

VALUE-ADDING REVAMPS AND MODERNIZATION MODULES*

*Eddy Dierckx¹
Stephan Kraemer²
Ruediger Holz³*

Abstract

Modernization of flat rolling plants is essential to sustainably fulfill increasing market demands and to improve competitiveness. Intelligent modernizations ensure getting maximum prime yield of existing mills, even if they have gone through half a century of operation. Existing mills were designed based on former production, consumption and quality targets. Ever increasing requirements such as increase of productivity, change of product mix (e.g. new steel grades), reduction of energy consumption and improvement of product quality lead to the necessity to adapt the existing equipment to the new target. SMS group provides, besides the reliable equipment and automation solutions to successful upgrades of existing mills, also a systematic approach to develop technical and economical solutions together with our customers (conceptual engineering). This paper describes the SMS group approach to modernizations / upgrades, introduces powerful performance modules and provides a number of successful examples that have been implemented recently.

Keywords: Hot rolling mills; Cold rolling mills; Modernization; Upgrade; Performance modules; Conceptual engineering; Return of investment (ROI).

¹ *Engineer, Senior Application Engineer, SMS Siemag do Brasil, Belo Horizonte, Brazil.*

² *Engineer, Flat Rolling department, SMS group GmbH, Hilchenbach, Siegen, Germany.*

³ *Engineer, Flat Rolling department, SMS group GmbH, Hilchenbach, Siegen, Germany.*

1 INTRODUCTION

In the light of a changing world economy, utmost efforts are being made to improve the competitiveness of plants. Production cost and product quality are of highest importance for steel producers in these times. Flexibility is another key to success, as it enables quick adaptation to customers' needs and to changing market requirements.

Market requirements for flat rolled products have increased considerably during the last years. One characteristic is the extension of the product spectrum. Today, steel grades with tailor-made mechanical properties are demanded. Exemplary fields of application of these steel grades are the automotive industry or the manufacturing of pipelines. At the same time, steel users demand hot rolled flat products with close geometrical tolerances and excellent surface quality. Together with the continuous improvement of operational efficiency, the environmental compatibility of production is also becoming more and more important.

Existing mills have to be adapted to these new targets and demands. For numerous cases SMS group developed modernization concepts, scheduled the shutdowns, supplied the equipment and brought our customers to the required market position. In the following, the general approach of SMS group for modernization concepts is explained. Based on examples, the practical results are shown and, in the last part of the paper, summarized in a so called toolbox with performance modules.

2 MATERIAL AND METHODS

Customer targets are the drivers in the development of modernization concepts. Typical project targets are:

- Increase of productivity
- Stable operation
- Enlargement of product range, e.g. high-performance material grades
- Improvement of product quality
- Replacement of worn out equipment
- Reduction of maintenance efforts,
- Compliance with stricter environmental requirements

Last but not least the available project budget is of major importance.

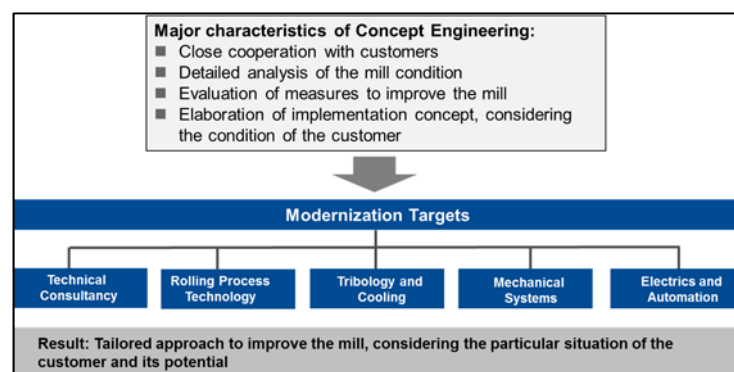


Fig. 1: Major characteristics of Concept Engineering

As a first step, the actual situation of the existing rolling line has to be investigated. A fact finding or mill survey audit at site reveals approaches for improvement. Plant operators may trust on SMS group's vast and long-time experience as a mill builder.

