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CSP® CASTING TECHNOLOGY – INDIVIDUAL SOLUTIONS FOR ALL PRODUCTION REQUIREMENTS[1]

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Abstract

Due to continuously driven developments in thin slab casting, several CSP® (Compact Strip Production) lines have exceeded their rated capacity and with VSB (Vertical Solid Bending) casters have reached almost 1.5 million tpy per strand. Market demands today require an even higher production and/or an increased final strip thickness for special applications (like thick API grades). The casting thickness therefore needs to be increased and the extended metallurgical length of the caster consequently leads to a VLB (Vertical Liquid Bending) caster. The new CSP® VLB caster is based on SMS Siemag's more than 20 years of experience in thin slab casting and combines proven CSP® technology with new technical solutions. The design capacity is 2.0 Mio tpy and the caster fulfils the requirements for endless rolling.

The different CSP® caster concepts (VSB and VLB) with an annual production of 1.0 to 2.0 million tons per strand are compared with each in terms of special design features and their operational window that is required by the steel grade, casting thickness, width and speed.

Keywords: Compact strip production; Continuous casting; Thin slab casting; Production increase.

TECNOLOGIA DE LINGOTAMENTO CSP® – SOLUÇÕES INDIVIDUAIS PARA TODAS AS DEMANDAS DE PRODUÇÃO

Resumo

Devido aos contínuos desenvolvimentos em lingotamentos de placas finas, diversas instalações CSP® (Compact Strip Production) excederam suas capacidades nominais de produção, e atingiram em torno de 1,5 Milhões de toneladas anuais por veio com o conceito VSB (Vertical Solid Bending). Hoje o mercado demanda por maiores níveis de produção e também por maiores espessuras de tiras para aplicações especiais, como graus API. Assim a espessura de lingotamento deve ser aumentada, e o consequente aumento do comprimento metalúrgico conduz à aplicação do conceito de lingotamento VLB (Vertical Liquid Bending). O novo lingotamento CSP® VLB, está baseado na experiência da SMS Siemag em lingotamento de placas finas por mais de 20 anos, e combina a comprovada tecnologia CSP® com novas soluções técnicas. A capacidade de projeto atinge 2.0 Milhões de toneladas anuais por veio, e o lingotamento está apto a operar, em conjunto com o laminador, no modo de laminação contínua (*endless rolling*).

Os diferentes conceitos (VSB e VLB) para lingotamentos CSP®, com produção anual por veio de 1,0 ou 2,0 Milhões de toneladas, são comparados em relação às características especiais de projeto e suas vantagens operacionais, dados os tipos de aços, espessura de lingotamento, largura e velocidade.

Palavras-chave: *Compact strip production*; Lingotamento contínuo; Lingotamento de placas finas; Aumento de produção.

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1 INTRODUCTION

With the commissioning of the Nucor Crawfordsville facility in 1989, SMS Siemag laid the foundation for the world's leading thin slab technology: CSP®, Compact Strip Production.
The reliability of these units was reflected, among others, by their steep run-up curves. Today, our customers not only receive the mechanical equipment, but also the complete electrical equipment and automation system from a single source, which also contributes to the success. For example, Severstal Columbus had reached 90 per cent of its rated capacity after just 5 months.
During the last two decades, the range of steel grades processed was continuously extended and the production of each casting strand raised to about 1.5 million tons per year.[1] In the recent past, customers have urged us to raise annual production further up to 2.0 million tons per casting strand. To be able to serve this market and given today's customary casting speeds of around 6 m/min, the casting thickness is raised further and the length of the strand guide system is increased. This necessarily leads to a VLB (Vertical Liquid Bending) caster.
The following takes a closer look at the current development in the field of CSP® caster technology. It offers individual solutions to meet all production requirements of our customers.

VSB – Vertical **S**olid **B**ending

- Unique caster with vertical solidification

VLB – Vertical **L**iquid **B**ending

- High production caster

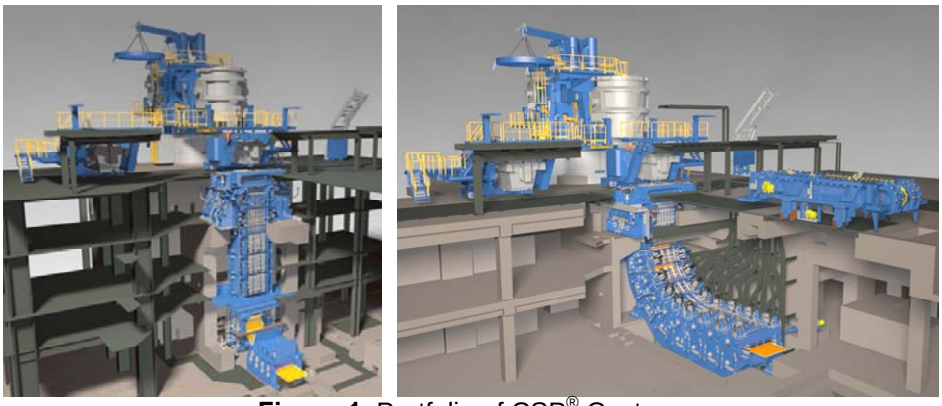

Figure 1. Portfolio of CSP® Casters.

