UPGRADE POSSIBILITIES FOR LONG-PRODUCT CASTERS FROM SIEMENS VAI[1]

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Abstract
The casting speed and thus productivity is primarily defined by final product-quality requirements. In order to satisfy increasing demands while assuring low operating and maintenance expenses and a high level of productivity, steel producers must continually upgrade existing casters to remain competitive. During the past decades, Siemens VAI Metals Technologies has continuously developed and installed technological packages which include hydraulic oscillation in the machine head, mold-level control, mold stirring, 3-D dynamic soft reduction and dynamic secondary cooling. These can be implemented within a short caster shutdown period. Improvements in the surface and internal quality of the strand, higher productivity as well as lower maintenance requirements are the proven results. With tailor-made upgrades, the performance of the caster can be optimized to fully meet today's production demands. This paper provides an overview of revamping concepts supplied by Siemens VAI Metals Technologies.
Keywords: Long-product casting; Quality improvement; Revamp; High productivity.

POSSIBILIDADES DE MELHORIA PARA MÁQUINAS DE LINGOTAMENTO CONTÍNUO DE PRODUTOS LONGOS DA SIEMENS VAI

Resumo
A velocidade de lingotamento e assim a produtividade é definida primariamente pelas exigências da qualidade final do produto. Para se satisfazer as crescentes demandas enquanto assegurando-se baixo custo operacional e de manutenção e um alto nível de produtividade, as empresas Siderúrgicas tem que melhorar continuamente suas máquinas de lingotamento existentes para permanecerem competitivas. Durante as décadas passadas, a Siemens VAI Metals Technologies desenvolveu continuamente e instalou pacotes tecnológicos incluindo oscilação hidráulica na cabeça da máquina, controle do nível do molde, agitação do molde, redução suave dinâmica 3-D e resfriamento secundário dinâmico. Estes podem ser implementados num curto período de parada da máquina de lingotamento. Melhorias na qualidade superficial e interna do veio, produtividade mais alta assim como menores exigências de manutenção, são resultados comprovados. Com melhorias sob medida, o desempenho da máquina de lingotamento pode ser otimizado para se atingir integralmente as demandas de produção atuais. Esta apresentação dá uma visão geral dos conceitos de reforma fornecidos pela Siemens VAI Metals Technologies.
Palavras-chave: Lingotamento de produtos longos; Melhoria de qualidade; Reforma; Alta produtividade.

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Introduction

Market need in continuous casting of long products is based on a synergy between requirements of high speed/high productivity and high quality requirements, due to the increasing quality demand also in such fields (i.e. rebar production) which were in the past considered as “low quality” demanding.
For such a reason it is necessary to provide solutions able to withstand both of these requirements.
Siemens VAI, thanks to its high level of competence in continuous casting field, is able to provide technological solutions which can be implemented in new or existing plants, reaching both goals.
Some of these technological solutions and their applications are presented in this paper.

Ultra High speed casting

Due to the increasing demands in terms of productivity and quality for its long products, SEVERSTAL CHEREPOVETS awarded Siemens VAI Metals Technologies (Siemens VAI) a contract for the installation of a test strand for ultra high speed casting, in excess of 7 m/min, as a basis for a further modernization of the complete machine.
Specially designed SIMETAL DiaMold mold tubes with lengths of 1000 mm and with different profiles were supplied in order to ensure a correct billet shell formation through correct parabolic taper, and in the meantime reduce the resulting high friction related to the high casting speed with the well proven SIMETAL DiaMold patented shape.
Since it is necessary to apply oscillation parameters, which not only ensure the correct values of negative strip and negative strip time that are necessary for the correct lubrication of the cast product, but which also prevent vibrations and deviation of the movement during the oscillation, SIMETAL DynaFlex hydraulic oscillation with leaf spring guidance was applied, substituting the existing electromechanical type oscillation.
The already proven SIMETAL DynaFlex technology was further implemented with adoption of new generation automation controls and hydraulic features.
The requirements of correct billet cooling at the mold exit and the necessity of maintaining the correct billet surface temperature, thus avoiding re-heating phenomena and ensuring an optimal billet cooling, as well as the proper solidification pattern required to avoid the presence of liquid core in the cutting area, resulted in the modification of the existing secondary cooling with a adoption of prolonged intensive cooling at mold exit, as well as with the implementation at all secondary cooling areas, including a new billet guiding system inside the cooling chamber.
The cooling control software system was also implemented for flow regulation, allowing use of a SWV (specific water volume) close to 3.0 l/kg at higher casting speeds.
Due to an increase in throughput, it was also necessary to increase the diameter of the tundish nozzle used in the existing tundish nozzle changer to 20 mm.
After installation of the new components, the test period for the redesigned strand started on 7 July 2007, with good results in terms of increased casting speed and quality.

