NEW TANDEM COLD MILL AT CORUS, NETHERLANDS[1]

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Abstract
July 2006, Corus Group awarded to Siemens VAI the contract for the supply of a new tandem cold mill, coupled to an existing pickling line, and a new hot-dip galvanizing line for the company's plant in IJmuiden in the Netherlands. Corus wants to use the new installations to further expand its product range capabilities for the automotive and constructive markets, including advanced high-strength steels (AHSS). This new mill is equipped with 4 stand 6-high and with an exit section with Carousel reel and flying shear. Necessary up-grades have been carried out on the pickling to bear with the new operation mode and production target. The automation system includes technological control systems and complete process automation equipment including rolling process set-up based on online analytical mathematical models. In addition to first rank product performances, the main targets of the line are operation easiness, versatility and capability to process the actual and future steel grades. The new line starts its production in the middle of 2008. In this paper, after a brief overview of project implementation, the first results in terms of operation performance and product quality will be presented.
Key words: Cold-rolling mills; Tandem cold mills; 6-high; Future steel grades; Carousel tension reel

NOVO LAMINADOR DE TIRAS A FRIO TANDEM NA CORUS, HOLANDA

Resumo
Em julho de 2006, Corus contratou a Siemens VAI para o fornecimento de um novo laminador tandem, acoplado com um decapagem existente e uma nova linha de galvanização para a planta de IJmuiden na holanda. Corus pretendeu de usar esta nova linha para expandir o mix na área automotiva e de construção, incluindo aços AHSS. Este novo laminador tem 4 cadeiras de tecnologia 6-high e uma saída de bobinadeira tipo “carousel” e uma tesoura “flying shear”. A área de decapagem foi modernizada onde necessário. O sistema de automação incluiu os modelos matemáticos e set-up e os sistemas de controle tecnológico. Alem de desempenho a meta foi de “operação fácil” a versatilidade e a capabilidade de produzir o mix atual e o mix futuro de produtos. A nova linha partiu em junho de 2008. Neste trabalho será apresentado a implementação deste projeto e os primeiros resultados de desempenho operacional e de qualidade de produtos.
Palavras-chave: Laminação a frio; Laminador tandem 6-high; Grãos de aço futuro; Bobinadeira tipo carousel.

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Introduction

At the beginning of 2000, Corus Strip Product IJmuiden pushed forward with the plan for the development of cold-rolled production in its integrated plant of Ijmuiden in Netherlands. With around 6.5 Mt of crude steel per year, the IJmuiden plant produces hot-rolled, cold-rolled and metallic-coated steels for many industries, including the automotive and transport industries, building and construction, consumer appliances and electronics industries and for general engineering.
One part of the project was to develop a short and versatile route from liquid steel to cold-rolled product via DSP (Direct Strip Production) and one new cold-rolling facility to produce a wider range of products for household and automotive applications.
Common work with Siemens VAI has been done during nearly two years to define the optimum solution within the assigned investment budget considering the requirements of the plant in IJmuiden, the wide product mix and specific market demand:

- Specific strip profile
- Wide range of product to be processed
- Compact layout
- Optimum investment and production cost

In July 2006, Siemens VAI was awarded a contract by Corus for the supply as turnkey process project of the new Cold Mill 22 for the production of cold-rolled strip up to 1,650 mm wide, material. The contract also included an automotive CGL line for wide strip.

Figure 1: CM22 during assembly at Corus IJmuiden, Netherlands.

