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# COMBI-CASTERS FOR THE PRODUCTION OF BLOOMS AND BEAM BLANKS – AN ALL-IN-ONE SOLUTION FOR TOP PRODUCTION FLEXIBILITY[1]

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**Abstract**
In the last few years, Siemens VAI Metals Technologies (Siemens VAI) has developed a specially designed combi-caster for long products, which offers the operator highest flexibility with respect to different casting sections and steel grades. The operator can easily transform its casting machine in a couple of hours from a High Quality Billet/Bloom Caster with soft reduction technology and mold EMS to a Special Beam Blank Caster according to the changing market demands. With Siemens VAI it is possible to combine the production of billet, bloom and near-net-shape beam blank at one single casting machine. These special casters are equipped with the latest casting technologies like mold stirring and soft reduction functionality. Latest improvement of the internal quality was the implementation of dynamic soft reduction technology on long product casters. Siemens VAI runs the soft reduction technology in a fully dynamic mode and continuously uses all relevant casting parameters in its computer model during the casting process. An optimization for beam blank casting has been reached with latest developments in the equipment design and in the fine tuned mold tapers. Siemens VAI beam blank casters provide a wide operation window with respect to casting speed and steel grades including as well as the peritectic steel analysis. Near net shape beam blank casting is an excellent alternative to the more conventional bloom casting route for the production of H-beams and profile shapes.
**Keywords:** Combi-caster; Bloom and beam blank; Casting flexibility.

## MAQUINA DE LINGOTAMENTO CONTINUO “COMBI” PARA BLOCOS E *BEAM BLANKS* – UMA SOLUÇÃO DE “TUDO EM UMA” PARA ALTA FLEXIBILIDADE DE PRODUTOS

**Resumo**
Nos ultimos anos, a SiemensVAI desenvolveu um tipo de maquina de lingotamento para produtos longos, chamado ”maquina combinada” (*combi caster*), qual oferece a maior flexibilidade em termos de formatos diferentes e de graus de aço. O pessoal de operação pode facilmente transformar esta maquina em poucas horas de uma maquina de tarugos / blocos com tecnologia de *soft reduction* e agitador eletromagnético para uma maquina especial de *beam blank* seguindo a demanda do mercado. Com esta maquina da SiemensVAI e possivel de combinar a produção de tarugos, blocos, e beam blank (near net shape) em uma única maquina de lingotamento, na qual as ultimas tecnologias estão aplicadas. As ultimas melhorias de qualidade interna do produto referem se a redução dinâmica, sendo aplicada em um modo “*full* dinâmico” sempre considerando todos os parâmetros relevantes do processo de lingotamento. A otimização de beam blank foi atingida com o ultimo desenvolvimento de equipamento e no aperfeiçoamento do molde, também possibilitando uma faixa grande de velocidades e graus de aço a serem lingotados, incluindo aços peritecticos. *Near-net-shape* é uma excelente alternativa para produção de vigas H e de perfis em geral.
**Palavras-chave:** Lingotamento; Bloom / beam blank; Alta flexibilidade.

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## VISION FOR BLOOM AND BEAM BLANK CASTING

The visions for the continuous casting machines of today are maximum productivity, high production flexibility and best product quality.
This vision requires a casting machine equipped with an optimized combination of technological equipment, process technology and automation packages. These casters are able to cast several different casting sections; from small billets in open stream casting, to round section and heavy blooms with mold stirring and soft reduction technology. They are also able to cast near-net-shape beam blanks.
Siemens VAI has combined these demands and in the last few years designed its combi-casting machines with unique modular design for long products.
Several of these combi-casters have been in operation since the year 2002, with the first billet cum bloom cum beam blank caster at Jindal Steel & Power Ltd in India. Siemens VAI has designed combi-casters for small billets of 140 mm round, large rail blooms of around 400 mm and medium section beam blanks of 500 mm width on one single casting machine. Latest technologies like dynamic soft reduction have also already been implemented at these combi-casting machines. For example a 5-strand beam blank cum bloom caster was designed for Handan Iron & Steel Co. Ltd., China in 2010 in order to cast three beam blank sections of maximum 750 mm width and two bloom sections of maximum 380 mm width for rail steels with DynaGap dynamic soft reduction technology.

## COMBI-CASTER TECHNOLOGY FOR HIGH-QUALITY STEEL AND OPERATIONAL RESULTS

The following main technological components are designed according to a strict modular concept and can be installed according to the customer's requirements. The modular design of the machine head and strand guide enables the quick exchange of the casting size units and a wide range of different casting sections. Figure 1 and 2 shows two examples of this caster design.