Today's portfolio of CSP® casters includes

- The VSB (Vertical Solid Bending) caster with its unique, wholly vertical strand guide system is predestined to produce a casting thickness of up to 70mm and production volumes of up to approx. 1.6 million tpy per strand.
- The newly developed VLB (Vertical Liquid Bending) caster for production volumes of approx. 2.0 million tpy per strand, accompanied by a higher casting thickness. This caster is specially suited for processing API grades with higher final strip gauges. The design allows the caster to be operated both in uncoupled as well as coupled (endless) rolling.


		Vertical Solid Bending			Vertical Liquid Bending
Metallurgical length	m	6.34	8.33	10.38	16.44
Annual capacity*	mio t/y	1.2	1.4	1.6	2.0
Thickness range	mm	60 – 50	85 – 55	90 – 60	100 – 70
Optimum Thickness @ 6 m/min	mm	54	61	69	88
Throughput @ 6m/min - 1,000 mm	t/min	2.6	2.9	3.3	4.2
- 1,350 mm	t/min	3.5	3.9	4.4	5.6

* = 70% LC – 5.75 m/min / 30% MC – 4.75 m/min @ 1,350 mm average width

Figure 2. Type of Caster depending on production requirements.

The two CSP® caster types thus complement each other and each offer optimal conditions for the different requirements. The table above shows operating data of both caster concepts. The bow type concept produces the mass flow of >3.5 t/min at 1m casting thickness, as required by the rolling mill for coupled (endless) rolling.

2 DESIGN FOCUS – THE MACHINE HEAD

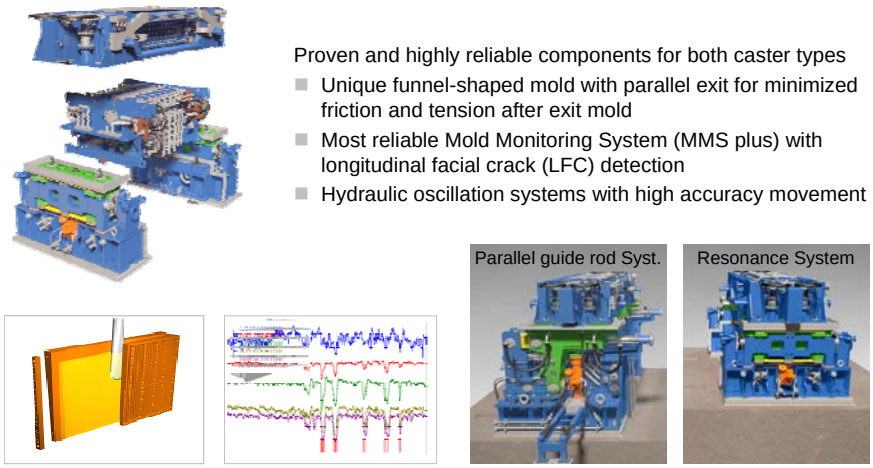

Figure 3. Machine head – Key element for thin slab casting.

The machine head is the core component of each CSP® caster. Components that have been successfully used for many years and undergone permanent further development warrant reliable casting operations.

The CSP® funnel-shaped mould with parallel exit at the end of the mould is used for both caster types. A rectangular slab section thus exits the caster from the start of casting.

The mould itself is of particularly rigid construction to withstand bending. This includes an O-frame with top and bottom chord that ensures dimensional stability even at the high thermal loads that result from high casting speeds. Further, a 400m thick and thus particularly flexurally rigid narrow-face support is used to warrant a constant taper of the narrow faces.

In addition to the already known capabilities of breakout prediction and temperature visualisation, the new Mould Monitoring System MMS plus also includes the detection of

longitudinal cracks.[2] This allows an even more immediate response to unfavourable casting situations.
The spring-loaded thermocouples (TC) ensure a reliable heat transfer between TC and copper plate. The pre-manufactured cable harness with plug-in connectors at both ends reduces the commissioning/maintenance time. The field bus modules are safely protected inside water cooled boxes. By connecting a single plug, caster operators make the system ready for operation.
While in the VSB caster the oscillation unit has a direct drive system with parallel guide rods, SMS Siemag have chosen a more compact design for the VLB caster in order to create additional space for the removal of the curved segments. Used here is an adapted leaf spring guided “Resonance Oscillation” unit whose reliability and extremely high running accuracy has been known from conventional continuous casters. [3]

3 DESIGN FOCUS – STRAND GUIDE SYSTEM

Where the customer-required product mix can be attained with a metallurgical length of 10m or less, the VSB (Vertical Solid Bending) caster is an optimal solution.With its wholly vertical strand guide system and thus absolutely symmetrical solidification, it also has the metallurgical advantage of no bending and straightening of the partially solidified strand taking place.

