

# LADLE ROCKER FOR THE NEW RH AT TERNIUM SIDERAR<sup>1</sup>

*Raúl Daniel López<sup>2</sup>  
Mariano Aguirre<sup>2</sup>*

## **Abstract**

In order to supply new steel grades to the local Argentine market which are currently imported, Ternium-Siderar decided to enhance their treatment of secondary metallurgy with a vacuum degasser of RH-TOP type design. The start-up is expected in late 2013. With the operation of RH, steel grades such as deep drawing steels, IF (interstitial free) grades and degassed steels will be added to the Ternium Siderar production programme. A major challenge during the bidding stage for this new facility was the selection of equipment that would provide flexibility and operational reliability and, at the same time, reduces costs by using the existing building in an optimal manner. Moreover, a further request was made to consider a future upgrading of the facility for operation with higher throughput by feeding two continuous casting machines by just adding a second ladle car. During the equipment design and layout, an interesting new solution of development called Ladle Rocker system emerged. This solution facilitates a quick change of the ladle car for liquid steel during vacuum treatment, with greater safety margins to avoid a risk of damaging the equipment in case of ladle refractory failure. This paper aims to present the considerations taken during the study, alternative solutions and the reasons for the final adoption of the mentioned system.

**Key words:** Secondary metallurgy; Ladle rocker; Vacuum degassing; RH.

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<sup>2</sup> *Project Manager of Ternium-Siderar, Planta General Savio, Buenos Aires, Argentina.*

## **1 INTRODUCTION**

The main equipment of the Ternium Siderar steel plant consists of a Desulfuring Station for hot metal and 3 LD Converters with combined LBE blowing, each with a capacity of 200 tons, and for secondary steel metallurgy, a conventional Ladle Furnace LF with a rating of 35 MVA and a Stirring or Trimming station.

The Ternium Siderar expansion plan includes in the project execution a degasification station of steel that works by recirculation the liquid steel within a Vessel under vacuum combined with oxygen blowing using a cooled lance (RH-TOP type). This new plant will be linked to and coordinated with a new future Ladle Furnace No. 2 and a new Trimming Station No. 2, which will share a single Control Pulpit.

With the new installation of the RH-TOP, and as per the Plan of 4.000.000 t/year, Ternium Siderar will be able to move into local markets that demand greater quality (Deep Drawing, Interstitial Free, and Degassed steels) while also supplying steel slabs to the Ternium-owned steel plants in Mexico.

As of now, 100% of the engineering has been completed, with the provision of all the principal components and the civil works, with the related assembly projects already well underway. Commission is planned for the end of 2013.

One of the main issues that arose during the preliminary stage concerned the system and technology to be adopted regarding the movement between the ladle with the steel and the vacuum Vessel where the vacuum degassing would take place

## **2 DEVELOPMENTS**

When the study for the new RH installation began, the Ternium Siderar technicians were updated regarding new existing technologies with the assistance of the representatives of SMS Mevac.<sup>(1,2)</sup> They also visited and were advised by colleagues in the main plants in Brazil.

During the start of the RH project, two situations were presented that merited special detailed study, and for which it was necessary to resort to the development of alternatives, including a series of numeric modeling and verification with electronic models. This stage generated material of interest that serves as the reason for this presentation.

## **3 PRIOR STUDIES**

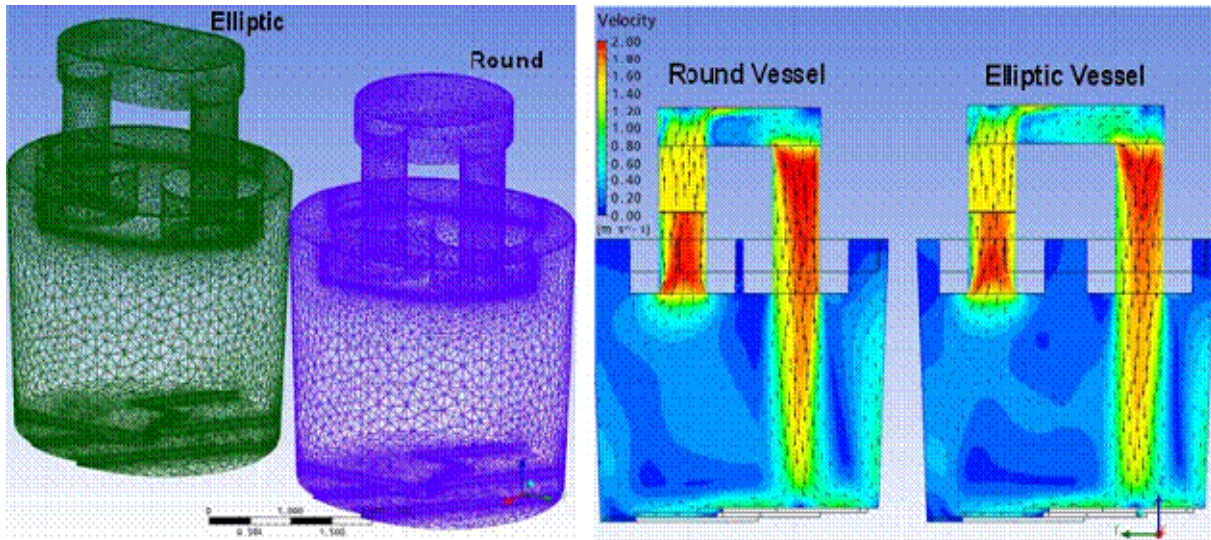
The two studies most challenging for the RH project concerned the following: (3.1) the special oblong shape of the Ternium Siderar steel ladles; and (3.2) the question of which Vessel or ladle lifting system would adapt better to the characteristics of the existing building and provide the best safety conditions.

