DEVELOPMENT OF SLAG STABILIZER FOR AMP CONVERTERS*

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Abstract

The slag volum is a commom problem in steelshop during tapping of oxidazided slag. It is specially important to ArcerlorMittal Pecém where the double slag practice is a current practice. This paper describes a solution for this problem showing the development of a product SUDFLUX PPC4 by Sudamin to stabilize the slag to reduce its volum. The product acts reducing the slag viscosity around its particles permiting the liberation of the exceed oxygen, necessary for the oxidation of slag during the primary refining process. The use of developed stabilizer reduces the process time with a positive impact on the productivity.

Keywords: Slag, stabilizer, emulsion.

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1 INTRODUCTION

In the liquid steel production, the use of the slag is essential to achieve the steel quality, free of impure elements, mainly phosphorus and sulfur. The slag is used in both phases, primary and secondary refining.

In the primary refining, it is necessary the emulsification of the slag. In converter, all the reactions of steel refining occur at contact between metal and slag. The foaming slag is necessary to increase this contact area and permits the refining reactions, mainly de dephosphorization. In the electric arc furnace, the foaming slag has another important function, keep the electric arc covered during the refining phase, reducing the energy consumption.

After the refining process, the steel is tapped to the teeming ladle and the slag is tapped in a slag pot. If the process requests also the double slag in converter, the slag is also removed in the initial phase of the process (30% of the blow) increasing the production time. During slag removal, sometimes the slag keeps the foamed condition of the process and can cause problems to be tapped at the slag pot. These problems can be the insufficient slag pot volume or splashing outside the slag pot, with safety and productivity issues associated.

ArcerlorMittal Pecém considers the Double Slag as a standard blow practice. This process is characterized by two very characteristic stages, one focused on DeP and the other on DeC. This practice uses the optimal time during the blowing, when the hot metal silicon is totally oxidazed and with the high FeO content, the dephosphorization is at the maximum value (Figure 1). The slag from the DeP stage has oxidation levels (FeT) greater than 30%, consequently, a very reactive and foaming slag. Tapping this slag requires expertise from the tilter operator and a long execution time. The use of materials that reduce process time, as well as control the condition of the slag, is of paramount importance. It should be noted that these oxidation levels can be critical in hot metal conditions where silicon is at high levels. ArcerlorMittal Pecém , having knowledge of these practices, produces steel with silicon levels of up to 2% in a stable and safe way. Figure 2 presents a summary of the Double Slag process at ArcerlorMittal Pecém.

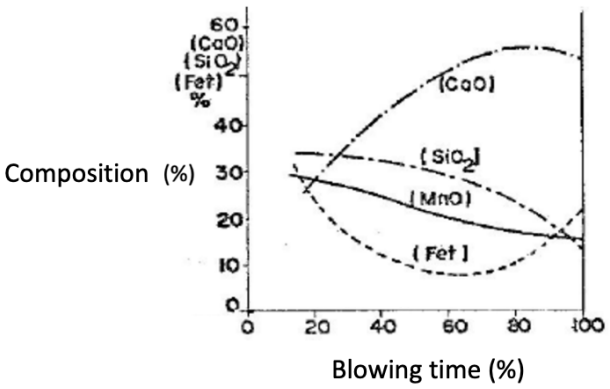

Figure 1 – Slag composition during the oxygen blowing[4]

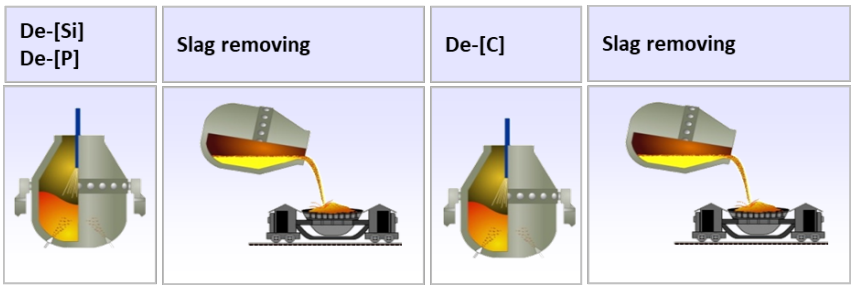

Figure 2 - Summary of the Double Slag process.

The slag remove after the first blow is very important to the slag quality of the second blow. Table 1 shows the basicity, MgO and P_2O_5 contents and the slag condition evaluation.

Table 1 – Second blow slag condition

Variable	Normal	Good	Excelent
MgO (%)	8,0	8,2	8,5
P_2O_5 (%)	1,4	1,2	0,9
Binary basicity	4,1	4,6	5,4

To support the addition process of the slag stabilizer material, the adding system was prepared to directly add in the slag spot, as showed in Figure 3.

