FREE AND LOW CARBON ALUMINA-MAGNESIA BRICKS FOR STEEL LADLE METAL LINE

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Abstract

IF (interstitial free) steels are defined by the ultra-low carbon content, which ensures good ductility and plasticity, important properties for a good mechanical shaping and energy releasing during impact. Those properties are essential needs for automotive applications. Currently refractory solutions for steel ladle in Brazil are based on magnesia-carbon system, applied for slag lines, and alumina-magnesia-carbon, applied for metal lines. Both systems, which includes carbon levels generally above five percent weight, assure good performance, but are questionable considering carbon pick-up levels. Based on customer needs to produce low carbon IF steels, new families of free and low carbon alumina-magnesia bricks were developed. Wall and bottom metal line solutions were based on carbon-free alumina-magnesia system, with high corrosion resistance, high penetration resistance, adjusted in situ expansion and low thermal conductivity, which also assure no carbon pick-up into the steel. For the specific case of impact pad, a low carbon alumina-magnesia brick, with high hot mechanical strength, was developed to improve local erosion resistance and to reduce carbon pick up possibilities. Both solutions allowed the customer the possibility to increase steel ladle life to 130 heats, safely working to avoid carbon pick-up in ultra-low carbon steel production.

Introduction

Being a current supplier for one of the biggest IF steel producer in Brazil, Saint-Gobain do Brazil LTDA has been implementing a continuous improvement for steel ladle refractory lining practice on customer plant that produces IF steel. Although MgO-C and Al_2O_3-MgO-C[1, 2)] products have been the common practice at almost all integrated steelmaking producers in Brazil, that particular case requires low carbon MgO-C for slag line, and free carbon products for most of the metal line, including the biggest extension at the bottom, mainly to avoid carbon pick up at steel processing. The steel ladle lining practice was them limited by fired or unfired Al2O3-MgO products[3, 4)], which have lower spalling resistance when compared against carbon containing products.

Since 2013, products have been improved to reach new life records, year by year, with a current scenario that shows a huge improvement of more than 20% of life increasing for the first semester of 2017, as show in Fig. 1.

On the increasing life history, only 2015 was out of the rule, mainly due to spalling issues that happened on the bottom, especially between well blocks (plug and slide gate), and also because of impact pad high wear. The slag line relining at the middle of the campaign is a common practice during all steel ladle supply. Fig. 2 presents a steel ladle bottom after 72 heats, with a clear aspect of spalling that happened between well blocks.

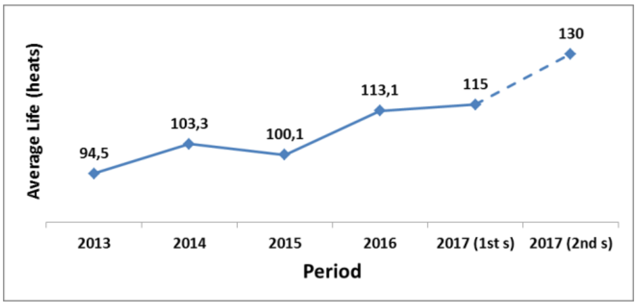

Fig. 1 - Average steel ladle life improvement for IF steel producer in Brazil.

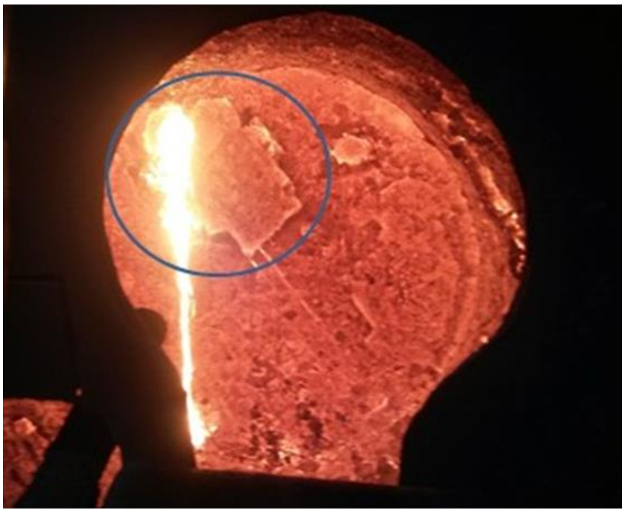

Fig. 2 - Steel ladle bottom after 72 heats, showing spalling of bricks at region between well blocks.

