REVAMP OF CONTINUOUS CASTING MACHINE AT VILLARES METALS[1]

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Abstract
The demand on cast products increased continuously for production of high alloy and specialty steel grades in the last years, as the continuous casting-route is cost beneficial versus the ingot-casting-route. To achieve appropriate quality and to reduce production and maintenance-costs, VILLARES METALS S.A. has invested in a "New Machine Head" for their 1-Strand Billet Caster. SIEMENS VAI METALS TECHNOLOGIES has delivered all the equipment and technology for this caster on a turn key basis. The paper describes the installed equipment and the preliminary results achieved with metallurgical aspects improvements, as also latest developments of several equipment groups applied to this caster.
Key words: Continuous casting; Tool steels; Valve steels; Stainless steels.

ATUALIZAÇAO DO LINGOTAMENTO CONTÍNUO NA VILLARES METALS

Resumo
A demanda de produtos siderúrgicos vem aumentando continuamente nos últimos anos para a produção de aços especiais e alta liga e, em termos de processamento, o lingotamento contínuo apresenta melhor custo benefício em relação ao processo de lingotamento convencional. Para atingir níveis de qualidade satisfatórios e reduzir os custos de produção e manutenção, a Villares Metals S.A. investiu em uma "Máquina de Alto Nível" no processo de lingotamento contínuo. SIEMENS VAI METALS TECHNOLOGIES forneceu equipamentos e tecnologia para a atualização do equipamento. Este artigo descreve os resultados preliminares alcançados com seus respectivos aspectos metalúrgicos, bem como a tecnologia empregada no processamento.
Palavras-chave: Lingotamento contínuo; Aços ferramenta; Aços válvula; Aços inoxidáveis.

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1 INTRODUCTION

Villares metals S.A. is the largest producer of long products of highly alloyed specialty steels in Latin America. Villares Metals plant has a complete production chain including EAF, LF, vacuum treatment, ingot and continuous casting, hydraulic forging presses (up to 3.000 t), rolling mills and roughing mills, and complete heat treatment, finishing and inspection installations.

Additionally for the production of specialty steels and alloys a Special Melting Shop exists, which includes: VIM ("Vacuum Induction Melting"), ESR ("Electroslag Remelting) and VAR ("Vacuum Arc Remelting").

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.

Up to now just for a relatively small part of the production, particularly Stainless steel and Valve steel, the continuous casting route is applied (Table 1).

Table 1. Actually CC produced steel grades

Grade	Average chemical composition					
	C%	Mn%	Cr%	Ni %	Mo%	Other
304 L	<0.03	1.85	18.1	8.1	-	
316 L	<0.03	1.85	16.0	10.1	2.1	
HNV-3	0.45	0.40	8.5	-	-	Si 3.3
EV-12	0.55	8.0	20.0	2.2	-	N 0.3

For further development Villares Metals plans an increase of the continuous casting production especially 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, one of the main objectives of Villares Metals further development, 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 designing the continuous casting process.[1-3]

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, including the adoption of well proven technological solutions like Dynaflex, Diamold, Levcon, Stirrcon.[4-7]

2 REVAMPING AND FIRST RESULTS

The development of such a new a process therefore 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 existing continuous caster in Villares Metals had the main characteristics reported in Table 2 hereafter.

Table 2. Main characteristics of existing caster

Machine radius	10 m
Strand n.	1
Ladle Capacity	25 t (nominal)
Tundish Capacity	5 t
Cast Section	145 X 145 mm
Mould type	Curved, 750 mm
Oscillation type	Electromechanical
Stirring	M + S-EMS
Secondary cooling	Air Mist
Containment	2 rows foot rolls + 4 rolls containment

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

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

The experience from four months of practical operation proves that the combination of new stopper and new mould level control system is showing the required precision, maintaining mould level with variation in the range of maximum 2 mm, as shown in Figure 1 in the green line.