### **3.1 The Vacuum Vessel Shape**

First, with respect to designing the Vessel shape, the suitability of the following alternatives was evaluated: follow accepted good practice, design it with a circular section, or copy the oblong shape of the steel ladle (two semi-circular sections united by a rectangular section 400 mm wide). For this study, Ternium Siderar collaborated with the Argentine Steelmaking Institute (IAS),<sup>(3)</sup> that already had developed a numerical fluid dynamic modeling for the stirring of liquid steel for the study of the

various positions of porous plugs in the ladle bottom and as concerns the various stirring flow rates.

Figure 1 shows the study (mesh and one of the Results for both alternatives). Given that the IAS, as mentioned above, already had the modeling available, it was possible in just two weeks to reach important conclusions.



**Figure 1.** Mesh (right) and velocities in the middle plane (left), in CFX for both shaped Vessel alternatives.

Although the oblong configuration has some advantages with respect to the traditional cylindrical configuration in that it leads to fewer dead volumes and less stirring at the surface free of the ladle, it has the disadvantage of having the highest level of shear stress in the refractory lining due to the action of the flow coming from the RH.

With this prior study, one of the two principal questions was clarified at the time of initiating the project development phase, namely deciding the shape of the Vessel.

### 3.2 Determining the Lifting System for the Vessel or Ladle

As the installation of the new RH was going to be carried out within Ternium Siderar's existing steel plant building LD, the layout specifications also had to be considered in determining the optimal mechanism to include. These considerations were above and beyond the operating and process requirements associated with the maximum leveraging of the structures and parts of the existing building.

The best practices were analyzed, both older ones and current ones, in the design of a new RH. Furthermore, criteria were examined to determine whether the steel ladle or the Vessel would be lifted and lowered relative to the column of liquid steel inside the snorkel for the process of recirculation of steel in the vacuum chamber.

Once the most apt alternative was determined for the best utilization of the existing building and its operative layout from an economic perspective, both for the current situation and the second stage of the plan for 4 MMt/year (for which a second continuous casting of slabs is under consideration), it became clear that the ladle should incur the lifting and lowering movements.

For the principles of ladle lifting, information about such mechanisms was gathered from 60 of the most recent global projects, and mainly, in addition, special attention was paid to those available at that time in the sister plants in Brazil.

As the final deciding factor, Ternium Siderar and SMS Mevac discussed the alternative to combine the advantages of the well-proven Vessel rocker system (safety and reliability) with advantages of a ladle lifting system (simple connection of the vacuum pump and the alloy system to the vacuum Vessel). As the output of this discussion, the ladle rocker, which keeps the ladle car in a free position and is the innovation in this project and focus of the present presentation, was deeply studied. Besides other benefits of operating flexibility and low maintenance, the chief motive for Ternium Siderar was the minimizing of the possible risks to persons and installations in the event of ladle perforation or liquid steel spills.

In fact, in 1992, the hydraulic room for the continuous casting of slabs was totally destroyed by fire due to the perforation of a ladle in a similar situation; it had a trimming station over a rotating support and below it were the hydraulic motor and piping tunnels. The liquid steel ran out through that tunnel and right into the hydraulic room. This was the main reason for the agreement to use the system known as the “Ladle Rocker” as a maximum safety device. Figure 2 illustrates the “Ladle Rocker” device.

Shortly after initiating the project as discussed, the Ternium Siderar and SMS Mevac engineers began to see additional important benefits derived from the application of this.

