ADVANCES IN SLAG CARRYOVER CONTROL IN C. S. HUACHIPATO, CHILE[1]

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Summary

As steel products are developed, one of the main targets in a modern steel industry is the high cleanliness of those products. In the present reality, this must be associated with less production costs, ensuring a greater profitability. Within the factors to be considered for such profits, to avoid the slag carryover from the converter to the steel ladle shows as a key element, specially due to the direct influence of the presence of undesirable elements retained in the slag over the quality of the steel, and also to the greater consumption of alloying elements. This study shows the advances in slag carryover control practices during the tapping in the steel vessels of Compañía Siderúrgica Huachipato (CSH), through modifications in the design of slag retentors, discussing the characteristics and benefits reached in the process.

Key-words: LD furnace, slag carryover, dart, tapping.

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1. INTRODUCTION

During the BOF tapping, an important quantity of slag carryover from the vessel through the steel ladle is registered; its high oxidation level negatively influences the process and the product, reducing the yield of the ferroalloys and facilitating the reversion of injurious elements, like phosphorus. It is for that reason that the reduction of the slag carryover at tapping has such importance in the quality control of the steel.

It is considered that a 15% of the total slag carryover occurs at the beginning of the tap, a 60% in the middle and a 25% in the final stage. The most important proportion, which occurred during tapping is difficult to control and only some gas impinging techniques[4] or vortex inhibitors are mentioned as slag carryover controllers.

In general, as the beginning as the end of tapping, they are the moments in which the slag carryover control takes place mainly in most of the steel plants around the world. At the end of the tapping stage, several techniques and/or devices are used, like early vessel tilting, double tapping, balls, tetrahedrons and darts,[1, 2, 4] being the last ones the most used today, thanks to their better performance.

2. METHODOLOGY

In CSH, the experience in the use of darts as slag carryover control devices lasts more than eight years, having previously tested several techniques, as the ones already mentioned. However, the slag carryover stands still as a continuous problem to be solved, due to such factors as a slow tilting of the vessel, absence of slag detectors, like infrared cameras, and also because of the darts that are used do not accomplish completely with an adequate restriction of the steel/slag stream at the end of tapping.

In a first stage of testing, it was determined to carry out several modifications to the conventional dart, in order to reach a greater flow restriction, under a basis of a better taphole seal or deeper penetration of the dart head into the taphole.

Some of the first conducted modifications over the darts heads included ones with relative densities between 3,0 and 4,5; elliptical shapes, heads without grooves, heads with just one smaller groove of smaller dimensions, etc. The obtained results allowed to define the use of a dart with two grooves and relative density of 3,3; this format allowed a smaller slag depth in the ladle, maintaining the values of phosphorus reversion reached when the use of darts was originally implanted.

Despite this, cases of heats with poor restriction, high phosphorous reversion during secondary metallurgy or high slag depths were still observed. In all those cases, the product quality was affected and a greater cost of the heat due to extensive treatment or different final destination was reached, when the original specifications are not fulfilled.

The objective of the developed study was to obtain a better steel/slag flow restriction near the end of the tapping of a heat, under the principle that does not exist a dart that totally restricts the flow during tapping and considering that at this moment in CSH there aren't any other slag carryover control schemes.

It was considered that an adequate option was the use of an alternative design for the dart heads, with smaller dimensions, referred to the darts at present in CSH.

The main characteristic of this design is that the dart head penetrates deeper into the taphole, restricting in a better approach the stream during the final stage of tapping. This scheme, named “cork”, facilitates the required flow restriction, reducing the tapping stream passing through the grooves in the design of its head.

The following pictures show both darts format. The shorter dimensions of the head of this alternative dart have to be emphasized, because this design allows a deeper penetration of the dart into the taphole.