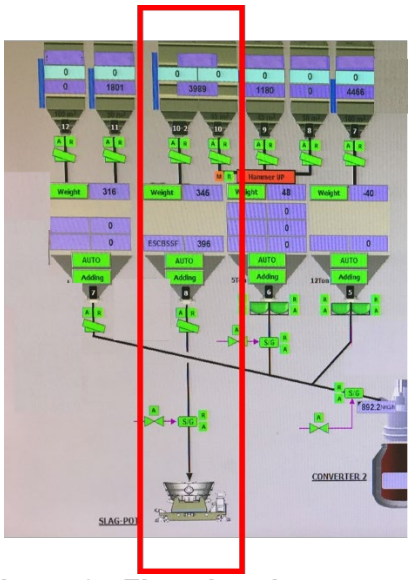

Figure 3 - Flux charging system.

The slag foaming depends on several factors. Mainly are basicity, viscosity, surface tension, presence of suspended solid particles, FeO content and injection rate of carbon particles (for EAF operation) and oxygen [1]. The foaming effect is obtained by the difficult of the gas bubble to pass through the slag. According to Luz, A.P. et al[1], the foaming index or the average travelling time of the gas (Σ, unit is defined as seconds) in the generated foam is attained by the ratio between the change of the slag height Δh (cm) and the superficial gas velocity ΔV_g^s (cm/s), which is defined as the ratio between the flow rate of the gas through the slag (Q_g, cm^3/s) and the cross-sectional area of the vessel (A_c, cm^2), Equation 1.

$$\Sigma = \Delta h/\Delta V_g^s \qquad (1)$$

The Figure 4 shows the close relationship between the foaming index and the effective viscosity, μ_e [1]. The residence time of the gas bubbles increases with the higher effective viscosity. However, there is a maximum amount of second phase particles that is beneficial for the slag foaming.

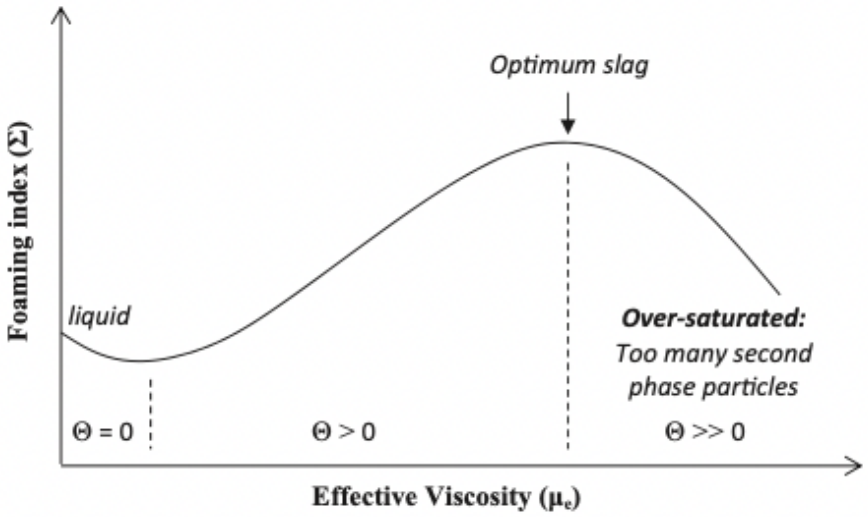

Figure 4 – The relationship between foaming index and effective viscosity [1].

The high foaming index, which is good during the refining process inside the converter or electric arc furnace, causes a problem during the slag tapping. According to Monbelli, D. et al [2], the use of silica during the slag tapping reduces the slag's melting temperature, allowing it to be maintained in a liquid stare for a prolonged period.

2 DEVELOPMENT

2.1 Materials and Methods

The use of oxygen to oxidize the bath inside converters of electric arc furnaces produces a slag with high content of FeO. The basicity necessary for the dephosphorization determines the quantity of lime add during the refining period. The Table 2 shows the typical slag analysis of BOF and EAF process.

Table 2 – Typical slag analysis of BOF and EAF

Process	CaO (%)	MgO (%)	SiO_2 (%)	Al_2O_3 (%)	MnO (%)	FeO (%)
BOF	25 - 35	6 – 10	15 - 25	6 - 10	2 - 6	25 - 35
EAF	30 – 40	6 – 10	10 – 20	4 – 8	4 - 8	25 - 40

The slag at the 30% of the blowing, where the addition of stabilizer is done, is not analysed due to the difficult to sample it. This analysis was object of studies as conducted by Baricová, D. et al[3]. Figure 5 shows the slag composition variation

during the blowing time. When can observe that the mainly difference between this slag and the final one is the proportion of free CaO, which contributes to the slag foaming by the viscosity increment.