Developments

The practice for IF steel ladle lining had been applied products described in Tab. 1. As can be seen, products show low carbon content for slag line, and no carbon to metal line, which is appropriate for IF and ULC steel grades to avoid carbon pick up.

Tab. 1 – Steel ladle products used for IF steel production from 2013 to 2015.

Properties	Slag Line	Wall	Bottom
Al_2O_3		88,0	91,3
MgO	87,5	6,9	3,7
C	5,6		
Others	6,9	5,1	5,0
A.D.(g/cm³)	3,12	3,28	3,28
A.P. (%)	5,3	12,6	10,7
CCS (MPa)	45,0	52,9	103
MOR(MPa)	19,0	14,0	30,6

After spalling issues at the region between well blocks, and observation of higher wear speed on the impact pad, two new products have been developed to be applied on those regions to solve the problems. Developed products are shown in Tab. 2, comparatively with bottom current product.

Tab. 2 – New products developed for impact pad and region between well blocks.

Properties	Bottom	Impact	Well block region
Al_2O_3	91,3	89,1	93,6
MgO	3,7	2,5	3,9
C		4,2	
Others	5,0	4,2	2,5
A.D.(g/cm³)	3,28	3,32	3,20
A.P. (%)	10,7	5,5	16,0
CCS (MPa)	103	33,7	100,0
MOR(MPa)	30,6	7,5	25,0

The wear index during dynamic slag attack (rotary lab kiln, at 1680°C, per 2 hours) of the new developed products is presented in Fig. 3. The well block region product showed a slag corrosion resistance compatible with the previously applied bottom brick. However, the new impact product was clearly improved in terms of corrosion resistance. Aspect of developed products after corrosion tests can be observed in Fig.4.

Also, the thermal shock resistance was improved for the new product of well blocks region when compared to current product that was previously applied for all bottom. Fig. 5 shows the residual elastic modulus (by ultrasound determination) after thermal shock at several temperature differences for those products. For the impact pad product, which contains carbon, thermal shock test is done at air, while for bottom and well block products it is done at water. Because of that, data for impact pad is not presented and cannot be compared. Although, is well known that carbon containing products present better thermal shock resistance than free carbon ones.

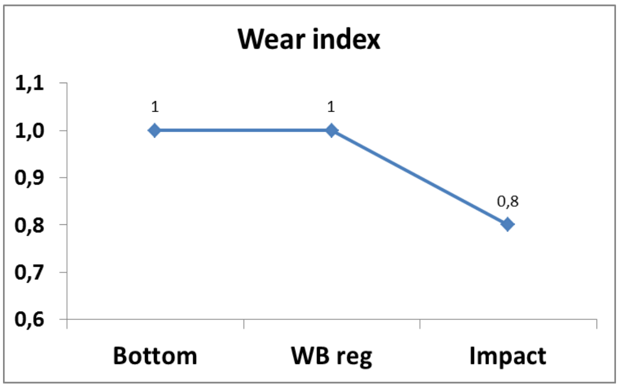

Fig. 3 – Wear index of steel ladle products, after dynamic slag attack at rotary lab kiln, at 1680°C, per 2 hours.