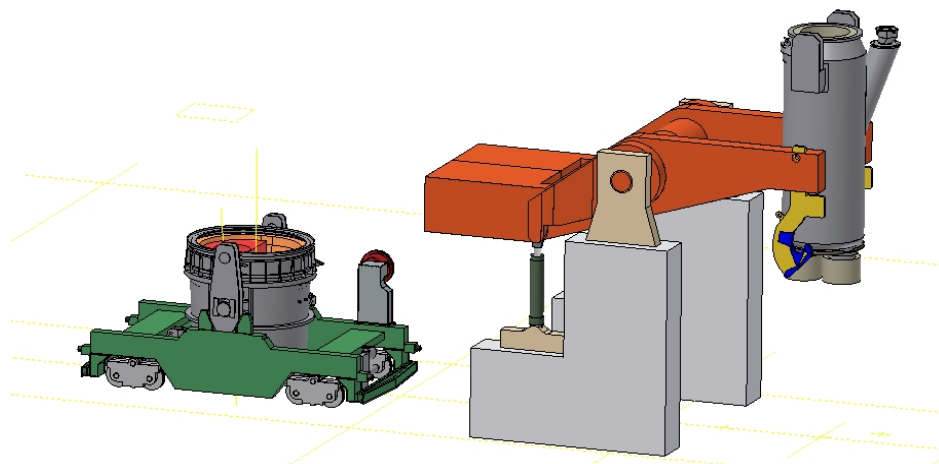


Figure 2. Ladle Rocker design.

## 4 BENEFITS OBTAINED BY ADOPTING THE LADLE ROCKER

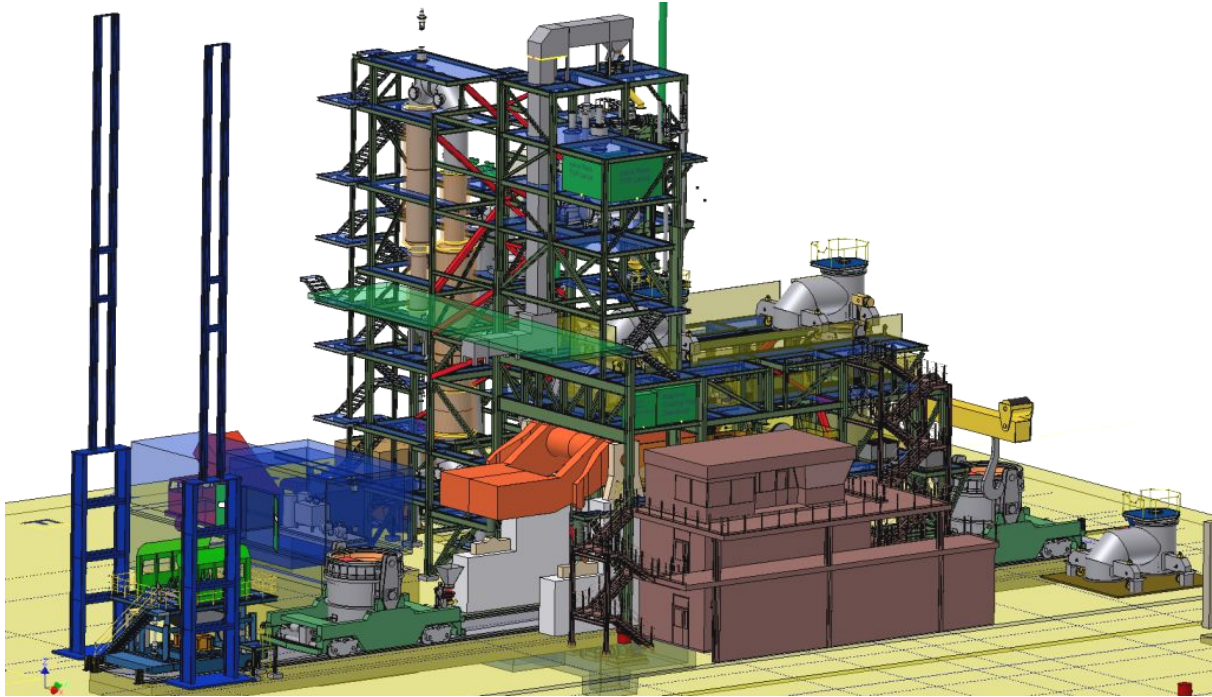
### 4.1 Better Utilization of the Existing Building

First of all, this alternative permitted greater utilization of the existing structures with minimal raising of the roof (just twelve meters), keeping the actual structures. In a photo of the model shown in Figure 3 the Ladle Rocker System and Super-structure that supports the equipments of the RH can be seen.