SMS group's experts can support plant operators getting a clear and detailed understanding of today's performance, problems and bottle necks. Together with the existing preconditions and space limitations, those studies provide a clear picture of the current situation and are basic for finding the customized revamping concept.

The results of these investigations are applied to SMS group's mathematical/physical models. Technological investigations, such as pass schedule calculations, provide bottle neck information etc. of an existing rolling plant.

Based on these findings, optimized solutions can be defined and verified by simulation. In parallel, skilled mechanical engineers elaborate on scenarios for a revamp and get an overview on the cost situation, e.g. FEM calculations assure the possibility to use existing equipment at a higher load level. Finally the best concept under techno-commercial conditions will be selected.

To keep mill down times as short as possible, modernizations may be executed in steps.

In many cases the existing automation system is affected. For this task, SMS group works out concepts to add new or partly new systems which work in parallel to existing systems. The so called "Shadow Mode" allows testing all parts of the automation system without any risk to cut productivity.

Performance Modules

SMS group developed a lot of different measures - also called performance modules - to meet customer requests and market demands. The following figures refer to the modernization references mentioned in this paper and provide an overview on a selection of performance modules and the possible impact on customer targets. In addition with other proven and innovative "instruments" available by SMS group, they form a "Tool Box" with proven technical solutions. Selected by SMS group specialists and based on customer targets, the "Tool Box" contains individually adaptable modules in order to generate the best solution for your modernization project.

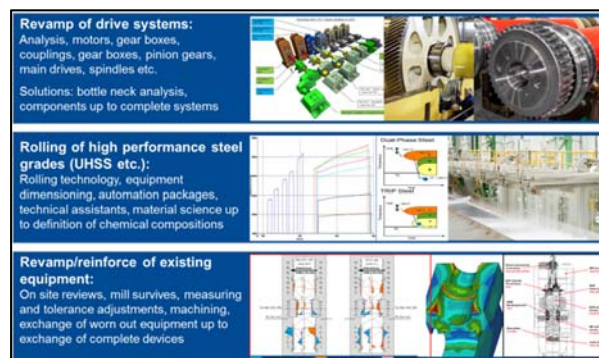


Fig. 10: Some examples of Performance Modules in modernization projects

3 RESULTS AND DISCUSSION

Bellow we add some value-adding revamp examples

3.1 ArcelorMittal Gent (AMG), Belgium: Higher capacity and improved quality

Initial situation: ArcelorMittal Gent is operating a seven stand hot-wide strip mill since 1967. Between 2012 and 2014 SMS group upgraded the drive trains of the finishing stands F1 through F3. The revamp included the installation of more powerful main gears and pinion gears as well as Sieflex®-HT high-performance spindles. Also SMS group supplied a new profile, contour and flatness system (PCFC®) for the mill.

Modernization target: By an ongoing upgrade, AMG intends to make its Gent hot strip mill fit for further market requirements. The main targets are to further improve the quality of its products and to expand the portfolio, especially for high-strength and multi-phase grades.

Modernization concept development: Offline pass schedule calculations showed clearly the demand of higher rolling forces in mill stands F1 and F2. As a result of detailed off-line profile and flatness simulation, in the future, all finishing stands will be equipped with CVC® contour.

To assure the required thickness tolerance demands, simulations were carried out with the result that highly dynamic HGC systems in the first four mill stands are necessary, together with the installation of highly dynamic loopers in between all mill stands.

Modernization steps were defined in order to meet the pre-scheduled shut-down in close cooperation with AMG.

Modernization measures: The order comprises the installation of new finishing stands F1 and F2 as well as modifications to stands F3 and F4. Additionally, SMS group will support AMG in optimizing the rolling process for its third-generation UHSS and AHSS grades.

The Modernization concept by SMS group minimizes the impact on the running production and the need to adapt the existing equipment. During the first phase, at the end of 2015, stands F3 and F4 have been provided with new hydraulic screwdown systems, new oil film bearings and additional components that will facilitate an increase in rolling forces.

