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Physico-Chemical Ways of Improving Oxygen Converter Lining

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Abstract

This paper is a file of analytical information with intent to summarize so far known knowledge and to anticipate new development and possibilities of improving oxygen converter lining. Technological methods currently used in steel production put high requirements for the quality parameters of used refractory building materials. The article pursues the analysis of balance thickness of the magnesium-carbon refractory lining of basic oxygen furnace during the campaign. Development and innovation of the technologies of steel production is also reflected in increment of the requirements for magnesium-carbon refractory materials for basic oxygen furnace linings. Permanent increment in steel production has substantial influence on the refractory materials consumption in the worldwide scale. Specific methods proceedes during refining process of scrap material as quick temperatures alternation, changes in slag composition or impacts of heavy pieces of scrap material, influences destructively the basic lining of basic oxygen furnace. The static crucible corrosion test, as a simple experiment, is very useful for study of these processes because a direct observation of refractory – slag reactions in real systems is impossible. For that reason, corrosion crucible tests were adapted so that carbon basic refractories was isolated from the atmosphere by high alumina cast able cover. For such reason the high accent is put to the charge of refractory lining during the campaign which is connected with permanent increment of gunning repair refractory materials consumption. Continual increment of refractory bricks quality leads to the prolongation of time of the basic oxygen furnace campaigns.

Keywords: Refractory material, Lining of converter, Steelmaking process, Basic oxygen furnace, Corrosion tests

1. Introduction

This paper is a file of analytical information with objective to summarize so far known knowledge and anticipate new development and possibilities with increasing lifetime of oxygen converter lining. I have chosen this subject because there are many possibilities to try new technologies, to improve properties of oxygen converter linings and consequently improve steel quality. Decrement of steel-making costs is becoming ever more important issue. Cost of OC is one of the most important cost factors. Information on lining wear is very important for improvement of its quality and lifetime.

The aim of the work is to investigate and also describe physicochemical factors which affect depreciation of basic refractory converter slurry (spraying) fettling and thus the whole lifetime of the MC cap sills during the steel production. The most important factor which affects the lifetime of the MC cap sills is the carbon bond in MC cap sills. Basic refractory fettling of oxygen converter is composed of several oxides which creat the basic lining.
There are $MgO–CaO–SiO_2–Al_2O_3$ (Fig.1). The basic oxides are products of interaction of the lining and the converter slag /$MgO–CaO–SiO_2$/. MgO features in this system, i.e. oxid, dissolved partially in the slag. In the oxygen converter, the phase ratios at the boundary of the lining as

well as slag are too complicated. It is caused by the change of basicity of the slag melt. The objection of the introduction of the new repair technologies is to decrease the cost of steel production for 1 ton of steel during campaign, mainly by intensive using of repair procedures in cold sand and hot condition.

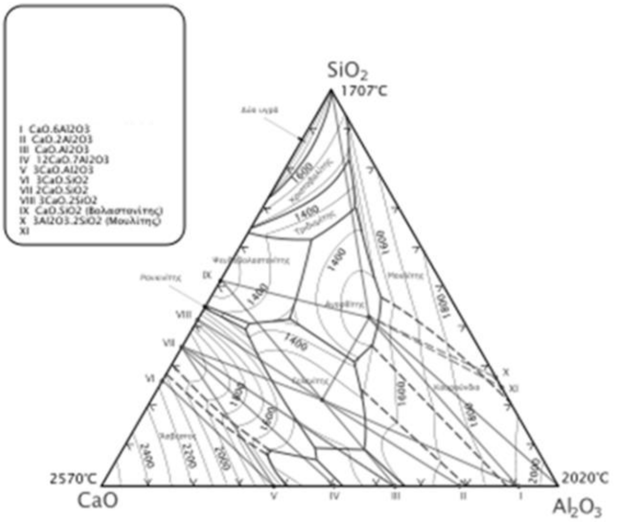

Fig. 1 Diagram of system $CaO-Al_2O_3-SiO_2$

Refractory corrosion is a complicated thermochemical and thermophysical process. Existing thermochemical reaction can be described with thermodynamic criteria of stable conditions. Corrosion reaction depends upon chemical character of refractory and melt. Nonetheless, the corrosion of lining depends on speed that slag eliminated MgO from the lining. One way to efficiently decrease wear of OC converter and increase its lifetime is to enrich slag with MgO. We can either add:

- dolomititic lime,
- burned or caustic magnesia,

in order to achieve about 8 % MgO, which is limit of its solubility. If we have excess MgO we will create a protection coat upon on the surface of working lining, this has a beneficial effect upon the lining lifetime in the area of trunnions and bottom of the oxygen converter.