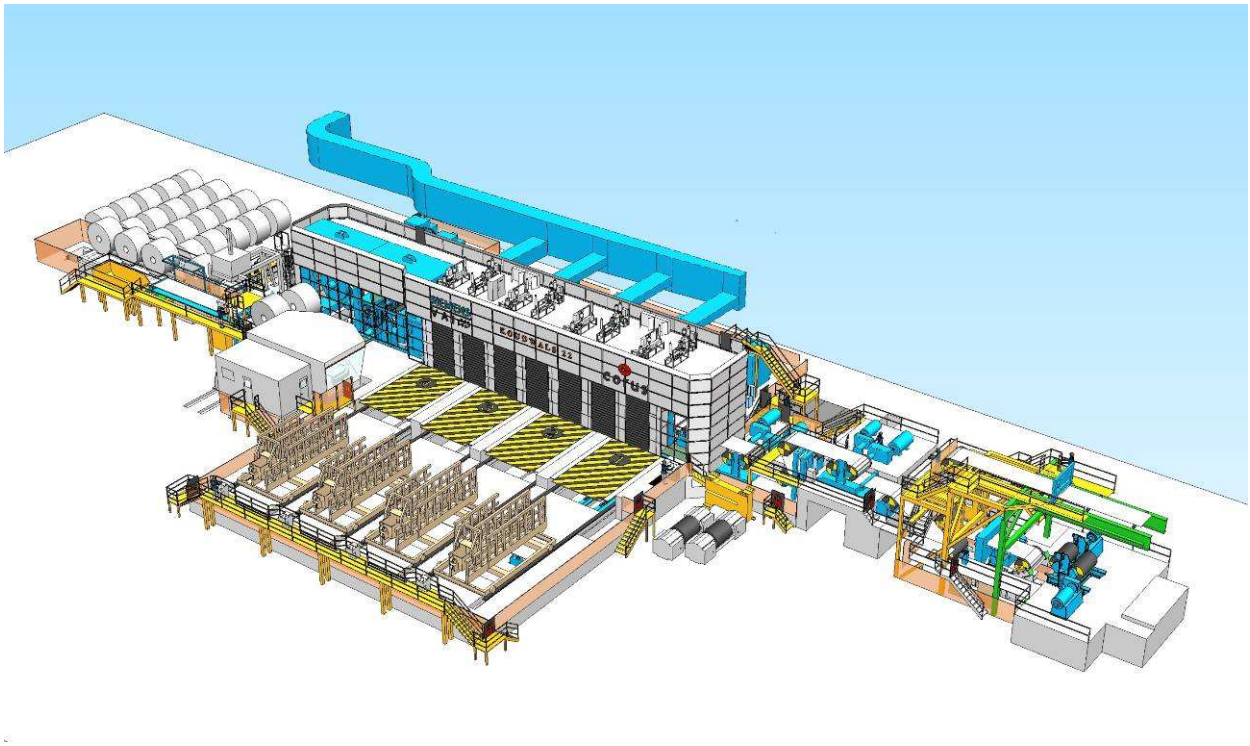
Layout, product mix and plant data

The new mill has been installed inline with the existing pickling line considering the limited length availability of the facility. Also in future it will be possible to use the pickling line alone to produce pickled and oiled coils when necessary.
The line consists of an entry coil handling section, including an automatic debanding machine, a pay-off reel, a laser welder, entry looper, process section, intermediate looper, side trimming section, coupling looper, diverting station to choose between coupled or uncoupled mode, tandem mill, a SIROLL^{CIS} Sias automatic inspection system, a carrousel tension reel, an off-line inspection station, and exit coil handling equipment (automatic marking, banding, coil eye welding).
The Siemens VAI scope of supplies and services includes mechanical equipment, hydraulic and pneumatic systems, all drive systems, electrics and automation, safety equipment, assembly, installation and commissioning for the coupling and tandem

mill area. Up-grades have been carried out on the pickling line to fit with the new requirements of the CM22 (re-engineering of the automation system, improvement of entry downtime, adjustment of tension map).

Product mix

The annual rolling capacity is 1,600,000 t. The product mix consists of IF steels (DX56, DX57), CQ and DQ grades and HSS grades, including DP (600 to 1000).



1 Diverting system
2 Steering device
3 Entry Bridle
4 4-stand 6-high tandem
5 Roll changing device
6 Main pulpit
7 Carrousel reel exit section
8 Inspection station

Figure 2: Layout of the tandem cold mill 22 of Corus IJmuiden, Netherlands.