- No bending and unbending forces during vertical solidification
  - Reduced risk of LFC breakouts at loose side of bending zone
- Protection of lower segments against breakouts
  - High availability
- Special segment design (grid or roller cassette in segment 1; axle type rollers for small roller diameter, bearing window and roller pitch; uneven roller pitch)
  - Excellent stability against bulging effect

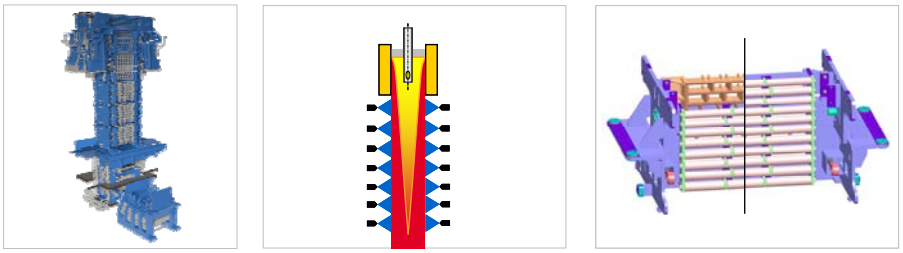

Figure 4. Strand guides system of VSB CSP® Caster.

In addition, vertical strand guiding also offers operational advantages in terms of plant availability and maintenance effort. For example, the vertical design alone provides excellent protection of the lower segments against steel splashes resulting from a breakout. The mould and segment 1 are designed as quick-change unit, which in many instances makes the caster ready for casting again within one hour after the incident.
The VSB caster uses exclusively axle rollers with which particularly small roller diameters and narrow bearing windows can be realised. The uneven roller pitch further contributes to attaining an excellent stability against dynamic bulging and hence a high quality of the thin slab. The axle rollers and bearings are at all times sufficiently and uniformly cooled by the secondary cooling system. Additional external roller cooling is provided merely in the lower part of the strand guide system in order to additionally protect these rollers in the case of seriously reduced secondary cooling. No elaborate and high-maintenance internal cooling is needed here.

- Minimized and uneven roller pitch
  - Optimum strand support (reduced bulging and strain)
- New STEC rollers from segment 3 onwards
  - Small bearing windows combined with internal roller cooling
- CYBERLINK segments in horizontal area
  - Self-centering top frame and easy maintenance access by open frame design

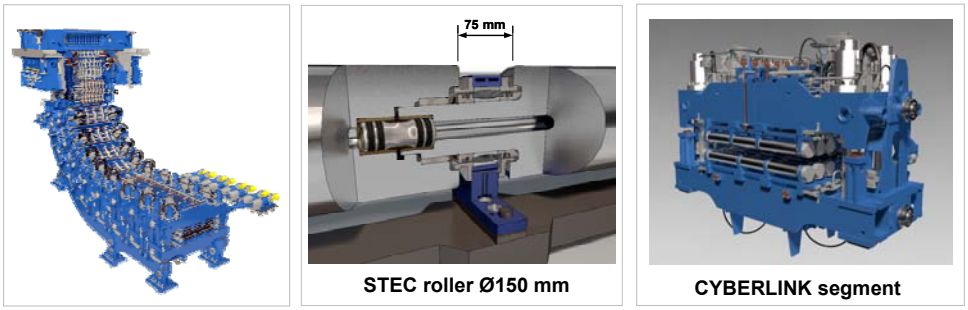

Figure 5. Strand guides system of VLB CSP® Caster.

The VLB caster adopts the concept of the axle rollers in segment 1 and segment 2 (bending segment). In the further course of curved strand guiding and in the horizontal area, the internally cooled STEC roller is used. This novel roller for the first time allows internal roller cooling to be combined with narrow bearing windows even where small roller diameters are involved. This design is also used as driven roller. The three horizontal segments 8-10 are designed as CyberLink segments featuring self centering top frames. Easy maintenance access is given due to the lack of side frames.

Secondary cooling in VSB casters is designed completely as width-dependent, controllable single-medium cooling. The offset arrangement of the nozzles in casting direction additionally ensures uniform heat dissipation. Based on the features described, the necessary control range can in the case of strand guide lengths of 6 to 10m be perfectly covered by the low-cost single-medium cooling system. The strand guide system is totally enclosed in the (box-type) cooling chamber.

