Cold Rolling Mills by SMS group – flexible plant concepts tailored to the demand of emerging markets

BY

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SYNOPSIS:

Cold strip producers, who are investing in their business and are establishing them in emerging markets, have special demands on their production equipment and its supplier. SMS group is well aware of these requirements and offers cold rolling mill concepts for cost-effective production of a wide range of different capacities and product qualities.

The design of SMS group for single stand Reversing Cold Mills (RCM) and two stand Compact Cold Mills (CCM®) is optimized in terms of investment cost (CAPEX) and operating cost (OPEX). The tandem cold mills (TCM) are the appropriate solution for larger production capacities. The installation of a TCM can be the first step towards the implementation of a continuous production process (PLTCM).

The paper introduces several design solutions, including technological features and actuators as well as upgrade opportunities in order to meet current and future demands, allowing producers of cold rolled strip to grow with their market.

One example for the flexibility of the RCM and the adaptability to future needs is the capacity enlargement of an existing RCM by installation of a second mill stand and thereby turning the RCM into a Compact Cold Mill (CCM®). As latest references of SMS group have shown, these installations take only a shutdown time of approx. two months until the mill starts operation again. It is also possible to convert a CCM® into a TCM. Other upgrade opportunities are related to performance, quality and yield, like e.g. the yield optimizer or automatic flatness control.

Keywords: Reversing Cold Mill (RCM), CVC® plus, Compact Cold Mill (CCM®), Tandem Cold Mill (TCM), yield optimizer

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1. Introduction

In general the world steel market is characterized and driven by overcapacity, however there are regional differences to be considered. It was the world steel association, who recently identified Southeast Asia as an expanding market, of course depending on the geopolitical situation. [1]

Proof of the growing market Southeast Asia is e.g. given by the Steel Statistical Yearbook in the 2017 edition. [2] Looking at the production of hot rolled sheet and strip in Indonesia, the Steel Statistical Yearbook shows for the period between 2007 and 2016 a production increase of more than 93% (fig. 1).

![Annual Production of Hot Rolled Coil, Sheet and Strip (< 3mm) in Indonesia](image)

Figure 1: Since 2014, the production of hot rolled steel products is increasing significantly

Now, comprising the apparent steel use per capita for the same time period, a growing demand for crude as well as for finished steel is appearing (fig. 2).

![Annual use of steel per capita in Indonesia](image)

Figure 2: Steel use per capita in Indonesia, comparison of crude and finished steel

Let’s examine the crude steel use in a more detailed way. First, there is to be asserted a strong increase from 37 kg per capita in 2007 up to 61 kg per capita in 2013. After 2014, the use has slightly alleviated and recently stayed at 58 kg per capita. Looking at the use of finished steel, the development is proceeding in parallel but on a marginally lower level. This is the current
This leads us to the central topic of this paper: What are the appropriate solutions from the viewpoints of steel producers and their equipment suppliers operating in emerging markets facing the declining global steel market? Plant operators are well advised, to focus on quality, flexibility and sustainability regarding the production technology and equipment. The quality of the equipment is the precondition for durability. Flexibility of the equipment is the basis for the option to adapt to future market requirements. As it is true for the fully industrialized countries, there is also the necessity to look at environmental sustainability and digitalization. All this should be available at reasonable investment levels.

SMS group is a well-known supplier of equipment for the steel industry with a portfolio of technology and technical services covering the complete process routes in steel and non-ferrous production. This paper will focus on cold strip production. In recent years, SMS group has especially supported cold strip producers in several emerging countries, like Indonesia, Vietnam, Thailand, Bangladesh and Pakistan in providing optimal and flexibly adaptable cold rolling mills and strip processing lines, tailored to the specific needs, which differ in some features from the needs of the well established players on the world steel market. Some examples of these success stories are given in the following.

2. Reversing Cold Mills in single and twin stand design – all-rounder for small and medium capacities

2.1 Single Stand Reversing Cold Mill (RCM)
Single stand reversing mills by SMS group are ideally suited to roll cold strips of a large variety of material grades and dimensions. SMS group’s RCM concept ensures low investment levels and minimum time from order placement to production of the first coil. The mill is available as CVC® four-high or as CVC® six-high design – depending on the product spectrum.

