LAMINAÇÃO - 2011
48º SEMINÁRIO DE LAMINAÇÃO
PROCESSOS E PRODUTOS LAMINADOS E REVESTIDOS
24 a 27 de outubro de 2011 — Santos - SP
ISSN 1983-4764

# ECONOMICAL LEADING-EDGE TECHNOLOGIES FOR ROLLING OF BEAMS, STRUCTURALS AND BILLETS[1]

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**Abstract**
A number of new technologies and innovative equipment have been developed and implemented on the market for the production of rails, beams and sections. Universal rail rolling on reversing tandem mills, XH® rolling technology for beams, CCS® mill stands and CRS® straightening machines for higher product quality and better time utilization are well known and successfully in operation in many plants worldwide. A brief survey and introduction to these technologies and innovations is given in the paper. The main focus of this paper lies on the introduction of innovative concepts for the cost effective production of sections and billets in order to meet the market demand based on several mills in successful operation. The benefits for the user's competitiveness of the remarkable innovations developed in the past are illustrated, namely: Streamlined process flow; Closer tolerances thanks to under-load roll gap adjustment and automatic gap control; Improvement of final product properties, Reduced production costs. The concepts described in this paper enable an excellent product quality to be achieved, whilst at the same time allowing the products to be produced at lower conversion costs.
**Key words**: Section mills; Continuous mills; Universal rolling; Reversing tandem mill.

## TECNOLOGIAS ECONÔMICAS PARA LAMINAÇÃO DE VIGAS, PERFIS ESTRUTURAIS E TRILHOS

**Resumo**
Uma quantidade razoável de tecnologia e equipamentos inovativos vem sendo desenvolvida e implementada no mercado para produção de trilhos, vigas e perfis. Laminação universal de trilhos em laminadores tandem reversíveis, uso da tecnologia XH® para produção de perfis, gaiolas de laminação CCS® e endireitadeiras CRS® já são hoje tecnologias bem conhecidas, instaladas e operadas com sucesso em várias plantas ao redor do mundo proporcionando no final produtos de melhor qualidade e uma melhor utilização do laminador. Uma breve abordagem e introdução destas tecnologias serão dadas neste trabalho. O foco principal deste trabalho é introduzir e demonstrar os conceitos de inovação aplicados na produção de perfis e trilhos de forma a atender às demandas nos diversos laminadores em operação e bem sucedidos e a um melhor custo benefício. Os principais benefícios trazidos por essas inovações para uma melhor competitividade dos usuários são: Fluxo de Processo In-Line; Melhores tolerâncias do produto final graças ao ajuste de bitola sob carga e controle automático da bitola; Melhoria nas propriedades mecânicas do produto final; Redução dos custos de produção. Os conceitos descritos neste trabalho proporcionam a produção de um produto de excelente qualidade, ao passo que ao mesmo tempo permitem produção destes produtos a baixos custos de conversão.
**Palavras-chave:** Laminadores de perfis; Laminadores contínuos; Laminação universal; Laminador tandem reversível.

[1] *Technical Contribution to the 48th International Seminar of the ABM, October 24-27th - 2011, Santos - SP – Brazil.*
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ISSN 1983-4764

## 1 INTRODUCTION

The world demand of structural steel shapes and rail has increased consistently in the last twenty years. Major infrastructure projects and developments are the driving force behind the increase in demand. High speed rail transport is becoming the norm in the industrialized world and in particular in China, spurring the demand for high quality rail.
SMS Meer however developed in the recent past a number of technologies, equipment designs and customer support activities that allow the reliable and cost efficient production of these demanding products.
Among the multitude of recently built new rolling mills (Figure 1), the structural and rail mill at SDI, Columbia City, USA and the light and medium section mill at Siam-Yamato Steel in Thailand are examples of modern mills covering the whole range of structural shapes, sheet piles and rails. This paper will cover the technologies and practices that made these rolling mills today's industry standards. In addition, a new concept for higher efficiency, reliability and closer tolerances on finished products for large quality steel billet production will be briefly introduced.

