

# TECHNOLOGY PACKAGE FOR COLD ROLLING MILLS<sup>1</sup>

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## Abstract

With recent capacity increase cold rolled strip supply will soon exceed demand and result in a more competitive market. To respond to this trend, steel producers have no choice but to modernize their installed base in order to achieve better quality and throughput, and/or adapt their production mix to fit a new market demand. This paper presents some recent examples of high added value modernization projects demonstrating Siemens VAI's capability to supply proven packaged solutions for cold mills that not only surpass the customer requirements in terms of yield and productivity, but also drastically reduce implementation risks and associated costs.

**Key words:** Cold-rolling mills; Revamping; Quality; Yield; Productivity.

## PACOTES TECNOLÓGICOS PARA A LAMINAÇÃO A FRIO

### Resumo

Com os recentes aumentos de capacidade, a oferta de tiras laminadas a frio logo excederá a demanda, resultando em um mercado mais competitivo. Para responder a esta tendência, os produtores de aço não têm nenhuma opção, a não ser modernizar sua base instalada, visando obter melhor qualidade e produção e/ou adaptar seu mix de produção para se adequar às novas exigências do mercado.

Este artigo apresenta alguns exemplos recentes de projetos de modernização de alto valor agregado, demonstrando a capacidade da Siemens VAI de fornecer soluções comprovadas na forma de pacotes para laminadores a frio que não apenas excedem os requisitos do cliente em termos de rendimento e produtividade, mas também reduzem drasticamente os riscos de implementação e os custos associados.

**Palavras-chave:** Laminadores a frio; Reforma; Qualidade; Rendimento; Produtividade

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## Introduction

With the recent and still ongoing installations of new cold rolling mills the capacities for cold rolled strip production will soon exceed demand and result in a more competitive market. To respond to this trend, steel producers have no choice but to modernize their installed base in order to achieve better quality and throughput, and/or adapt their production mix to fit a new market demand.

Siemens VAI has developed several technology packages which are especially dedicated to the modernization of existing mills and which include mechanical equipment, hydraulic and drive systems as well as controls. Additionally this paper presents some recent examples of high added value modernization projects demonstrating Siemens VAI's capacity to supply proven packaged solution for cold mills that not only surpass the customer requirements in terms of yield and productivity, but also drastically reduce implementation risks and associated costs.

## Plant life-cycle and modernization business

Continually increasing demands on product quality and low-cost production force cold strip producers to permanently seek for equipment improvements and more efficient rolling operations. Two target groups are the main motivators for modernization projects: The decrease of conversion-costs and the adaptation of the cold rolled products to market requirements. Looking into more detail this leads to the following five reasons for modernizations, whereby the reason safety issue is observed especially in the last 3 years:

- Equipment relocation to a lower cost country
- Productivity increase
- Quality improvement (thickness, flatness, surface)
- Product mix extension (new dimensions and / or additional steel grade)
- Obsolescence and / or safety concerns.

A detailed knowledge of the mill condition, the cold strip quality produced and the connection to costs lead to different measures. Some of these targets can be fulfilled by Siemens VAI technology packages of which are dedicated for specific revamp needs. If it is not clear from the beginning of a modernization package our rolling mill engineers are ready to provide e.g. studies for your mill when e.g. yield improvement, quality improvements or the extension of your product mix to new steel grades are required.

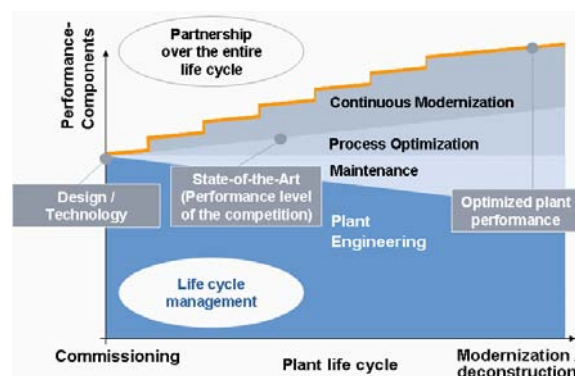


Figure 1: Motivation for modernization projects

The sample of projects presented hereafter show Siemens VAI strong presence in each of the above mentioned types of projects.