The main shut down in December 2016 will see the installation of the new rolling stands F1 and F2, which will be pre-assembled besides the rolling line. The first stands will feature high rolling forces and torques enabling the production of thin final gauge also when rolling AHSS and UHSS grades.

Modernization results: After the modifications of stands F3 and F4 being completed, these stands can be already operated with higher rolling forces up to 45 MN. The PCFC® model is already in operation and new dimensions can be rolled.

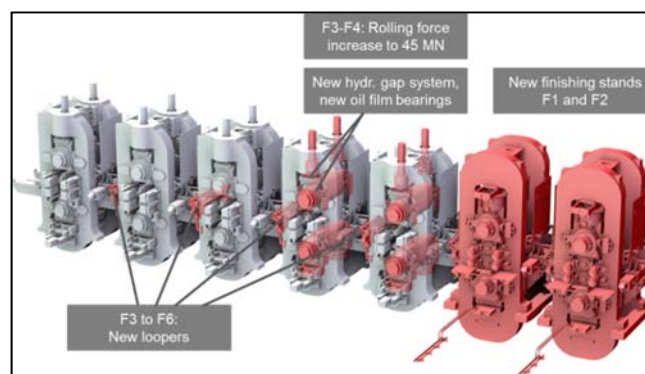


Fig. 2: ArcelorMittal Gent, HSM: Main scope of modernization

3.2 Handan Iron & Steel, China: Modernization of 3.5 m Heavy Plate Mill

Initial situation: Since 2006, Chinese steel producer Handan Iron & Steel Company operated a 3.5 heavy plate mill at the location in Handan, Hebei province, China.

Modernization targets: Main target was the improvement of plate quality in terms of geometrical tolerances, flatness and edge quality, expansion of the product spectrum and the increase of a share of thermo-mechanically rolled plates.

Modernization concept development: Simulations show that the required thickness tolerances can only be met by a highly dynamic HGC, a powerful work roll bending system together with an exchange of the automation systems.

Productivity targets, especially for the amount of thermo-mechanically rolled plates, were investigated with the PSC model and predicted the necessity of an additional roller table, parallel to the existing rolling line, to allow cooling phases with the mill stand continuing the rolling process for other products.

Target product properties made the installation of a high performance cooling line necessary together with a new hot leveler. The capacity of existing shearing line was also not capable to meet future market demands and had to be replaced.

Modernization measures: In 2011, Handan Iron & Steel decided for a comprehensive modernization of the heavy plate mill and chose SMS group as supplier.

Finishing stand: The 3.5 m finishing stand was revamped leaving more or less only the housings, the rolls and the chocks left, which were machined, too, in order to achieve the new performance targets.

New HGC system for closest thickness tolerances and new work roll bending systems were installed. Directly downstream of the stand, a 3-point thickness and profile gauge with integrated width measuring function was installed. On the exit-side, two roller tables were provided alongside the rolling mill to raise the production capacity during thermo-mechanical rolling.

The roll stand has received a completely new L1/L2 automation. For L1, this includes the sequence control system and the technological controls of the stand, as well as a new automation for the utility systems. The core component of the L2 is SMS group's model for pass schedule calculation (PSC[®]), including the model for flatness control (PFC[®]). The material tracking system and a comprehensive reporting system are further part of the L2.

New combined spray & laminar cooling system: The existing plate cooling equipment was replaced by a combined spray and laminar cooling system. The new cooling line ensures flexible setting of the cooling strategies for accelerated cooling (ACC) and direct quenching (DQ) from rolling heat. This enabled Handan Iron & Steel enlarging its product spectrum. The correct cooling curve for each type of material is calculated by the X-Pact[®] cooling model, based on the transformation kinetics of the material as well as the plate and process data. In this way, the cooling model also contributes to achieve the desired microstructure.