| Order in | Customer | Products | XH® Rolling |
|---|---|---|---|
| 2011 | Baotou Iron & Steel, P. R. China | Sections (1000 x 300), Rail, Sheet Pile | X |
| 2010 | SAIL, Bhilai Steel, India | Rails | |
| 2010 | SULB, Bahrain | Sections (920 x 300), Sheet Pile | X |
| 2010 | EVRAZ Holding, NKMK, Russia | Rails, Sections (500 mm) | X |
| 2010 | Handan I&S, P.R. China | Rails, Sections (600 mm), Sheet Pile | X |
| 2007 | Jiexiu Xintai Iron & Steel Co., Ltd., P.R. China | Beams (1 000 mm) | X |
| 2007 | Peiner Träger GmbH, Germany – CCS-TDM stands | Sections (500 mm) | X |
| 2007 | Steel Authority of India (SAIL) – IISCO | Sections (750 mm) | X |
| **2007** | **Siam-Yamato Steel, Thailand** | **Sections (350 mm)** | |
| 2006 | Steel Dynamics, USA | Sections (450 mm) | |
| 2006 | Wuhan Iron & Steel, P.R. China | Rails, Sections (600 mm), Sheet Pile | X |
| 2005 | Kardemir Iron & Steel, Turkey | Rails, Sections (500 mm) | X |
| 2005 | Jindal Steel & Power, India | Rails, Sections (1 000 mm) | X |
| 2004 | Hebei Jinxi Iron & Steel Co., P. R. China | Beams (1 000 mm) | X |
| 2004 | Baotou Iron & Steel, P. R. China | Rails, Sections (450 mm) | X |
| 2003 | Laiwu Iron & Steel, P. R. China | Beams (1 000 mm) | X |
| 2003 | Changzhi Iron & Steel, P. R. China | Sections (500 mm) | X |
| 2003 | Panzhihua Iron & Steel, P. R. China | Rails, Sections (400 mm) | |
| 2002 | ARCELOR (ProfilARBED), Luxembourg | Sections (500 mm) | X |
| 2001 | Angang New Steel Co., P.R. China | Rails, Sections (400 mm) | X |
| **1998** | **Steel Dynamics, USA** | **Sections (1 000 mm), Rails, Sheet Pile** | **X** |

**Figure 1.** Selected SMS section mills.

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## 2 METHODS AND MATERIALS

### 2.1 SDI Columbia City, Heavy Section Mill

Steel Dynamics has operated the heavy section mill in the Columbia City facility since 2002. That mill, based on the reliable SMS Meer reversible universal tandem concept, has achieved record productivity, surpassing 1.2 million tons in 2008. The product range of the mill reaches up to 1,000 mm and as low as 150 mm. Additionally, SDI added a rail finishing line to the heavy section mill soon after its start-up.

#### 2.1.1 Plant I.D.

- Customer: steel dynamics
- site: Columbia City, IN - USA
- rated capacity: 1.000.000 tpy
- products: 150 mm to 1,000 mm beams, 43 kg/m – 75 kg/m rail
- feed sizes: beam blanks and blooms
- start-up: 2002.

