New tandem cold mill coupled to a pickling line

Tata Steel Europe, IJmuiden, Netherlands
Latest SIROLL CM 6-high technology to expand the product mix

The challenge:

In July 2006, Siemens VAI received an order from Tata Steel Europe (formerly Corus) to supply a new tandem cold mill to be coupled to an existing pickling line and a new hot-dip galvanizing line for the company’s plant in IJmuiden, Netherlands. The company wants to use the new installations to continue to expand the capabilities of its product range in the automotive and construction markets, including advanced high-strength steels (AHSS).

All investments upstream to the new tandem mill were already made to support the concept of producing thin hot band as the substrate material for a subsequent moderate cold rolling step, or to be sold as pickled and oiled hot band after substituting the thicker portion of a standard cold mill product mix with thin (0.7 mm or greater) hot band.

Our solution:

Tata Steel Europe’s decision to select Siemens VAI was based on careful studies to determine the most suitable and flexible configuration. The new tandem cold mill was installed at the exit of the pickling line to couple the line and extend it into a PLTCM (pickling line tandem cold mill). The Siemens VAI solution permits the rolling of a wide range of products – from soft steel to the high-strength steels of tomorrow.

To accommodate advanced high strength steel grades (AHSS) in the future, the decision was finally made for a 4-stand mill with special features implemented. The new plant has been in successful operation since 2008.

Achieved results:

- **Completely integrated equipment and automation** – control over productivity, quality, and availability performance, which are key factors for profitability
- **High environmental and safety conditions** – all mechanical and electrical equipment, in conjunction with a detailed risk analysis, meets the highest European machine directive standards
- **Fast project realization and production start-up** – thanks to immediate response and fast delivery, supported by a worldwide supply chain
- **Risk-free execution** – engineering, delivery, and supervision of construction and start-up of mechanical equipment and automation from a single source
The customer:

Name: Tata Steel Europe (formerly Corus)

Location: IJmuiden, Netherlands

Total output: 6.9 million tons per year

Services: Tata Steel Europe is Europe’s second-largest steel producer. With steelmaking operations primarily in the Netherlands and the U.K., the company supplies steel and related services to the construction, automotive, packaging, mechanical engineering, and other markets worldwide.

In IJmuiden, Tata Steel Europe operates an integrated steelworks with an annual capacity of 6.9 million tons of liquid steel from which hot rolled, direct rolled, pickled and oiled, cold rolled galvanized, and organic coated strip products are processed.

The company is part of the Tata Steel Group, one of the world’s top ten steel producers. The combined enterprise has an aggregate crude steel capacity of more than 28 million tons.
The optimal solution
Layout, product mix, and plant data

**Layout**
The new mill has been installed at the exit end and in line with the existing pickling line. The pickling line is still able to produce in the uncoupled mode, pickled and oiled material which is taken off the line at the exit section of the pickling line.

The line consists of an entry coil handling section including an automatic debanding machine, a pay-off reel, laser welder, entry looper, process section, intermediate looper, side trimming section, coupling looper, diverting station that selects either coupled or uncoupled mode, tandem mill, a SIROLL SIAS automatic inspection system, carousel tension reel, off-line inspection station, and exit coil handling equipment (automatic marking and banding).

**Pickling and coupling section**
The pickling layout and the operating parameters of the existing pickling line had to be adapted to the required performance and operating principles of a state-of-the-art PLTCM.

A production study was conducted to detect the bottleneck in the line in the future configuration. In addition, the necessary equipment has been installed to couple the pickling line with the TCM. One coupling looper with a 450-meter 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 number 1. This arrangement allows very precise strip centering and an optimal response in tension control at the mill stand entry, providing an advantage for our advanced mass flow thickness control. For harder strip grades, the entry tension can be regulated up to a level of 40 tons to improve the reduction capability at mill stand number 1.
Product mix
The annual rolling capacity is 1,600,000 tons. The product mix consists of IF steels (DX56, DX57), CQ and DQ grades, and HSS grades, including DP (600 to 1,000).