The mill configuration can be adapted to customer requests within standardized mill concepts. The plant can be operated economically from an annual production of 100,000 t up to 300,000 t at a product width of up to 1250mm. RCMs for wider products can go up to 500,000 t/a.

Prime example
On August 2017, the first coil was successfully rolled on the new RCM of the Indonesian steel producer Gunung Raja Paksi (GRP) in Bekasi. The complete plant was supplied and commissioned by SMS group. GRP is now rolling and skin-passing cold strips with maximum width up to 1,270 mm and minimum final gauges down to 0.15mm on the RCM. The RCM in 6-high design is equipped with the CVC® plus, all advanced actuators and X-Pact® electrical and automation systems by SMS group, ensuring high yield and excellent strip quality. The actuators and technical features are described in chapter 2.3. Because all systems were supplied from a single source, they were perfectly technologically harmonized in order to support smooth commissioning and thus short run-up time enabling a fast ROI for the customer. In addition, the commissioning team on site was supported remotely by a team of specialists from Germany with the help of the service portal and other modern communication media.
The RCM gives GRP the opportunity to switch between the reduction and skin-passing mode according to the product requirements. A maximum of 200,000 tons of high-grade strips can be produced on the RCM per year.

![Image 1](image1.png) ![Image 2](image2.png) ![Image 3](image3.png)

Figures 3-5: GRP’s flexible RCM for rolling and skin-passing. Centerpiece is the rolling stand in CVC® plus 6-high design, ensuring excellent strip quality and high yield.

### 2.2. Compact Cold Mill (CCM®)

The new concept for two-stand reversing cold mills – Compact Cold Mills (CCM®) for short – is an invention of SMS group. Originally it was designed for the production volume of minimills arranged downstream of CSP® plants. It achieves capacities up to 900,000 tons of strip per year, so that this plant type closes the gap between the single stand RCM and a multi-stand tandem cold mill TCM. Included in a CCM® are two mill stands in CVC® four-high or CVC® six-high technology with variable, process-optimized work roll diameters as well as state-of-the-art thickness and flatness control systems.

**Prime example**

In fact, the CCM® is the most requested type of cold rolling mill on emerging markets. One example is the Vietnamese cold strip producer Hoa Sen Group, who ordered the third CCM® in September 2017. Placing this order with Esmech Equipment Pvt. Ltd., a member of SMS group, Hoa Sen Group is pushing on the expansion of cold strip production. The third CCM® in a row is dedicated to the new facility in Nhon Hoi in southern Vietnam. The quality determining core components of the rolling mill, as e.g. CVC® plus technology, will be provided by SMS group in Germany. The comprehensive X-Pact electrics and automation will be part of the overall supply scope just like the required auxiliaries.

The CCM® is designed for the rolling of low-carbon steel strips with maximum widths of up to 1,250 mm and final gauges of minimum 0.11 mm. The annual production capacity will add up to 350,000 tons, depending on the product mix. Among other quality features, the mill stands in 6-high design will be equipped with slim work rolls permitting high pass reductions to be achieved. Rolling will take place with a maximum rolling speed of 1,400 meters per minute. One pay-off and two reversing reels allow removing the finished coils from entry and exit side as needed. Both reversing reels are equipped with belt wrappers for easy coiling of thin strips onto sleeves. Work and intermediate roll changes will be performed automatically keeping non-productive times as short as possible. Beside the level 1 and level 2 automation systems, the X-
Shape flatness measurement and control system by SMS group will ensure excellent flatness results. The X-Shape flatness measurement rolls are installed on entry and exit side. Key component of the system is the flatness measurement roll, characterized by its robust, maintenance free design and, at the same time, by highly precise measurement accuracy and trouble-free optical signal transmission.

Figure 6: Since June 2017, Hoa Sen Group has been operating in Vinh City in Central Vietnam the first CCM® by Esmech Equipment Pvt. Ltd. It is the technical model for the new mill. The Commissioning of the second CCM®, also in the picture, followed shortly thereafter in September 2017.