### 4.2 Flexibility for the Operation of the Ladle Car During the Vacuum Treatment

The design of the ladle rocker eliminates the interference between the ladle and the ladle car during the vacuum operation. This opens the opportunity for future incorporation of a second car to the installation, thereby gaining a tremendous advantage from an operational perspective by optimizing the maneuvering times for loading and unloading of the ladle with liquid steel at the station.

In this way, operating partially with a car over the station loading area and with a second car over its unloading area, the installation gains both flexibility and productivity while lowering the tap-to-tap times. It should be noted that the addition of a second car to the installation does not involve any modification of the initial installation, i.e., the future layout of operating with two cars is similar and compatible with the current version.

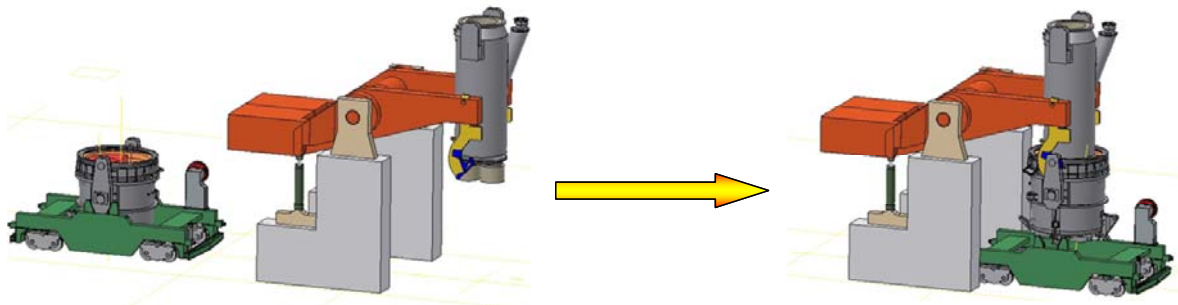


**Figure 3.** Use of the existing building and new roof.

Hence, for this project, there remained two configured layout alternatives for the installation.

#### **4.2.1 Initial operating layout (1 ladle car)**

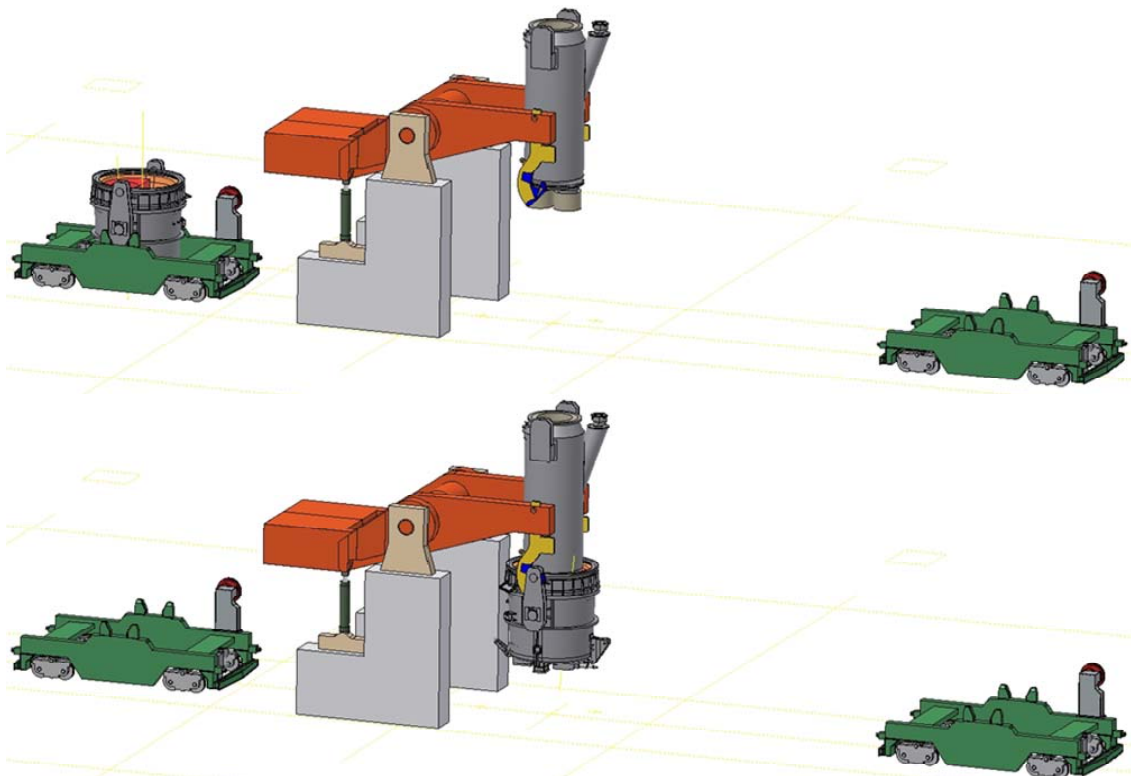
Operating with just one car, the station (Figure 4), although as clarified above, the car does not stay stuck below the ladle during the vacuum treatment after receiving the ladle with liquid steel and it is directed to the treatment position, remains close to the ladle waiting the end of treatment, although as mentioned, it does not remain trapped during the operation, there is no need for further movement until the treatment end. Finally, the ladle is lowered by means of the ladle rocker, resting over the car once again, so that later it continues its progress to unloading aisle, where the crane takes the ladle, guiding it to continuous casting. This also has the flexibility that the car can leave from the opposite side toward the crane in the other aisle, thus allowing two alternatives for entry-exit of the ladle.