New pre-leveler: SMS group relocated the existing hot-plate leveler to the upstream side of the new plate cooling system. Now serving as a pre-leveler, it removes flatness defects, which may impair uniform plate cooling. SMS group also equipped the pre-leveler with a new automation system and integrated it logistically into the overall production process.

Hot-plate leveler: On the downstream side of the cooling line a hot plate leveler and a marking machine were installed. The hot-plate leveler is of the 9-roll design handles plates in thicknesses of 8 to 100 mm. The adjustment of the leveler rolls is accomplished purely hydraulically and the levelling force amounts to maximum 26

MN. To guarantee the desired levelling gap profile also under high loads, deformations of the machine are compensated by means of hydraulic cylinders. The optimal leveling strategy for each plate is calculated by the X-Pact® leveling model on the basis of the material properties and the plate geometry.

New double-side trimming shear: In the shear line, the circular-knife trimming shear was replaced by a new double-side trimmer operating to the rolling-cut principle. This cutting mode ensures extremely precise cuts and good edge quality. The new shear is designed to perform up to 30 cuts per minute, allowing Handan Iron & Steel to increase the throughput of plates in the shear line.

Cross-cut shear: The cross-cut shear was equipped with a shiftable end stopper for exact setting of the lengths of the finished plates. On the shear exit-side, a new marking machine was installed.



Fig. 3: Modernized 4-high finishing mill stand in operation (l), new plate cooling system (r)

X-Pact® automation: To meet the challenges of performing the different rolling strategies, and, at the same time, maximizing the rolling mill output, a large variety of rolling modes under optimal use of the parallel roller table have been implemented in the mill automation system. They were tested in advance during the integration phase, in which the operators had been trained in parallel.

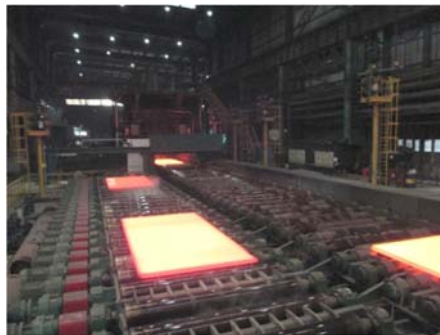


Fig. 4: A batch of totally four heavy plates rolled in thermo-mechanical mode in two phases, using the side roller table as material buffer for cooling two plates

Modernization results: Due to close partnership of Handan Iron & Steel and SMS group in the engineering and commissioning phase, a rapid production startup was given. From September 2014 to February 2015 nearly 340,000 tons heavy plate material were rolled totally. In February 2015, roughly 98 % of the rated capacity (83,300 tons per month) was reached. The share of normal rolled plates (NR) was 16.2 %; the balance (83.7 %) of thermo-mechanically rolled plates (TMR) was produced in two phases.

3.3 Nucor Steel Berkeley, USA: A novel concept for a larger product spectrum and increased energy efficiency

Initial situation: Nucor Steel's third CSP® plant went into operation in Year 1996 at Berkeley site with one casting strand. In Year 2000 the second casting strand of the Nucor Berkeley CSP® plant was hot commissioned and production capacity was increased to 2.4 million tons per year. The maximum product width to be produced was 1,680 mm.

Modernization targets: Nucor Steel's goals of the modernization were an increase of final width, reduction of final strip thickness, product mix extension and reduction of energy use. Maintenance efforts in roller furnace area should be reduced, too.

Modernization concept development: SMS group engineers investigated the max achievable rolling width with the existing housing configuration and figured out the possible max width of 1880 mm. An investigation of energy consumptions together with a reliability study on furnace rollers show, that the reduction of furnace temperature provides big advantages in consumption rates of natural gas together with an increase of furnace roller life times. Simulations with the PSC Model indicated the necessity of a 7th rolling stand together with a boosting of the incoming thin slab temperature. A share of the target product mix can be rolled with reduced temperatures but for some dimensions the thin slab temperature has to be elevated. An inductive bar heater in front of the finishing mill solves this task. Simulations predicted the required heat flux and inductor power. SMS group engineers worked out the necessary changes to all parts of the existing line, design figures and performed the project engineering.