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

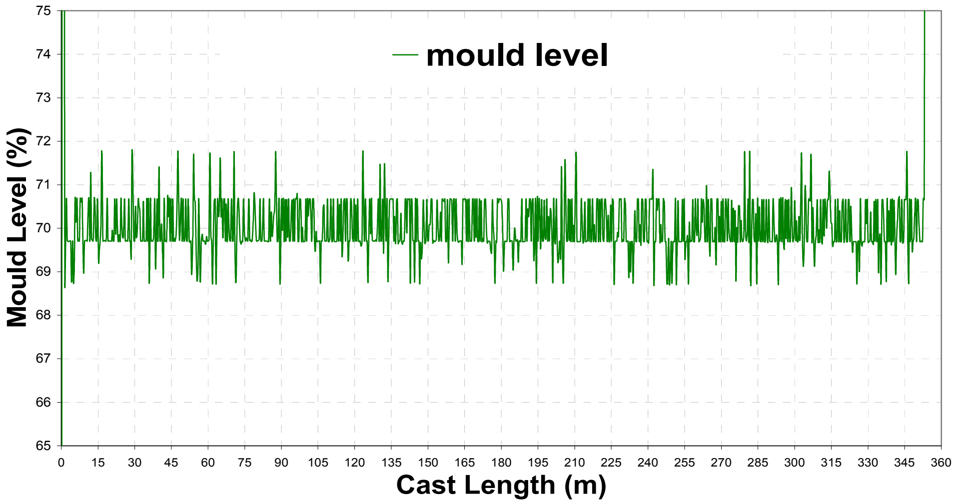

Figure 1. Mould level during continuous casting operation.

Mould tube design was differentiated in diverse taper according the different steel grades to be cast, including Diamold[6] profile to be used particularly for casting of high speed tool steel.

Modification of the mould tube also included an increase of the tube thickness from previous 10 mm to actual 13.5 mm, in order to ensure a better geometrical stability, to avoid the possibility of mechanical distortion and to guarantee a cast product within the required tolerances.

A new mould 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 mould slag entrapment, the mould 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 mould, thus also influencing the segregation behavior.

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 according a specific method [8]. For this reason 60 measurements of the Chromium content were performed on areas of 100 mm^2 at the surface and the core of 2 billets cast with the old and the new machine respectively. Figure 2 and Figure 3 are showing the results. 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.

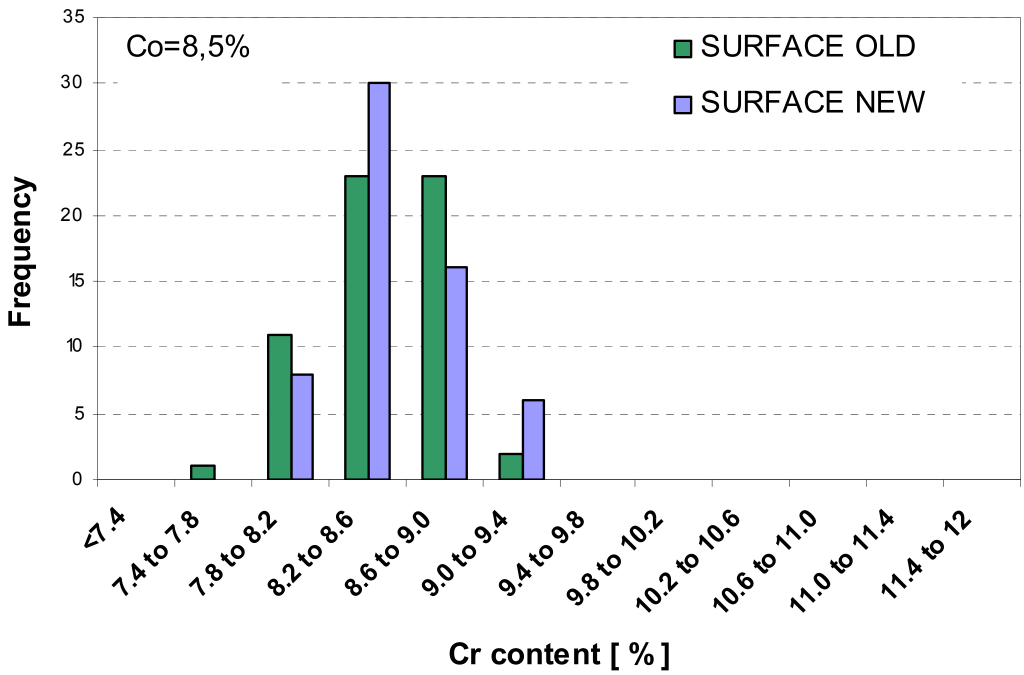

Figure 2. Comparison of the chromium distribution at the surface area obtained with the old and the new process.

