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Tema: Solidification / Casting

TERNIUM-SIDERAR SLAB CONTINUOUS CASTER N°1, 20 YEARS OF TECHNOLOGICAL CHANGES*

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Abstract

Ternium-Siderar steelmaking has been focused in permanent improvements and process optimization. At present the Slab Continuous Caster N°1 has been totally transformed after 20 years of uninterrupted work. The authors of this paper summarize and comment on aspects which were the main changes and place emphasis largely on those technological developments in which they have been active during that period. Productivity and quality have been our goals during the last 20 years; it has led us to improve process and to achieve better control tools. In the development of this presentation, the authors will put special emphasis on the explanation of those works that were made following their own experiences through the technical personnel who belong to the staff of the company.
Keywords: Slab continuous caster; Continuous casting; Process optimization.

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1 INTRODUCTION

Today's Ternium-Siderar LD Steelworks was first introduced in February in 1973 by the former state-owned company, SOMISA. It was part at that time of a Plan of 2,100,000 tons/year.
Until its privatization, the LD Steelworks was also going through various changes and extensions, so that at the time of takeover (November 26th, 1992) it was made up by the following facilities:

- (Three) LD Converters, 200 tons capacity by top lance blowing only; it is to say, without combined blowing. It is worth noticing that Converter Nº 3 start-up took place in a second stage in December, 1978.
- 4 (Four) Conventional Ingot Casting Pits (one of them adapted for casting by bottom source)
- 1 (One) Bloom Continuous Caster with 6 lines of 190x190 mm, in a circular arc of 10m radius.
- 1 (One) Bloom Continuous Caster for Rails of six lines of 290x290 mm in two circular arcs (9.60 and 20 m radius) with two straightening points, 100% protected stream and electromagnetic stirring in order to break with the central macro-segregation.

Finally, the last two facilities that were added in October 1984 in order to produce slabs directly to start replacing the basic rolling mill are:

- 1 (One) Secondary Treatment Station for chemical and thermal adjustment (by cooling scrap), wire aluminum addition and lance argon agitation.
- 1 (One) Slab Continuous Caster of 2 lines of 165 and 180 mm thickness and a width from 670 to1600 mm. The lines are at two circular arcs (10 and 20.40 m radius) with two straightening points.

2 PRODUCTION BEFORE THE TRANSFORMATION PLAN

The diversity of products obtained in SOMISA LD Steelworks was:

- Ingots for their later basic rolling mill.
- 190 x 190 mm blooms to be rolling mill to billets and structural profiles.
- 290 x 290 mm blooms to be rolling mill to rails.
- Slabs of 165 and 180 mm thickness and 670 mm to 1600 mm widths for flat products (sheets and coils).

It was impossible to achieve an efficient production capacity of so many lines of solidification depending on the availability of steelmaking we had. In Figure 1 it is shown the total steel production before and after privatization.
That is why the proposed efficiency goals were aimed to select more specific products (steel sheets), to improve the quality and to make the facilities reach their highest point of use. This is to say, to increase the efficiency and productivity according to the balance of possible production.

3 TRANSFORMATIONS IN THE SLAB CONTINUOUS CASTER

Soon after the takeover, on November 26th in 1992, and during 20 years, the uninterrupted modification of the facilities began, meeting the targets and obtaining scores and efficiencies never thought before.
Among the main changes and addition of new facilities, one outstanding example is the case of the Slab Continuous Caster N° 1 which allowed 100% of the liquid steel

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production to be solidified in slabs in this only continuous caster, reaching production levels of around 3,000,000 tons/year.

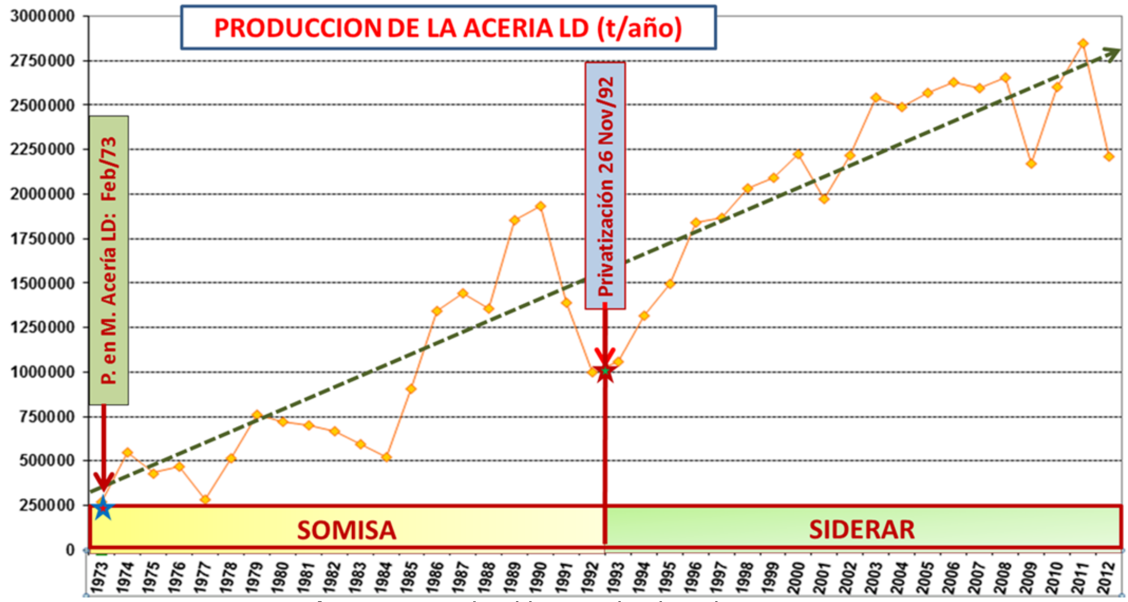

Figure 1. Steelmaking production since 1973.