**Figure 4.** future operative lay out (1 ladle car).

#### 4.2.2 Future operating layout (with two ladle cars)

When the station is operating with two cars (Figure 5), the first car over the loading aisle side receives the ladle with liquid steel for guiding it afterwards to the treatment position. The ladle rocker takes the same, lifts it, thereby submerging the Vessel snorkels in the liquid bath. Free of ladle interference, this car then withdraws again to the loading aisle, awaiting the next ladle in the circuit. On the other side, the second car (which is over the unloading aisle) moves to the treatment position and waits for the end of the process, at which time the ladle rocker lowers the ladle, resting it on the car. It is then guided afterwards to the unloading aisle, and the aisle crane takes the ladle, guiding it to continuous casting.



**Figure 5.** Future operative lay out (two ladle cars).

With this alternative it will be possible to carry out the ladle treatments for two continuous casting machines and take into account Ternium Siderar expansion plans.

### 4.3 Highest Allowed Tolerance for Ladle Arm Shapes

During the design and subsequent calculation for the ladle crane hooks, a decision was made to use lamella hooks with accessories in critical wear areas, of Hadfield cast alloy steel, whose lesser thickness, for example, with respect the crane hooks of the bridge cranes at the same steel works, resulted in a greater margin of entry inside the ladle arms with large dispersion product from deformations. In this way, no additional demand is required for the current allowed deformations in the dimensional control of the ladles.

Figure 6 shows the analysis and specifications for the adopted tolerance.

