THE "STATE OF ART" SLAB CASTER FOR STAINLESS STEEL IN THYSSENKRUPP ACCIAI SPECIALI TERNI (TKAST), ITALY [1]

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Abstract

On April 23, 2009, a new single strand slab caster at ThyssenKrupp Acciai Speciali Terni (TKAST) was successfully started up with the first cast of AISI 304 grade in Terni plant, central Italy. TKAST is the Italian company of ThyssenKrupp Stainless group. The new caster is designed for a total capacity of approx. 900.000 tpy of stainless steel slabs covering the complete range of stainless grades, including AISI 300 and 400 families (austenitic, ferritic and martensitic grades).This state of the art caster for the production of 215 mm thick slabs replaced an existing thin slab caster installed in the late nineties by other supplier, which demonstrated to be unable to supply stainless steel slabs of acceptable quality, considering ThyssenKrupp standards. This paper resumes the reasons of the installation of the new plant designed, manufactured erected and commissioned by Danieli and describes the technological solution, main features as well as the excellent results of this state of the art caster.

Key words: New single strand slab caster; Stainless steel; sState of the art caster.

O ESTADO DA ARTE NA MÁQUINA DE LINGOTAMENTO PARA AÇO INOX NA THYSSENKRUPP AÇOS ESPECIAIS TERNI (TKAST), ITALIA

Resumo

Em 23 de abril de 2009, uma nova máquina de lingotamento de placas de um veio partiu com total sucesso na ThyssenKrupp Aços especiais Terni (TKAST) com primeira corrida em AISI 304 na planta Terni na Itália central.TKAST é a empresa italiana do grupo ThyssenKrupp de aço inox. novo lingotamento Fo projetado para uma capacidade total de 900,000 toneladas por ano de placas de aço inoxidável para a gama completa inoxidável, incluindo AISI 300 e 400 famílias (austeníticos, ferríticos e martensíticos).O Lingotamento, Estado da Arte, para produção de placas de 215 milímetros de espessura foi colocado em substituição de lingotamento de placas finas instalado no final dos anos noventa por outro fornecedor, que demonstrou ser incapaz de fornecer placas de aço inoxidável de qualidade aceitável, considerando as normas ThyssenKrupp.Este artigo sintetiza as razões da instalação da nova máquina projetada, fabricada, montada e partida pela Danieli e descreve a solução tecnológica, características principais assim como os excelentes resultados do presente lingotamento estado da arte.

Palavras-chave: Nova máquina de lingotamento de placas de um veio; Aço Inox; Lingotamento estado da arte.

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1 INTRODUTION

In the 1990s, ThyssenKrupp Acciai Speciali Terni (TKAST) decided to install one thin slab caster to feed the existing hot strip mill via roller type tunnel furnace. The caster was designed to directly provide the finishing mill with thin slabs in hot charge mode, by-passing walking beam furnaces and rougher mill as an alternative route the original conventional route through caster-reheat furnace-roughing mill.
The caster has been supplied by SMS DEMAG, according to CSP design vertical caster.
However, the installed Compact Strip Production (CSP) caster demonstrated to be unsuitable to produce qualified stainless steel slabs, especially in terms of surface quality in the next years after commissioning in spite of several revamps and a lot of efforts.
Hence, TKAST had to decide to replace the CSP caster with a state of the art conventional caster for 215 mm thick, 800-1600mm wide slabs. Only the existing ladle turret, casting floor equipment and steel structure could be retained. All the rest had to be rebuilt.
The original roller furnace between CSP caster and mill has been replaced by a 200 meters long roller way, in order to allow the hot charge of the slabs.
The main purpose of this challenging job is to improve the slab quality and to cut the operational costs. Therefore at the new caster, the inspection and grinding of the slabs before rolling are minimized with hot charge.
The scope of work of Danieli Davy Distington includes:

- A new slab caster with hot charge roller table, supply of mechanical and hydraulic equipment and installation;
- Supply and installation of Level 1 and Level 2 systems;
- Supply and installation of dedicated water treatment plant, compressed air plant and iron powder exhaust system for torch cutting machine to serve the caster production.