Introduction of new technologies for construction and repair of lining by gunning materials increases the lifetime for lining. Gunning materials have been widely used for maintenance and repair for linings of industrial furnaces. Improving its physical and physico-chemical properties will be introduced new technologies so that will reduce the production costs on 1 tone of steel and subsequently improve the processes of steel production in the OC. New technologies for construction and repairs of MC cap sill have been carried out by the gunite substances. The aim is to increase the holding time of oxygen converter lining and therefore it is necessary to create magnesite tag which protects the lining (Fig.2). For maintenance and repair of steel production furnaces lining, the gunite substances have been used. To improve the physical and physicochemical properties it is neccessary to introduce new repair technologies by which expenses for the production of 1ton of steel can decrease and by the improvement of process of steel production in oxygen converter.

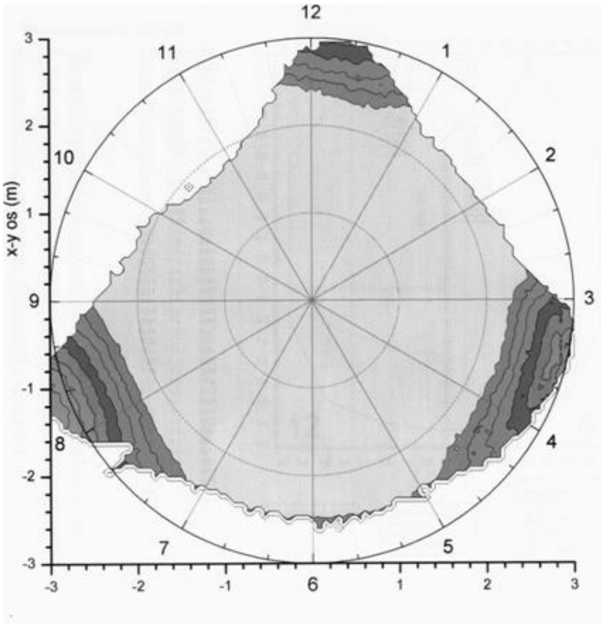

Fig. 2 Visualisation of thermo-vision camera LAND

2. Experimental work

We tested and mutualy compare several types of gunite materials designed for repairs of MC cap sills from their physico-chemical properties. Also, we will test by us designed the MC cap still of specific composition and properties (bond, substantial base).

1. Methods of processing and evaluation of experimental testing will be applied.
2. The corrosion test on different materials will be carried out.
3. New types of gunite materials will be mutually tested.

Visual assessment of the penetration depth and uniformity of the converter slag into heatproof (system MgO-C) gunite mixture can be observed as was necessary infiltration of slag into the molten material. (Fig. 3).

An experimental meltings were realized at laboratory for foundry experiments at Department of Technological engineering. Melts was carried out in an electrical resistance furnace T15, controlled by PID regulator CAL 3200 in a graphite crucible treated by protective coating. Individual casts consisted from creating four samples poured at a temperature 760 ± 5°C. Melt was poured into metal mold with three different temperatures (100°C, 150°C and 200°C. As an experimental material was used steel. The chemical composition of used alloy is in Table 2**.**