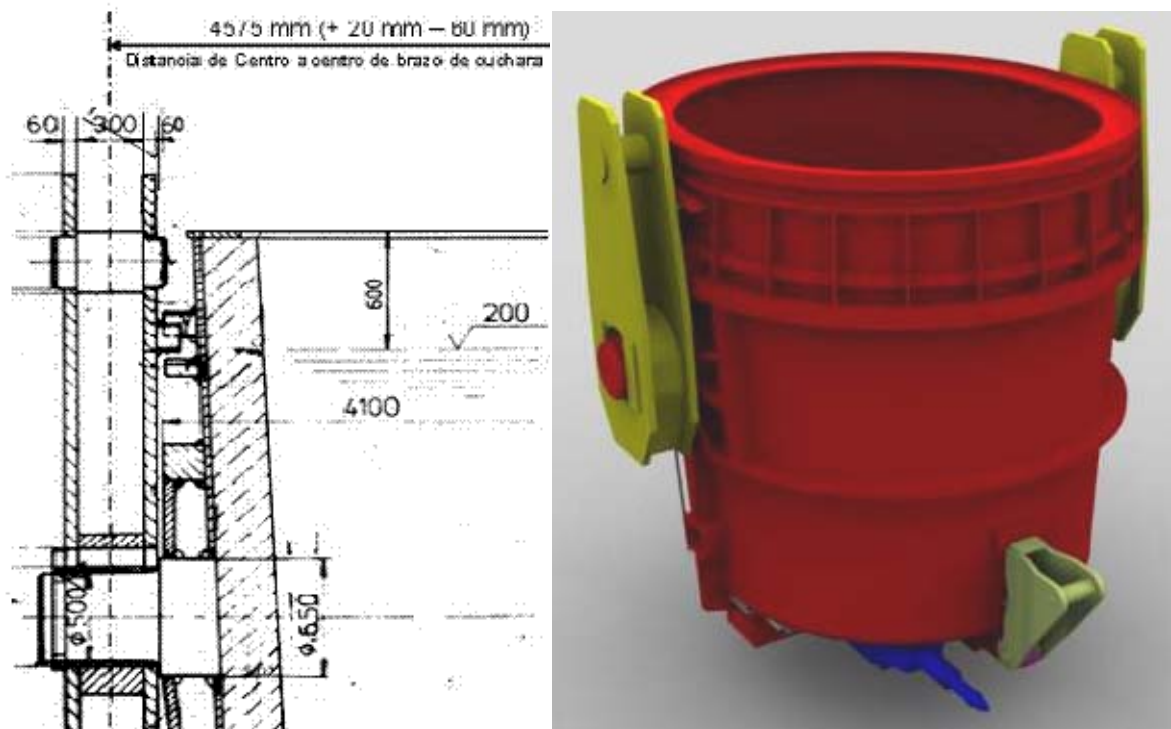
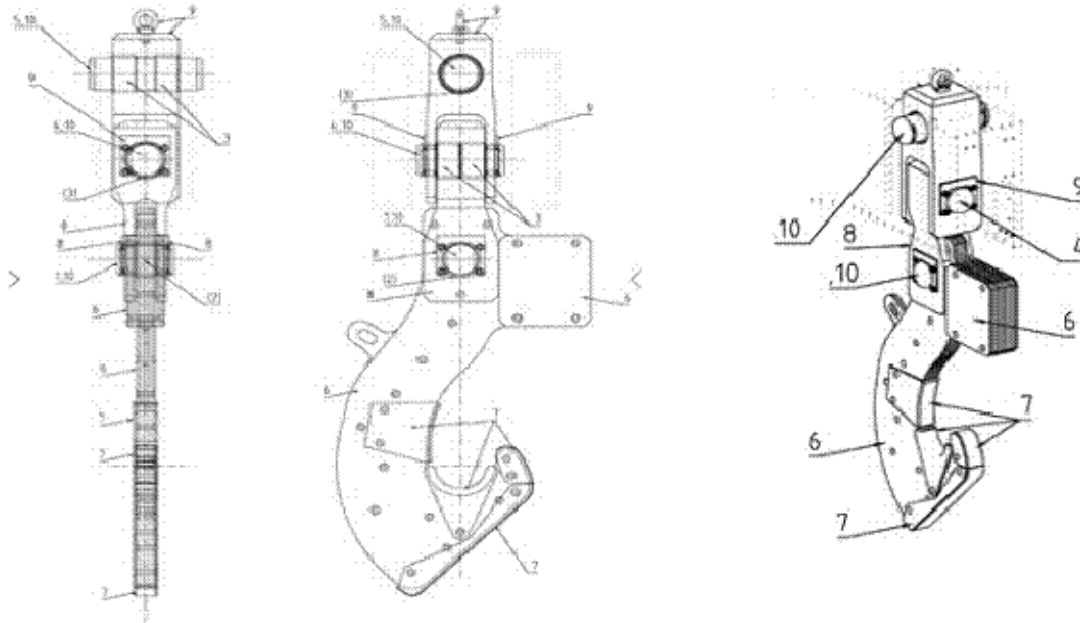


Figure 6. Analysis about allowed tolerance of the ladle arm.