Technical Solution: Design Concept

To meet the strict quality requirements for slab quality at ThyssenKrupp Stainless, Danieli Davy Distington considers the following criteria during design:

Optimised roller geometry

As the product mix covers a wide range of stainless grades such as 300 and 400 series (austenitic, ferritic and martensitic grades) and the slab is 215 mm thick, the newly built Danieli caster is a vertical curved type machine with 8.5m radius and over 2.8m vertical length followed by multi-point bending and straightening. The design allows the sufficient inclusion floatation as well as appropriate bending/straightening stress. The typical Epsilon graph is shown in Figure 1.

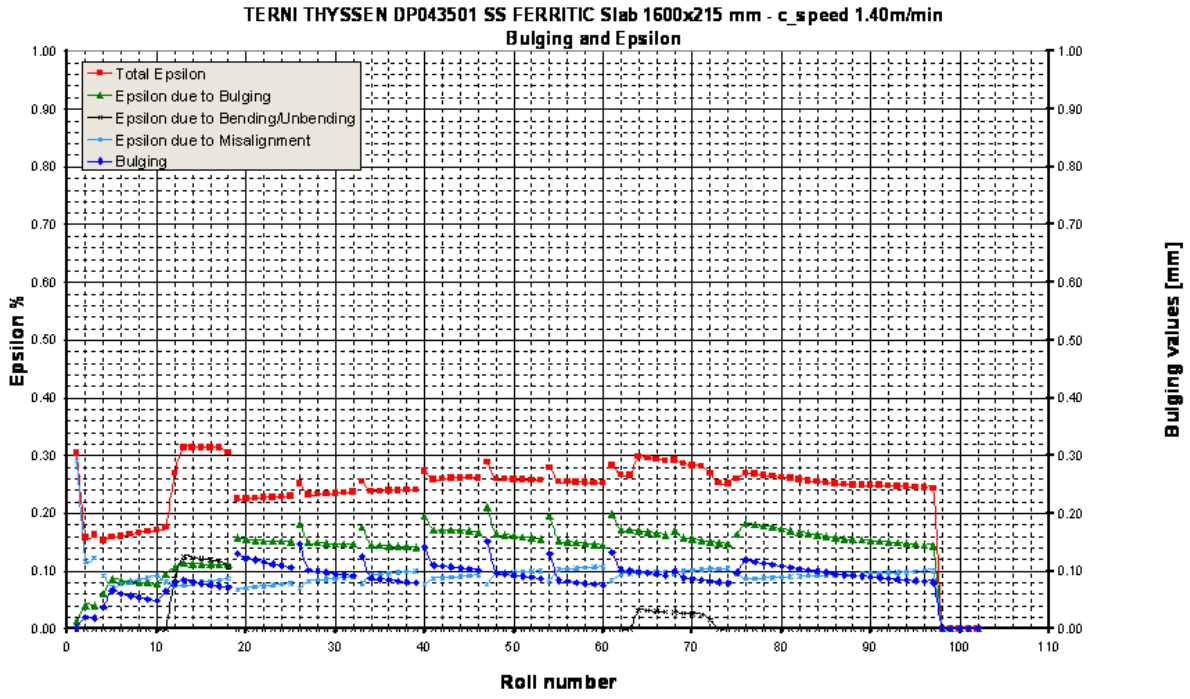

Figure 1 : Bulging and epsilon of ferritic stainless grades at Vc=1.4 m/min

The 27.3 m machine length permits the maximum casting speed of 1.45 m/min for austenitic grades while 1.4 m/min for ferritic and martensitic grades.

As known, the b.c.c. structured ferritite leads to deformation and creep of the stainless steel. So the best support to the slabs has to be taken into account during the roll diagram determination. Especially in the upper part of the caster, sufficient support is crucial. During the selection of roll geometry, the dynamic bulging near the meniscus particularly at high casting speed has to be overcome. To keep a balance between the stringent dimensional requirements and the deformation tendency because of small roller diameter, multiple split rollers are adopted. Three split rolls are used for bending and straightening zones, while two split rolls are considered for other areas.