The CCD1 original basic data, whose start-up had been in October 1884, were:

- Tecnology: SMS / Concast
- Casting Lines: 2
- Casting Widths: 750 to 1630 mm
- Thicknesses: 165 and 180 mm
- Mold Type: curved 900 mm length
- Tundish Capacity: 24 t
- Metallurgical Lenght: 19662 mm
- Cast Radius: 10.400 / 20.000 mm
- Straightening Points: 2
- Line Guide Segments: 7 with 5 pairs of rollers
- Extractor Segments: 5 with 3 pairs of rollers

Since 1992, the Continuous Caster is the production line which has undergone most of the transformations throughout the Steelworks. This was done in order to increase the production, the quality of steel processing and the machine availability, as this is the only solidification possibility in the LD Steelworks.

The basic data of the transformed Continuous Caster are:

- Cast Sections: 750 /1630 x 200 mm thickness
- Mold Type: Variable width
- Tundish Capacity: 36 t
- Tundish Transfer Cars: Servo-controlled hydraulic lifting
- Metallurgical Lenght: 24462 mm
- Extractor Segments: 9 with 3 pairs of rollers
- Lines Independence: Weighing, burring, slabs identification

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4 APPLIED CONCEPTS FOR THE PRODUCTION INCREASE

It is highlighted the successive and uninterrupted career to increase the casting speed, from 1.30 m/min in 1992 with 180 mm thickness to 1,95 m/min with 200 mm thickness. This was achieved not only by the performed investments but also by a series of our own technological developments to be described in this paper.
Three concepts for the production increase were applied:

- 1º) Increase in casting speed
- 2º) Increase in sequence
- 3º) Increase in machine availability

"in a reliable context"

These three concepts were carried out working with the increase in the casting metallurgical length, and also with the increase in the cooling systems, with full practical and real knowledge of the machine Solidification Constant "K".

4.1 Increases in the Metallurgical Lenght

In Figure 2, it can be seen how the metallurgical length of the Continuous Caster was increased in 3 stages.

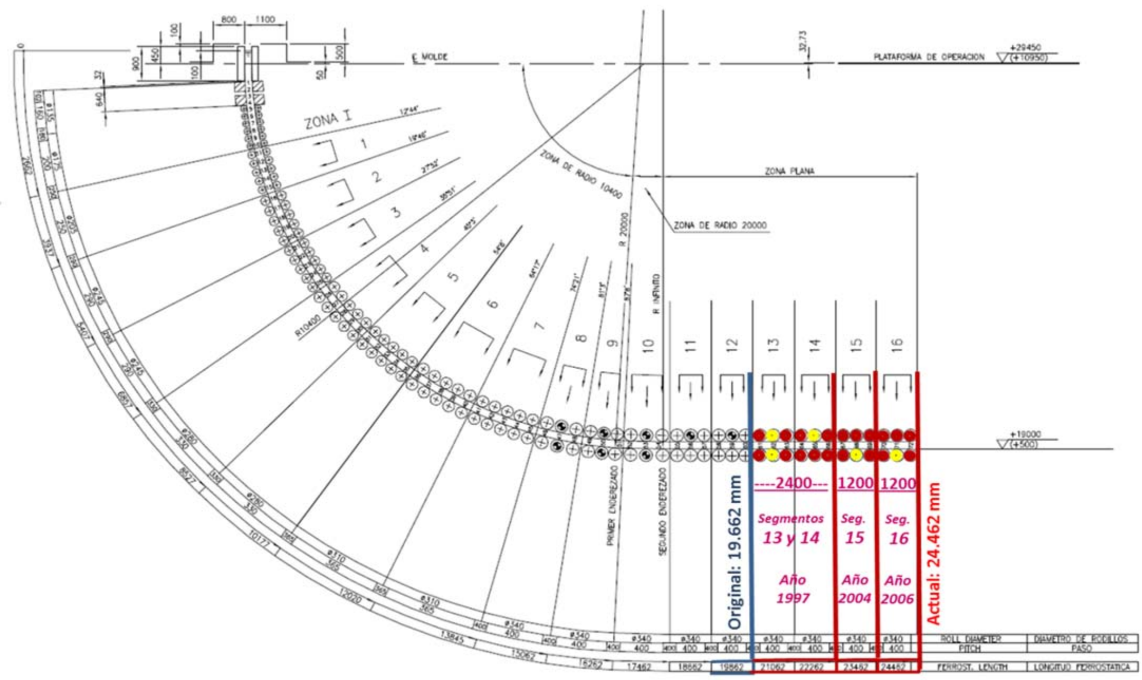

Figure 2. Evolution of metallurgical length.

4.2 Increase of the Cooling and Heat Balance

We worked continuously on the improvement and increase of the primary and secondary cooling and of the closed cooling machine. In addition, a Thermal Balance of the casting and a macroscopic model of the solidification calculation were performed [1], whose idea and results are seen in Figure 3.