## 5 LADLE HOOK UP SIMULATION

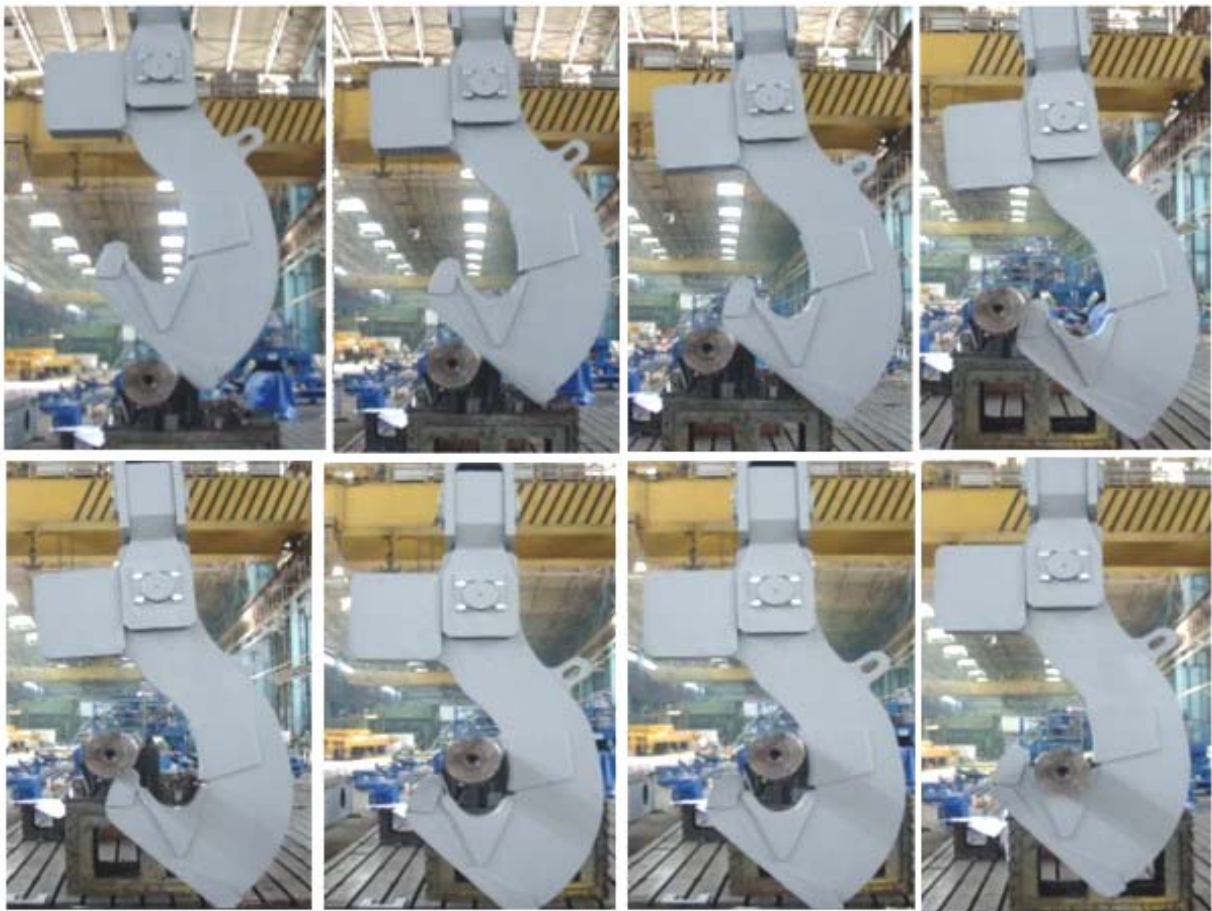
During the manufacturing phase of the ladle rocker, the engineers at Ternium Siderar and SMS Mevac designed and agreed to carry out a test of ladle “latching,” i.e., a cold test simulation for approximating the real maneuver necessary for lifting the ladle.

Figure 7 illustrates the design of the Lamella hook. Basically it involved locating the hook above the ladle (ladle rocker above), then beginning to pivot the same until it reached a point of contact with the lower inclined plane of the hook over the axis of the ladle arm. The hook continued to be lowered until contact was made between the pieces and the hook’s articulation, which was then swiveled as it continued descending until it reached the point where it no longer was in contact with the ladle arm axis, at which time the hook grommet remained under the axis and was raised again, making contact with the pieces and in this way, the latching of the ladle.



**Figure 7.** "Lamella" hooks design.

The following sequence of images (Figure 8) was filmed during the aforementioned test, and illustrates the described maneuver.



**Figure 8.** Testing and simulation of ladle latching.



## 6 CIVIL WORKS AND FOUNDATIONS

The civil works have started during the beginning of 2012. Figure 9 shows the construction procedure of concrete plinths one on each side in order to support the rocker beam pedestals and bearing.



