 had been commissioned, revamping of the first downcoiler could be started. This last revamping phase required the only production stoppage of several days throughout the entire modernization project. During the 9-day shutdown the roller tables at the entry of the downcoiler group were replaced, a carry-over table and new side guards were set up and the new pinch roll unit of downcoiler 1 was installed. Final assembly of the downcoiler and cold commissioning then took place in full production again. Around seven months after the start of the revamp the replacement of the downcoiler group was completed (Figure 15).

3.4.4 Similar downcoiler modernizations

A similar modernization project was realized by us at NLMK (Novoliptesk Steel), Russia. At NLMK, all work was carried out with production under way or during regular maintenance shutdowns, with no interruptions in operation needed for the installation of the three new downcoilers. Throughout the whole modernization two downcoilers were at all times in operation, thus allowing production to be continued to its full extent. For this modernization job, too, we delivered the downcoilers preassembled and just in time to the jobsite in Lipetsk, around 400 km south of Moscow. Due to the climatic conditions prevailing in Russia, the downcoilers had to be transported on waterways and on the road within a narrow time frame.

4 CONCLUSION

By taking appropriate measures, older hot strip mills can be modernized to the extent that their competitiveness in comparison with last-generation mills is ensured. Successful modernization jobs require the systematic determination of a mill's needs plus an ensuing intelligent, tailored modernization concept with a suitable revamping schedule. A consistent project management ensures that the activities are performed within the time and cost frame. The long-term success of a modernization project eventually depends on the quality of the installed equipment and on the automation system. SMS Siemag has demonstrated its competence in modernization jobs by a number of projects.

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