### Typical Technology Packages

**Table 1: SIROLLCIS CM technology packages**

	Market requirements						
	Reduction of operating costs			Adaption to market requirements			Adaption to legal requirement
	Utilities	Productivity	Yield	Product quality	Extension of strip dimensions	Extension of product mix	Adaption of safety equipment
Laser welder package							
Flash but welder upgrade for AHSS							
Side trimmer package							
X - High							
Flatness package							
Drive package							
Chatter package							
AGC package							
Coiler package							
Condition monitoring and maintenance							
Yield improvement study and/or package							
Safety study							
Safety package							

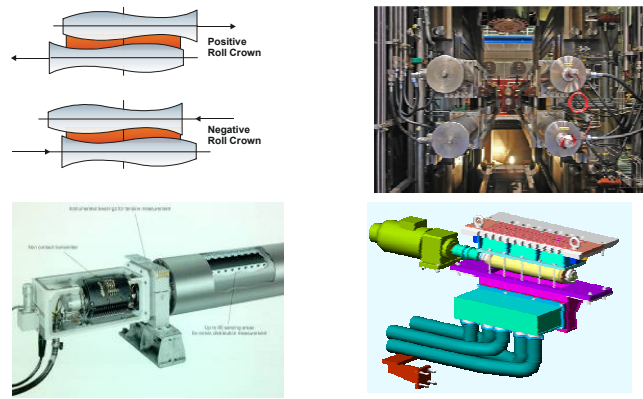
Analyzing the revamp business over the last years leads clearly to the result that the market needs specific solution for individual improvement steps. Siemens VAI packaged these specific solutions and offers this in case of modernization projects.

**Table 2: Latest references in modernization**

Recent modernization projects	Technology Packages										
	Laser welder	Side trimmer	x - High	Flatness package	Drive package	Chatter package	AGC package	Coiler package	Yield improvement	Safety study	Safety package
Salzgitter											
Dunaferr SPM											
Essar CTCM											
CSN TCM											
BETAVAS											
Guangxi Liuzhou											
Benxi											
Corus SPM											
Arcelor Packaging Galvameuse RCM											
Duferco Coating RCM											
Arcelor St Chely RCM											
Panzhihua RCM (new)											
Arcelor Cockerill TCM											
Arcelor Florange TCM											
Arcelor Aceralia RCM											
Arcelor Sidmed CTCM											
WISCO PLTCM #1											
WISCO PLTCM #3 (new)											
Rasselstein											
Utham											
Dofasco PLTCM											

### Flatness packages

Our flatness solution includes all required mechanical actuators, control and measurement systems to ensure highest flatness performance. Depending on mill type and product mix, the mill stands are equipped with work roll bending and shifting, Smartcrown® work-roll contour and multi-zone cooling. The flatness control system features self-learning parameter optimization for adaptation to the rolling conditions and material properties.

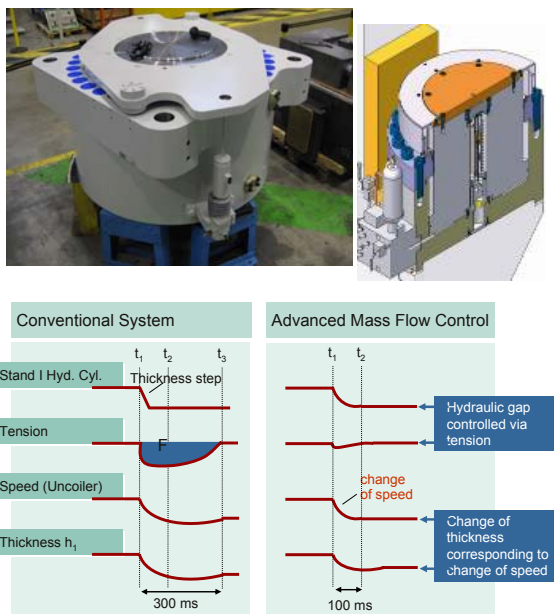


**Figure 2:** SIROLLCIS CM Smartcrown® roll contour, work roll bending/shifting device with and flatness measurement systems – lanicim roll and Siflat contactless measurement

To complete our package we can either use the contactless Siflat system or the Planicim® flatness measurement roll depending on technical and ambient conditions

### AGC package

The automatic gauge control package of Siemens VAI combines the hydraulic capsules, servo-valves, transducer and the control system to create a comprehensive solution. SIROLLCIS CM's advanced mass flow control ensures thickness precision to a few thousandth of a millimeter. Our improved REC - Roll eccentricity compensation system also contributes to a further improvement of thickness performance and is especially beneficial for modernizations projects.