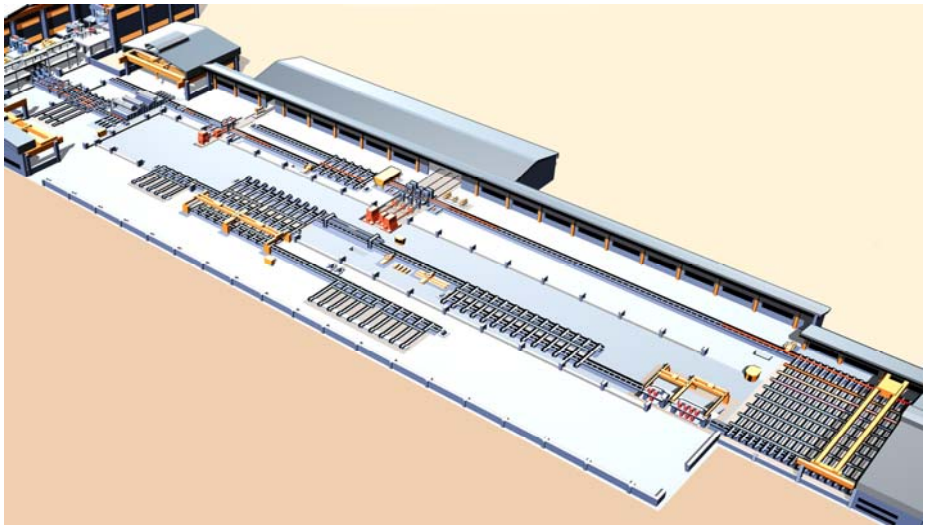

**Figure 2.** SDI structural and rail mill.

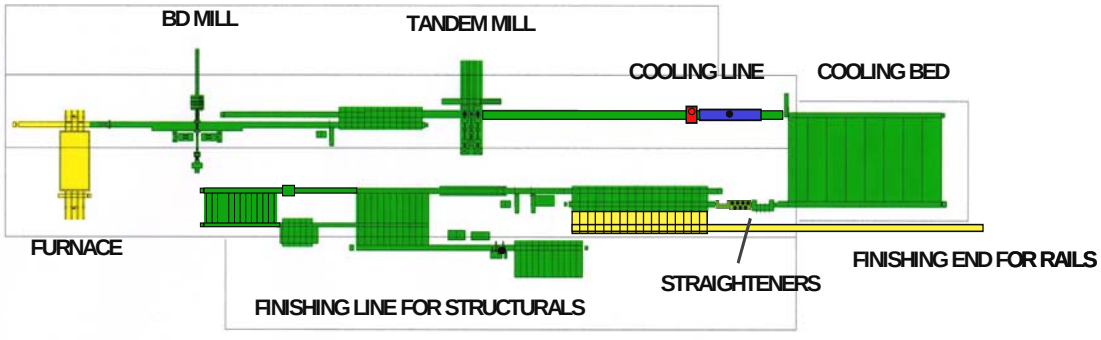


**Figure 3.** Layout of structural and rail mill steel dynamics Inc.

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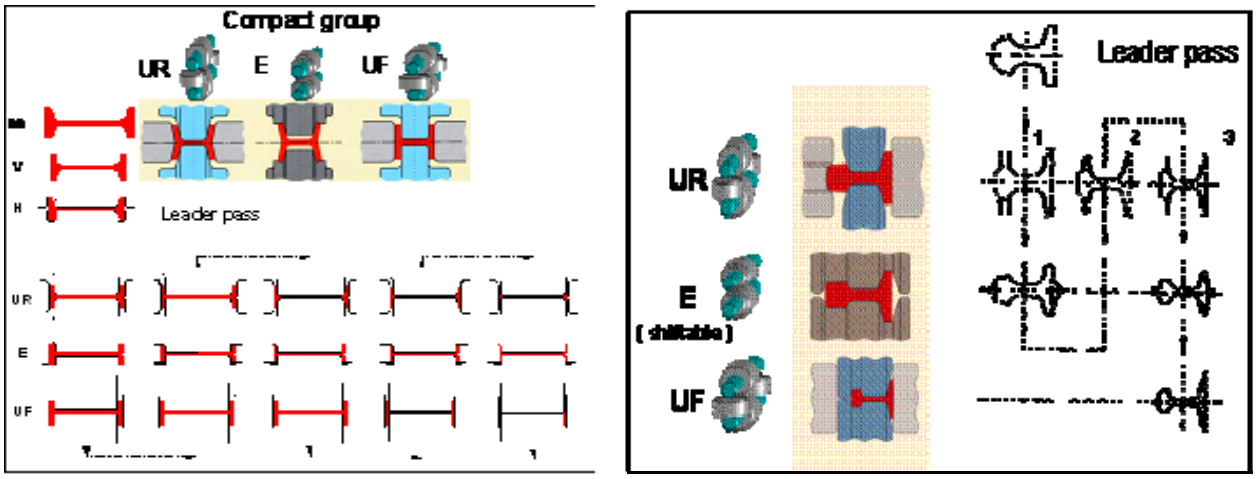
### 2.1.2 Mill description

The mill comprises a walking beam reheating furnace, a high-pressure water descaler for primary descaling, a two- high BD- stand equipped with tilting and manipulating devices, which reduces the as-cast sections into the appropriate leader pass for finish rolling. If required, a hot saw can crop the sections before entering the tandem mill. A secondary descaling head is arranged in front of the tandem mill specifically for rail rolling, to ensure that the rail surface is free of secondary scale before rolling the final pass.

Finish rolling takes place in the Tandem Mill consisting of a universal roughing stand, a shiftable edging stand and a universal finishing stand. For rolling beams, all stands are in operation simultaneously using the patented XH®-rolling method, which is now the standard method for producing beams (Figure 4a). Rail is also rolled in the tandem mill using the universal rolling method (Figure 4b). Sheet pile will be finished rolled in two-high mode on reversing tandem mill.




(a) (b)

**Figure 4.** (a) XH® roll pass design for beams; and (b) universal rail rolling.

The stands of the tandem mill are of CCS®-design (Compact Cartridge Stand), which are designed for quick program changes of rolls and guides as a cartridge, which allows a size change within 20 minutes. Further, the stands are equipped with hydraulic adjustment systems featuring automatic roll zeroing and determination of mill spring as well as automatic gauge control (AGC) (Figure 5). These adjusting systems allow a precise roll alignment ensuring close tolerances also along the bar length thanks to the Automatic Gauge Control System (AGC).

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**Figure 5.** Reversing tandem mill with AGC-control.