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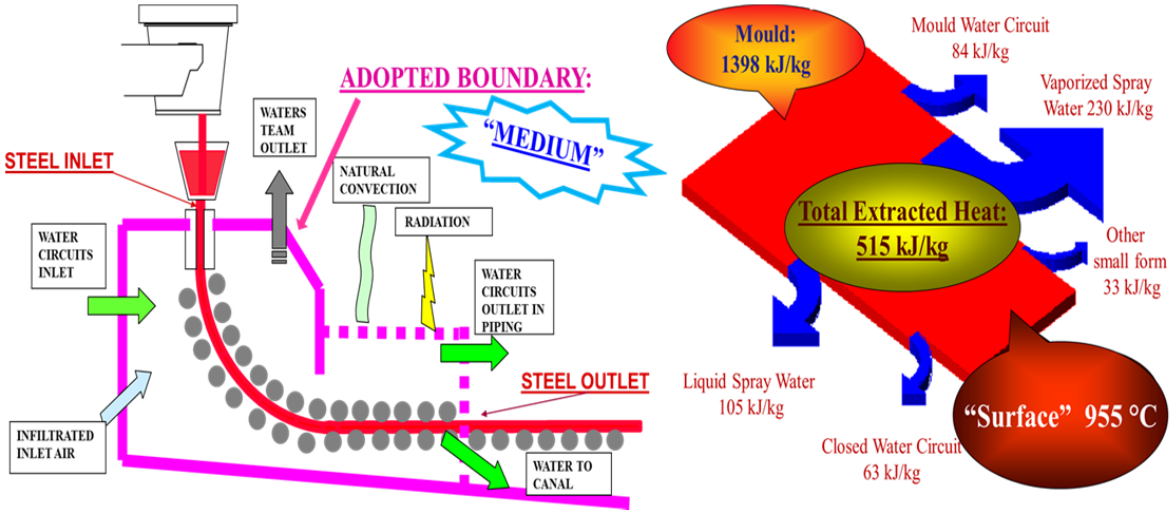

Figure 3. Thermal Balance Macroscopic Solidification Model.

4.3 Determination of the Actual Solidification Constant "K"

The solidification model was applied in order to adjust it to the operational reality [2] For this, and in coincidence with the target for increasing the casting speed to the maximum possible values, it came as a trial (sometimes accidentally) to extreme values as not to complete the 100% of the solidification within the supported machine length. In this way, the exact values of the solidification constant "K" were obtained whenever a barrel-shaped slab was produced, as shown in Figure 4.

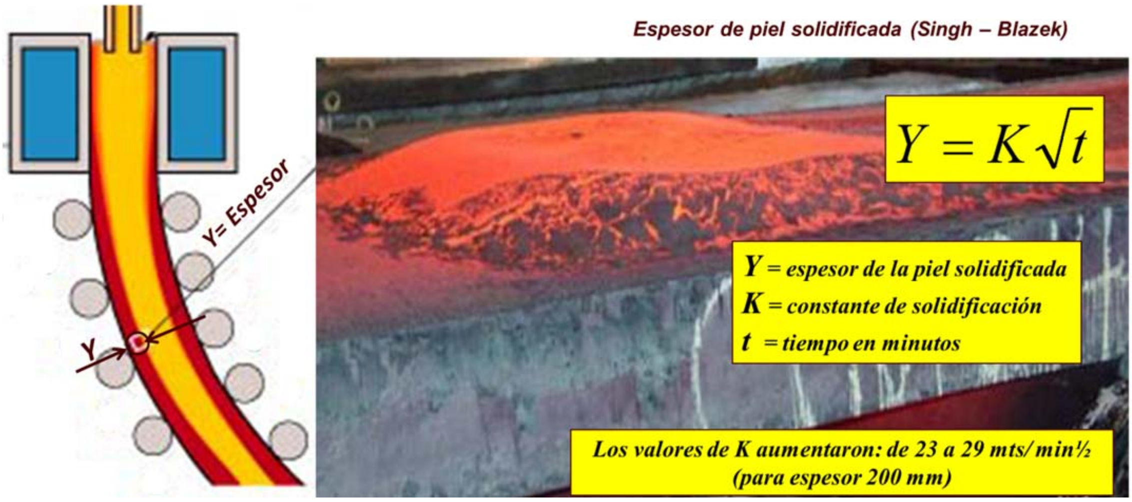

Figure 4. Barrel-shaped slab to define the constant solidification "K".

4.4 Casting Speed Advance

In Figure 5, it can be seen a summary by chronological stages of the increase in the casting speed related to the metallurgical length increase and the modifications in the cooling system [3].

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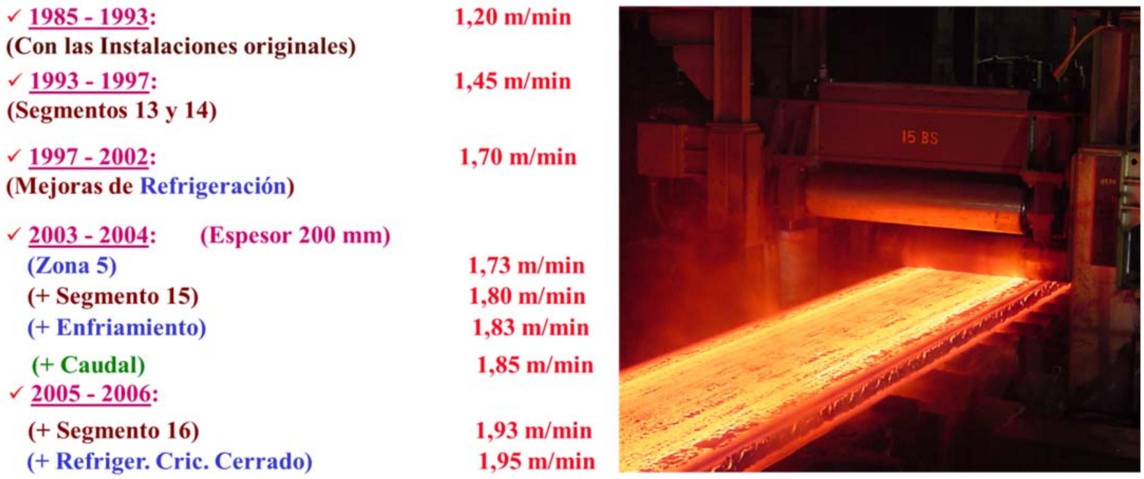

Figure 5. Evolution of the casting speed.