Looking at the sequence of three CCM® in a row, Hoa Sen Group benefits from both: mill design, comprising the latest rolling technology by SMS group and tightly organized order execution by the regional well known and nearby supplier Esmech Equipment Pvt. Ltd., member of SMS group. This concept comes with reasonable CAPEX on the one hand and low OPEX on the other.

2.2.1 Upgrade to CCM®
Both of the reversing mill types by SMS group – RCM and CCM®) feature compact design, which benefits in reduced investment costs of the infrastructure and in high yield. Upgrading an existing single stand reversing cold mill into a CCM® is not just possible, but on top also affordable with SMS group’s expansion strategy. It’s a budget-friendly solution, which, especially in recent years, has been in strong demand from customers in young, emerging markets. By installation of the second mill stand, production will be increased in a range of 60% to 70%, depending on product mix.
Figure 7, 8: Pakistani cold strip producer ISL operated a RCM, supplied by SMS group (1), which was upgraded to a CCM® (r) after a few years of operation.

### 2.3 Mill design for optimized CAPEX and OPEX

Typically emerging markets require thin-gauge cold strip in low carbon qualities with a maximum width up to 1300 mm. It depends on the product mix and final gauge of the product to decide for a RCM in CVC® plus 4-high or CVC® plus 6-high design. The table shows the main data in comparison.

<table>
<thead>
<tr>
<th>Strip dimensions</th>
<th>CVC® plus 4-high design</th>
<th>CVC® plus 6-high design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil weight</td>
<td>Approx. 25 t</td>
<td>Approx. 25 t</td>
</tr>
<tr>
<td>Strip width</td>
<td>650 – 1,300 mm</td>
<td>650 – 1,300 mm</td>
</tr>
<tr>
<td>Strip thickness entry</td>
<td>1.60 – 4.0 mm</td>
<td>1.60 – 4.0 mm</td>
</tr>
<tr>
<td>Strip thickness exit</td>
<td>0.15 – 1.60 mm</td>
<td>0.09 – 1.20 mm</td>
</tr>
</tbody>
</table>

#### Table 1: Mill design and main data

Equipment by SMS group comes with proven technological features and actuators. Product quality determining key components are manufactured in the German workshops according to highest quality standards. The mill design is simple and robust and therefore easy to operate and maintain. Adequate automation function ensures easy and safe mill operation.

The Reversing mills are provided with powerful actuators (Standard equipment), able to cope with any rolling task. But SMS group is continuously developing the equipment further and offers advanced or new features (Additional equipment), which can be retrofitted in existing mills to enable them to grow with the market or to fulfil more sophisticated customer requirements and offer maximum flexibility. An overview about the standard and the additional equipment is given in the following.

<table>
<thead>
<tr>
<th>Technical feature</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic roll force cylinder</td>
<td>High position accuracy for precise roll gap adjustment, located at the top</td>
</tr>
<tr>
<td>CVC® plus roll shifting</td>
<td>Perfect flatness and reduced off-gauge length</td>
</tr>
<tr>
<td>Work/Intermediate roll bending</td>
<td>Precise and efficient adjustment of bending force</td>
</tr>
<tr>
<td>HS system</td>
<td>Horizontal stabilization of small work rolls, fixed</td>
</tr>
<tr>
<td>Dry strip system (DS system)</td>
<td>Finest surface quality, very cost efficient operation</td>
</tr>
</tbody>
</table>
Wedge adjustment system

| Wedge adjustment system | Finely tuneable, step less adjustment, located at the bottom |

Figure 9: CVC® plus 6-high stand (l) provided with standard design features and associated advantages, (Table 2) (r)

One example for SMS group’s standard rolling technology coming with a low OPEX is the CVC® plus roll shifting system. The proven CVC® plus technology (fig. 10) is characterized by less roll consumption due to uniform load distribution and therefore

- less wear on CVC® rolls
- extended lifetime of rolls
- higher production per roll life time.