Plant data

Mill characteristics

Mill type	4-stand, 6-high	
Roll separating force per stand	25,000	kN
Work-roll bending force	max. 1,400	kN
Intermediate-roll bending force	max. 1,400	kN
Intermediate-roll shifting stroke	550	mm
Drive power per mill stand	6,000	kW
Drive power tension reel	2,300	kW

Strip dimensions

Entry thickness	1.0–4.0	mm
Exit thickness	0.4–3.0	mm

Strip width	700–1,650	mm
Coil weight	max. 48	t
Mill speeds		
Pay-off reel	max. 650	m/min
Process speed	400	m/min
Entry tandem mill	max. 485	m/min
Exit tandem cutting speed	300	m/min
Exit tandem mill	max. 1,200	m/min

Specific requirements for CM22

From the start of the definition of the project one of the goals was to process a wide range of products in terms of hot coil, rolling process or grades.
A high percentage of the production is coming from the DSP (Direct Strip Production) route with specific strip shape and low crown profile. High ability to control the strip and roll bite was one key point of the new rolling facility. A second point was to improve the serviceability of Corus and provide stability by being able to process a part of the production of the existing tandem cold mill CM21, if required. Among the existing customers, there are automotive producers with steel grades that required the mill to have the features to process high surface quality. Additionally the mill should have the capability to bear with the current trend of increasing tensile strength of HSS steel grades. The third target was to produce thin pickled and oiled strip with specific roughness on the CM22. Therefore a specific skin-pass mode was implemented on the tandem mill to address this specific process.
In addition to those process requirements, the space constraint, due to the installation in the existing plant of IJmuiden, was limiting the overall length of the tandem mill and associated utilities.
The solution to fulfill all the requirements was found to be a highly powered 4-stand 6-high tandem cold mill. Extended action and comprehensive operation of the edge-orientated shifting strategy of the 6-high mill ensure optimum control of the roll gap and enhanced flatness quality. The coiling section is equipped with a rotary shear and a carrousel coiler, which gives the advantage of a compact layout and identical coiling conditions for all coils. In addition a SIROLL^{CIS} Sias automatic strip inspection system at the mill exit for immediate detection of surface defects and an oiling machine for the production of skin passed coils are installed.

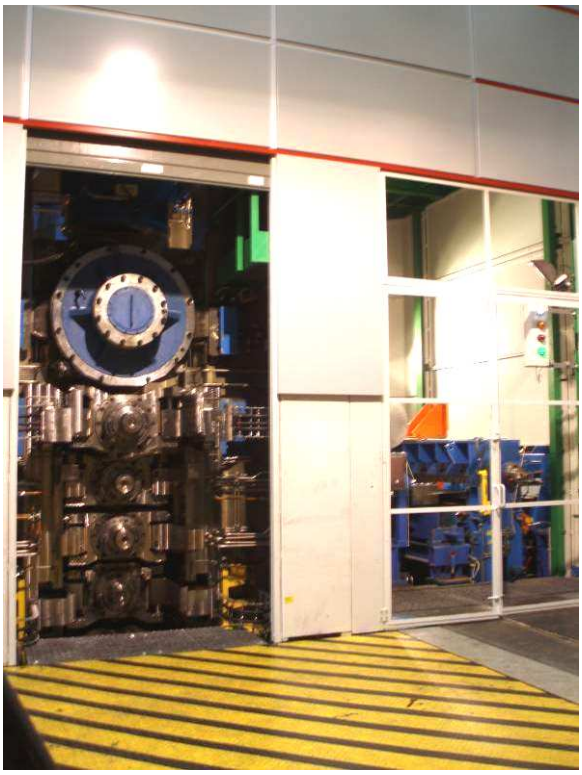


Figure 3: Tandem cold mill – mill windows.

Pickling and coupling section

The pickling layout and operating parameters of the existing pickling line had to be adapted for the required performance and operation principle of a state of the art PLTCM.
A survey was carried out to detect the bottleneck of the line in the future configuration. Long entry downtimes, insufficient tension at the line exit and low software maintainability were identified. Those points have been corrected to guarantee that the performance level of the pickling line fits to the tandem mill performance.
In addition, the necessary equipment has been installed to couple the pickling line with the TCM. One coupling looper with 450 m capacity compensates for the speed difference between the side trimming section and the mill. A diverting station allows for coupling and uncoupling of the tandem to/from the pickling line in order to be able to process pickled and oiled coils when required.