Between tandem mill and cooling bed, there is a cooling line arranged for selective cooling of beams as well as for rails (Figures 6 and 7). The cooling bed is designed as walking beam/chain type bed. The cooling bed can operate with natural or forced air or even with aerosol cooling from underneath.

**Figure 6.** Cooling line for selective cooling and cooling bed.

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**Figure 7.** Cooling line for selective cooling and cooling bed.

Horizontal and vertical roller straighteners are arranged directly behind the cooling bed. Once straightened, the rails will be transferred into a rail finishing line and the section will be transported to a finishing end for sections and includes a collecting bed and cold saws, and piling, tying and shipping facilities.
A new straightening technology was developed in 2000 and is meanwhile in operation in 9 rolling mills. The new generation of straightening machines, so-called CRS®-straighteners are double supported, hydraulically adjusted and equipped with fully automated quick changing devices of all straightening rollers at once within 20 minutes (Figure 8). CRS®roller straigtening provides better straightness and less residual stresses of the finished product.

**Figure 8.** CRS®-section roller straightening machine during roller change.

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### 2.1.3 Key and unique features

What makes SDI different to other structural and rail mills is shown below:

- rail rolling in a mini mill by EAF-steel;
- universal structural and rail rolling on a compact reversing tandem mill;
- in-line rail cooling without pre-bending;
- in-line rail finishing;
- in-line rail cooling without pre-bending;
- in-line rail head hardening;
- adjustable distance between straightening discs in order to minimize straightening roller changes.

## 2.2 Siam Yamato Steel, Light & Medium Section Mill

Siam Yamato Steel has commissioned a new Mini Mill supplied by SMS. The mill is fed by several continuously cast billet and bloom sizes. The maximum starting length for the reheating Furnace is 12 m. The mill is designed to roll a variety of structural shapes: Beams from 100 mm to 350 mm; channels from 75 mm up to 250 mm; equal and unequal angles from 50 mm up to 250 mm. There are provisions for future inclusion of rolling of round and flat products. The finished product lengths are from 6 m to 24 m.

### 2.2.1 Plant I.D.

- Customer: Siam Yamato Steel Co.;
- site: Maptaphut, Thailand;
- capacity: 400,000 tpy (expandable to 600,000 tpy);
- products: 100 mm to 350 mm beams, channels, equal & unequal angles;
- feed sizes: billets and blooms;
- start-up: 2009.

**Figure 9.** Top view of new Siam-Yamato Mini Mill in Maptaphut.

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### 2.2.2 Mill description

The stock re-heating to rolling temperature is performed by a 130 tph walking beam reheating furnace. The furnace is equipped with ultra-low NOx burners. The cold charge capacity can be increased to 160 tph by adding of further burners in the future.

**Figure 10.** Ultra-low NOx reheating furnace (130 tph/160 tph).

At the exit of the furnace, a high pressure descaler (210 bar) prepares the stock for rolling. The billets and blooms will be pre-rolled in a reversing break-down mill stand in three to nine passes. The mill stand is equipped with hydraulically unjamming device, roll separating force measurement device and hydraulically overload protection. Of course, quick program changing is provided. The manipulation of the rolled stock is done by grip-type tilter and centering devices.

**Figure 11.** New compact reversing breakdown-stand.

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The finished rolling takes place in a continuous mill train made of nine stands, in horizontal, universal positions. All stands are the same size and based on the innovative SMS Meer ultra-rigid closed top CS® stand design (Figure 12). The continuous mill is equipped with quick changing platform that allows a complete size change of the entire mill in 20 minutes.

**Figure 12.** Finishing mill train (operator's side).

Four mill stands of the finishing train are already equipped for future extension into convertible (H/V) stands for possible implementation of round and flat rolling.
The off-line preparation area for the CS-changing stands is equipped with three preparation stations for preparation of all CS® - mill stands within less than 6 hours.
As realized at SDI's light and medium section mill, the last two finishing stands could be equipped with hydraulically screw-down devices and a laser profile gauge can be positioned downstream the last finishing stand. The SMS Meer profile gauge (system TBK) is characterized by a high degree of precision due to the following:

- sealed laser-CCD assemblies, factory calibrated;
- temperature controlled mounting surface to eliminate thermal distortions;
- optical path kept constantly free by on-board mounted blower;
- overhead traversing from operating to service positions;
- "double" reading with different laser colors and data averaging via software.

**Figure 13.** In-line profile gauge in operation.

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The gauge has the capability of feed-back to the AGC hydraulic control on the last two stands for real-time under-load adjustments (automatic sizing).
Further in the process flow, a hot saw divides the as-rolled stock into cooling bed length and takes samples. Space is provided for future extension of a flying dividing shear downstream the last finishing mill stand.