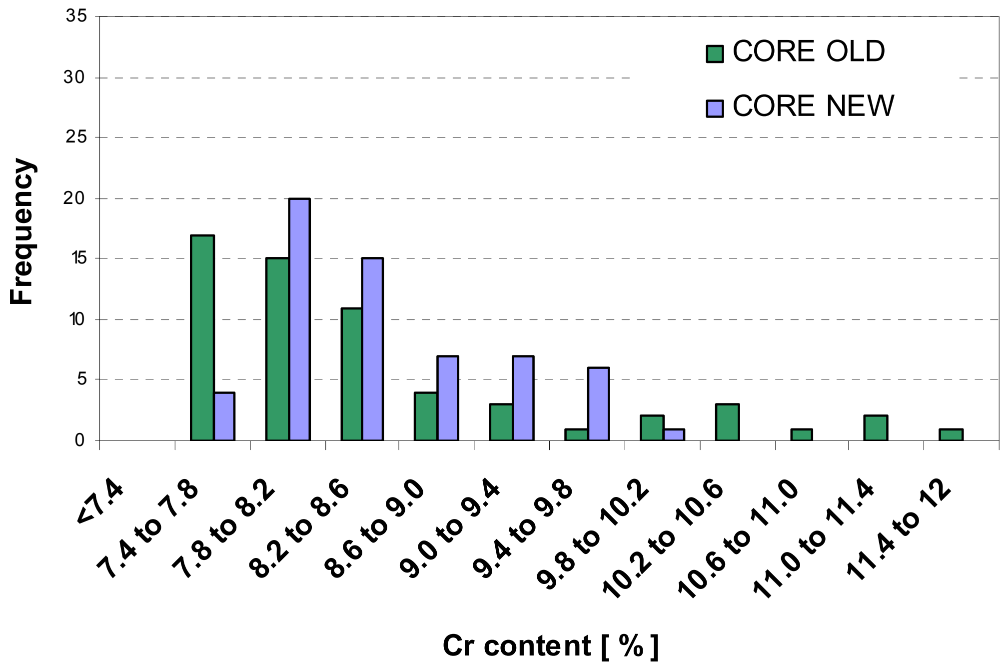

Figure 3. Comparison of the chromium distribution at the core area obtained with the old and the new process.

The existing electromechanical lever type oscillator was substituted by a 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. Furthermore this arrangement is offering the opportunity to change different wave forms and different ranges of frequencies/strokes online during the operation in order to obtain the optimal oscillation parameters without any stoppage of casting and with no mechanical intervention.

The previous adopted billet containment at mould exit, consisting of mould foot rolls plus a subsequent containment sector, was replaced by a shorter containment only consisting of three rows of precisely adjustable foot rolls, directly attached to the mould and therefore allowing an easier and faster calibration to be performed in the mould shop, without any adjustment required further on the machine.

The new foot rolls assembly, together with the extended mould length, is ensuring an adequate support and containment of the billet, enabling production with no deviations in dimensional tolerances.

The mould assembly with the new containment (foot rolls) is shown in the following Figure 4.

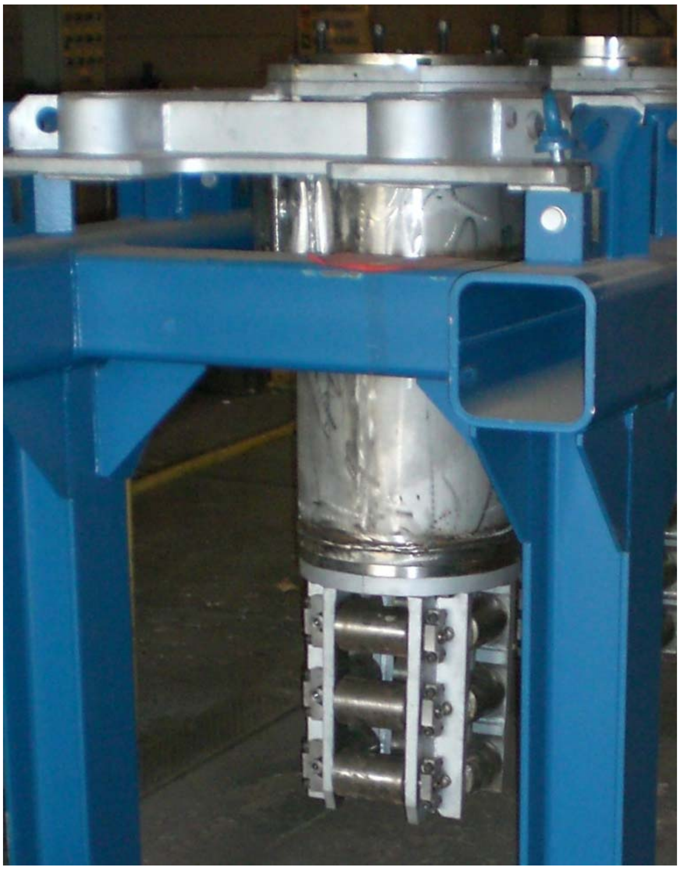

Figure 4. Particular of mould assembly and billet containment.