Modernization measures: The scope of modernization comprised the revamp of one of the two CSP® casters, the extension of the CSP® rolling mill, the X-Pact® automation system and – for the first time – the installation of an inductive heating system between the CSP furnace and the mill.

The CSP® caster was fitted with new molds, new four-cylinder oscillation system, markedly wider segments and a new bending and straightening unit. By this, width was increased by 200 mm. Thanks to the implementation of the Liquid Core Reduction (LCR3) module in the containment zone, the thickness of the thin slabs can be infinitely adjusted between 48 and 63 millimeters.

For the very first time, an induction heating system was installed upstream of the CSP® rolling mill between the equalizing furnace and the rolling mill entry. With the lower furnace temperature it was possible to use non-cooled, dry transport rollers inside the tunnel furnace.

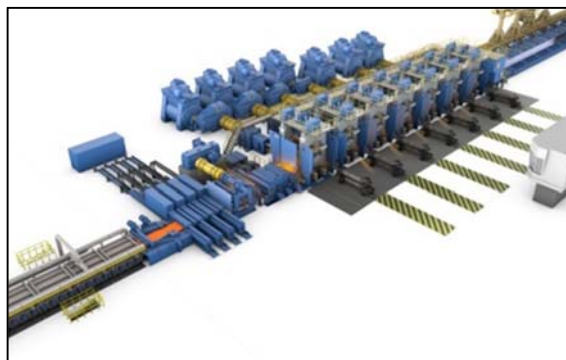


Fig. 5: Sketch of the mill layout after revamp with the inductive heater, heat cover hoods and the finishing stand F7

SMS group adapted the rolling width in the finishing stands F1 to F6 of the CSP[®] rolling mill to the extended casting width and added a seventh CVC[®] finishing stand F7. The exit roller table and the laminar cooling system were enlarged as well as one of the two existing coilers. The CSP[®] rolling mill also received a new X-Pact level 2 automation system including PCFC as well as a cooling model.



Fig. 6: New laminar cooling system (l); The X-Pact[®] automation system of the CSP[®] rolling mill comprises level 1: TCS and level 2: PSC,CSC with cooling model and PCFC (r)

Modernization results: In December 2013, the production started after few weeks down time. John Witherow, Hot Mill Manager at Nucor Steel said: *“SMS group has developed a cost-optimized modernization concept specially for us. It is perfectly tailored to our needs and provides us even more flexibility.”*

Through the revamp, the final strip width has been increased from 1,680 to 1,880 mm. A wider portfolio of grades are now produced on the CSP[®] plant comprise carbon steels, high-strength steels, pipe grades, DP and IF steel.

3.4 Bilstein GmbH & Co KG, Germany: High performance rolling of special steel grades in medium-wide format

Initial situation: Since its foundation in 1911, Bilstein GmbH & Co. KG, located in Hohenlimburg, Germany, has developed into one of the world’s largest suppliers of high-quality cold-rolled special steel products. The product range of Bilstein covers standard steels as well as a large range of special grades up to micro-alloyed high-strength steels of up to 1,400 MPa. As a supplier of cold-rolled narrow strip, Bilstein also uses slit strip with different strip wedges. Central to production at Bilstein is the four-stand batch tandem mill. It was built by SMS group in 1969 and has been extended and revamped several times over the years. The mill was equipped only with level 1 functions and four operators on floor level took care of rolling operation.

Modernization target: The goals of the revamp were to increase production by 60,000 tpy, to improve product quality and plant availability, to increase the degree of automation as well as to increase yield by decreasing the off gauge length per strip.

Modernization concept development: SMS group specialist figured out that a higher reduction capability is necessary to fulfill the demands. Strip tensions at entry and exit had to be increased. Together with higher rolling force capabilities and increased rolling speed modernization targets can be fulfilled. All this required modification and replacements of mechanical components and a new electrical and automation system to achieve reproducible rolling conditions at high quality level.