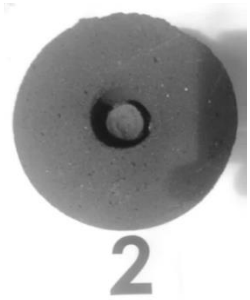

Fig. 3 Sample – after static corrosion test

Table 1. Composition of samples after corrosion test

sample	CaO	Fe_2O_3	SiO_2	MgO	loss of firing
1	48,41	0,492	23,50	25,46	1,469
2	48,41	0,331	22,85	24,44	1,523
11	48,41	0,308	22,90	24,92	1,485
22	46,89	0,390	23,15	27,09	0,942
1top	12,56	1,923	2,71	75,59	6,84
1center	16,51	1,659	2,38	70,59	8,88
1edge	15,71	2,028	2,26	68,88	9,58
2t	12,98	2,035	2,19	73,68	8,75
2c	21,24	0,937	2,12	63,05	15,21
2e	12,17	1,642	2,03	75,37	8,47
11t	14,94	1,122	0,92	72,06	8,94
11c	16,90	1,306	0,99	68,24	10,76
11e	15,32	1,234	0,80	71,91	8,54
22t	16,13	0,844	0,89	70,19	10,94
22c	21,24	1,015	0,80	62,10	14,90
22e	21,62	0,708	0,75	63,91	13,68

We had 4 samples of heatproof of MgO-C. The samples had been labeled as follows: 1-2-11-22. These materials use gunit materials oxygen furnace linings. (Fig. 4).

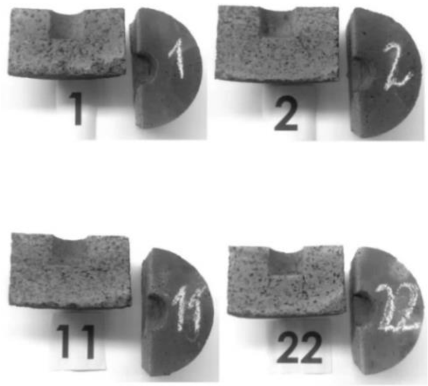

Fig. 4 Samples – after static corrosion test

Shows the penetration of slag melt into heatproof material. We carried out chemical analysis of converter slag after static corrosion test by U. S. Steel Košice (Fig.5).

Material for chemical analysis were taken from three parts of the sample / center, top, edge – Table 1/.

- penetration occurs,
- slag melt from 1311°C to 1318 °C,
- slag is diffused into the gunit material,
- creation of new phases,
- undisturbed material in temperatures of 1500°C.

Summarily, gunit materials was given in a dynamic process, i.e. the production of steel in basic oxygen furnace to high impact wear resistance base layer lining. Otherwise, it caused improvement of service life.

Evaluation of corrosion in high-temperature media microscope test.

Table 2. Steel slag composition of type A and type B

slag	basicity	FeO	MnO	SiO_2	Al_2O_3	CaO	MgO	P_2O_5	S
A	4,10	22,11	3,57	11,42	0,87	41,88	8,41	0,85	0,03
B	3,70	20,50	4,12	13,11	0,73	41,62	9,01	0,63	0,03

Formula for calculating the relative basicity of slag used in Table 2:

$$B = \frac{CaO + MgO}{SiO_2 + Al_2O_3} \% \quad (1)$$

Model tests have been realised in arc furnace with temperature regulation adjusted betwen 0-1500°C, at temperatures 250°C, 400°C, 720°C, 950°C, 1400°C and 1500°C.

Slag of type A
By to melt at 1353°C
Creep at 1418°C

Slag of type B
by to melt at 1333°C
creep to melt 1411°C

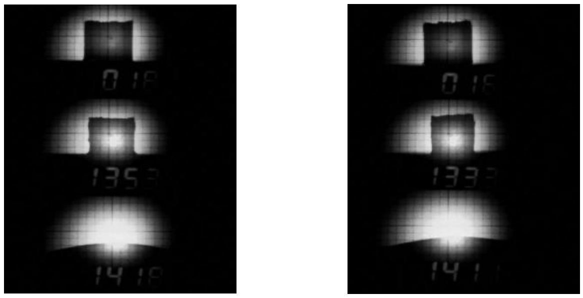

Fig. 5 Steel slags during high-temperature test

3. Conclusions

Experimental part of work contains laboratory test. Our purpose was to find out the temperature of melting torcrete substance that have been successfuly reached. We acknowledge that burning is faster at temperature over 1200°C – 1500°C. Moreover, the liquidity and the softness of mixture had lost faster – there is not enought time to melt - because there is too fast carbonization and solidify at the edges /caused by the heat/. On the basics of this practical gauging and following findings we can assume that improvement of oxygen converter lining life come into a force with use of highquality built up MgO-C materials and use of concrete mixtures for repair.