5 TECHNOLIGICAL DEVELOPMENTS

Among the technological developments that contributed to the increase in production, safety and operating continuity we can mention:

5.1 Booster Pump System for Water Spraying

It allowed to obtain a versatility of flows for a wide range of sections and casting speeds, avoiding in this way, and with identical results, an expensive replacement by the Air-Mist system for the secondary cooling [4] (Figure 6).

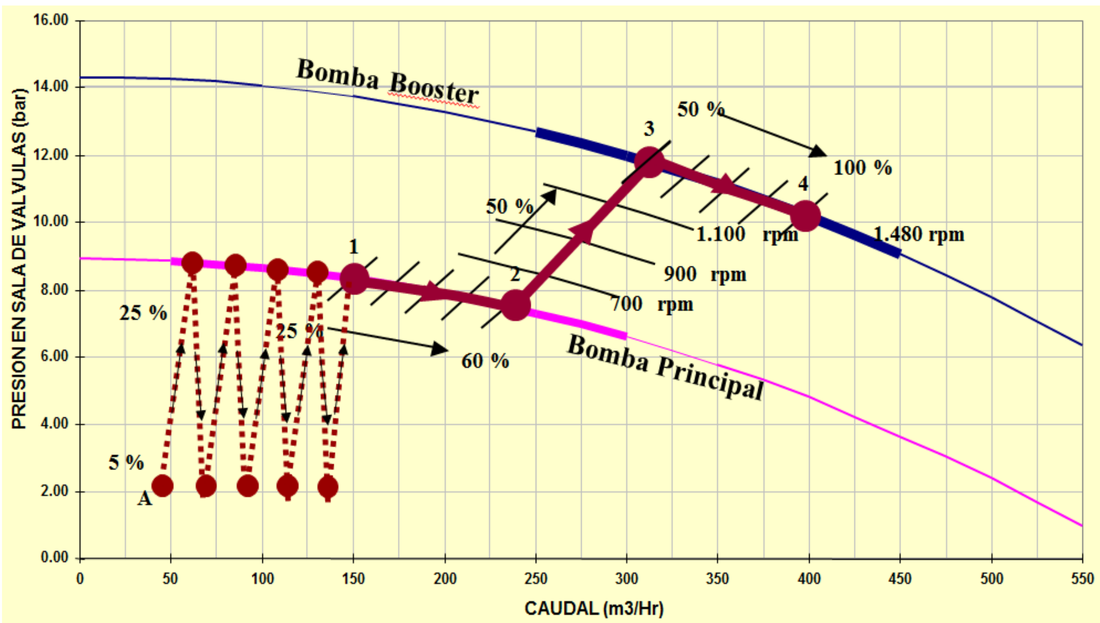

Figure 6. Flow rate-pressure curves.

5.2 Control System of Clogged Nozzles

Through on line pressure and flow measurements and in comparison with the admissible ranges, the programme calculates and indicates the area where the clogged nozzles or leakages are found, indicating the corresponding percentage [5] (Figure 7).

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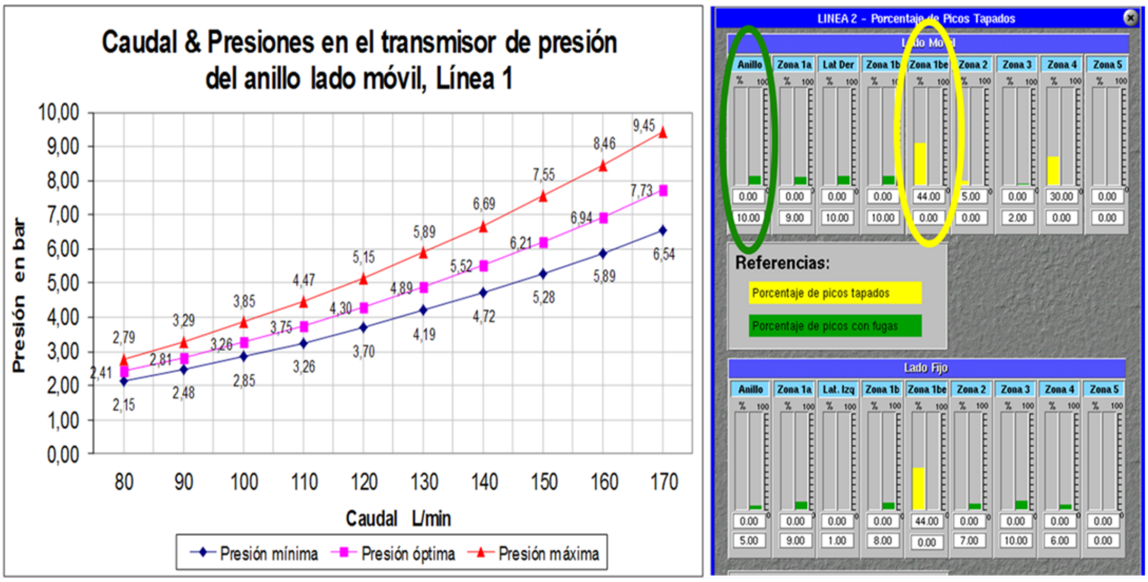

Figure 7. Control of clogged nozzles.