**Figure 3:** SIROLLCIS CM AGC cylinder - before mounting and design principle, comparison of response time of thickness control based on mass flow control

### Drive package

This package comprises all mechanical, electrical and automation components of the whole drive train for mill stands or coilers. It consists of medium voltage power supply and harmonic filters, the drive transformer, the drive system (Sinamics) and

contactors, motor, sensors and brakes, reducer or pinion gear, couplings, spindles and torque limiters (e. g. shear pins).

As Siemens VAI can act as supplier for mechanical, electrical and automation systems for the drive train we are in the position to avoid risks in project execution and to reduce project execution time. Depending on the targets of the project the scope of the package will be adjusted,

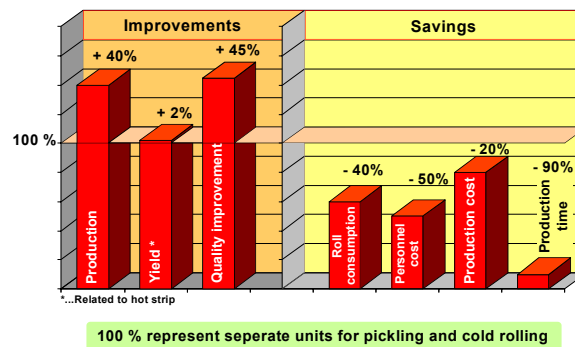
### Coiler package

Quality, yield or productivity improvements are often the reason to start modernization steps in the coiling area. The mechanical and hydraulic elements of the package include e.g. mandrel, gripper bar, outboard bearing, housing, drive system, snubber roll and stripper plate and are selected according to the targets of the customer. On the electric and automation side often improvements of main drive, drive system, tension control, diameter calculation or coil eccentricity compensation are necessary.

### Yield package

The SIROLLCIS CM yield package starts with a study or analysis in which the whole mill is screened to improve the yield ratio. This package includes the data collection based on the agreement with the customer, for data collection existing tools on the customer side or specific data collection tools of Siemens VAI are used. (PDA, KPI).

Based on the results of the study our senior experts propose improvement steps to reach the targeted yield performance. This improvement steps consider best practice experience and reachable performance results which we collect during projects around the world. To ensure fast evaluation of the existing information of the customer we apply special statistical tools which are dedicated to the cold mill operation. This can reach from individual packages such as the side trimmer package up to a bundle of different technology packages, additional measures in the mill and/or the software upgrades for portions or the total automation system.



**Figure 4:** Example for results of modernization steps based on a yield package

As a result of the study we propose the integration of applicable technology packages and/or automation solutions. Based on the result of this study the customer can more precisely decide which further improvement steps he will start in his rolling mill. In addition the customer is able, based on the result of this study, to decide more precisely about further improvement steps in his mill.

### **Safety studies and safety package**

The Siemens VAI safety package is a standardized methodology to design and implement safety solutions which are required according to the local regulations. This approach is divided into three steps. The first step is a safety study, where Siemens VAI makes a risk analysis in cooperation with the customer. A concept study has to be prepared by an expert team of electric and automation, hydraulics, mechanics and a safety specialist with the support of an external institute. This concept will be approved from the legal authority in cooperation with the customer and builds the baseline for step 2. The second step concerns the actual offer for the equipment and installation and is based on the concept study. Step 3, the implementation, includes supply and installation of equipment and automation systems according to the contract which is based on the study, validation of control based safety solution for automation and hydraulic and the whole documentation including the safety instructions.



**Figure 5:** Example for safety fences and instructions

### **Reference Examples**

Flatness packages for Reversing cold mill Duferco Coating Beator, France. Siemens VAI and Duferco share a long history of technical cooperation. Already in the early 90's, former Clecim revamped the Beator reversing mill to reach a production level of approximately 400 000 tons per annum. In order to reach the highest quality standards this project included one of the first Planicim® shapemeter rolls. Duferco Beator mill has thus been producing since 1991 a wide range of steel qualities including exposed automotive (electro-galvanized) and HSLA (High Strength Low Alloy) grades. At the end of 2006, the flatness quality requirements have become tighter and the product mix has evolved, leading Duferco to reconsider the technical solutions on the Beator mill. Siemens VAI has therefore proposed a new modernization project to improve the flatness performance of the mill. Siemens VAI offered to Duferco a two step flatness control upgrade: Mechanical and electrical refurbishment of the exit Planicim® shapemeter; Supply of a new multivariable automatic flatness controller; Revamping of the multi-zone cooling control.