The achieved casting speed during normal casting operations reached and even overrode the requirements, with a stable casting speed of more than 7.0 m/min and peaks up to 7.5 m/min. The machine demonstrated its capability of achieving a strand productivity of more then 34 ton/h/strand for this section, which is an approximate 20% increase in throughput.
Quality and dimensional results are shown in following figures.

Figure 1: Heat N. 64083, macro etch of StSp3, casting speed 7.1 m/min.

Figure 2: Heat N. 15564, macro etch of 35GS, casting speed 6.6 m/min.

Thanks to the results obtained on the test strand, SEVERSTAL confirmed its confidence in the Siemens VAI technology by awarding the contract for the implementation of ultra high speed technology on the five remaining strands.
The installation of this technology, with the same features already installed on the test strand, took place in summer 2008, thereby enabling the caster to increase actual production by roughly 20%.

High productivity with no cast stoppage

With a conventional billet caster design, a mold change means nothing short of a complete production stop. In order to change the mold of even a single strand, the casting operations on all other strands in a multi-strand caster must be interrupted.

The tundish has to be removed from its normal operating position before a service crane can lift the mold from the machine head and replace it. This invariably brings with it plant downtime and production loss.

Through the installation of a retractable Siemens VAI SIMETAL DynaFlex oscillator and mold unit, however, it is possible to uphold casting operations during a mold change. At the push of a button, all mechanical connections are hydraulically released and an entire billet machine head – including the mold, mold table as well as the oscillator itself – are removed from the casting position. This is made possible through the design of the SIMETAL DynaFlex mold unit as a retractable system, which is mounted on a moveable carriage outfitted with supporting wheels. From stop to restart of casting operations, the entire procedure takes only 15 to a maximum of 20 minutes, including mold replacement, insertion of the dummy bar, as well as all mold packing operations.

A retractable SIMETAL DynaFlex oscillator/mold system was installed on the existing 6-strand billet caster of FERRIERE NORD (PITTINI GROUP) in Rivoli di Osoppo, Italy. Additional implementation on the machine were regarding modification of existing ladle turret, new tundishes with increased capacity (from 17 to 25 ton), modification of existing tundish cars, new molds assembly for section 160X160 mm, with EMS and SIMETAL DiaMold mold tubes, new secondary cooling design with four cooling zones, modification of straightening unit to adopt progressive straightening, repositioning of cutting torches for increased metallurgical length, modification of existing roller tables, adoption of new billet pusher collecting table for direct linking to the rolling mill and Level 1 automation for Hydraulic oscillation control, integrated with existing Level 1 machine automation.

Implementation of the technology required only four weeks.

An uninterrupted casting sequence of 23 heats was already achieved on the first day following restart.

Production output was subsequently even increased to a record 49 cast heats in sequence, and the remarkable results of 837 heats (100.440 ton) cast in the first month of operation. With the help of the retractable SIMETAL DynaFlex oscillator/mold solution, FERRIERE NORD was able to reduce the breakout rate by 37 % while increasing overall productivity by 25 %. Simultaneously, the billet rejection rate at the bar rolling mill was reduced by 50 %.