5.3 Pulsating Flow

The pulsating flow technology was developed successfully in order to avoid the overcooling and the clogged nozzles when the casting speed is too low (Figure 8).

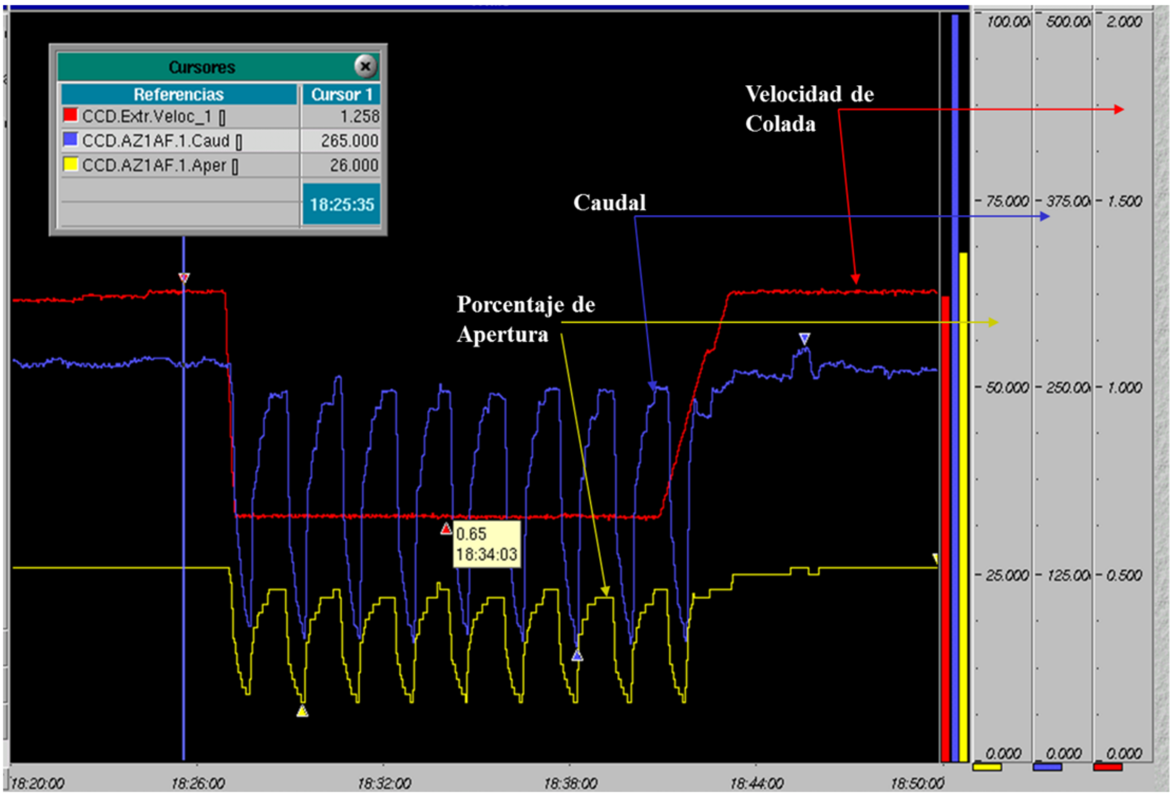

Figure 8. Pulsating flow and transient's regimes control in secondary cooling.

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5.4 Dynamic Control of the Secondary Cooling during Transitional Regimes

The flows are adjusted and compensated during the speed changes to avoid overcooling [4] (Figure 9).