Tandem mill features

Behind the coupling looper, the strip passes through two sets of steering units and two sets of bridle units, the last one being located just in front of mill stand No. 1. This arrangement allows very precise strip centering and optimum response for tension control at mill stand entry giving advantage for our advanced mass flow thickness regulation. For harder strip grades, the entry tension can be regulated up to a level of 40 tons to improve the reduction pattern at mill stand No. 1.
The mill stands are of 6-high type with long stroke shifting of the intermediate roll. A homogeneous roll force distribution across the complete strip width is a clear advantage to process low edge profile and allow to have extensive flatness control

on the strip. The powerful bending systems for work and intermediate rolls (up 70 t per side) are always working in their optimum range.
The total roll force of 2,500 tons per mill stand is generated through low-hysteresis hydraulic capsules. The capsules installed on the mill benefit from the latest improvements dedicated to higher performance: low friction seals, high-response servo-valves flanged directly on the cylinder and built-in hysteresis-free position transducers.

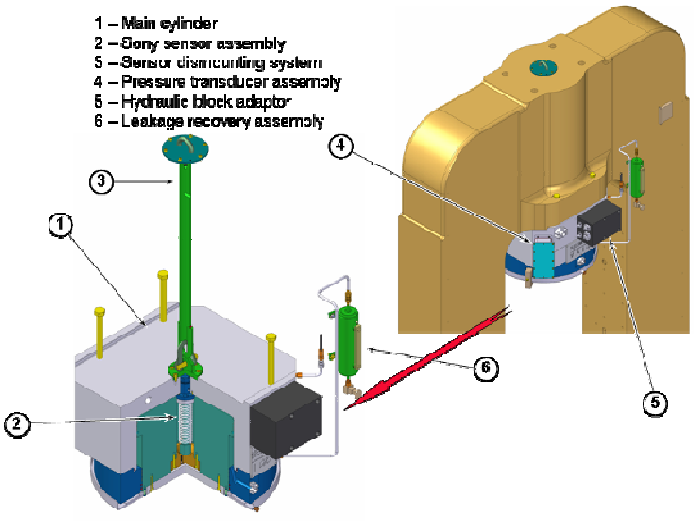


Figure 4: Hydraulic roll force cylinder principle

To ensure and control strip quality performance, speed, thickness and tension measurement systems have been installed at mill entry and in the inter-stand area. The instrumentation is suitable to be used either during rolling operation but also during skin-passing operation with specific requirements in terms of speed and tension control for the precise control of elongation and roughness transfer.
A key issue of the rolling process is lubrication of the roll bite and cooling of the rolls and the strip. Particular focus was given to the roll coolant and spray header system in the mill stands during the engineering phase. A state-of-the-art recirculation emulsion system with two tanks was installed. One tank can feed the first three mill stands or all stands with emulsion, depending on the rolled product. The second tank is dedicated to the last stand only to ensure strip cleanliness. Provision has been made to install two other tanks for the use of emulsion with higher lubricant properties to improve the rolling process for the next generation of HSS steel grades.
As skin passing and rolling operation for automotive products takes place, the highest level of cleanliness inside the mill has to be maintained. To fulfill this requirement, a complete mill washing system is installed, including a classical high pressure fire hose but also automatic cleaning nozzles in the mill stand areas. To avoid any strip contamination during dry skin-passing, all the roll cooling headers are air-purged.