Figure 3: Retractable SIMETAL DynaFlex oscillatiors at FERRIERE NORD

High quality results, square products

VILLARES METALS S.A. is the largest producer of long products of highly alloyed specialty steels in Latin America. The scope of products comprises specialty alloys and forged parts. Its main clients belong to the following segments: automotive, oil and gas, energy, aircraft and special applications as, for instance, surgical implant manufacturers.

Continuous casting route is applied particularly to stainless steel and Valve steel, but applications of CC technology are increasing considering tool steels and other high alloyed steels.

The production of these steels, especially of high alloyed high carbon tool steels on the continuous caster, is a remarkable metallurgical challenge. This is related to the higher concentration of carbide forming elements as Cr, Mo, V etc. On one hand these carbides are necessary to give the steels the required special properties; on the other hand, they are creating several metallurgical challenges as sensitivity to cracks and segregation during the solidification process. These challenges are related to the large solidification range which has to be considered when designing the continuous casting process.

To realize this strategy Villares had to revamp the existing caster in order to enable a more reliable operation using a higher variety of casting parameters. Due to these requirements to the process, Villares Metals was choosing Siemens VAI technologies.

The development of such a new a process requires improvements both in operation technology and casting facilities.

For this reason the revamp was mainly focused on the top part of the caster, considered the metallurgical core part.

The revamp was starting with the adoption of a new hydraulic stopper system for a better regulation of steel flow from tundish to mold.

In conjunction with the new SIMETAL LevCon mold level control, the new stopper system is able to provide a highly stable level of the molten steel inside the mold, a necessary prerequisite to avoid surface problems and possible inclusions due to mold slag entrapment. This system also provides the possibility of an automatic start of the process with a smooth and quick achievement of mold level stability right from the cast start.

With the complete redesign of the mold assembly, the mold itself was elongated to 800 mm length, and the mold water gap reduced to 4 mm to ensure a higher water speed in the channel with consequent improved heat extraction for enhanced shell growth.

Mold tube design was differentiated in diverse taper according the different steel grades to be cast, including SIMETAL DiaMold profile to be used particularly for casting of high speed tool steel.

A new mold stirrer, external type, with higher stirring efficiency and possibility for multiple current and frequency settings, was installed. In order to avoid any possible problem of mold slag entrapment, the mold stirrer was moved to a lower position respect to previous installation. Furthermore the stirrer allows a more reliable and uniform heat transfer from the steel to the mold, thus also influencing the segregation behaviour.

In order to investigate this effect of the new stirrer, the chromium distribution at a 8.5% Chromium steel produced with the old equipment was compared with the results obtained with the machine after revamp. Obviously the billet produced with

the new equipment shows a more uniform chromium distribution in the center as well as at the surface area, indicating a more even carbide distribution.
The existing electromechanical lever type oscillator was substituted by a SIMETAL DynaFlex hydraulic oscillation system. This system is ensuring optimum oscillation movements by a leaf spring guidance design with almost no deviations during the oscillation movements. The previous adopted billet containment at mold exit, consisting of mold foot rolls plus a subsequent containment sector, was replaced by a shorter containment only consisting of three rows of preely adjustable foot rolls, directly attached to the mold and therefore allowing an easier and faster calibration to be performed in the mold shop, without any adjustment required further on the machine.
The new foot rolls assembly, together with the extended mold length, is ensuring an adequate support and containment of the billet, enabling production with no deviations in dimensional tolerances.
Due to the extended mold length and the modified containment, also the secondary cooling was modified by the adaptation of a different spray configuration, comprising the use of air mist type nozzles in zone 1, and new spray risers in zone 2.
New billet guiding system was provided to ensure a correct guidance and centering of the strand in secondary cooling zone, to minimize thermal stresses caused by unsymmetrical heat extraction.
A complete new automation control (Level 1), allows to record and save data and trends of the main casting parameters for subsequent review and comparison.
Due to the particular features of the SIMETAL DynaFlex oscillator, the new automation system also allows to control the friction behaviour in the mold. This is a useful tool to check the effect of different parameters during casting, to verify casting powder behaviour or to evaluate the performance of different mold tubes designs.
Thanks to these implementations, the revamped caster was able since the first heat to obtain substantially good results from the quality point of view, showing satisfying results with respect to the internal quality as well as to the achieved surface results.
Examples of obtained internal quality on stainless steel grades, as coming form the first two heats executed on the machine after implementation, are shown in the following Figures 4, 5.