**Figure 14.** Hot dividing and sample saw.

The cooling bed is a combination rake type and chain conveyor and has a quick delivery system for lighter products. The rake type initial area ensures proper material straightening.


**Figure 15.** Quick delivery system for cooling bed.

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**Figure 16.** Equal Angles on the cooling bed.

The single line horizontal straightener is of cantilever design of the newest generation. All rolls are individually powered and the distance between the straightening rollers is adjustable.


**Figure 17.** Roller straightening machine with adjustable pitch.

A state of the art finishing end with a fixed pre-dividing saw and tandem cold saw line for cut to finished length, piling equipment with automatic single bar labeling and visual inspection stations are provided.

**Figure 18.** Cold saw with noise protection and adjustable length gauge.

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At the entry side of the piling machine visual inspection from all sides of the products can take place. Floor mounted single bar labeling stations are allocated to each piling bed. Piling in nested and un-nested mode is done by turning piling magnets.

**Figure 19.** Automatic turning magnet-type piling machines.

**Figure 20.** Finished products on the storage yard.

### 2.2.3 Key and unique features

The core new technology of the continuous mill is the innovative SMS Meer CS stand design. Made of fabricated and not cast components, this design merges high rigidity with low weight and reduced manufacturing and operational cost.

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The advantages of this design can be summarized as follows:

- ultra-rigid closed type fabricated housing;
- high screw down accuracy due to roll kissing (zeroing);
- modular design for universal, horizontal and vertical mode;
- different stand types completely interchangeable;
- use of different roll barrel length possible (universal barrel, 2-hi 1,100 mm, 2-hi 1,500 mm);
- individual or synchronized adjustments for top and bottom rolls;
- hydraulic balancing of top roll;
- backlash free axial adjustment of top roll;
- hydraulic under-load adjustment with AGC or mechanical adjustment system can be selected.

**Figure 21.** CS-stand in SMS Meer workshop for workshop test.

### 2.3 New Concept for Large Bar Mills

Beside the technology improvements in the field of section mills SMS Meer has developed a new concept for large bar mills respectively billet mills. The new concept is distinguished by:

- ¼ DIN tolerance over the bar length without additional sizing mill;
- higher degree of automation;
- higher flexibility (suited for small order lots);
- lower conversion costs.

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Figure 22 shows a typical Large Bar Mill Layout for large rounds from 120 mm up to 300 mm including squares. The starting sizes can be round or square continuously cast blooms or ingots. Typical annual production for such large bar mill could be about 1.000.000 t.