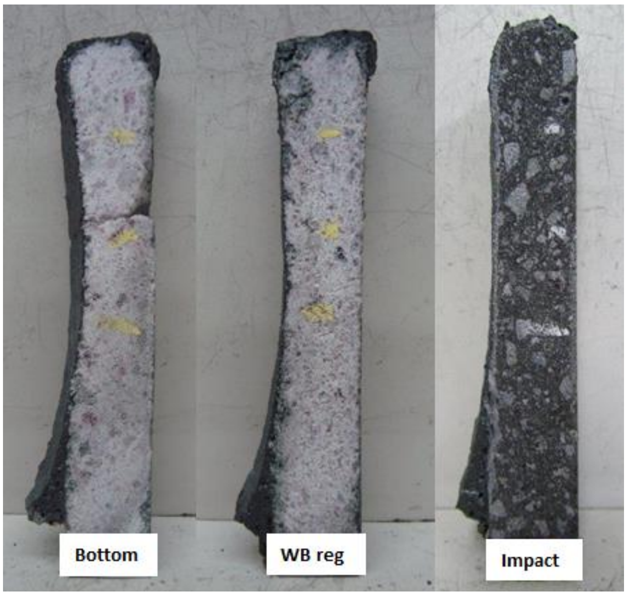

Fig. 4 – Aspect of steel ladle products, after dynamic slag attack at rotary lab kiln, at 1680°C, per 2 hours.

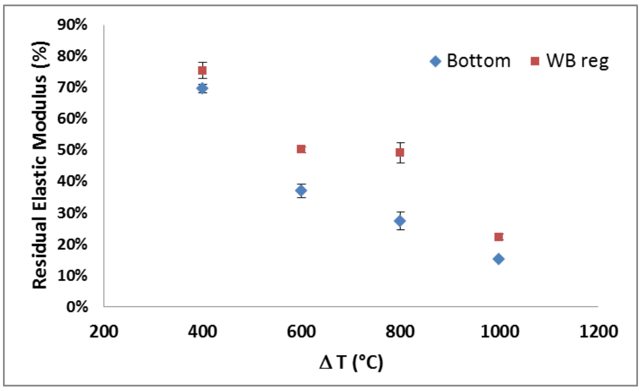

Fig. 5 – Residual elastic modulus (by ultrasound determination) after thermal shock at several temperature differences for developed products.

Field Application Results

Developed products have been applied at steel ladles for last campaigns. The steel ladle bricks aspect during operation is shown in Fig. 6. As can be seen, no more spalling is observed at region between well blocks, after 67 heats, what was very common to observe previously.

Although the steel ladle life was kept at 115 heats, the remaining thickness measurements of all brick regions have been pointing a minimal potential life of around 130 heats, considering a minimal safety thickness of 60mm defined by customer. Tab. 3 show the average potential life of the last 7 steel ladles lined with the developed products.

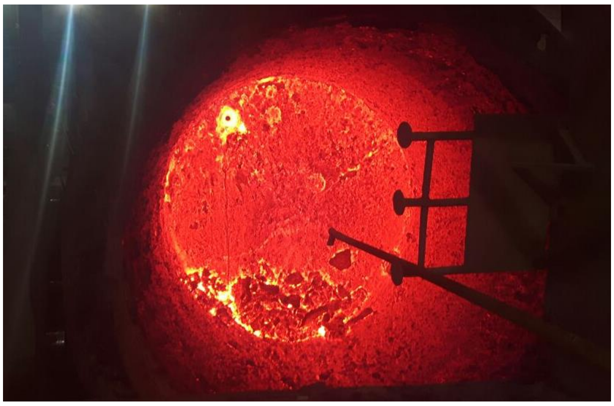

Fig. 6 - Steel ladle bottom after 67 heats, showing no more spalling of bricks at region between well blocks.

Tab. 3 – Average potential life (7 campaigns) of steel ladle regions lined with new developed bricks.

Region	Slag Line	Wall	Bottom
Average Potential life	130,4	157,0	143,0

Numbers in Tab. 3 show that life of 130 heats is completely possible for the steel ladles, considering the minimal safety thickness. However, the potential life of bottom showed more than 140 heats.

Conclusions

The life of steel ladles used for IF steel production has been improved using refractory lining solutions based on fired and unfired alumina-magnesia bricks. Those products allowed to solve spalling problems observed at the region between well blocks, and achieve the remaining safety thicknesses for bottom region of steel ladles above that stipulated by the customer. Wear profiles has showed that life of 130 heats is completely possible in a short future and that life of 140 heats, or more, is possible with slag line thickness increasing, to adjust the remaining thickness of that region for the safety value required by customer.

New developments are still on running with the objective to make possible life increasing to 160 or more heats. However, new challenges, especially considering slag line wear and repair practices should be overcome.

References

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