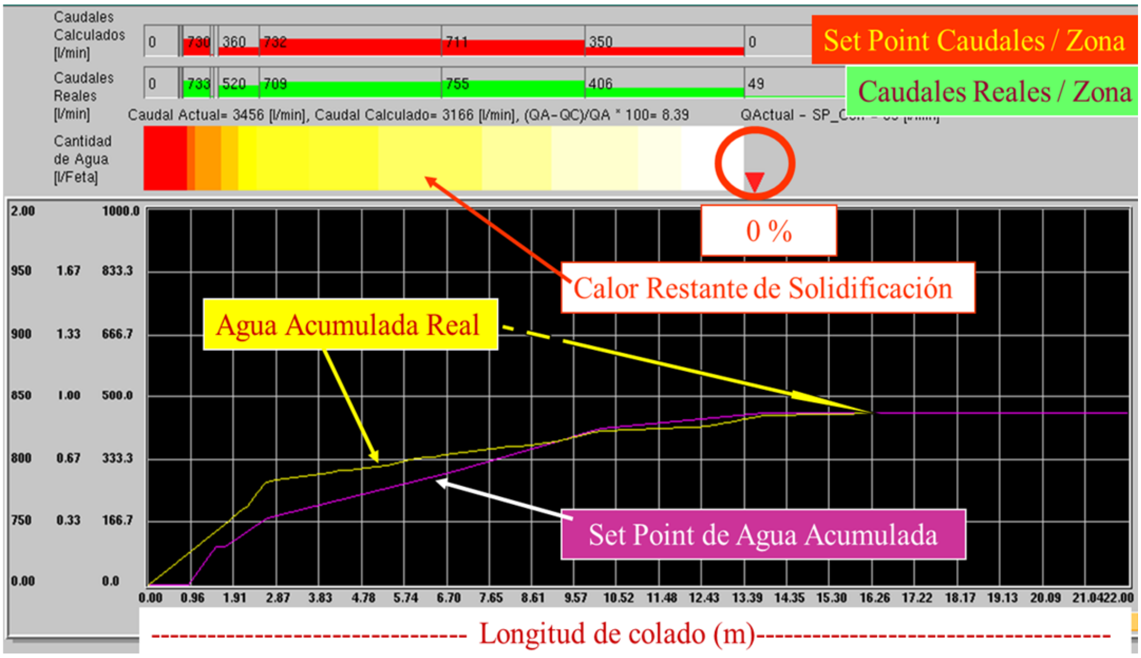

Figure 9. Transient regimes control in secondary cooling.

5.5 Nozzle Wear Control (NWC)

It is a control system that makes use of the hydraulic system of the tundish, assuring in this way the best distribution of the wear of the submerged nozzle (Figure 10).

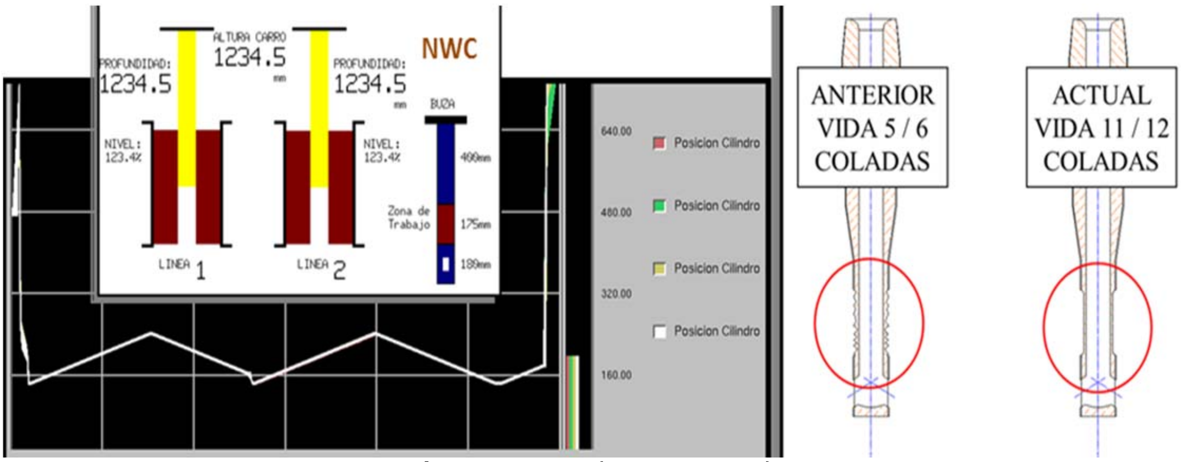

Figure 10. Nozzle wear control.

5.6 Mould Steel Level Control

This system allowed us to have a stable and controlled meniscus.
Basically, it has a structure of Master/Slave control. The first control loop controls the steel level set and the second one controls the position of the stopper with high accuracy (Figure 11).

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The main characteristics are:

- Level variations lower than +/-2mm amplitude.
- Speed of the change of the lower bath level lower than 1.5 mm/s
- Adjustable gain according to the slab width and thickness.
- d) "Feed forward" control with casting speed and weight of the liquid steel in the tundish.

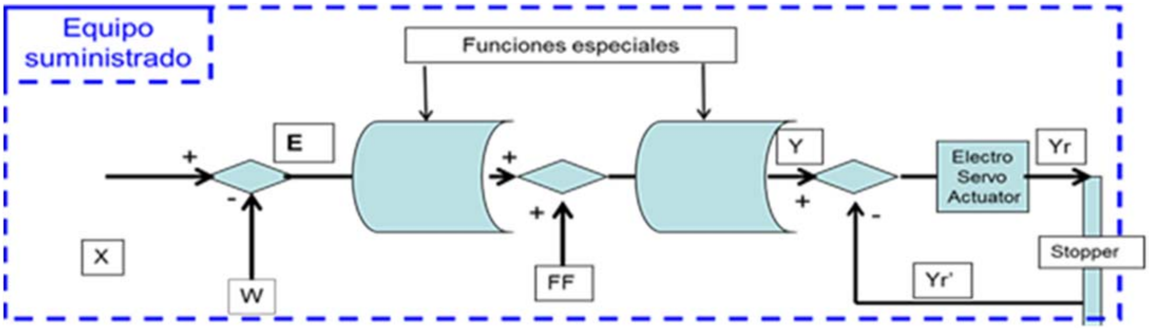

Figure 11. Steel level control in the mold.

5.7 Reciprocal Strand Technology for Tundish Exchange (REST)

This advanced technology allows to extend the times of the tundish exchange during sequential casts, avoiding, in this way, the deformation of the rollers, the effect of the slab barrel and the braking of the strand that was produced before the implementation (Figure 12).