Mill exit section

To meet the requirements of the highest strip quality level and improved operating cost, the entire length of the strip surface, top and bottom, is inspected by the SIROLL^{CIS} Sias automatic surface inspection system at the exit of mill stand No. 4. Any defect will be detected, recorded and classified in real time. According to the

type of defect, the information is only recorded or transmitted to the operator. If the defect is classified with an origin of the tandem mill itself, such as roll mark, information regarding the defect origin is given and the operator is asked to take corrective actions, such as changing of the faulty work roll.
Due to its compact layout, the carrousel reel solution is ideal for CM22. In addition it gives the advantage of identical coiling quality coil after coil, shorter strip length and a smooth threading route during coil change. Served by a high speed rotary shear and three tail rolls with magnetic table, a strip cutting speed of 300 m/min is achieved. Advantages are increased productivity and improved off-gauge due to highest speed while the seam weld is going through the mill.
After rolling, the coil is managed by the coil transportation system. The coil is automatically weighed and strapped, and dispatched to the Corus internal transportation network. If required, the coil can be shifted to the visual inspection station just after discharging of the carrousel reel. The station is located next to the main pulpit in front of the carrousel reel for additional inspection.

Figure 5: Rotary Shear in Siemens VAI MT workshop in

Drive system

The main and auxiliary drives, in combination with the mill stands, play a key role in the success of a continuous tandem cold mill. When it comes to final strip quality, the performance of a multi-stand mill depends substantially on the main drives.
For the drive systems at Corus the completely new Sinamics SM150 and S120 converter family has been used. Based on a single platform, our Sinamics drives combine to form a complete and consistent drive family that spans the entire performance range with regard to flexibility, functionality and engineering design. The Sinamics SM150 uses low to high-speed applications with regenerative supply. This requires high output power, torque and dynamic response. These IGCT (Integrated Gate Commutated Thyristor) technology-based medium-voltage source converters are applied to the main motors of the mill stands. These compact and reliable systems feature quiet operation and excellent dynamic response.

The modular design and high performance of the Sinamics S120 IGBT (Insulated Gate Bipolar Thyristor) low-voltage converters are installed for the drives of bridles, pumps and coilers.

Figure 6: Pulpit and roll change platform

SIROLL^{CIS} CM completely integrated solution

The SIROLL^{CIS} CM automation solution is based on Simatic PCS7 as the standard engineering and control system for plant operation and fault diagnosis.
The entire automation uses the high-performance Simatic TDC automation system, which provides maximum computing power for sequence and technological controls. All peripheral process equipment is connected via ET200 distributed I/Os. An open communication system allows data to be exchanged between the different automation tasks, using the

- Fast Ethernet bus as the process bus
- Simatic TDC global data memory for real-time data exchange between the system controls
- Profi-bus as field bus for peripheral equipment
- Simatic WinCC as plant-wide visualization system, which features central power-up capability, central message and diagnostic system which can be operated from any plant monitor

The plant relies on the highly successful Siemens VAI thickness control concept which uses the advanced mass flow technique to ensure tight tolerances under all operational conditions. The advanced mass flow control concept for tandem cold mills developed by Siemens controls reduction at the individual stands, decouples the stands by means of strip-tension controllers, and thereby achieves very close strip gauge tolerances. An automatic flying gauge change system is included to minimize the off-gauge length.
The flatness control system stand 4 makes use of neural networks that have a self-learning function, allowing precise adaption to production requirements.
The process automation system (level 2) includes auto-adaptive process models based on advanced physical models and neural network for optimization. An ideal combination of physical models and auto-adaptive algorithms is the key to success in process modeling.