Modernization measures: In the entry area of the tandem mill, a new pinch roll unit was installed to increase the tension in front of the first stand to decouple the rolling section from the pay-off reel. The new HGC increase the rolling force by 30%. Direct roll-gap measurements at all stands ensure direct thickness control as precondition for semi-automatic threading-in of the strip especially for rolling of slit strips.

To reduce the residual oil content and improve strip dryness, as well as to avoid marks and corrosion, a latest-generation dry strip system from SMS group was installed in the exit area of the final stand.

The new swiveling bridle S-roll set decouples the strip tension between the final mill stand and the tension reel, and ensures that the strip travels smoothly through the flatness and thickness measurement area.

The modernization also increased the rolling speed of the tandem mill. For this purpose, new gear wheel sets were installed. All main motors were replaced, and modern synchronous motors with medium-voltage technology were installed in the mill stands. The coilers, the mill drives, and the S-rolls are equipped with efficient low-voltage motors. This idle-power-free drive constellation significantly saves energy and minimizes negative effects on the power supply system.

Beside a new Level 1, the new automation system includes a full-fledged Level 2. On the basis of a model, the system calculates the set-up of the mill for each strip, dependent on mill conditions and rolling stock. It is based on a complete mapping of the rolling processes by self-adopting physical models. The Level 2 also gives Bilstein the opportunity, to enlarge the product range in an economic way, by exact pre-calculation of the pass-schedules. Trial rolling in context with new products can be reduced significantly.

Further advantages are provided by the threading in/out assistance, called Total Roll Gap Control (TRC®), developed by SMS group. It takes into account the wedge and the thickness deviation at the head and tails ends of the strip, and ensures flat, straight strip travelling.



Fig. 7: Bilstein TCM before (l) and after revamp (r)

Modernization results: The measures described resulted in improved process stability and the desired increase in production by at least 15%. Also improved was the plant availability. At the same time, the specific energy consumption was decreased. TRC® reduces off-gauge lengths by more than 50 % and makes rolling operation more efficient. Thickness tolerances have been improved significantly. Operational results show that thickness is kept in tolerance across the entire strip length, even for strips with different strip wedges.

3.5 International Steel Limited (ISL), Pakistan: 70% capacity increase

Initial situation: Pakistan's first RCM with CVC[®] plus technology, supplied by SMS group, was operated by steel producer International Steel Limited (ISL) since 2011. The annual capacity of the RCM was 250,000 t.

Modernization target: Only a few years after commissioning, the cold rolled products have become so successful in the markets that ISL urgently required a capacity increase up to 450,000 tpy.

Modernization concept development: The conversion to a CCM by adding a second stand was the best and cost efficient solution, because already when designing the RCM, SMS group had considered this opportunity for the later extension.

Modernization measures: In 2014, ISL placed an order with SMS group for the extension of the existing RCM to a CCM. In addition to the existing mill stand, SMS group supplied for the CCM[®] an identically constructed second mill stand in CVC[®] plus 4-high design with hydraulic gap control and work roll bending as well as X-Shape flatness measuring and control system. During the installation of the new equipment, the concept of SMS group has proven itself. To create space for the new mill stand, only the exit side equipment had to be relocated. Because the capacity of the emulsion plant was dimensioned for operation as twin stand from the very beginning, no further adjustment of capacity was necessary.

Modernization results: After only one short mill shut down and rapid commissioning, the new CCM[®] produced its first coil in summer 2015. ISL is now provided with a state-of-the-art twin stand reversing cold mill for precise, reproducible high-quality rolling results of carbon steel and deep drawing material. The capacity is increased up to 450,000 tpy. This is a boost up to 70 %.



Fig. 8: RCM before revamp (l) and as Compact Cold Mill after revamp(r)

3.6 Outokumpu Nirosta Krefeld, Germany: 45 years old mill – ready for new challenges

Initial situation: Outokumpu Nirosta in Krefeld, Germany, was running a 20-high cold rolling mill “SG3” of type 21BB-61”. The mill had been supplied by SMS group (previously Demag) in 1969. It was modernized in 1991. Following the closure of the Outokumpu works at Düsseldorf Benrath locations, the production previously carried out there, like e.g. thin mirror-finish material, was transferred to the Krefeld works.