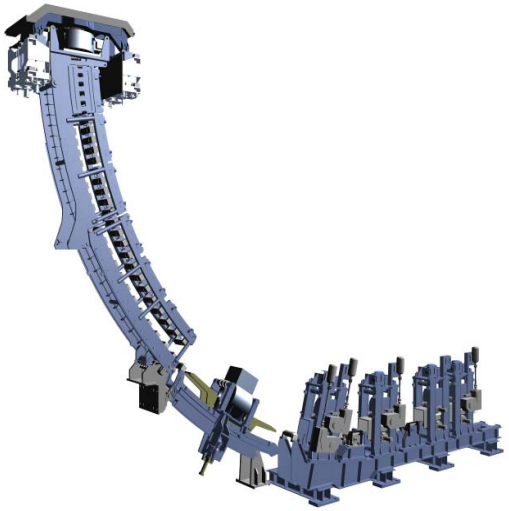

**Figure 1**: Typical machine head and strand-guide design.

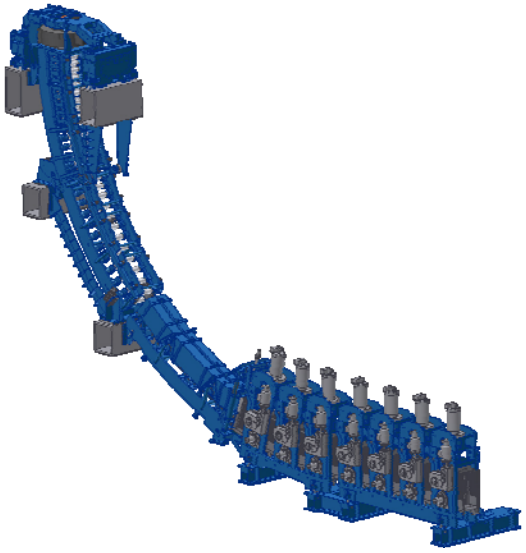

**Figure 2**: Typical machine head and strand-guide design.

The high-performance machine head of Siemens VAI has the following advantages, as listed below and shown in Figure 3 and 4:

- Curved plate mold with LevCon mold level control and external electromagnetic mold stirrer. The plate molds guarantee homogeneous water cooling over the complete circumference of the bloom and therefore also a constant shell growth. The thickness of the copper plates is reduced in order to optimize the mold stirring force and to reduce investment costs for the copper plates.
- DIAMOLD mold tubes are used for billets and smaller beam blank section sizes. DIAMOLD stands for high speed casting of billets ensured by its unique parabolic taper as well as for excellent surface quality of the billets and a long life-time of the copper tube. The rapid and homogeneous shell growth provides operators with a wide operation window for casting speed and different steel grades.
- DynaFlex hydraulic oscillator for molds with online stroke, frequency and wave pattern adjustment. The leaf spring guidance for the mold table provides best guiding accuracy and at the same time is a wear-free and backlash-free guiding system for the reliable and maintenance-free operation of the mold oscillation unit.