**Figure 9.** Foundations of the ladle rocker.

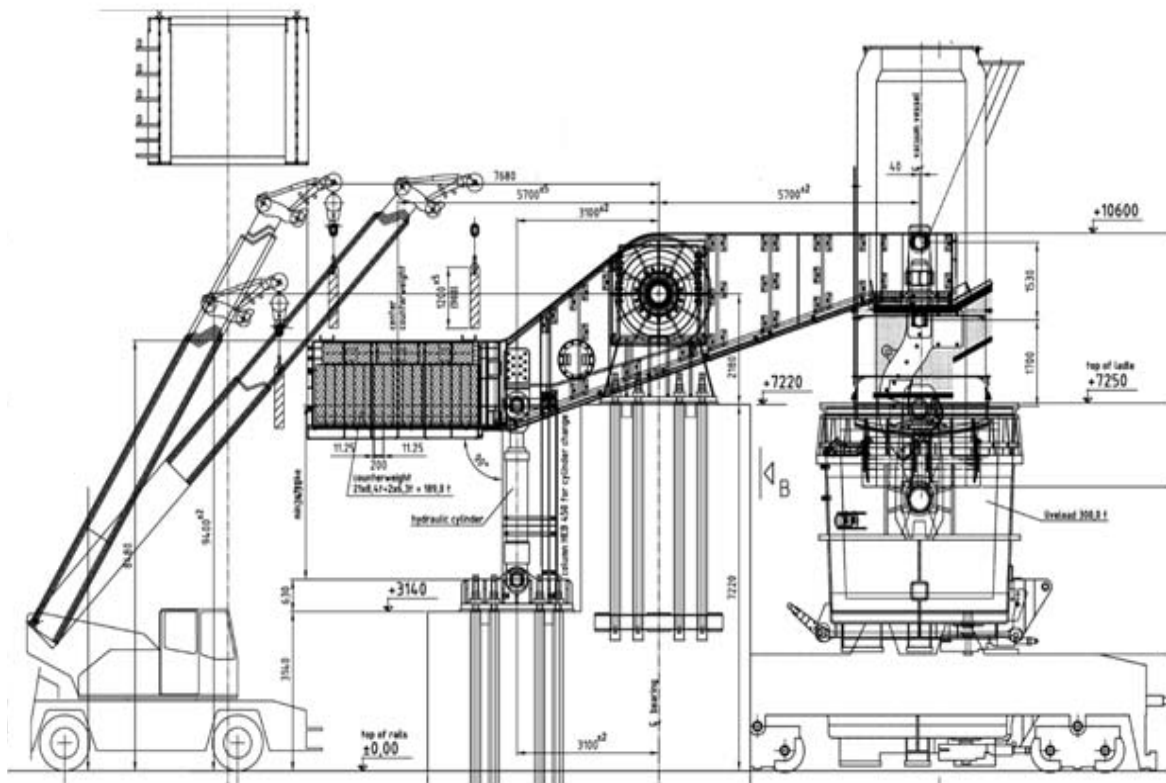
## 7 MOUNTING OF THE LADLE ROCKER SYSTEM

Figure 10 shows the ladle rocker arms being positioned over the concrete plinths. For this purpose was used a large mobile crane of 575 t maximum capacity which it was available as support for this work.



**Figure 10.** Rocker arms hosting sequence.

Figure 11 shows the previously analysis made for hoisting the 189 ton counterweight in pieces (by using 23 slabs of 200 mm thicknesses). This counterweight is about half of the total ladle weight with liquid steel.



**Figure 11.** Hoisting the counterweight pieces.

Figure 12 left picture shows the ladle rocker mounted in its final position. The counterweight being welded is shown in the right picture.



**Figure 12.** Fixing the counterweigh together.

Figure 13 shows a hydraulic cylinder jack and a lamella hook placed.



**Figure 13.** Hydraulic cylinder and lamella hook already placed.

## **8 ADDITIONAL COMMENTS ON THE LADLE ROCKER DESIGN**

In addition, the hooking procedure will be visually controlled by the operator via camera system with monitor. The lifting stroke will be monitored by angle encoder arranged in the axis of the torsion tube.

The pressure required to operate the hydraulic equipment is generated by means of hydraulic pumps of variable delivery for control of the lifting/lowering speed of the cylinders.

The ladle lifting position will be monitored by an absolute encoder. Limit switches will be indicating the stroke and position. The raising/lowering motion will be controlled by means of various solenoid and hydraulic-operated valves.

The double lever arms with the counterweight can rest on a supporting structure in case of hydraulic cylinder exchange.

In case of emergency, one hydraulic cylinder failed, the second hydraulic cylinder is able to lower the ladle down on the car and disengaged the hook.

Finally, in case of total absence of electric power and hydraulic pressure available in the accumulators, the ladle descends by its own weight which it is greater than the counterweight. In this way the ladle is not attached to the RH vessel and thus could save of any damage these equipment.

## **9 RESULTS AND CONCLUSION**

With the adoption of the ladle rocker design, a design for installations was achieved at minimal investment in comparison with alternatives that currently serve as best practices for movement between the Vessel and the ladle. This design offers the best safety conditions for personnel and equipment as well as benefits for operational flexibility, both for the start-up of the current project and for future developments, when it will be necessary to carry out the ladle treatments for two continuous casting machines and take into account Ternium Siderar expansion plans.

## **Acknowledgments**

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- Finally, our directors and colleagues at Ternium Siderar for having given us their trust and support in making the critical decisions that were adopted and agreed upon regarding the design for the so-called ladle rocker ladle-lifting design for the new RH.

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