Scope of supply and services:
- Construction and commissioning as well as supervision of construction and commissioning
- Mechanical equipment
- Hydraulic and pneumatic systems
- Drive systems
- Electrics and automation
- Safety equipment

Main features:
- 6-high technology in all stands
- Long stroke intermediate roll shifting system
- Hydraulic automatic gauge control
- Positive and negative work roll bending and positive intermediate roll bending
- Continuous pass-line and automatic work-roll change
- Skin-pass function
- Rotary shear
- Carousel coiler
- AC main drives powered by SINAMICS voltage-source converters

Plant data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill type</td>
<td>4-stand, 6 high</td>
</tr>
<tr>
<td>Annual capacity</td>
<td>1,600,000 t</td>
</tr>
<tr>
<td>Installed power</td>
<td>28,600 kW</td>
</tr>
<tr>
<td>Roll force per stand</td>
<td>25,000 kN</td>
</tr>
<tr>
<td>Intermediate roll shifting stroke</td>
<td>550 mm</td>
</tr>
<tr>
<td>Rolling speed</td>
<td>max. 1,200 m/min</td>
</tr>
<tr>
<td>Tandem exit cutting speed</td>
<td>max. 300 m/min</td>
</tr>
<tr>
<td>Mill exit type</td>
<td>carousel coiler</td>
</tr>
</tbody>
</table>

Production data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>LC, IF, CQ, DQ, HSS, DP</td>
</tr>
<tr>
<td>Entry strip thickness</td>
<td>1.0–4.0 mm</td>
</tr>
<tr>
<td>Exit strip thickness</td>
<td>0.4–3.0 mm</td>
</tr>
<tr>
<td>Strip width</td>
<td>700–1,650 mm</td>
</tr>
<tr>
<td>Coil diameter</td>
<td>max. 2,800 mm</td>
</tr>
<tr>
<td>Coil weight</td>
<td>max. 48 t</td>
</tr>
</tbody>
</table>
4-stand 6-high tandem cold mill

The optimum solution in terms of CAPEX and OPEX to fulfill the production requirements imposed was found to be a high powered 4-stand 6-high tandem cold mill. As per customer requirement, all mill stands are equipped with a long stroke intermediate roll shifting system to facilitate edge oriented roll shifting for enhanced edge drop and flatness control.

The mill stands are of 6-high type with long stroke shifting of the intermediate roll. A homogeneous roll force distribution across the entire strip width is a clear advantage in processing low edge profiles and permits extensive flatness control on the strip. The powerful bending systems for work and intermediate rolls (up to 70 tons per side) always operate in their optimal range.

The total roll force of 25,000 kN 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.

To ensure and control strip quality, performance, speed, thickness, and tension, measurement systems were installed at mill entry and in the inter-stand area. The instrumentation is suitable for use during rolling and also skin-pass operations, with specific requirements for speed and tension control for the precise control of elongation and roughness transfer.

Tandem cold mill operation

Fig. 1 shows strip thickness reduction and specific rolling force per mill stand for soft and hard steel grades. Even with a 4-stand mill, the last stand can be effectively used in skin-pass mode (typical in 5-stand mills) for controlled surface roughness adjustment. Major cold reduction is done on the first three stands only.

For hard grades, the reduction pattern shown is certainly not the limit, since specific roll force utilization is only about 14 kN/mm. This can be increased width-dependent (maximum roll force is 25,000 kN per stand) to 18 kN/mm or more, demonstrating a considerable reduction potential for AHSS grades as well.
Skin-pass mode

Another design requirement was to utilize the mill in part for skin-passing/tempering operations to produce custom pickled, skin-passed, and oiled hot band as cold-rolled substitution products. For this purpose, stand numbers 1 and 4 are also equipped, for example, anti-crimping rolls that facilitate this operation. Skin-passing and cold-rolling operations for high surface-quality products require the maintenance of the highest levels of cleanliness inside the mill. Special features incorporated to facilitate these requirements include air-purged cooling headers in all mill stands to avoid strip contamination during dry skin-passing operations.

The installed equipment and automation makes the skin-pass/tempering mode available with either one stand (typically stand number 4) or two stands (stands numbers 1 and 4).

As seen in Fig. 2, the predominant elongation level in the observation period is between 2.5 and 3.0 percent, which is easily performed with two stands. A single-stand mode is typically employed at elongation levels below 1.5 percent. Per the design, it is possible to perform tempering up to ten percent, if required. Fig. 2 shows an example up to eight percent. Therefore, a wide operational range for tempering is available, enabling a custom treatment of thin hot band to the end user’s differing metallurgical- and surface-related requirements (as cold-rolled substitution products).

Elongation control

The superimposed elongation balance controller (ELB) optimizes the elongation portions of both stands in order to most economically distribute the total elongation requirement for the two stands. This in turn leads to significantly improved overall dynamic response behavior and better elongation control quality. The best results are achieved by controlling both stands independently.
Carousel coiler and rotary shear

Due to its compact layout, the carousel reel solution is ideal for CM22. In addition, it offers 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 meters per minute is achieved. Other advantages are increased productivity and improved off-gauge, thanks to the highest possible speed while the seam weld is going through the mill.