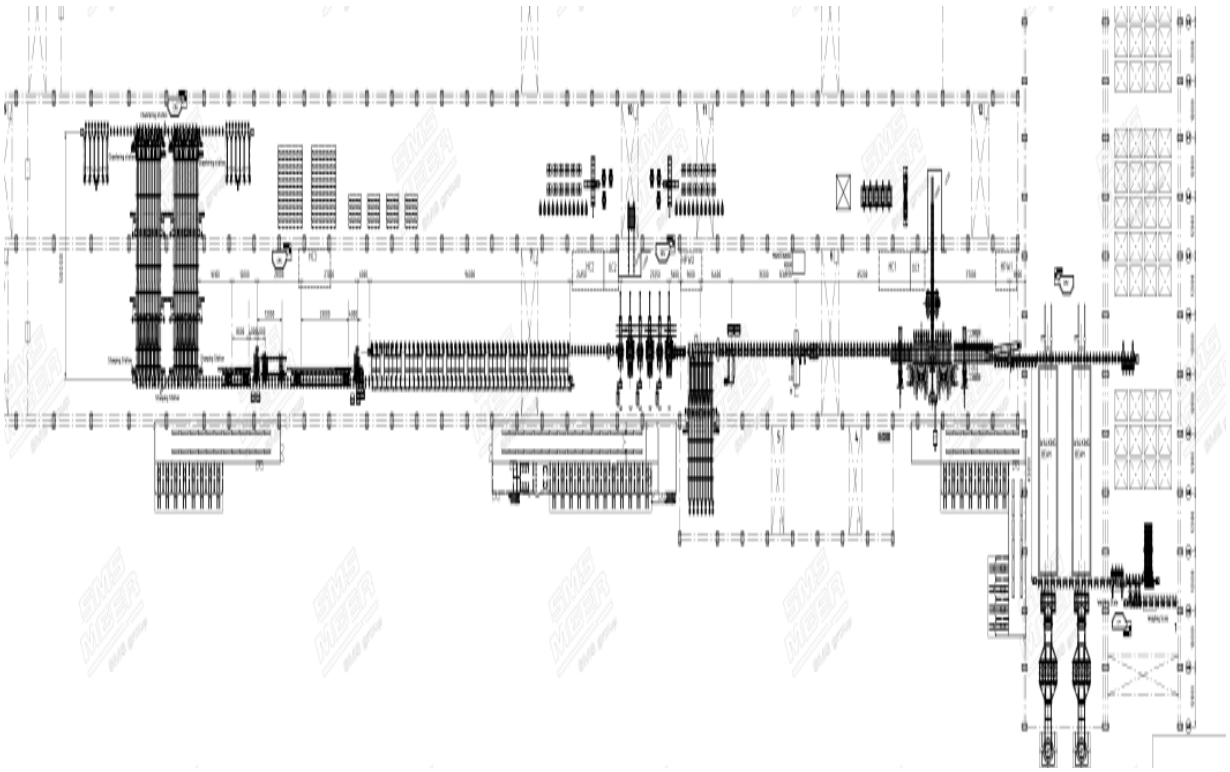

**Figure 22.** Typical Large bar mill layout for 1.000.000 tpy.

Key feature of the new concept are the HCS®-mill stands in horizontal and vertical arrangement. HCS®-mill stands means Hydraulically Compact Stand, which is distinguished by following features:

- under Load adjustment with AGC in order to compensate any dimensional deviations over the bar length (like “temperature wedge”);
- roll gap zeroing and roll gap adjustment in the mill line;
- detection of mill stand modulus in the mill line possible;
- hydraulically axial shifting of rolls;
- automatic roll separating force measurement.

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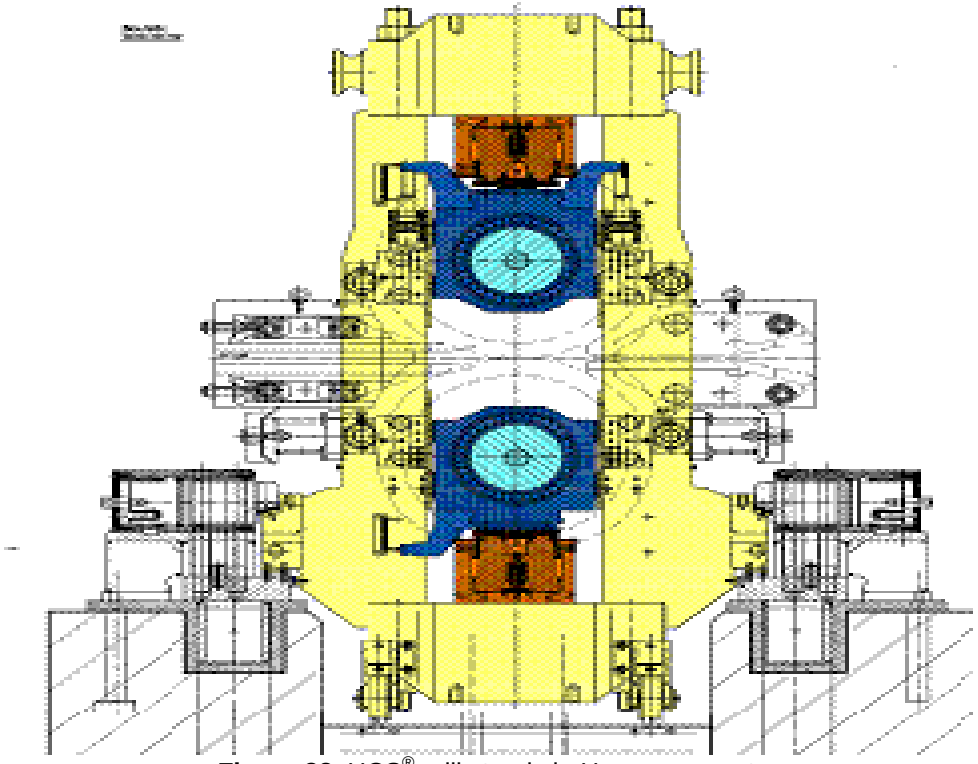