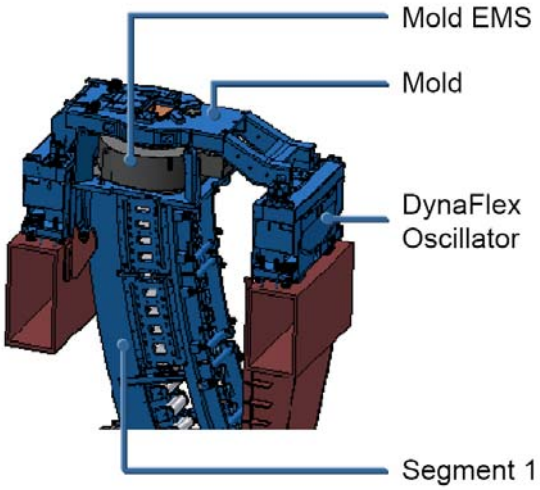


**Figure 3**: Modular machine head from Siemens VAI.

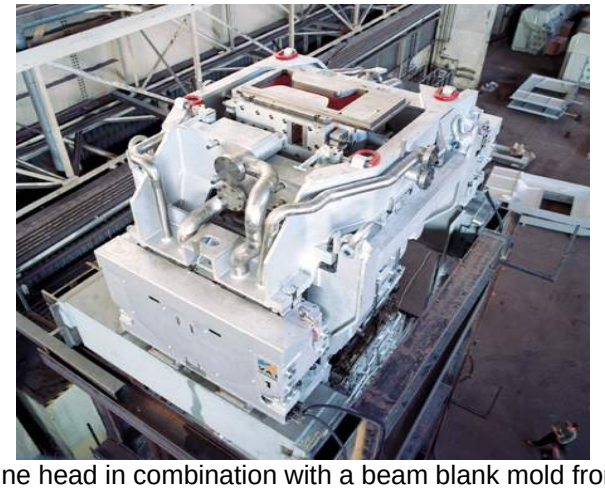

**Figure 4**: Machine head in combination with a beam blank mold from Siemens VAI.

## COMPACT STRAND-GUIDE SYSTEM

The modular design of the strand guide enables a quick turnaround by changing the mold with segment 1 and segment 2. A Siemens VAI strand guide consists of three strand-guide segments, which are designed with

- A divided frame with internal symmetrical cooling concept
- Internal roller cooling for bloom sections and a smaller roller pitch in the upper segment part
- Easy maintenance due to modular roller units
- Pre-assembled, calibrated and easily exchangeable foot rollers
- Highly accurate and easily maintainable spray headers between the rollers
- Fast segment exchange and optimum alignment of strand-guide components
- An integrated water deflection system for beam blank segments which enables a fast and easy change of the strand guide.

## STRAIGHTENING AND WITHDRAWAL UNITS

Continuous straightening using a cassette type design allows operators to later expand their casters to add soft reduction functionality. Continuous straightening over a long distance ensures minimized surface and internal stress for the cast products.

Each pinch roller cassette is equipped with a hydraulic cylinder for independent roller gap adjustment. The operation results from dynamic soft reduction can be seen in Figure 5 and 6 on a cross section and longitudinal section of a rail bloom. Figure 7 shows a longitudinal sample of a 200x200 mm billet with dynamic soft reduction.


**Figure 5**: 280x380 mm Rail bloom with dynamic soft reduction.


**Figure 6**: 280x380 mm Rail bloom with dynamic soft reduction.

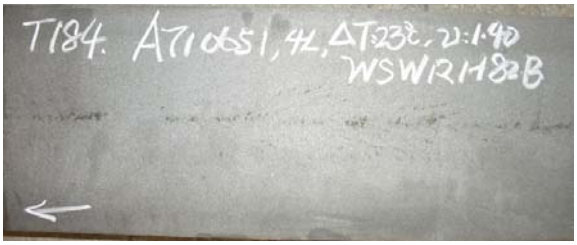


**Figure 7**: 200x200 mm Tire cord billet with dynamic soft reduction

## DISCHARGE EQUIPMENT

The discharge area is designed according to the client's requirements based on well-proven standard components from Siemens VAI. Newly designed cross transfer manipulators lift the products individually from the roller tables and transport them to the cooling bed or hot charging roller table. A specially designed combined cooling bed enables turnover functionality for billets and walking functions for blooms.

## BEAM BLANK CASTING TECHNOLOGY

Siemens VAI has developed a near-net-shape beam blank caster, which lowers rolling costs, increases productivity and reduces energy consumption. Beam blank casting is therefore an excellent alternative to the conventional bloom casting for the

production of beams and sections. The largest benefits can be achieved through the direct coupling of the caster to the rolling mill.
Siemens VAI has developed a special mold taper design, which has astonished operators with its large operation window in respect to casting speed and steel analysis.
A thermo-mechanical coupled finite element analysis calculates the shrinkage and shell formation of the beam blank within the mold. Using this tool and in combination with practical experience, it was possible to optimize the mold taper with respect to section size, steel grade and operation window. Below, Figure 8 shows an example of the finite element analysis. Figure 9 shows a photo of a cast beam blank sample from a Siemens VAI caster.

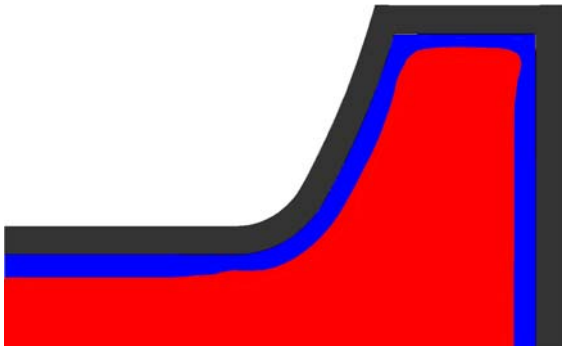

**Figure 8**: Optimized mold taper with shell growth inside of mold.

**Figure 9**: Macro etch sample of a near-net-shape beam blank.

## CONNECT & CAST® AUTOMATION

Siemens VAI automation solutions boost caster performance, product quality and operation reliability. The programming for level 1, level 2 and automation packages is carried out by our automation experts in-house. Therefore these programs have full functional capability right from the start of the first cast, hence the name Connect & Cast®. These technology packages include

- LevCon for mold level control during stopper casting with SEN and/or open stream casting. This controller applies an advanced control algorithm, which takes into account delayed system reaction, clogging and mechanical wear of the tundish stopper through improved dynamic behavior.
- Hydraulic oscillation control for control of the oscillation parameters of the mold.