These upgrades already brought measurable benefits on the flatness measure and control. Excellent signal/noise ratio, accuracy and resolution of the measure Very tight flatness control (typical 5 IU of standard deviation). Modern, high reliability electronics including non-contact Infrared link between rotating part and fixed part. Easy maintenance due to modular design including engineering screens

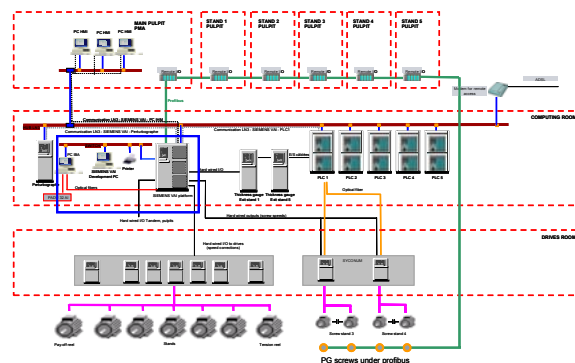
**Table 3:** Planicim® shapemeter characteristics

Performance evolution with new design Thickness= 1mm, tension=4kg/mm <sup>2</sup>		
	Version 2	Version 21
Measurement chain resolution	0.07 IU	0.035 IU
Measurement chain accuracy	1.45 IU	0.18 IU
Ability to measure % IU	3.4	38
Noise level	1.45 IU	0.18 IU
Signal/noise ration	13.8	111
Minimum operating tension	80 lbs/inch	80 lbs/inch

**AGC package for tin plate tandem cold mill Arcelor Mittal (Cockerill) Belgium**

In 2004, Cockerill initiated a revamping project of the tin plate mill in order to increase the yield and expand the product mix to sheet coils. During the pre-project phase a joint team of Cockerill and Siemens VAI specialists examined several revamping scenarios. The decision went towards the project with the best performance over investment ratio, consisting of the following mechanical & automation package: Replacement of electromechanical screws by fast acting hydraulic cylinders on mill stands no. 2 and 5; Supply of new automation controls including hydraulic gap control (HGC) on stand 1, 2 & 5, electromechanical gap control (EGC) on stand 3 & 4, automatic gauge and tension control (AGC, ATC) and support on the process model.

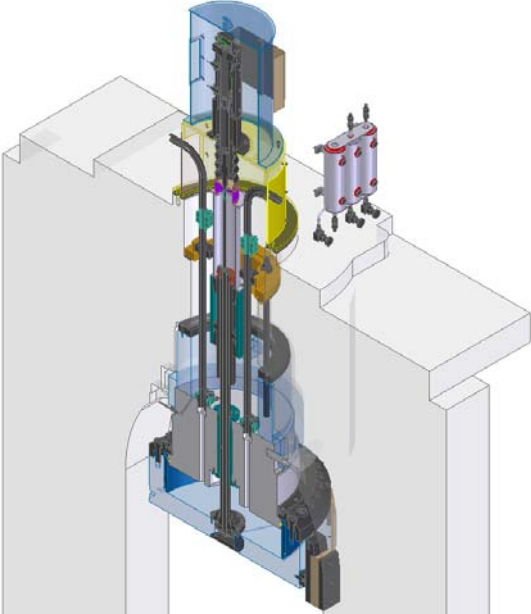
The project team had to take up several challenges: Integrate above mentioned automation functions in the existing mill control system, by working out in thorough details interactions of hardware components as well as software modules. For example a new communication protocol matching the existing one (Arcelor proprietary LN3) was implemented in the new controllers. On the software plan, new performance critical functions such as AGC & ATC were connected to existing remaining modules such as set points distribution, speed master & drives control blocks after a detailed reverse engineering so as to ensure a flawless startup. I/Os were implemented either directly (drives trims), or by Profibus remote I/Os.