If required, the coil can be moved to the visual inspection station just after discharging from the carousel reel. The station is located next to the main pulpit in front of the carousel reel for additional inspection.

SIROLL SIAS surface inspection

To meet the requirements for the highest strip quality and improved operating costs, the entire length of the strip surface, top and bottom, is inspected by the SIROLL SIAS automatic surface inspection system at the exit of mill stand number 4. The challenge was to ensure a perfect surface inspection in the tough environmental conditions at the exit of a PLTCM with a maximum strip speed of 1,200 meters per minute. Within a few weeks, the preliminary results were beyond our expectations. The image quality allows critical defects in a tandem mill to be addressed (including roll marks). Any defect will be detected, recorded, and classified in real time. According to the type of defect, the information is recorded and transmitted to the operator. If the defect is classified as originating in the tandem mill itself, as is the case with roll marks, information regarding the defect’s origin is provided and the operator is asked to take corrective actions.

Defect detection at each stage of the process route is important, as it enables the operator to minimize monetary losses resulting from defects through immediate action, rather than downstream on a higher-value product.
Lubrication and cooling

A key issue in the rolling process is lubrication of the roll bite and cooling of the strip. Special attention was given to the roll-coolant and spray-header systems 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. A provision has been made to install two other tanks for emulsions with different lubricating properties to improve the rolling process in the next generation of AHSS steel grades.

As skin-passing and rolling operations for automotive products are performed, the highest degree of cleanliness inside the mill must be maintained. To fulfill this requirement, a complete mill-washing system is installed, including a classic high-pressure fire hose and automatic cleaning nozzles in the mill stand area. To avoid any strip contamination during dry skin-passing, all roll-cooling headers are air-purged.

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 Tata Steel Europe, the totally new SINAMICS SM150 and S120 converter family has been deployed. 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 mill stands’ main motors. 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.
**Safe and reliable automation**

**SIROLL CM completely integrated solution**

### Automation

Automation includes the technological control systems and the complete set of process automation equipment. Thanks to the finely tuned interaction between accurate process models and high-speed control systems, it will also be possible to handle critical strip sections in fully automatic mode with minimal losses of time and materials. The equipment is based on the SIROLL CM concept, which was specifically developed for cold rolling mills.

The entire automation set uses the high-performance SIMATIC TDC automation system, which provides maximal 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
- PROFIBUS as the field bus for peripheral equipment
- SIMATIC WinCC for plant-wide visualization

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 operating 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 at stand number 4 uses 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 networks for optimization.

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
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 carousel reel, 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 responses to changing situations and enabling the operator to pre-diagnose problems fast without involving maintenance personnel.

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

Safety
Safety areas were defined to avoid any negative impacts on operation, and were divided into sections to enable recovery from malfunctions during operations. It is, for example, possible to enter the safety area of the exit coil transport without stopping the entire line. Specific areas were designed to enable changing or set-up procedures to be performed: for example, changing the binding strip in the coil binding area during normal operation. The fully automatic roll-change system has a safety-optimized design, ensuring that during an ongoing roll change the area can 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. It is TÜV-certified and used in combination with the SINAMICS safe torque-off function, with no hardware disconnector switch required.

Conclusion
The first coil was produced on June 27, 2008. That important milestone in the commissioning process occurred exactly 23 months after the contract was awarded to Siemens VAI. This impressive performance was attainable thanks to the highly motivated and professional teams from Tata Steel Europe and Siemens VAI working together to achieve their goals.
Competence Center:
Siemens VAI
Metals Technologies SAS
BP 154, 51, Rue Sibert
42403 Saint-Chamond Cedex, France
Phone: +33 4 7729-8056
Fax: +33 4 7729 8390

Headquarters:
Siemens VAI
Metals Technologies GmbH
P.O. Box 4, Turmstr. 44
4031 Linz, Austria
Phone: +43 732 6592 76809
Fax: +43 732 6980 3360
E-mail: coldrollingmill.metals@siemens.com
www.siemens-vai.com

Order No. E10001-M4-A83-V1-7600
Dispo No.: 21661 K-No.: 28103 | Printed in Austria
SVAI-09-00182 RF 10091. | © 09.2011, Siemens AG

The information provided in this brochure contains merely general
descriptions or characteristics of performance which in actual case of
use do not always apply as described or which may change as a result
of further development of the products. An obligation to provide the
respective characteristics shall only exist if expressly agreed in the
terms of contract.

All rights reserved. Subject to change without prior notice.
SIROLL is a trademark of Siemens AG.