Figure 4: Macro etch of 304 Stainless steel, casting speed 1.6 m/min.

Figure 5: Macro etch of 316 Stainless steel, casting speed 1.6 m/min.

High quality results, round products

TIANJIN PIPE CORPORATION (TPCO) is a Chinese metallurgical enterprise which has in its main end product a wide range of seamless pipes, among which 350,000 tons of casing pipe with its specification ranging from 114 – 273 mm in outside diameter and 4.5 – 35 mm in wall thickness.

The other major products include line pipe, high pressure boiler tube, medium low boiler pipe, oil cracking tube, high pressure chemical fertilizer tube, gas cylinder pipe, energy accumulator pipe, fluid transferring pipe, hydraulic cylinder tube, structural pipe and other special pipes.

TPCO received approval from API and has passed state level production licenses on HP, LP and MP boiler pipes. TPCO is also certified with the ISO 9001 Quality Guarantee System and certifications by China's Register of Shipping, Germanic Lloyd's Register of Shipping and ISO 14001 Environment Management System.

Due to the necessity to maintain and even improve such a quality level, and requirements for new steel grades to be cast, TPCO was choosing Siemens VAI Metals Technologies (Siemens VAI) for a two phase revamp on existing casting machine.

The first phase consisted in the adoption of new mold tubes, with a carefully studied design to ensure the proper and uniform heat extraction and correct shell formation. A new secondary cooling system with air-mist sprays was installed, with an optimized design for a better surface and internal quality of billets, thus avoiding excessive temperature drops or reheating during casting.

A new final stirrer, with higher stirring efficiency, was also put into operation in order to create a fine equi-axed structure in the center of the billet and to prevent center porosity.

The second phase consisted in substitution of existing electromechanical lever type oscillation with SIMETAL DynaFlex hydraulic oscillation with leaf spring guidance

Complete automation control (Level 1) was put into operation for the newly supplied equipment, thereby also enabling the customer to obtain data records and trends of the main parameters of the machine.

Figure 6: Casting strands.

Different high quality grades were cast on the machine; some results on internal quality are shown hereafter.
Particular mention needs to be made regarding the first-time production in China of T91 martensitic stainless steel in these round formats. The development of the family of 9-12% Cr martensitic steels for power generation components was a significant feature in the 1980s. The steel grade T91, which has the base composition of 9% Cr 1% Mo with additions of niobium, vanadium and nitrogen, has been developed for application at high working temperature (600℃), and it is therefore used for boiler tubes, tubes for water panels, tubes for heat exchangers and heater tubes.

Figure 7: Macro etch of T91 stainless steel, casting speed 1.20 m/min.

Figure 8: Macro etch of SUP13CRr stainless steel, casting speed 1.20 m/min.

Quality improvements in high C grades with SIMETAL DynaGap Soft Reduction®

To increase internal quality WISCO contracted Siemens VAI to install SIMETAL DynaGap Soft Reduction® at their bloom casters.

Adopting the SIMETAL DynaGap Soft Reduction® process, which has already been successfully implemented in slab casting for many years, offers a new dimension for improvement of internal quality of long products.

The arrangement of multiple continuous straightening cassette type stands (Figure 9), combined with a 3-D thermal tracking model, offers a much wider operating window (Figure 10) compared to final electromagnetic stirring.