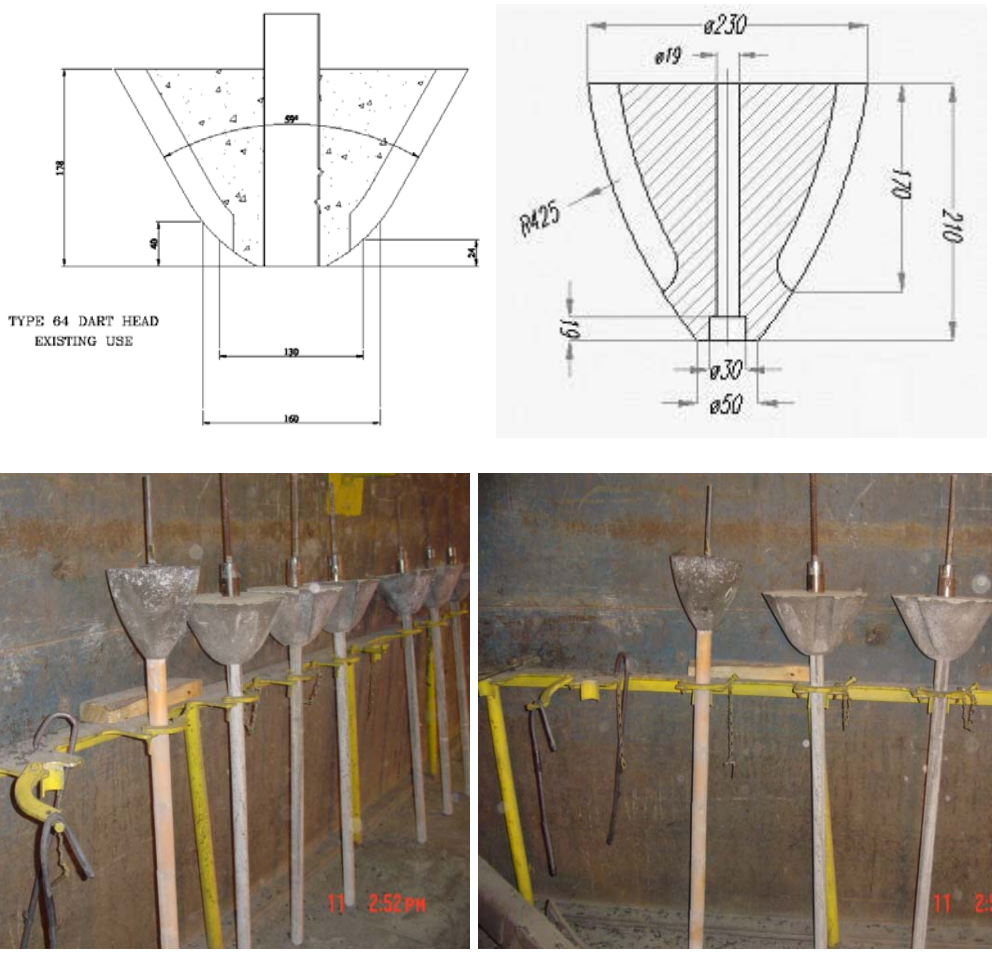


Figura 1. Conventional and Cork Darts.

For the development of the trials, a first essay was disposed with cork darts with relative densities of 3,0 and 3,3; in a second stage, trials with darts of relative densities of 2,7-2,8 were made.

