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RESEARCH ON THE MECHANISM OF DAMAGE LINE BRICKS IN THE SLAG LF

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ABSTRACT: This paper proposed to analyze, based on fundamental known, the slag influence generated on LF process on the ladle refractory. In this purpose were studied the refractory destruction mechanisms used on LF, the slag quality, quality refractory and the slag influence on refractory especially because of the interactions between them, definitely elements for steel quality and also for the refractory endurance.

KEYWORDS: refractory, interaction slag-refractory

INTRODUCTION

The main wear mechanisms of the refractory ladle slag line are chemical corrosion and mechanical erosion due to stirring of the steel bath. Chemical potential difference between the refractory and the slag under high temperature conditions is driving force for chemical wear mechanism. Destruction process depends on many variables: temperature, refractory composition, slag thickness, slag composition and stirring degree.

The objective of this paper is to analysis of the interaction between LF bricks steel ladle in contact with slag. In this purpose were determined the slag characteristics on the hot face brick, the slag and the refractory interaction carried out by optical and electronic microscopy (SEM) and X-ray diffraction.

THE STUDY

The study was carried out on scrapped brick from LF installation from Calarasi, the brick is part of the steel ladle refractory lining slag level. Determined proprieties for the studied brick are in the following table 1.

The slag deposited thickness on the refractory brick varies between 3-6 mm (fig.1).

The bricks appearance is shown in Figure 1 and in figure 2 is presented the bricks appearance after removal of an important part of slag layer deposited.

<table>
<thead>
<tr>
<th>Table 1. Properties of bricks used at slag level</th>
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<tr>
<td>Apparent density (g/cm³)</td>
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<td>Apparent porosity (%)</td>
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<td>Apparent density after heating at 1150 °C</td>
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<td>Apparent porosity after heating at 1150 °C</td>
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Fig.1. Deposited slag on brick after its used in LF

Fig.2. Interface between slag layer and brick
Tabel.2. LF slag chemical composition deposited on hot face brick

<table>
<thead>
<tr>
<th></th>
<th>CaO</th>
<th>MgO</th>
<th>Al₂O₃</th>
<th>SiO₂</th>
<th>SO₃</th>
<th>Fe₂O₃</th>
<th>CoO</th>
<th>TiO₂</th>
<th>MnO</th>
<th>Cr₂O₃</th>
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The removed slag was analyzed chemical and structural. The results are in Table 3. Slag layer shows pores and two different layers (Fig. 3). These layers contain phases and microstructural aspects of different chemical compositions.

- First layer has 2.2 mm thickness and it is composed from dendrites crystals of magnesium oxide, iron oxide, iron and calcium aluminates and calcium crystals silico-aluminates. All these are immersed in a matrix of calcium aluminates.
- The second layer has 3 mm thickness and it is composed of magnesium crystals damaged by iron and manganese alumino-silicates crystals with different contents of calcium, iron and titanium, calcium aluminates - magnesium - iron and calcium silicate crystals.

**INTERACTION SLAG AND BRICK GRAIN**

At the interface between slag and brick MgO grains were found torn from brick and immersed in slag. Distribution of elements in this area is shown in Figure 4. Corrosion can be observed due to the interaction between the iron grains oxide and magnesium oxide. Slag penetrates the silicate sinters grains network and melt intragranular silicates. This interaction speeds the lower temperature phase formed and facilitates separation from crystal.

**Slag- brick matrix**

Micro structural analysis reveals the decarburization process of the brick matrix in contact with slag (Fig. 5). Interface slag-brick is shown in Figure 6. In the brick matrix there are formed spinal crystals. Also, crystals were identified calcium silicate in the brick matrix.

**Analises, Discutions, Approches And Interpretations**

The first slag layer is composed on calcium aluminates matrix with melting temperature at 1400°C and different crystals:
calcium alumina and iron alumina, with softening temperature at 1336°C (equilibrium phase diagram for the system $\text{Al}_2\text{O}_3 - \text{CaO} - \text{FeO}$);

Calcium and aluminum silicates with softening temperature of 1380°C (equilibrium phase diagram for the system $\text{Al}_2\text{O}_3 - \text{CaO} - \text{SiO}_2$ Fig. 7);

MgO dendrites.

The chemical composition of the first slag layer is shown in Figure 6. This chart show that the slag is completely liquid at 1600°C, and therefore, it is not saturated endanger. First layer of liquid slag is not saturated with MgO and at 1600°C.

The second layer is composed from adhered slag stickled to the brick, this layer contains a higher level than the first layer of iron oxide slag. He probably comes mainly from the pot slag before the LF treatment. Also, the second slag layer has a lower content of calcium oxide than the first layer of slag. The second layer of slag is composed of calcium aluminates matrix and different types of crystals:

- calcium, titanium, and iron silicates and aluminum with different contents of these elements with melting point at 1400-1500°C;
- calcium silicates and aluminum with melting temperature at 1450°C (fig. 7 diagram of phase equilibrium in the system $\text{Al}_2\text{O}_3 - \text{CaO} - \text{SiO}_2$);
- different contents alumina of calcium, magnesium and iron;
- MgO crystals attacked with iron oxide first and then the manganese oxide and calcium oxide.

This mechanism is the result of iron elements, manganese and calcium existing in the slag that runs the fastest in the refractory material to form the corresponding reaction products.

The chemical composition of the second layer is shown in Figure 8. This slag is saturated with magnesium oxide at 1600°C.

**Conclusion**

The study of brick out off used was carried out through optical and electronic microscopy (SEM) and EDS analysis, allowed identification of slag- brick adherence characteristics, refractory wear mechanism and the microstructural changes inside the brick.

The slag on the brick hot face is composed of two different layers. Aceste straturi conțin aspecte microstructurale distincte și faze cu compoziții chimice diferite. Both layers are aggressive to the refractory material lining.
The first slag layer is not saturated with magnesium oxide and it is completely liquid at the process temperature. It is well known that this condition is the main cause of corrosions and bricklayer destructions;

The second slag layer is saturated with MgO but contains a high level of iron content. This oxide in growth the slag fluidity-broke the silicate network from the brick and allow the matrix decarburization, thus:

\[ FeO + C = Fe + CO \]

Graphite oxidation growths bricks porosity, allowing slag penetration in the system, following periclase grains dispersion in slag. Review mechanisms identified are: graphite oxidation, slag penetration into matrix and around MgO grains and finally MgO grains dissolution into slag. More over, iron spread in MgO grain and allows MgO slag molder. This new phase decrease the MgO grains refractory and also delay speed destroy of refractory material. This mechanism leads indirect MgO grain dissolution.

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