In VLB casters, a combined single-medium and air-mist cooling system is used. In segment 1, analogous to VSB casters, a single-medium cooling system is used in order to dissipate as much heat as possible in the first part of the strand guide system and to stabilise the strand shell (hard cooling). With air-mist cooling starting in segment 2 (bending segment), temperature control of the slab with its still liquid core is optimised in terms of straightening and maximum furnace entry temperatures, from the curved zone until the end of the strand guiding system. With the strand guide system being twice as long as compared to a VSB caster, this results in a large difference between the minimum solidification length and the strand guiding length. The high heat dissipation flexibility required in casting direction is thus achieved by the larger control range of the air-mist cooling system. The hydraulic and electrical components arranged directly on the segments are effectively protected against steam and corrosion by a tunnel-type cooling chamber that starts at segment 3.

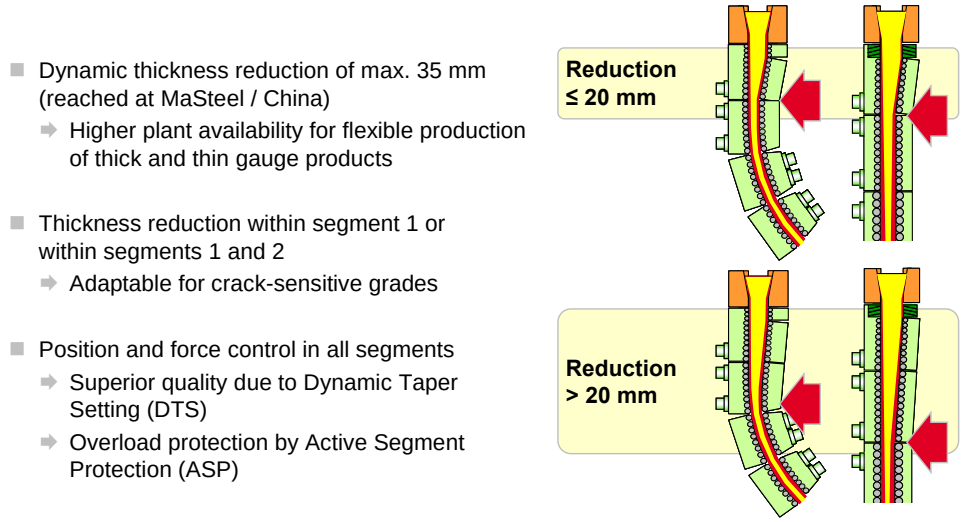

Figure 6. LCR - Liquid Core Reduction.

In both caster types the complete strand guide system is equipped with the hydraulic segment adjustment system HSA, with position and force control. Using the position-controlled cylinders, both the thickness reduction is effected in segment 1 or in segments 1 and 2 (LCR plus - Liquid Core Reduction) as well as dynamic segment adjustment (DTS – Dynamic Taper Setting) in the downstream segments. Irrespective of the casting speed or the shrinkage behaviour of the strand, DTS with its minimal force control in the HSA at all times ensures an optimal strand support. Further, a maximum force monitoring feature ensures active segment protection (ASP - Active Segment Protection).

At MaSteel in China, LCR plus for the first time achieved a thickness reduction of 35mm for LC grades.[4] Samples show a distinctly small amount of bulging of the narrow sides and a homogeneous internal structure. The option of supplying the rolling mill with 90 and 60-mm thin slabs without the need for changing over the caster increases the flexibility of producing material both with thick and very thin final dimensions.

The selection of the dummy bar system directly affects the availability of the caster. In the VSB caster, the most impressive feature of the dummy bar system is its simple concept which provides for a rigid steel plate to be introduced from below within a very short time.

For the VLB caster, SMS Siemag use a dummy bar that is introduced from above. Based on the SMS Siemag system which in 1974 was supplied as the world's first for the conventional continuous caster of ThyssenKrupp Steel Europe,[5] this concept has been successfully employed in high-performance casters for years. Both dummy bar solutions lead to the shortest possible distance between the caster and furnace entry. Thermal radiation losses on the way to the furnace entry are minimised.

4 SUMMARY

With the new CSP® VLB caster SMS Siemag extends its portfolio of successful CSP® VSB casters.
The proven CSP® design such as the machine head in combination with new technical solutions like STEC roller, CyberLink segments, tunnel cooling chamber and top feeding dummy bar system are the features of the new VLB caster for high production of up to 2.0 million tpy. The strand guide design with minimized roller pitch and small bearing guarantees optimum strand support at low bulging and strain levels.
Up to a design capacity of approx. 1.6 million tpy, the unique VSB caster with the pure vertical solidification is the well-established alternative to the VLB caster.

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