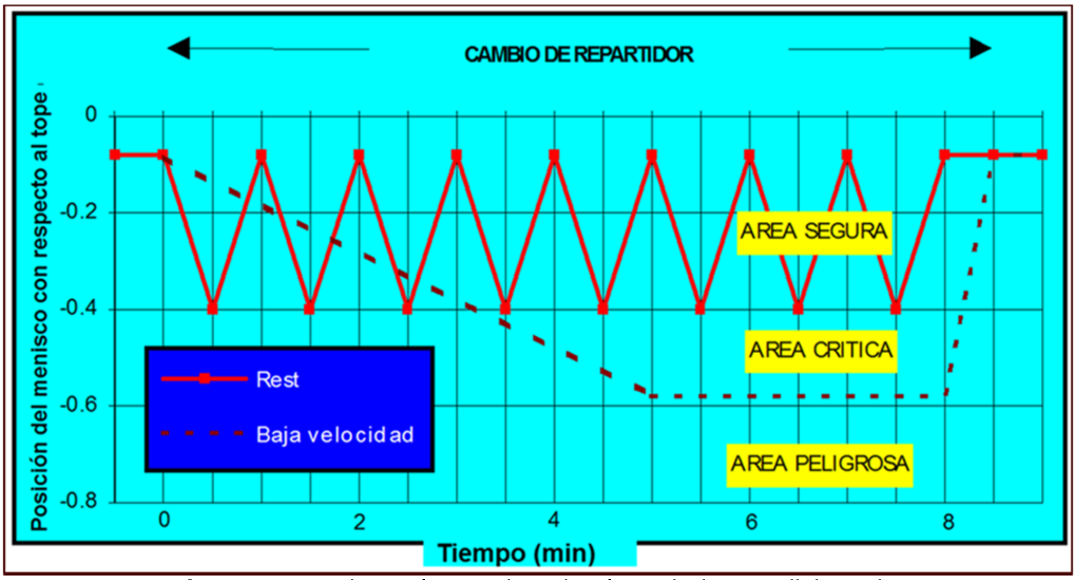

Figure 12. Reciprocal Strand Technology during tundish exchange.

6 INVESTMENTS AND PERFORMANCES IN THE 1992-2012 PERIOD

The investments in projects in the Steelworks in millions of U$S/year and accumulated are shown in Figure 13. As it can be appreciated, in these 20 years of transformation, we have already invested and accumulated, since 1992, a sum of U$S 350.000.000.

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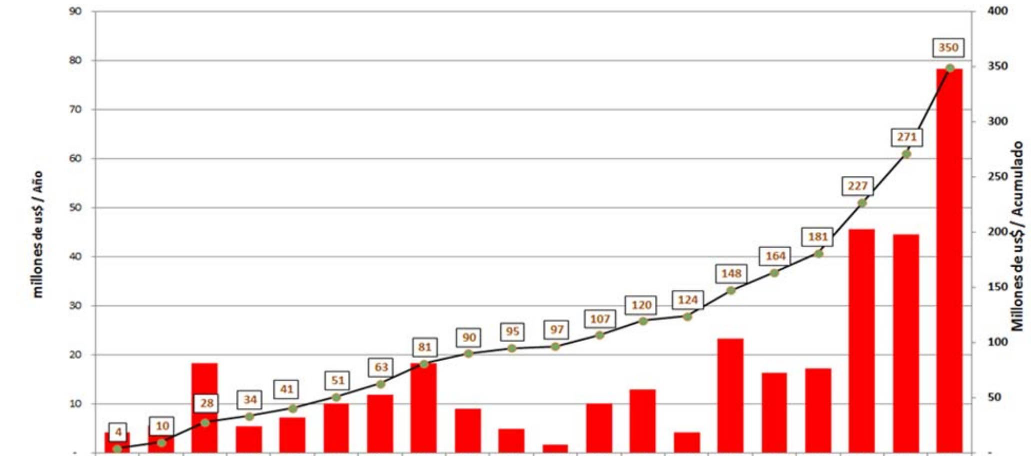
The following indicators are the ones that have had the greatest improvement during this period:

- CC production increase from slabs of 780 Mt/year in 1992 to slabs of 2847 Mt/year in 2011.
- Industrial Safety: Frequency Index from 32 to 6, safer work and less accidents.
- Net Productivity Increase: from 180 t/h to 360 t/h
- Increase in the percentage of time in which the steel remains in molds during the continuous casting (from 58 to 95%).
- Increase in the Casting Maximum Speed from 1.30 to 1.95 m/min.
- Qualitative improvement: Lower class reduction from 2.3% to 0.53%.



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total Año	4	6	18	5	7	10	12	18	9	5	2	10	13	4	23	16	17	46	45	78
Acumulado	4	10	28	34	41	51	63	81	90	95	97	107	120	124	148	164	181	227	271	350

Figure 13. Investment Projects, period 1992-2012.

Figure 14 relates to the percentage of time in which the continuous casting molds were with steel inside them.

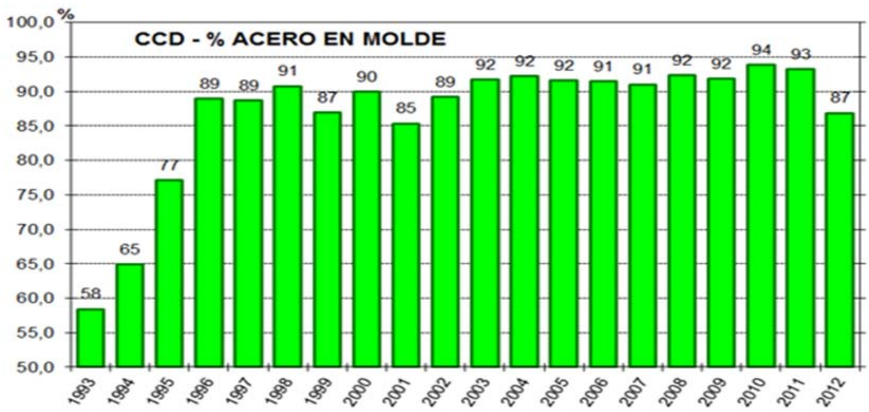


Figure 14. Percentage of time with steel in mold.