![Figure 10: Basic principle of CVC® plus shifting technology and effects.](image)

Using the CVC® plus technology helps investors to reduce the bound capital, because the costs of the roll stock (inventory) are low compared to other rolling technologies available on the market.

<table>
<thead>
<tr>
<th>Technical feature</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge Drop Control (EDC®)</td>
<td>Optimized yield by constant thickness up to the strip edge</td>
</tr>
<tr>
<td>Yield optimizer and TRC®</td>
<td>Reduction of off-gauge weight and increase of yield</td>
</tr>
<tr>
<td>Automatic Flatness Control with multizone cooling system</td>
<td>Perfection of final flatness results in combination with X-Shape flatness measurement and control system</td>
</tr>
</tbody>
</table>

Table 3: Additional RCM/CCM® equipment and associated advantages

Customers can choose between standard and additional equipment, depending on if they are newcomers on the market or if they have already established themselves and would like to grow with the market. This is one strategy to keep initial investment on a reasonable level. SMS group offers the opportunity to reduce the costs of the civil works as well, because mill and foundation design are very compact. The newly developed Emulsion Compact Unit (ECU) is one example for compact foundation design (fig. 11). The ECU helps to reduce cellar size significantly and come with further advantages, like reduced piping efforts and energy consumption.
Figure 11: Since 2017, the Indonesian cold strip producer Gunung Raja Paksi is operating a combined reversing cold mill/skin pass mill, supplied by SMS group, which is equipped with an ECU. One feature is the multi-level arrangement of the components.

Workshop preassembly and functional testing as well as Plug and Work of the automation system are strategies for fast commissioning and production ramp-up and therefore fast return of investment.

The design solutions by SMS group help to keep operating costs (OPEX) low. One example is the optimal equipment configuration for the entry and the exit side of the mill and – in case of a CCM® – the interstand distance. As a result, off-gauge lengths are kept short. Another example is work roll dimensioning. Because the smallest possible work roll diameter is used, smaller torque is required. This means reduced cost for electricity.

Further design solutions for low OPEX, like e.g. features for yield increase, actuators to improve the strip quality and the X-Pact® electrical and automaton systems will be shown in the presentation.

Cold rolling mill owners, are facing changing market demands and need to decide whether to adapt to the new requirements and to grow with the market or not. SMS group offers mill solutions that make this decision easy, because costs are moderate and shutdown times are short.

2.4 Growing with the market: From RCM to CCM®
It is possible to upgrade an RCM into a CCM® at reasonable cost. In a recent extension project the production capacity was increased by 70 percent. The customer could reap the full benefit of the initial planning of the RCM. It was designed with the option of future expansion into a two-stand CCM®. Most important here was the preparation of the foundations and media systems. The exit-side equipment such as tension reel and coil cars had to be moved to make room for the installation of the second mill stand. The shutdown time was not longer than two months.
Since 2000, SMS group supplied 22 single stand RCM and 14 CCM®. The market share of CCM®, compared to the main competitors of SMS group is about 90 %. One reason for the success story of these mill types in emerging countries is that customers will not be left alone after the mill being put into operation. They are well aware, that the experts of SMS group are always nearby and will be able to give support during the entire life cycle of a plant. And if further extension of capacity or improvement of product quality is requested, SMS group will help with a tailored concept for the mill upgrade.

3. Tandem Cold Mill design for emerging markets – high performance rolling for efficient production of advanced steel grades

Designed for the efficient production of high quality strips in large capacities between 0.9 and 2.5 million tons per year, tandem cold mills (TCM) are the most powerful flagships in the cold rolling sector. The great number of plants built by SMS group, especially for very wide strips, reflects the faith that customers worldwide have in the proven plant technology. Steady advancement of the cold rolling technology provides steel producers with the reliability, to produce also newly developed material grades (e.g. 3rd generation grades) accurately and economically.

TCMs are the solution for a large production per year. They can either be operated in batch or in continuous mode as CTCM. Furthermore they can be arranged as coupled pickling line tandem cold mill (PL/TCM).

3.1 PL/TCM – the flagship of cold rolling

Main characteristic of a PL/TCM is the direct coupling of pickling and mill section. This ensures a continuous production flow.