As far as secondary cooling and closed machine cooing are concerned, special care is taken to secure the best slab quality under all casting conditions.

Surface quality is the most critical issue for stainless steel production. And the accurate control of the temperature between the slab and the roller surface plays a key role to prevent the formation of scales.

For this reason, peripherally drilled rolls (PDR) are adopted in the segments as long as the roller diameter can stand load, i.e., from segment 4 and downstream.

The roll geometry shown in Figure 2 guarantees the even load distribution on the rolls and can effectively counteract on the thermal distortion under variable heat fluxes, which is of great importance during casting speed transition.

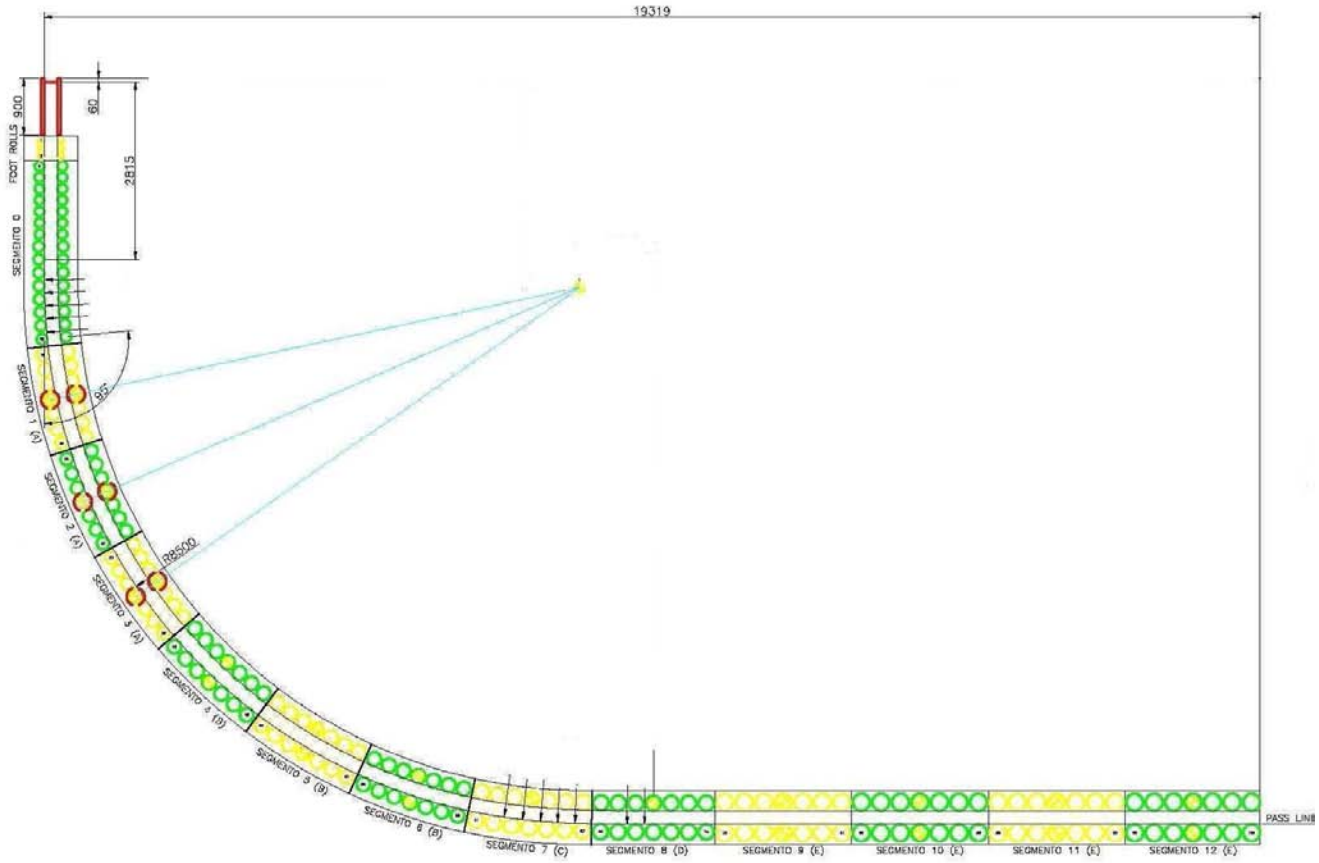

Figure 2 : Roll geometry of the caster[1]