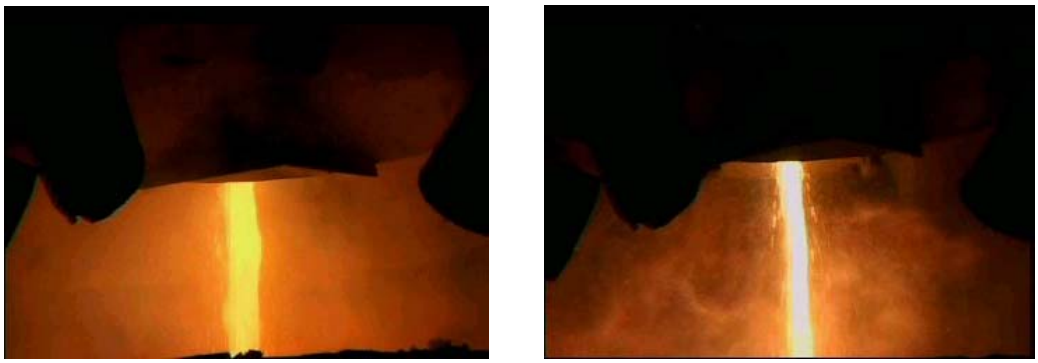
Initially, it was observed that the cork darts were tending to extend excessively the time of tapping in the heats where the taphole was relatively new. From it, a limitation was determined for the use of this kind of darts; the darts were used preferably in heats where the taphole life was upper to 15.

Total tapping times, dart insertion and dart restriction times were registered. In addition, diverse observations presented within the tests were registered, such long restrictions, null on inefficient restriction and also eventual taphole clogging due to stuck dart head.

Besides, phosphorous reversions between BOF preliminary analisis and the first simple in Ladle Furnace (E-1 sample), along with slag depths in the secondary metallurgy station were evaluated.

3. RESULTS AND DISCUSSION

The use of cork darts instead of the conventional ones, results in a higher reduction of the slag carryover at the end of tapping. As it is shown in the following pictures, the final stream is restricted nearly to the half of the slag/steel stream observed when the common dart is used. Both pictures were taken at a same phase of tapping, in consecutive heats.



Conventional Dart *Cork Dart*

Figura 2. Comparison of flow restriction.

From the point of view of the measurement of slag depth in the Secondary Metallurgy, an important decrease of the slag layer height in the ladle is registered, as it is observed in Figure 3.

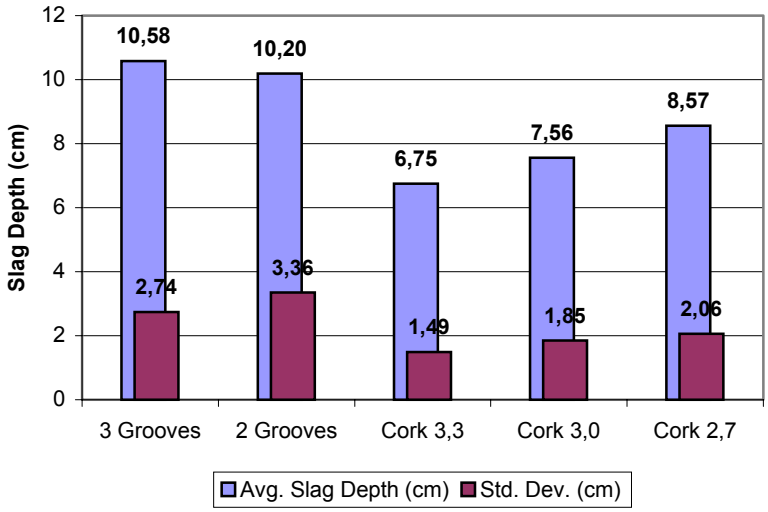


Figure 3. Slag depth at steel ladle.

By reducing the slag carryover from the vessel to the ladle, the use of cork darts also allows an important decrease of phosphorous reversion in the steel, even less than the reversion noted with the conventional dart. Figure 4 shows the results of phosphorous reversion registered in the several trials carried out to date.