**Figure 6:** Automation architecture (blue line surrounds newly supplied cabinets & computers; brown colour: LN3 communication backbone)



On the mechanical side, custom design new hydraulic cylinders replacing existing electromechanical screws on stand 2 and 5, with two constraints: minimize on-stand installation work during the outage, and provide high performance actuators. It consists of single effect double acting hydraulic roll force cylinders with pull back cylinder in the center of the capsule. High speed movements are controlled by servo valve, while long stroke opening and closing are controlled by proportional valve in parallel with the servo valve. The design allows low friction movements with hysteresis under 3 tons with slight rotating possibility and low friction center rod. In addition, special coating of the inner and wear parts provide an extended lifetime.



**Figure 7:** New hydraulic cylinder for gauge control

Due to high pressure from production, all preparation, erection and start-up work had to be completed together with other mechanical upgrades during the main outage of winter 2004. After 18 days of intense work by the Siemens VAI site team, the mill was started up on schedule and the gauge control tuning phase started.

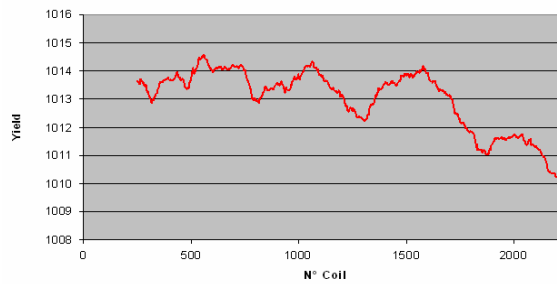
**Added value**

The most tangible indicator of the project success is the measured yield, defined as

$$Yield = \frac{Final\_product\_weight}{Weight\_inside\_tolerance} \times 1000$$

After the tuning campaign, the average yield was improved by 0.3%. In addition to this, the new controls allowed for a much smoother threading in and speedup process. The resulting operators' confidence allowed increasing the mill productivity by more than 6%.





**Figure 8:** Yield evolution after mill startup

### **Drive package for Baoshan CTCM No.1**

The Baosteel five-stand tandem cold rolling mill is one of the largest of its kind. It was originally built in the late 1980s and was part of the first expansion steps of Baosteel flat steel production in Baoshan. The mill was built for discontinuous and mainly continuous operation.

Beside the investment in new capacities and the extensions of the amount of production, Baosteel is investing in continuous improvement of their existing plants in order to follow the market requirements and to strengthen their cost position in the Chinese market.

The Targets of the drive upgrade project were as follows:

Higher accuracy, higher dynamic and more stable digital drive control

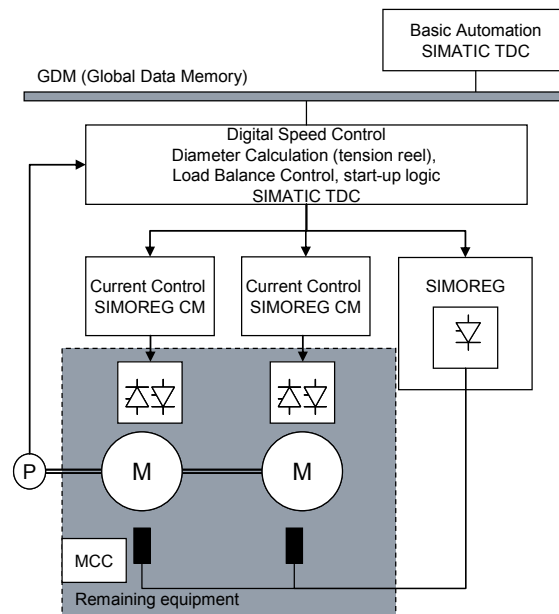
High resolution pulse generators (5600 p/rev)

Synchronous set-point transmission for mass flow control

Integrated diagnostics

SIROLLCIS CM for Cold Mills from Siemens VAI, which includes the digital drive controls for highest accuracy formed the core of the automation concept. Before the main shut down, the control- and thyristor power units for all the smaller strip transporting drives were replaced and commissioned during regular maintenance shut downs using the existing cubicles and wiring. Also the test of the firing pulses for the main drives and larger strip drives to the remaining thyristor units and the software of the auxiliary function were carried out at this time.

The cabling and installation of the cubicles was carried out prior to a scheduled three-week shutdown for modification of the mill. This included the connection of new terminal boxes to the Profi-bus field network, installation of a industrial Ethernet network, and the removal of old cables and equipment.