Cooling control during slab solidification

Apart from the optimized roll diagram, it is another paramount issue for getting the best slab quality to properly control the slab temperature during cooling. In Figure 3, the correlation between the specific flow rate of secondary cooling water and the casting speed for austenitic and ferritic steel grades is demonstrated.

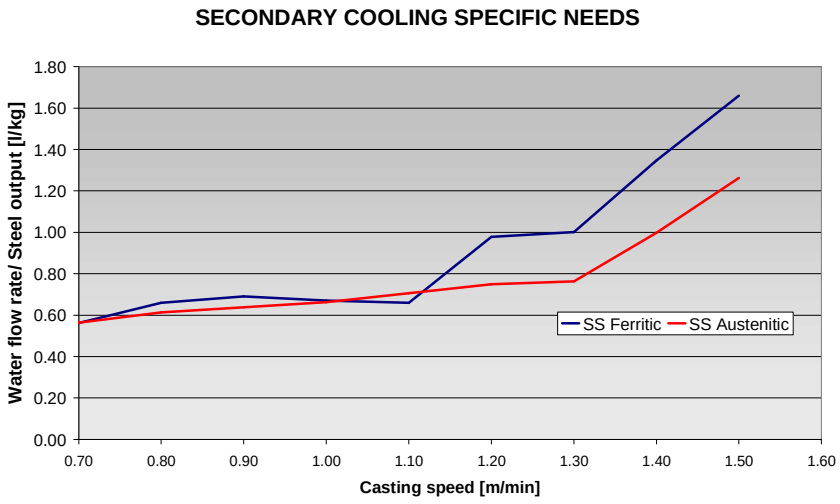

Figure 3 : Specific secondary cooling flow rate as function of Vc for stainless steel grades[1]

Due to the wide range of the steel grades to be produced, different solidification characteristics have to be taken into consideration during the conception of the secondary cooling system. As a result, water cooling and air mist cooling are employed.
In the top zone water nozzles are installed to permit the hard cooling at big flow rate for ferritic grades. In the bending area and in the following segments, air mist cooling is applied to enable fine tuning.
The whole secondary cooling is controlled by means of a dynamic model that continuously adapt the cooling fluids flow rate and pressure in order to guarantee the proper slab temperature profile, predicted with virtual sensor mathematical modelling that takes into account “live” the status of all the parameters of the casting process that are effecting the slab temperature (superheat, casting speeds, flows, roll cooling , etc) as well as specific steel grade solidification behaviour and metallurgical needs.
In order to cope with different slab widths to be cast (from 800 to 1600 mm) and avoid overcooling of narrow slabs, the lateral zoning in the secondary cooling area is considered from the bending zone. As illustrated in Figure 4, a total of 19 independent control loops are considered.