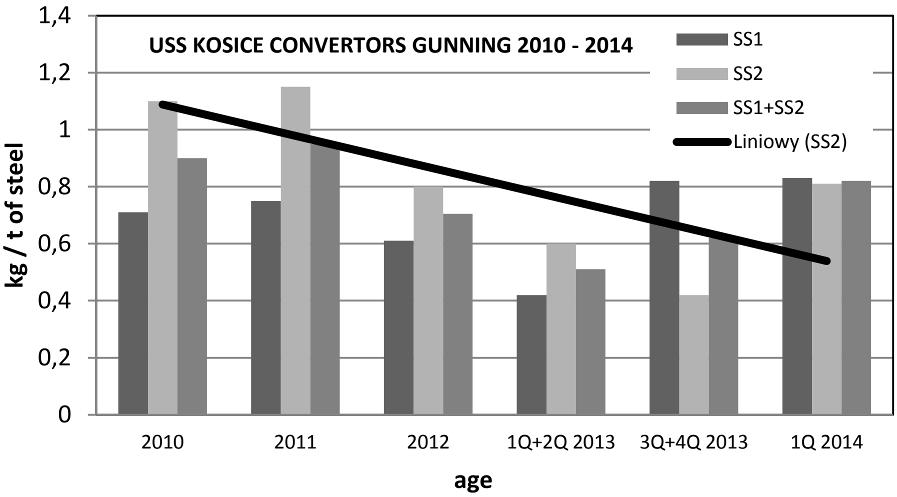

Fig. 6 Convertors gunning materials at 2010 to 1Q 2014 to USSK

Design optimal composition of the lining band MgO-C specific bands for specific composition of bulding materials. Optimal content is 8% MgO in the melt of oxygen converter. Based on the long term practical experience, it is expected that with careful treatment of the lining by gunning and splashing of the lining by modified slag with MgO content min. of 8% according to the measured wear of lining service life will improve significantly and the specific consumption of materials for the lining repair will be decreased.

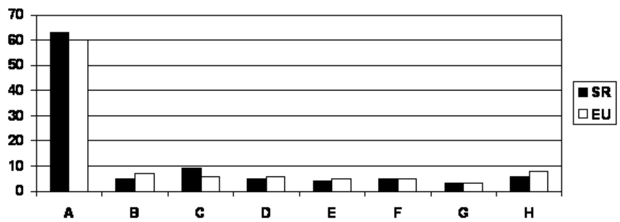

Fig. 7 *METALRGY INDUSTRY* (A) glass-making (B); cement(C); ceramics(D); non-ferrous metallurgy (E); power engineering (F); chemistry (G) and others (H)

Development of new technologies in the steel industry and also the effort of steelmakers to decrease the specific consumption of the refractory materials for a metric tone of produced steel and to prolong cycles between each revisions lead to increase the pressure on producers of the refractory materials year by year to bring out new products of better utility (working) attributes to the market. While couple of years ago it was sufficient to bring several basic range of goods of gunite to the market, their current situation has changed. The assortment of products has extended in totally to more than 50 different basic substances in categories of spraying, gunite, stamping, repair and filling substances (masses). Gradual transfer from extensive development of society to produce goods of higher quality last several years have shown an rapid increase of refractoery and materials productioon (more than 20%). Increase of special refractory materials production has been recorded in 2012 as well (Fig.7). Last 11 months since the beginning of the previous year more than 61 685 tons has been produced than it was planned for the world-wide refractory materials of this type of production.

In the future it is anticipated that refractory lifetime will exceed 19 000 heats per campaign. The object of the introduction of the new repair technologies is to decrease costs of steel production per 1 ton of steel during campaign, mainly by intensive using of repair procedures in cold sand hot condition.

Object of these repair technologies is to do decease costs per 1 ton of steel per campaign, mainly by intensification of repair technologies performed on hot and cold OC.

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