**Figure 9:** Drives package for Baoshan CTCM No.1 - realization

### Coiler package for Arcelor Mittal, Saint Chely, France

The reversing cold mill of Arcelor Mittal in Saint Chely produces Silicon steel for high-quality requirements. Siemens VAI completed a first upgrade in 2005, including a new roll change system and mill window modification. Main objective was to improve the operation safety and increase mill operation time. In 2007, Arcelor renewed its confidence to Siemens VAI and placed an order for the replacement of the coilers by very powerful units. Two objectives were driving this upgrade: yield and productivity increase.



**Figure 10:** Reversing Cold Mill in St Chely and applied pyramidal type mandrel

Considering the very stringent process requirements, Siemens VAI proposed powerful, pyramidal type mandrels with hydraulically actuated gripper bar. In order to cope with high temperatures, the mandrels are lubrication free. Available maximum tension goes from the actual 16 tons to 25 tons; the possibility to reach 32 tons when the motors are upgraded is foreseen.

The special gripper bar design allows applying the tension very early which leads to yield improvements of 0.3 to 0.6%, depending on the product type. In addition, the higher available tension gives the opportunity to apply greater reduction and reduce the number of passes. Resulting productivity gains are not finally assessed but shall be in the range of 15%.

### Safety Study for voestalpine PLTCM in CRM no 2

Target of the concept study was the investigation of the existing equipment regarding the potential for extension, which is necessary according to a hazard

and risk analysis prepared by the customer. The required safety relevant measures will be carried out by fixed or moveable separative protection devices. For operational entrance request panels at doors and for not monitored areas lock solenoids in the occasion of entrance are used. Objective is to reach the required safety under minimum disturbance of the operability of the plant. All safety relevant actuators were listed and grouped according to safety areas and shut down groups. Additional required safety relevant actuators and sensors were listed in a motor and component list. Based on exemplary investigations of the existing automation equipment the feasibility was checked for selected safety areas. Basic idea of the safety modernization project is the complete exchange of the existing safety controls by new and modern S7-400F controls. The existing safety controls are mainly used for safety controlled stop of the plant in case of an emergency stop. The new safety control system will be extended by the function safety stop. The other controls will be further used. The new safety controls will be connected to the existing H1 bus. The entire communication of the visualization concerning status, input and notifications of malfunction run over the existing S5-systems. The existing E/A cabinets in the area of the hydraulic blocks are only partly further used, some of the cabinets have to be totally replaced.

The realization of the safety upgrade will be executed in several steps, the weekly maintenance shutdowns will be used as preparation phase. During a big shutdown in Nov - Dec 2009 the migration of the existing safety functions to the new controls will be performed whereby the emergency stop function will be retained. Step by step the individual safety areas will then be extended to the function safety stop. Finalization of the project is forecast for 2010.

Bundle of tech packs for skin pass mill modernization for DUNAFERR – Hungary Dunafer decided 2001 to modernize the 1700 mm skin pass mill, which was originally installed in 1963 by Uralmash. Target of the largest modernization since the installation was to establish a state of the art skin pass mill. The upgraded 4-high mill is designed for a production of 600,000 tons per year, 0.3 – 3.0 mm strip thickness and 800 – 1,550 mm strip width. For this product several technological packages were applied. The AGC, flatness and elongation control packages targeted on the improvement of strip quality with hydraulic roll load adjustment and by positive and negative work-roll bending for exactly determining the strip elongation rate and for best strip flatness. These packages included the renewal of the mill-control system including HMI as well as the technological controls for elongation rate and strip flatness. The main drive systems were modernized and partly modernized. A dry-skin-passing system was installed to eliminate the need for wet skin-passing agents and for improved strip-surface adhesiveness during subsequent painting. The project included the supply of new entry and exit coil conveyor systems as well as an automatic work roll changing system to reduce the non-productive time and to reach the target capacity.

## **Conclusion**

Siemens VAI has developed several technology packages which are especially dedicated to the modernization of existing mills. The packages include mechanical equipment, hydraulic drive and automation systems and have been proved in several modernization projects with specific improvement according to the needs of the customer.

## Outlook

With a consolidation on the market and the high installed capacities for cold rolling upgrading of existing mills will be a fixed portion of Siemens VAI business in the future. Service throughout a life-cycle plays today a major role. Siemens VAI is your life-cycle partner, from project start throughout your plant life and supports this strategy with specific technology packages.



**Figure 11:** Skin Pass Mill in Dunaújváros, Original, dismantled and modernized mill

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