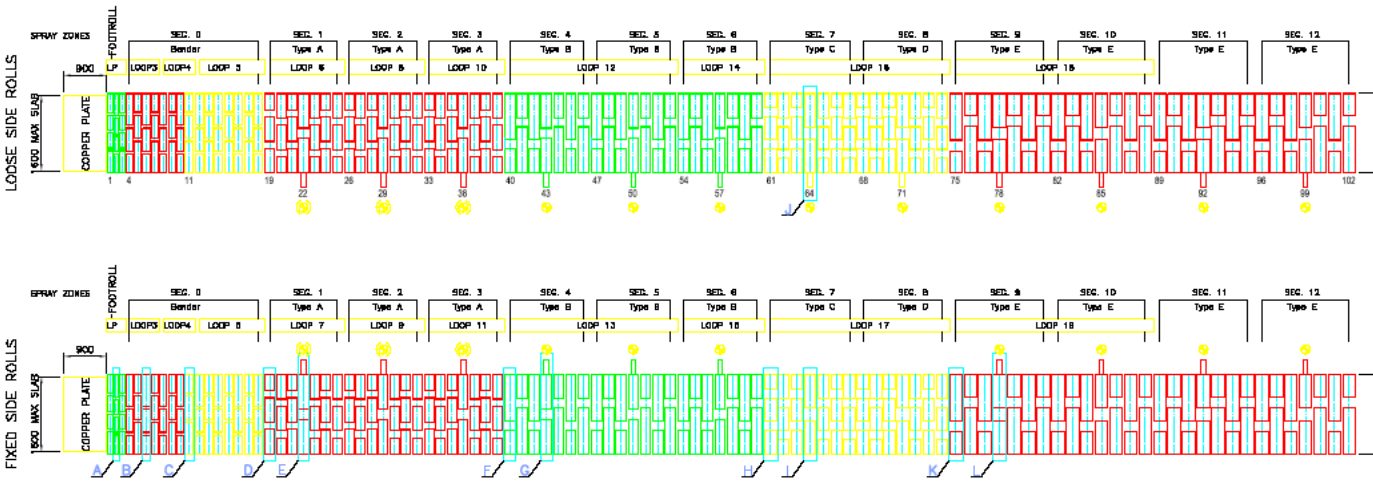

Figure 4: Control loops for secondary cooling[1]

In addition to secondary cooling nozzles, a dedicated set of tangential water nozzles are considered along the caster, in order to promote scale detachment from the roll surface (hence reducing the risk of scale “printing” on the slab surface).

Layout

From lay out point of view, the caster design had to cope with the need to reuse existing casting platform and civil works, with a casting floor at 14,7 meters from ground level (level dictated by vertical design of the old CSP caster).
As a consequence, the new pass line of he caster is now located at an elevation of about 3,3 meters from ground level. Hence the caster body as well as slab torch cutting and bottom dummy bar parking area have been installed on an elevated supporting structure.
Specific structural simulations have been carried out on this supporting structure in order to ensure that even under severe mechanical and thermal load, the rigidity of

the caster is ensured, to avoid vibrations and unwanted deformations.
As shown in Figure 5, from the end of the caster and to charging are of the mill, (area previously occupied by a thin slab roller type tunnel furnace) an inclined roller table has been installed (230 meters in length) to gradually transfer the slab from the 3.3 meter elevated platform level to 800 mm mill entry level.

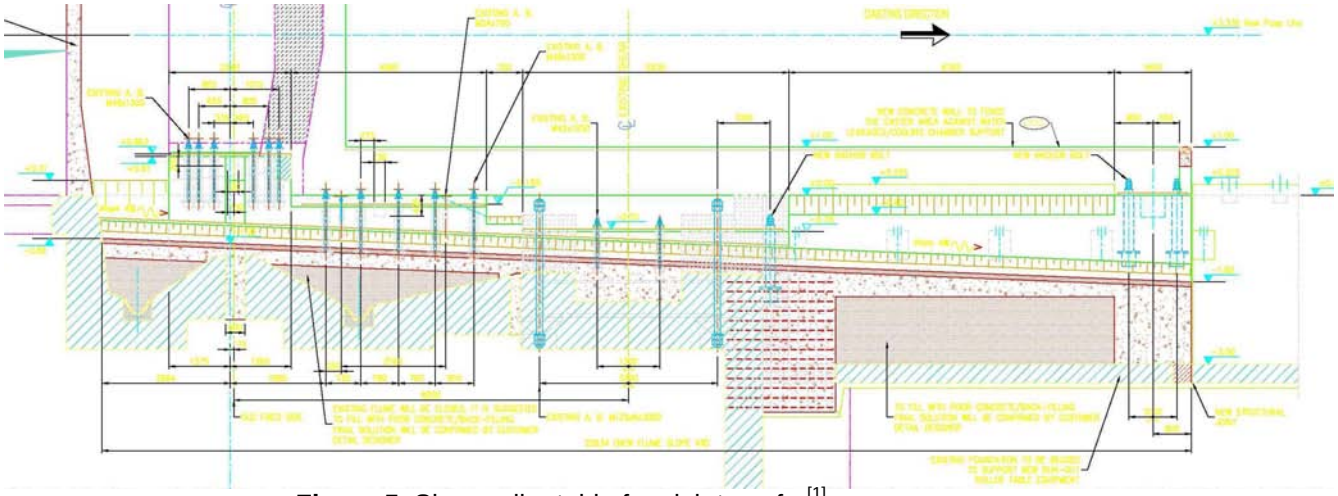

Figure 5: Slope roller table for slab transfer[1]