Modernization target: The “SG3” should be used for the production of high-grade special-steel strips made of austenitic, ferrite and martensitic materials. The mill's future rolling tasks included thin-gauge ferrite strips in high-gloss quality (2R bright-

annealed). The 45-year-old 20-high mill needed technically updating in order to satisfy the preconditions for rolling mirror-finish material. Another target of the revamp was to enable the entire thickness range to be rolled at maximum rolling speed.

Modernization concept development: SMS group engineers adapted proven design to the mill to ensure a perfect strip surface and higher rolling speed. The optimization of the existing rolling oil system was a consequence out of the demand producing such high-gloss grades.

Modernization measures: The order was placed in September 2014. SMS group's supply scope comprised changes to the entry and exit sides and on the mill stands itself. To achieve the desired strip surface quality, the existing squeezer system was converted to a dual cassette wiper system, including changing device, which can be operated with various types of wiper rolls. The existing cooling system was equipped with a volume control so as to allow pre-setting of different rolling-oil quantities, depending on the pass schedule. In the mill stand, the axial shifting system of the first intermediate rolls was renewed. Also, the mill was provided with a new mill stand door and new exhaust hoods. The pinch roll situated at the entry was replaced by an adjustable, swiveling pinch roll. This allows easier threading of the strip into the stand. The exit end was provided with a bending and pinch roll, too. Furthermore, new carry-over tables ensure that the strip head end can be inserted directly into the reel slot.

Beside the equipment, the SMS group scope of supply also comprised the dismantling of the components to be replaced, the performance and supervision of erection of the new equipment items and the commissioning of these items. Here, a tight time schedule had to be observed. The commissioning of the modernized mill took place in July 2015, following a revamp shutdown of 21 days.

In 2015 SMS group awarded a follow-up order by Outokumpu Nirosta, covering the next step of the revamp project covering the modification of the rolling oil plant. The equipment was partly exchanged and partly re-used. The newly installed equipment included a dirt oil tank with automatic pre-separator and the extremely fine filter system SUPAFINE® from SMS group. The SUPAFINE® system is provided with vertical filter pumps discharging the rolling oil contaminated by the rolling process from the dirt oil tank to the filter system for cleaning. The cleaned oil will then be fed to the existing clean oil tank and be used again for the rolling process. Already in November 2015 the mill could be put into operation again.

Modernization results: The mechanical modifications ensure safe, gentle and rapid threading and tailing out of the strip and therefore efficient mill operation. The 20-high mill is able to process a large scale of thickness ranges with entry gauge of maximum 10.0 mm and minimum final gauge of 0.5 mm with widths up to 1,570 mm. The maximum rolling speed to be realized is 500 m per minute. In addition the SUPAFINE® filter system ensures efficient and sustainable mill operation, because it recovers a large amount of the rolling oil used and it achieves extremely high filter fineness without using any filter aids that would create high additional costs for consumption and disposal.



Fig. 9: More than 45 years old 20-high mill of Outokumpu Nirosta – ready for new challenges

4 CONCLUSION

The SMS group approach for modernization of rolling mills is described. Customer targets are the key to select the necessary measurements. SMS group specialists are ready to provide their knowledge and experience to find the modernization concept with the best approach to meet these targets in close cooperation with our customers.

Based on modernization targets, investigations covering rolling technology, mechanical equipment, automation systems etc. were carried out to generate the best solution. Project engineering is done in parallel to meet both economical and down time preconditions.

Some examples explain this approach more in detail and illustrate the conceptual work, the projects, the realizations and the results achieved.

SMS group developed a “Tool Box” containing numerous modules to “Make the Best of your Flat Rolling Mill”. These well proven tools can be selected to meet the individual targets of each customer.