Prime examples

In 2017, steel producer JSW Steel Coated Products Ltd., placed an order with SMS group for the complete supply of two PL/TCM to be erected at the company locations Tarapur and Vasind in western India. SMS group supplies each of the two pickling lines with an entry section for continuous operation, scale breaker, high-performance pickling section, three horizontal strip
accumulators and ASC trimming shear. The maximum process speed is 180 m/min, while the continuous pickling process is ensured by three horizontal strip accumulators. The ASC-double-head trimming shears featuring the integrated trimming scrap drum shears allow width- and knife change during operation. Afterwards the strip is fed into the five-stand tandem cold mill.

Both of the tandem cold mills are provided with five mill stands in 6-high design with proven CVC® plus technology, positive and negative work and intermediate roll bending, multizone cooling and exit side DS-system for first-class strip quality. The finished strip will be continuously wound in coils on the carousel reel. The quality determining key components, including cylinder and bending blocks, hydraulic adjustment systems, CVC® plus technology as well as the exit side carousel reels are supplied from SMS group’s German in-house-production. The supply is carried out by an internal consortium of SMS group Germany, Esmech Equipment Pvt. Ltd., member of SMS group, as well as SMS group India Pvt. Ltd. The supply concept has many advantages for JSW Steel: short ways by closeness and availability of the major suppliers, fast service response, moderate invest and the premium-quality rolling technology of a worldwide leading plant manufacturer.

Although the PL/TCMs are designated to roll different product ranges – the production focus of the Tarapur PL-TCM is put on tinplate -, the design differs only slightly from one another, resulting in significantly reduced investment cost. According to the schedule commissioning will take place in spring 2019.

3.2 (Semi-)continuous Tandem Mill (CTCM)
The semi-continuous tandem mill - is provided with a continuous entry section with pay-off unit, welding machine and strip accumulator to ensure a permanent production flow. The typical installations in the semi-continuous exit side are drum shear, tension reel and Rotary Inspect.

Depending on the product mix and/or capacity requirements it is possible to upgrade a CTCM to a PL-TCM. One example is the installation of a continuous exit section at the tandem cold mill of AM Vega, Brasil, carried out by SMS group a few years ago. AM Vega operated a semi-continuous PL-TCM, being provided with a continuous entry section and a semi-continuous exit end (fig. 15). By installation of a second tension reel and a drum shear, the plant was turned into a fully continuous PL-TCM with reasonable invest but remarkable capacity increase.

Figure 15: AM Vegas semicontinuous PL-TCM before exit side upgrade
When mainly rolling high-strength steels or stainless steels with a high yearly production and down to final gauges below 1.00 mm, the CTCM is the optimum configuration to be operated with small work rolls achieving high pass reduction, like the 18-HS design. In recent years, SMS group supplied several TCM in 18-HS design, prepared for continuous operation to customers in South Korea and China.

Establishing a continuous production flow is beneficial for large batch sizes. Smooth production flow, low roll wear, high yield and consistent product quality are further advantages of the CTCM.

3.3 Batch Tandem Cold Mill (BTCM)
Especially in Europe, America and Russia there are still many TCM operating in batch mode. Concerning flexibility in the production planning, the Batch-TCM has advantages compared to a higher degree of process integration, since bottlenecks from other line parts do not have to be taken into consideration. Among the limitations of batch operation, there is increased effort in coil handling and limited yield to be considered. SMS group is providing technical solutions to eliminate these limitations. As an example: To increase the yield of batch mills, SMS group has developed some trend-setting technical features in recent years, like e.g. the threading assistance system TRC®. By using Concept Engineering SMS group offers tailored and efficient Greenfield as well as modernization concepts to empower the mills. Of course, the newly developed features can be easily retrofitted in existing mills. Thus, even today it is possible to operate a TCM in batch mode in a very flexible and competitive way.