- The new 3 dimensional thermal condition monitoring algorithm, Thermex 3D, accurately determines the thermal content of the individual strands by using advanced techniques to solve finite element algorithms on-line. Thermex 3D calculates the 3 dimensional temperature distribution and determines the final point of solidification. Figure 10 below shows a lateral temperature profile of a bloom section.
- The new advanced secondary cooling model SIMETAL Dynacs 3D derives adequate water flow rates even in transient casting situations such as steel grade changes, casting speed variations, different tundish temperatures, tundish changes, and at the beginning and end of a casting sequence. It is a highly accurate online strand-surface temperature control based on elaborate physical model and results in a higher product quality.
- DynaGap for dynamic soft reduction technology. This technological package, in connection with the 3-D thermal tracking model, allows for a fully dynamically optimized adjustment of the roller gap and taper during transient casting conditions. This results in improved internal quality especially for higher carbon grades.
- DriveCon for control of the withdrawal drives and the opening/closing of the roller gap of each single pinch roller unit. Furthermore, this controller handles automatic dummy bar insertion, bloom tracking and load sharing of the withdrawal motors.
- VAI-Q Quality Control. This quality control tool is part of level 2. It tracks and predicts the bloom quality.
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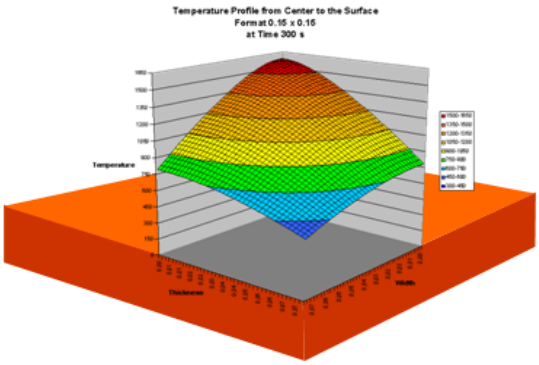



**Figure 10**: Calculation of the thermal profile of a bloom section.

These Connect & Cast® automation packages from Siemens VAI ensure a fast start-up.

## OUTLOOK

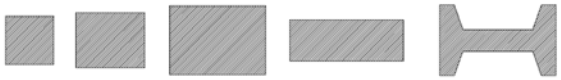
Steel mill operators are able to cast several billet, bloom and beam blank sections at one single casting machine. Depending on the current market demand, production can be switched between the different casting sections during one working shift. The next technological innovations will be permanently implemented at our casting machines. Siemens VAI also keeps an eye on improvements in operation safety and protection of casting personnel. One example of this is the latest development of LiquiRob®, which is an industrial robot that carries out several functions at the tundish mold area.

## CONCLUSION

The Siemens VAI combi-casters for billet, bloom and beam blank production result in greater production flexibility in order to meet the specific market requirements and maximum machine utilization. They also lower overall investment costs. Quick section exchanges and thus increased productivity is assured by Siemens VAI's advanced casting machine design. These new cost-saving casters are equipped with the latest technology to ensure superior-quality products – as required for the casting of rail, wire, bearing steel, etc. Optimized logistic planning tools enable the direct hot charging for uninterrupted, seamless production.
Below are four samples for these combi casters with their individual mix of different casting sections:

Jindal Steel & Power LTD (JSPL); India:
Round billet/blooms: 140, 162, 200, 220, 305 mm
Blooms: 250x250 mm and 285x390 mm
Beam blank: 355x280x90 mm and 480x420x120 mm

Steel Dynamics Inc; USA
Billet: 178x178 mm and 204x254 mm
Bloom: 254x355 mm and 152x420 mm
Beam blank: 430x260x80 mm



IISCO Steel Plant; SAIL; India
Billet: 235x235 mm
Bloom: 200x280 mm
Beam blank: 292x205x85 mm; 430x350x90 mm, 686x350x90 mm

Handan Iron & Steel Co. Ltd., China
Bloom: 280x325 mm and 280x380 mm
Beam blank: 446x260x85 mm; 450x350x90 mm; 750x370x90 mm