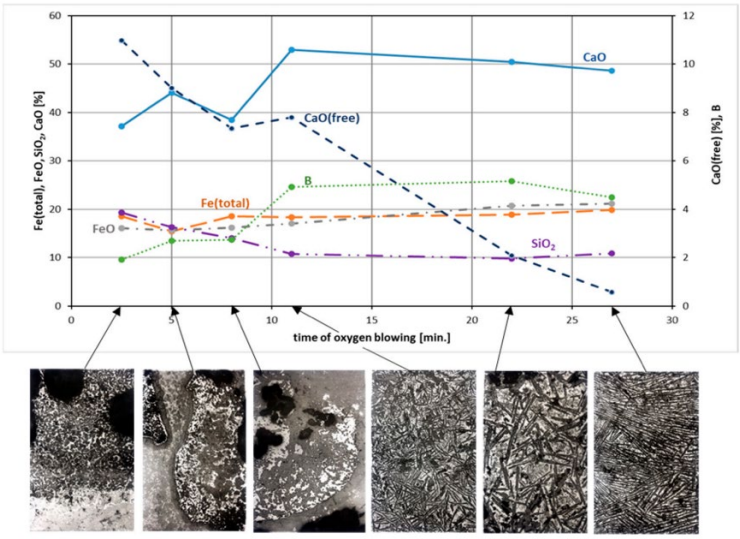

Figure 5 – Slag composition variation during the blowing time, according ot Baricová, D. et al[3]

The viscosity of BOF or EAF slag is necessary to keep the CO gas, produced during the oxidation of bath. This effect foams the slag with benefits for the dephosphorization reaction. The stabilizer must be capable to modify that situation after slag tapping. The quantity added has not to change all the slag composition, but acting locally, it permits the gases output and so, the slag volume reduction. Table 3 shows the Sudamin stabilizer specification.

Table 3 – Stabilizer specification SUDFLUX PPC4 used.

Al_2O_3 (%)	MgO (%)	K_2O (%)	SiO_2 (%)	Na_2O (%)	LOI (%)
10 -20	2 – 10	2 – 10	40 – 70	1 – 5	< 10

2.2 Results

The maximum addition predicted to get the slag stabilization is 0.7 kg/ton of steel. In the Table 4, the simulation of the final slag composition with after the stabilizer addition.

Table 4 – Final slag viscosity before and after addition of 0,7 **kg of stabilizer per ton of steel at 1500ºC**

	CaO(%)	MgO(%)	SiO2(%)	Al2O3(%)	MnO(%)	FeO(%)	Na2O(%)	K2O(%)	Visc(Pa.s)
BOF slag before	32,0	8,0	21,0	6,0	3,0	25,0	-	-	0,101
BOF slag after	31,9	8,0	21,1	6,0	3,0	25,0	0,004	0,008	0,101
EAF slag before	33,0	8,0	15,0	6,0	3,0	30,0	-	-	0,082
EAF slag after	32,9	8,0	15,1	6,0	3,0	30,0	0,004	0,008	0,082

The slag stabilizer developments achieve the aimed results in BOF, reducing the 1st blow deslagging time in 36%, from 3,8 minutes to 2,4 minutes. Figure 6 shows the time evolution, from the initial results to the routine consolidation stage.

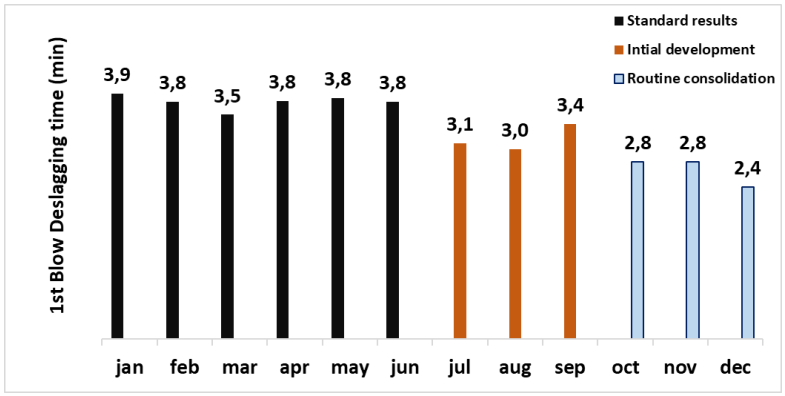

Figure 6 - 1st BOF deslagging time.

2.3 Discussion

Considering the final composition (Table 4), no change in the slag viscosity. The stabilizer acts around the region where it falls in the slag pot. It is important to notice that there is no significant change of the final slag composition.

The optimization of 1st deslagging time has a direct impact on BOF TTT (Tap To Tap) time and consequently, on the leadtime (full ladle cycle). The total leadtime was reduced in 12% due to equalization of BOF TTT and casting time. The entire steelmaking plant results was positively affected.

3 CONCLUSION

The new stabilizer SUDFLUX PPC4 developed permits the reduction of 36% of the time expended to slag tapping and them with the posivity impact on productivity and without impact the final slag composition.

The use of slag stabilizer opens new opportunities for the use of different compositions which can do the job of slag pot volume reduction and modify the slag composition. In this way it is possible to adjust the slag composition to recycle it as a component of concrets or agricultural usage.

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