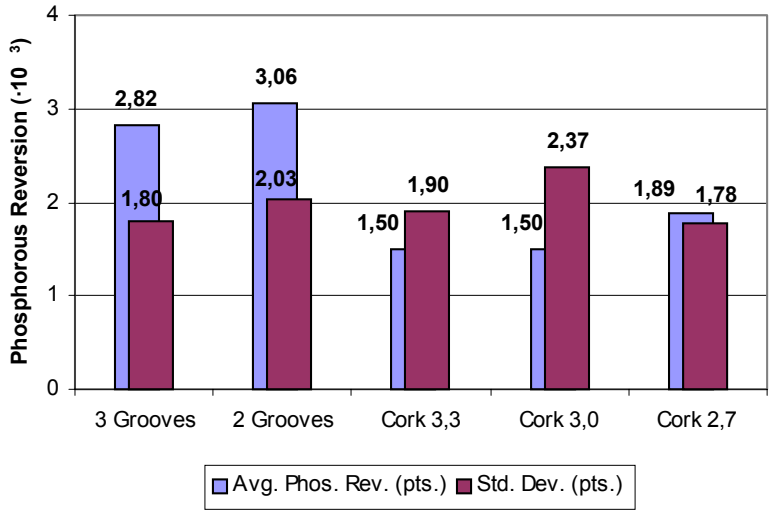


Figure 4. Phosphorous Reversion.

As it was explained previously, the effect caused by the vortex over the dart directly affects the restriction of the stream at tapping. In the first evaluations, a clear trend to the extension of total tapping time was registered, mainly in heats were darts with higher density were used. On the basis of these preliminary results, a major use of low density cork darts was determined.

Figure 5 shows the average tapping times registered for different shapes and densities of darts tested to date; Figure 6 shows the tapping times dispersion for each kind of dart tested.

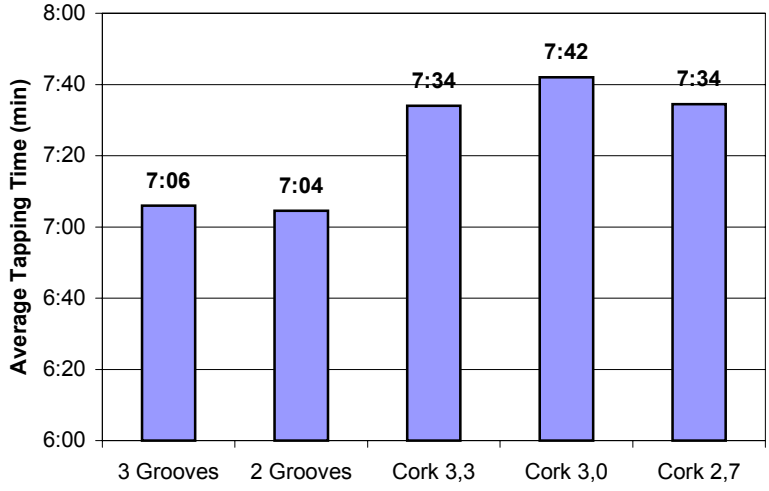


Figure 5. Average Tapping Times.

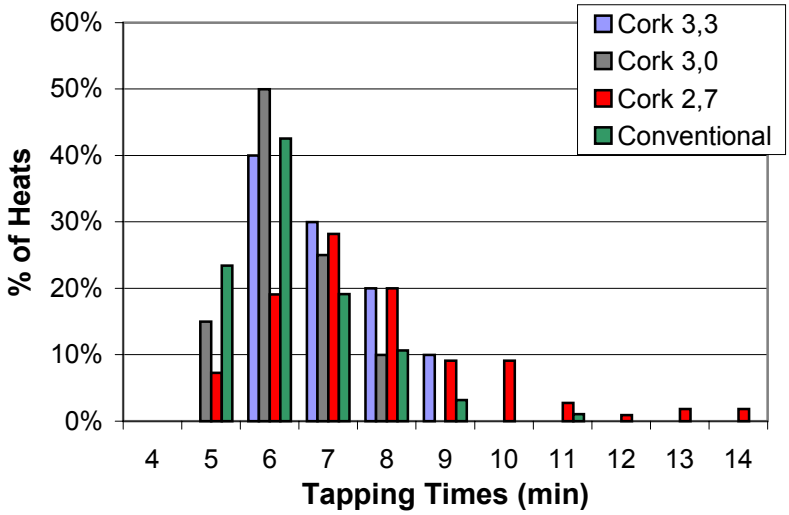


Figure 6. Tapping Times Distribution.