Mechanical solution

Figure 6: Mould and its oscillating, width adjustment devices.

Strict control in oscillating parameters as well as limitation of lateral movements of the mould and oscillation marks are particularly important in casting stainless steels.

This INMO (INtegrated MOtion) mould and oscillating system have been developed by Danieli to provide both a very precise guidance of the oscillating mould with respect to the strand pass line as well as a wide flexibility of operation in terms of the applied stroke, frequency and waveform. This gives new possibilities to provide the best oscillation condition for both good mould lubrication and the best conditions for good surface quality through the wide range of casting speeds and/or steel grades.
“Spring free” guiding system with 8 rolling elements and 2 servo-controlled hydraulic cylinders comprises the precise oscillating system. This allows the utilisation also of the so called " inverse oscillation " where frequency decreases and stroke increases as casting speed increases.
For the new Terni caster, the maximum frequency will be 300 opm and the maximum stroke setting will be + / - 6mm.
The copper mould plates are designed to give uniform cooling around the slab surface, especially at the critical meniscus area.
The mould is capable of being adjusted remotely to any width in the design range both during and outside the casting operation. The mould wide face tapers are fixed; the narrow face taper will be automatically varied during width changing to suit the slab width and steel grade being produced.

Strand guide system

As mentioned above, special emphasis has been paid in defining roll diameter and pitch distribution (multiple split type), secondary cooling and machine cooling, with the purpose to ensure the best strand support and actively counteract creep and dynamic bulging under all casting conditions.
For the containment, Danieli OPTIMUM segment design has been adopted, mechanically conceived for the application of soft reduction process.
In order to avoid any negative influence on surface quality, an important role is played by the cladding used for the casing rolls.The correct balance in surface hardness has to be selected in order to avoid the risk of slab damage , but also ensuring the proper roll service life.The correct balance is achieved by a multiple layer roll cladding with stainless steel of different mechanical properties and final heat treatment.The selection of these parameters has been agreed between Danieli and the Customer considering their specific experience on stainless steel slab casters.

Automation System

From the automation point of view, Danieli Automation has installed a new L1 and L2 advanced control system with client/ server architecture and a complete set of mathematical models for castingprocess control, including:

> Slab width control in mold;
> Dynamic control of hydraulic oscillationparameters;
> Advanced breakout prevention system withcomplete with both mould thermal mapping and main rows temperature trends, as shown in Figure 7