Figure 15 shows the improvement in terms of the "Not approved for Scheduling Order."

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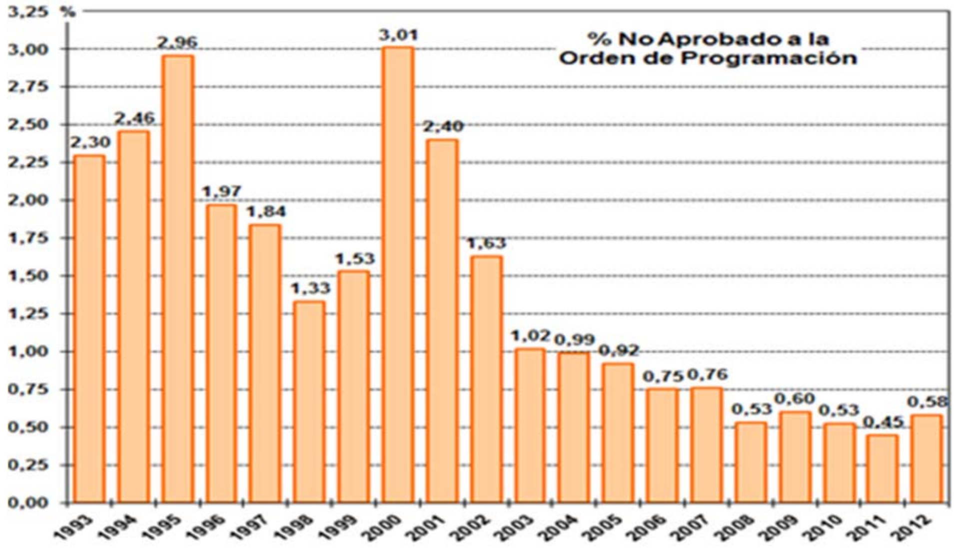

Figure 15. Not approved for Scheduling Order.

Another distinguished figure is the size of the sequential castings, particularly to enable the increase in production. The sequential average in 2011 was 203 ladles. The different sequential records are marked temporarily in Table 1.

Table 1. Registration of sequential record

CCD1: SECUENCIALIDAD									
	11/01/96 al 17/01/96	29/02/96 al 09/03/96	20/03/96 al 01/04/96	23/06/96 al 10/07/96	13/10/96 al 31/10/96	19/10/00 al 03/11/00	05/08/04 al 21/08/04	10/09/04 al 30/09/04	04/02/06 al 27/02/06
Cantidad de coladas	178	270	348	481	517	520	560	830	965

7 CONCLUSIONS

The modification of the Continuous Caster Nº 1 made it possible to meet productivity and efficiency goals that exceeded the initial expectations. It also allowed the technical staff to make countless technological developments which, due to their innovations and contributions to the process, helped these goals to be achievable.
With the addition of a steel vacuum degassing station type RH-TOP in the present, to expand the secondary metallurgy treatment, and of a new slab continuous caster N°2 for the year 2014, a new cycle begins in Ternium-Siderar which will certainly be as promising as the one wording in this document.

Acknowledgements

The authors of this paper wish to thank our respective directors for trusting us and for giving us the freedom needed to introduce many new technological developments. This, together with the planned investments, helped to reach the figures described. We are also grateful for the enormous satisfaction we feel because we left our own footprints not only in our own Company but also in the fascinating technology involved in the making steel process.

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REFERENCES

1 López RD, Di Gresia G, Castellá A, Balante W, Usart J, Riboldi H, *et al.* Thermal balance of Siderar slab continuous casting. In: ISSTech. Iron and Steel Society Conference; Apr. 2003. Pittsburgh: AIST; 2003. p.27-30.

2 Sylvestre S, Usart J, Riboldi H. Medición de la temperatura superficial del planchón durante el enfriamiento el enfriamiento secundario. In: Jornada sobre Acería; oct. 2002; Buenos Aires, Argentia. Buenos Aires: UTN-FRSN. 2002. p.65-72

3 López RD, Di Gresia G, Castellá A, Balante W, Pereyra J, Riboldi H, *et al.* Evaluación, evolución e intervenciones en los circuitos de refrigeración de la Colada Continua de Siderar. In: IAS. 13° Seminario de Acería del IAS; 29th oct. to 1st nov. 2001. Buenos Aires: IAS; 2001.

4 López RD, Olocco JC, Balante W, Di Gresia G, Rubén V, Usart J, *et al.* Innovaciones y mejoras tecnológicas en el enfriamiento secundario de la colada continua de Siderar. In: IAS. 14° Seminario de Acería; 11-13 nov. 2003; San Nicolás, Argentina. Buenos Aires: IAS; 2003.

5 Cejas P, Cepeda I, Deltone Walter, Palmieri Fernando, Puchet Hernán, Velásquez Lucas, *et al*. Incidencia del agua sobre el planchón durante el enfriamiento secundario. In: IAS. 15° Seminario de Acería del IAS; 7th to 10th nov. 2005; San Nicolás, Argentina. Buenos Aires: IAS; 2005.