Figure 9: SIMETAL DynaGap Soft Reduction® stands.

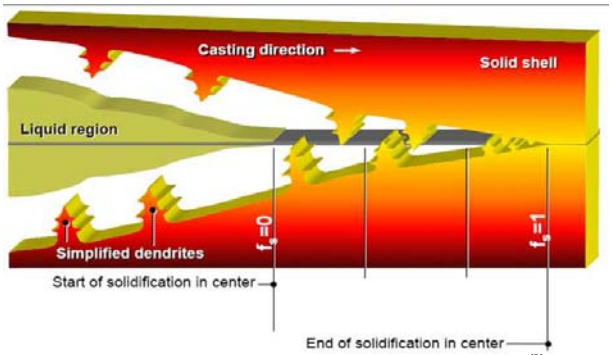

Figure 10: SIMETAL DynaGap Soft Reduction® bloom.

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 at precise position deriving from mathematical algorithm related to proprietary metallurgical know how and calculation in relation to actual casting situation. The operational results from SIMETAL DynaGap Soft Reduction® can be seen in Figure 11 and without SIMETAL DynaGap Soft Reduction® in Figure 12 on a longitudinal section of a bloom.

Figure 11: Longitudinal sample with SIMETAL DynaGap Soft Reduction®.

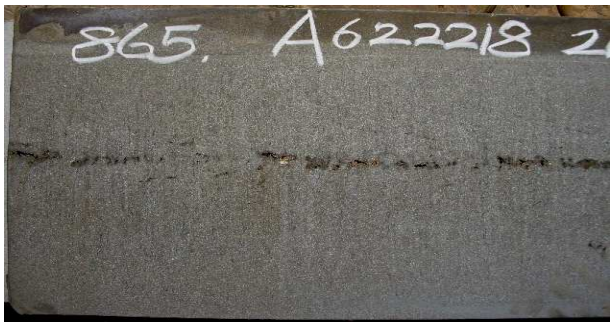

Figure 12: Longitudinal sample without SIMETAL DynaGap Soft Reduction®.

Revamp of 3-strand bloom and beam blank caster – Quality and productivity improvements at SDI, USA

Steel Dynamics (SDI) was founded in 1993 and began production at a rolling mill located in Indiana, USA. Now SDI is the fifth largest producer of carbon steel in the United States and runs five electric furnace minimills. Half of the products are flat rolled and the other half are bars, beams for the construction industry and rails.

SDI planned to improve the product quality, increase productivity and reduce costs in the continuous casting plant at its mill in Fort Wayne, Indiana. The casting speed of the beam blank profile had to be increased. A fourth strand and a new casting section for rail blooms with 320 x 250 mm also had to be added to the caster. The new equipment was installed and tested during regular maintenance without interruption to operations. Commissioning was completed during a 6-day shutdown.

These are the main features of the revamp:

- New tundishes with capacity increased to 40 tons
- Modification of existing tundish cars with the addition of a fourth strand
- New mold assembly for 320x250 mm bloom with SIMETAL DiaMold
- New alignment tools for transition mold to segment #1
- Adaptation of spray water cooling profile by means of new process models
- New mold taper and extended strand containment

- New segments #2 for containment of beam blanks
- Revised unbending profile in order to increase internal quality

Achieved results:

- Flange bulging in the beam blank sections reduced by nearly 50% (Figure 13)
- Caster throughput more than 280 short tons per hour (stph).

Figure 13: SDI - Beam blank profile

Conclusions

Application of SIEMENS VAI MT Technologies like SIMETAL DynaFlex, SIMETAL DiaMold, SIMETAL LevCon and SIMETAL DynaGap Soft Reduction® on continuous casting machines gives continuous casting a new perspective, enabling in the same time higher productivity with reliable and safe operation, combined with highest performances under the quality point of view.

Such technologies can either be adopted in new casters or retrofitted in existing ones, thereby boosting the actual results and retrieving the necessary level of competition requested by the nowadays market situation.