**Figure 23.** HCS®-mill stands in H-arrangement.

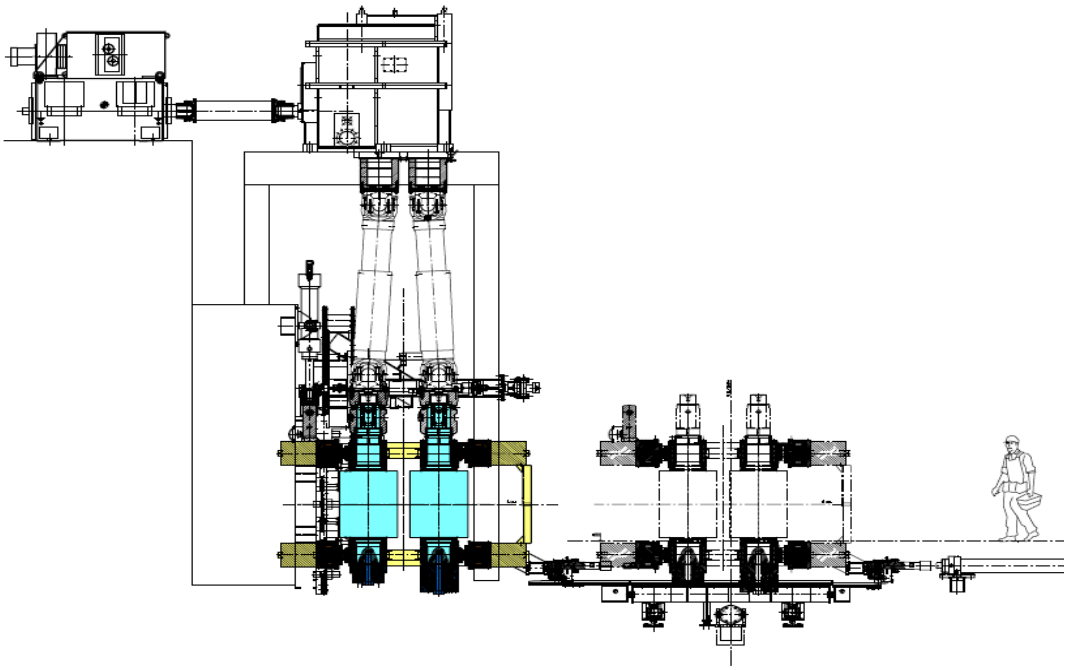

**Figure 24.** HCS®-mill stands in top driven V- arrangement.

Figures 23 and 24 shows the HCS®-mill stand horizontal and in top driven vertical arrangement. Horizontal and vertical mill stands are of identical design and are exchangeable.

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The close tolerance over the bar length of ¼ DIN-standards is achieved due to extreme rigid stand design and a Hydraulical Size Control-system (HSC®). This control system consists of three levels of control systems, namely Hydraulic Position Control (HPC), Automatic Gap Control (AGC) and the closed loop control (MON) between the actual measured dimensional value by an laser-type profile gauge and the hydraulically adjustment system of the last two mill stands. The laser-type profile gauge is arranged directly behind the last finishing mill stand.

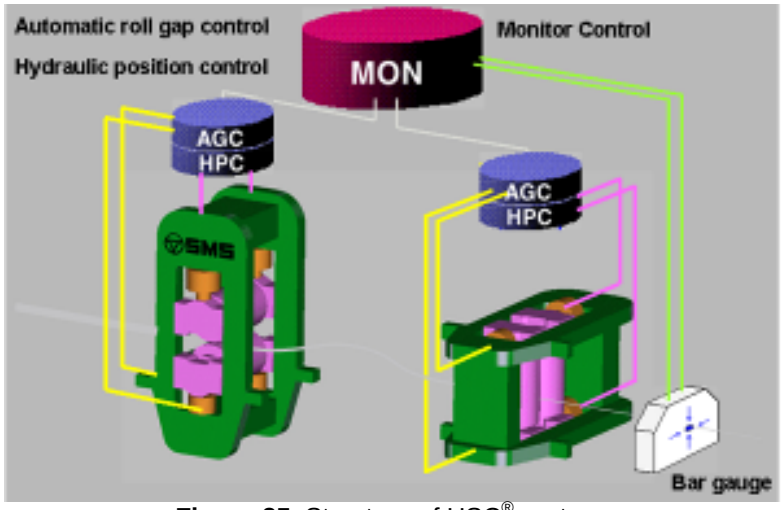


**Figure 25.** Structure of HSC® system.

Figure 26 shows the efficiency of the individual systems (HPC, AGC, MON) in terms of improvements on final dimensional tolerances over the bar length. The achieved tolerances over the bar length achieved with such controlled system is shown in the Figure 27.