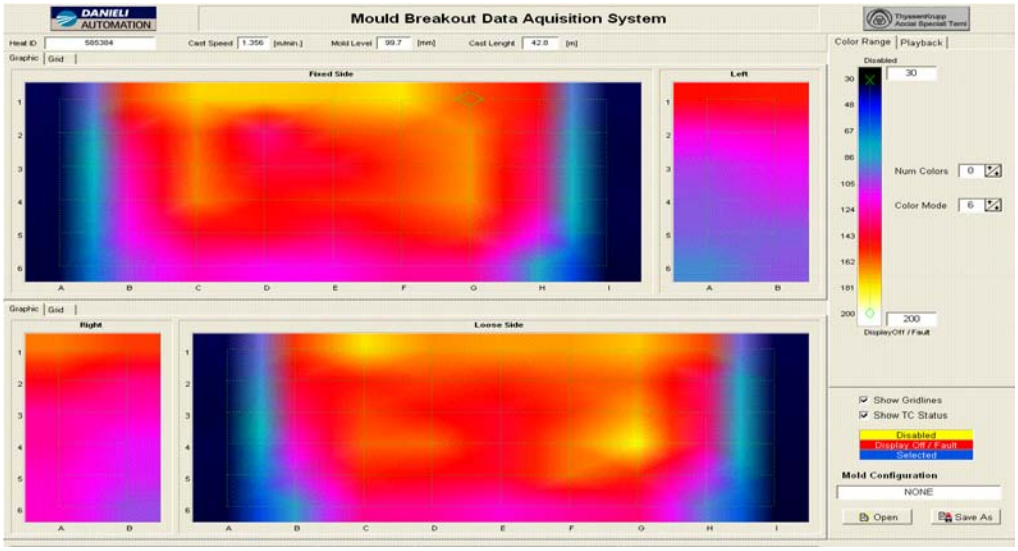

Figure 7: Mould breakout prevention system with thermal mapping

Of particular interest is the MORE Intelligence advanced tool for multi-dimensional analysis of
the process, and plant data and performance. This innovative engineering and production tool, developed by Danieli Automation, offers a totally new scenario for process data analysis
for steelmaking and casting plants. Simple and economically efficient, it offers the customer
the possibility of analyzing, in real time, all production aspects, with particular attention to the productivity and quality items, as shown in Figure 8.

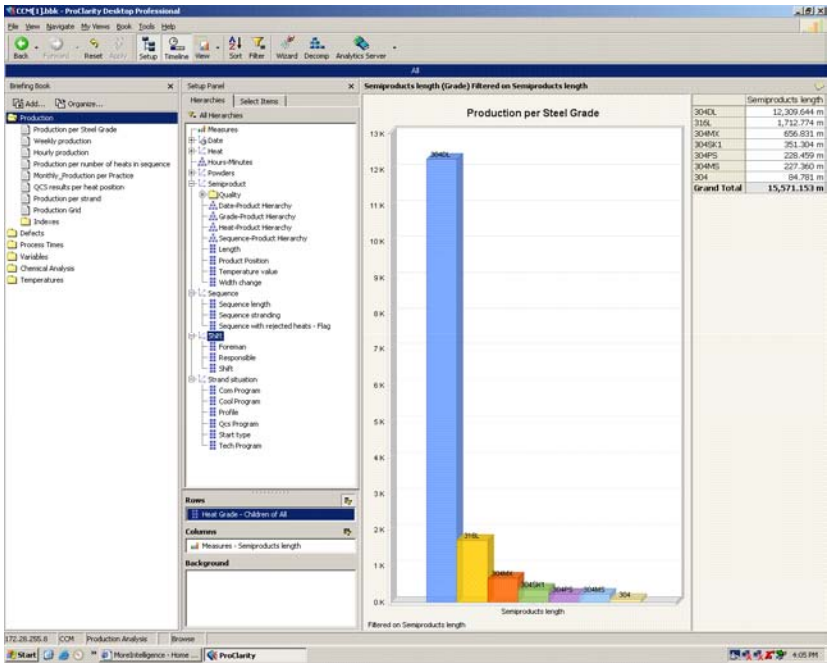

Figure 8: MOREIntelligence Data analyzer system

Operation results

Figure 9: Slab during first casts

After a flawless commissioning and performance test period, the caster has been fully accepted by the Customer with the signature of Final Acceptance certificate in Setember 2009, after 5 months from first heat only.
During commissioning ,austenitic grades have been produced together with a significant amount of ferritic grades.
As for quality results, they are in line with TKAST expectations and internal standards: namely:
- around the 99.6 % of the Hot rolled coils produced from the slabs coming from the new Danieli caster was free of any defect.
-around the 85 % of cast slabs did not require any kind of conditioning prior to rolling.
These statistical data, collected during performance tests, are quite significant being based on almost the 94 % of cast slabs that have been inspected for testing purposes.
Thanks to this performance the machine is presently running limited only by market condition.

Conclusion

Stainless steel producers are among the most demanding on the market about the quality (namely surface quality) of the slabs they use in their mills. The Danieli concepts for process and mechanical engineering guarantee the ultimate product quality for stainless steel as well as virtually eliminate all off line inspection before rolling at this new TKAST caster.