Due to the extended mould 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.

Inside the cooling chamber, a 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.

Following Figure 5 is representing the billet inside the cooling chamber, during the first cast heat, with particulars of the billet guiding system.

Figure 5. Secondary cooling area.

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 Dynaflex oscillator the new automation system also allows to control the friction behavior in the mould. This is a useful tool to check the effect of different parameters during casting, to verify casting powder behavior or to evaluate the performance of different mould tubes designs.

3 CONCLUSION

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 Figure 6, Figure 7.

Figure 6. Macro etch of 304 Stainless steel, casting speed 1.6 m/min.

Figure 7. Macro etch of 316 Stainless steel, casting speed 1.6 m/min.

It has additionally to be mentioned that the revamp project and the restart of the machine was performed without any evidences of particular problems from the mechanical or automation point of view.

4 OUTLOOK

Based on the achieved results and experiences Villares Metals SA is convinced that the caster now is offering the necessary technical preconditions to realize the intended expansion of the casting program to high alloyed tool steels and specialties.

For this purpose, based on the good cooperation between SIEMENS VAI and VILLARES METALS, it is provided to cooperate also on the solution of future technical problems arising during the realization of this proposed expansion of the casting program.

An example of this ongoing cooperation is the study of optimization of stirring parameters in respect also to fluid dynamic patterns in the mould created by use of different kind of submerged entry shrouds.

The following Figure 8, Figure 9 are representing the results of some of these studies, showing the different behavior of fluid flow while using MEMS in case of single port and multiport shrouds respectively, and their influence on the stirring effect.

These studies are of utmost importance to define optimum stirring parameters, avoiding in the meantime any possible problem of slag inclusion.

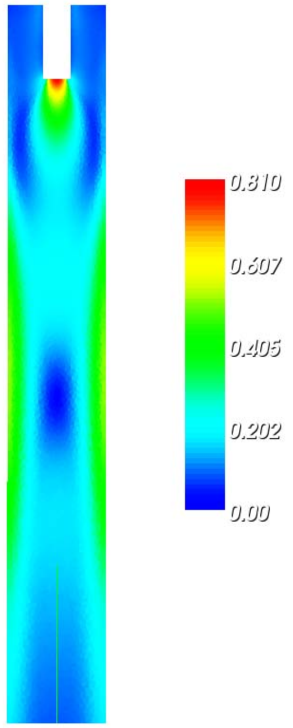

Figure 8. Axial velocity (single port SES).

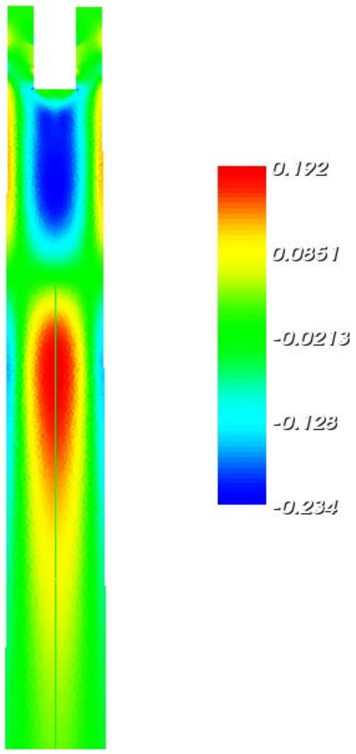

Figure 9. Axial velocity (multiport SES).

A further result of the good cooperation and of the achieved result is the recent order placed by Villares Metals SA to Siemens VAI MT for a new casting section, in order to meet the always increasing and developing request of the market of special steel.

The new casting section is expected to go on stream in the late summer of 2008.

Acknowledgements

We want to thank Villares Metals SA and Siemens VAI for providing the preconditions which allowed us to perform this interesting project in good cooperation.

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