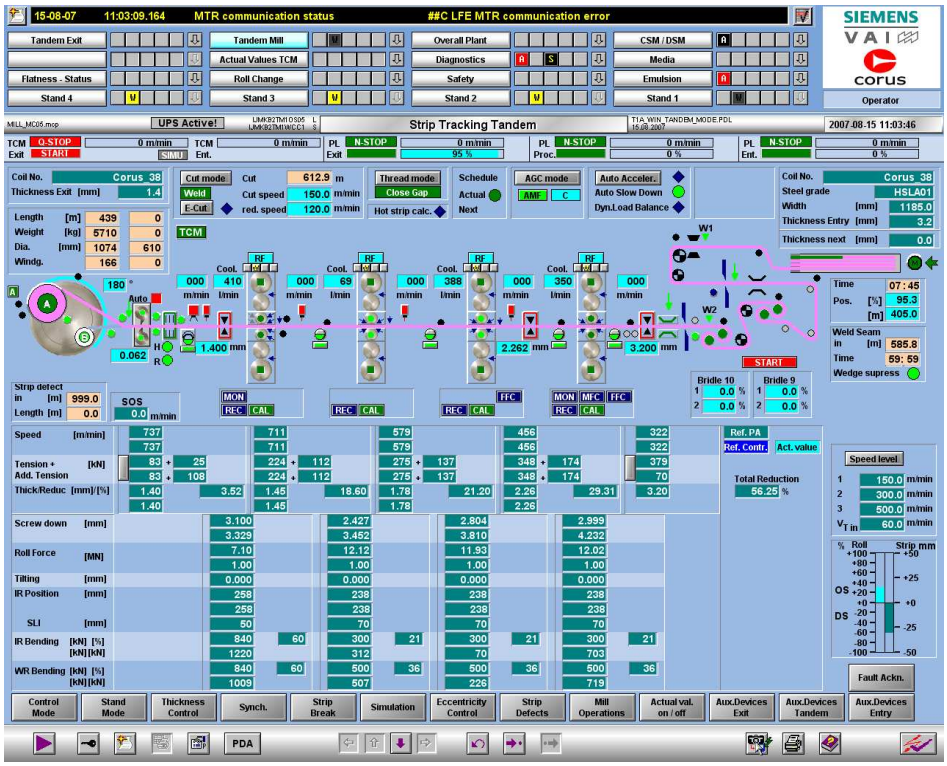


Figure 7: HMI View for on Corus CM22

For the flexible operation of high-performance continuous tandem cold mills, the following functionalities are implemented in the level-2 system:

- Speed optimization
- Coil building
- Interfacing to level 3
- Production planning
- Quality data evaluation

Integration test for automation and drive system

Integration tests using plant simulations are essential to success. Siemens VAI thoroughly tested the complete automation system, including all visualization systems, control consoles and the drive systems in the test facilities in Erlangen, Germany, before shipment.

Figure 8: Integration test at the test facilities in Erlangen, Germany

Safety

Safety areas were defined to avoid any negative impact on operation and were partly divided into sections to be able to recover malfunctions during operation. It is, for example, possible to enter the safety area of the exit coil transport without stopping the whole line. Specific areas were designed to enable changing or set-up procedures to be performed, e.g., change of binding strip in the coil binding area during normal operation. The fully automatic roll change system is of a safety-related design ensuring that during an ongoing roll change the area is allowed to be entered if any malfunction of the roll change car occurs. The mechanical and electrical equipment, in conjunction with a detailed risk analysis, meets the highest European machine directive standards.

The safety functionality is implemented using the Simatic S7 400F system. The Simatic S7 400F provides maximum computing power for all safety control functions. Most peripheral process equipment is connected via the ET200 failsafe remote I/O. The system is TÜV-certified and used in combination with the Sinamics safe torque-off function without any hardware disconnector switch. SIROLL^{CIS} CM automation system allows for single-operator control.

Siemens VAI paid particular attention to the design of the continuous tandem cold mill's main control pulpit. The high degree of automation in all operating modes allows a single operator to control the intermediate section, the tandem cold mill and tension reels, up to the removal of the coil from the line. The intelligent diagnostic and alarm system gives the operator all relevant information in an easily understandable form, allowing quick response to changing situations. The intelligent diagnostic and alarm system enables the operator to pre-diagnose problems fast without involvement of maintenance personnel.

Conclusion

The first coil was produced on June 27, 2008. That important milestone of the commissioning process happened exactly 23 months after the contract had been awarded to Siemens VAI.
This impressive performance has been attainable thanks to highly motivated and professional teams on both sides of the project, working together to achieve the same target. Especially during the critical phases of commissioning and ramp-up, the close cooperation was a key factor of our common success.
The future common development along the lifecycle of the equipment will benefit from our common understanding of driving our business to perfection.

Figure 9: First coil at CM22