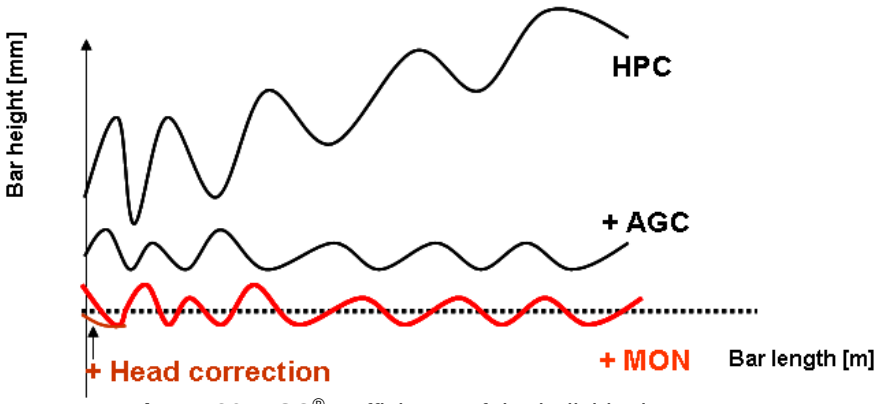


**Figure 26.** HSC® - Efficiency of the individual systems.

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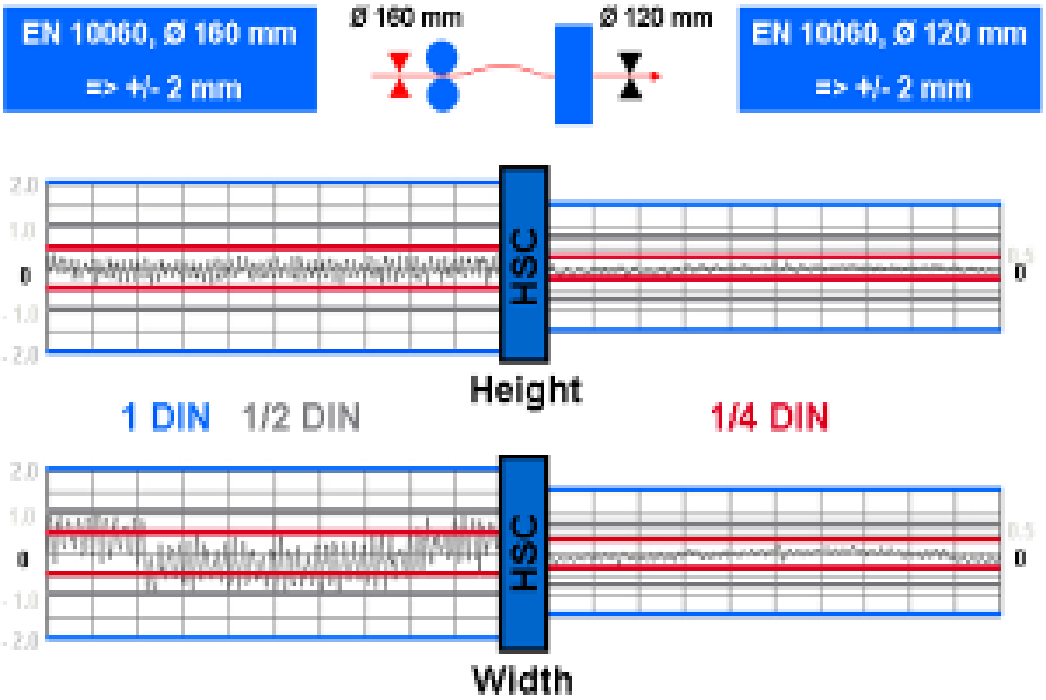


**Figure 27.** HSC® - Hydraulic size control – achieved dimensional tolerances.

### 2.3.1 Key and unique features

The SMS Meer concept for large bar mills provides following unique advantages and benefits:

- ¼ DIN tolerance and better on final product for round and other shapes (square, etc.) without additional reducing and sizing system resulting in less investment costs;
- more roll pass design flexibility;
- improved rolling yield by 2,5% – 3% (due to ¼ DIN-tolerance);
- higher process reliability and availability due to roll gap zeroing and possible adjustments in the mill line.

## 3 CONCLUSION

The described rolling mills are just examples for quite a number of SMS section mills which have been gone on stream in the recent years. All these section mills are distinguished by advanced technology and equipment design in order to minimize the operating cost, minimise maintenance and to maximise the production capacity. In the favourable market condition of the recent years they produced 15% to 30% above the design capacity and have contributed to the competitiveness of our customers. On the other hand these modern mills are distinguished by a great flexibility in terms of product range and lot size. This provides our customers with a further edge to stay ahead even in unfavourable market conditions. The new concept for large bar mills for utmost flexibility and closest tolerances provides unique features in order to minimise operating and investment costs.