Summarizing the results obtained during the cork dart trials:

Advantages:

- Notorious reduction of steel/slag stream at the end of tapping.
- Shorter slag depths at steel ladle.
- Less phosphorous reversion.
- The deeper penetration of the cork dart into the taphole enables a strong decrease of cases in which the dart doesn't fit into the taphole. Therefore, it potentiates the use of this kind of darts in presence of an irregular inner taphole block.
- Related with the last point, it is possible to eventually extend the taphole life. This point has not been studied yet.
- There is no increase in the number of cases of heats in which the dart was stuck in the taphole, in spite of the shorter dimensions of the head tends to a deeper penetration into the taphole.

Disadvantages:

- The tapping time is extended in about one minute from the conventional ones, in the first 15 heats. With this taphole life, the restriction of a normal dart is as efficient as a cork dart. By this way, the use of the cork darts it is not suggested in the first heats of a new taphole, since it affects directly the productivity, by extending unnecessarily the tapping time.
- The use of this kind of darts does not become necessary in heats where the BOF slag shows high viscosity (for example, heats with more than 0,30%C before tapping), since it is the same slag that is producing a restriction effect at the taphole.

4. CONCLUSIONS

By using the cork dart, a strong reduction of slag carryover from the furnace through the ladle is observed. If with the use of a conventional dart, the slag depths

at the Ladle Furnace are lower than in cases with no final slag carryover control devices, by the use of cork darts the slag depths can be reduced even more.

A minor phosphorous reversion exists between the preliminary sample of steel in the converter and the first sample at the LMF (E-1 sample). This evaluation is directly related to the previous point, since the minor presence of BOF slag in the steel ladle derives in a less unfolding of phosphorous oxides, due to the inclusion of ferroalloys and deoxidants (rephosphorization).

In general, the average tapping time obtained by using the cork darts turns out to be similar to the one obtained by using conventional darts. However, this condition is not fulfilled during the first heats of a new taphole , registering cases in which the cork dart extended the tapping time even more than 11 minutes, reaching a top of 14 minutes (a normal tapping time at CSH is 7 minutes). From a productivity point of view, the use of cork darts should be restricted to taphole with its life upper to 15 heats, in order to assuring standard tapping times with optimum slag carryover control.

Since the cork dart head has shorter dimensions than the head of the conventional dart, it is assumed that the suction effect provoked by the vortex over the taphole during tapping is strongly related with the extension of tapping times. Therefore, the density of the head turns out to be a relevant issue at the moment to define the characteristics of the dart to be used in each BOF shop. It was observed than a reduction of 0,5 for the relative density, influences favorably in reaching an adequate restriction, regarded to tapping time and less slag carryover.

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AVANCES EN EL CONTROL DE PASO DE ESCORIA EN LOS CONVERTIDORES DE C. S. HUACHIPATO, CHILE[1]

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Resumen

A medida que se van desarrollando los productos de acero, uno de los principales objetivos de toda siderurgia moderna es optimizar al máximo la limpieza de dichos productos. En la realidad actual, esto debe estar asociado a menores costos de producción, asegurando una mayor rentabilidad. Dentro de los factores a considerar para tales logros, el evitar el paso de escoria desde el convertidor a la cuchara de acero se transforma en un elemento clave, especialmente debido al efecto directo de la presencia de elementos no deseados retenidos en la escoria, que inciden sobre la calidad del acero y también al mayor consumo de elementos aleantes. Este trabajo presenta los avances logrados en las prácticas para el control del paso de escoria durante el sangrado de los convertidores en CSH, por medio de la modificación del diseño de los retentores de escoria, discutiendo las características y los resultados obtenidos en proceso.

Palabras Clave: Convertidor LD, escoria, dardo, sangrado.

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