3.4 Tandem mill design and technology for optimized CAPEX and OPEX
In general, TCMs by SMS group are equipped with the technological features, described in chapter 2.3. But the flagship mills can be provided with some specific innovative technologies. Making use of these features, it is possible to design rolling mills in a much more compact way, resulting in lower investment levels and significantly reduced operation costs. The new high performance TCM is equipped with smaller rolls, resulting in lower investment and operating costs compared to a conventional mill. Based on the same product mix with focus on high strength material and thinner final gauges, the high performance TCM is characterized by an approximately 20 percent lower roll force requirement.

The main features of the high performance TCM are the Sieflex®-HT gear-type drive spindle and optimized roll diameters.
The high-performance TCM with smaller and driven work rolls requires a new spindle design and redesigned work roll neck for high torque transmission. The newly developed Sieflex®-HT gear type spindle fulfills these requirements. Due to the redesign of the gear rim and the adaption of the material used, the transmissible torque is increased by up to 100%. In addition, the alignment angle is extended to 3.5° with only a small reduction in the torque capacity. Added by a redesign of the work roll neck, smaller work roll diameters are applicable for more demanding rolling tasks. As a result the product mix can be extended in existing mills with low capital expenditures, by retrofitting the Sieflex®-HT spindle, (fig. 18).

Figure 18: Sieflex®-HT gear-type drive spindle with redesigned toothing of the gear rim

Yield and quality of cold rolled flat products depend on developing high capacity components. They have to fulfil the further increasing demand for cost and resource effective production of high quality rolled products. In the field of gear and main drive technology SMS group has come forward with further new developments. An example is the elimination of limitations in capacity and strip surface quality due to a high level of vibration coming from the mill’s drive train. SMS group supplied three next-generation spur pinion gears to a customer in the USA, fulfilling the requirements for low vibration and noise level [3]. One of the main quality criteria for cold rolled strips is the surface quality, vibrations caused by the gear tooth contact, must be kept to a minimum as it can be transmitted to the strip. The most modern calculation and design methods for reducing vibrations were used to develop these new gears.

The distinctive feature of the new spur pinion gears is to be found in the design of the gear toothing. This guarantees a homogeneous load distribution along the tooth flank and an extremely low vibration of the gear unit while running. The upgrade was achieved by macro- and micro-geometry optimization. In 2016, SMS group replaced the existing gear boxes for the

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1 Pass schedule calculation for: CQ-material, 1698 mm strip width, 1.8mm entry thickness, 0.25 mm final thickness.
mill stands three, four and five of the tandem cold mill by “Drop-in Replacement” for this customer in the USA. Due to the special design methods an extremely low excitation of the gear tooth contact was achieved and the rolling speed could be significantly increased in comparison to the original gears. This impression was confirmed by the “Genius Condition Monitoring System” through acceleration measurements at the gear housing. The “Genius Condition Monitoring System” also installed by SMS group for this new spur pinion gears, measures oil flow, oil temperature and vibration at various locations throughout the gearbox as well as vibration monitoring of the mill stands. The system is able to monitor the condition of the gears and permits for corrective actions in cases of mill chatter. In comparison to the original gears, the maximum acceleration values of the new gears are below 0.5g (9.81m/s²) at all measuring points (fig. 19).

Figure 19: Results of vibration measurement at gear housing before and after the revamp

Besides the increase in productivity, the noise level in the mill has been decreased considerably inducing a high level of customer satisfaction.

4. Summary

The paper provides an insight into appropriate technical solutions for cold strip producers who are asked to customize their business flexibly to the market demands. Looking at the different types of cold rolling mills, there is the reversing type in single-stand and twin-stand design the most flexible one regarding product mix and upgrade opportunities in the sense of growing with the market. This type comes also with moderate invest and operational expenditures. Probably the most economical solution for rolling large batches and high capacities is the tandem cold mill. It is the flagship among the cold rolling mills. In batch operation it is nearly as flexible as the RCM or CCM®. Further increasing capacity demands allow implementing a higher degree of process integration and continuous operation, like e.g. coupling of pickling line and TCM. SMS group as an experienced and reliable partner on the supplier side is providing reasonable customized technical solutions for every step of developing a highly competitive cold rolling business.

List of Citation