REFRACTORIES FOR OXYGEN STEEL-MELTING PROCESSES (DISCUSSION)

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The use of oxygen in the production of steel places more rigid conditions on the service of refractories. Therefore, the job of increasing the life of the linings of steel melting furnaces, and especially converters, in connection with the development of the converter production of steel, is extremely important.

The well-known method of increasing the life of refractories in service, as well as improving the quality of the raw materials, is to increase their density, while preserving adequate spalling resistance [1-6].

If an improvement in the life of aluminosilicate and silica refractories on account of increases in density is forthcoming and soundly based, then in regard to basic refractories, in particular magnesia, in our opinion this trend is not the only one, and does not fully exhaust the possibilities of these materials in regard to all service conditions.

The main factor producing wear in fireclay and silica refractories in metallurgy is the reaction with ferruginous and lime slags with the formation of liquid melts. In some cases, even the use of extremely dense fireclay and silica refractories does not increase their life in metallurgical furnaces [5, 8].

The mechanism of the wear of basic refractories is different. The main factor of erosion in the latter is the plate-like scaling and spalling of the pieces of refractory (about 25-40 mm in size) at the working surface. In many papers [1, 2, 3, 7, 9, 10] in which the wear of basic refractories is examined, there is confirmation of the necessity of investigating this type of wear. As a result of detailed analysis of the phenomenon of scaling, most authors consider that the main cause arising in the basic refractories is the sharp change in physical properties such as porosity, strength, linear expansion and spalling resistance of the working part of the refractory, having a zonal structure as a result of single-sided heating. Heterogeneous impregnation of the refractory by highly ferruginous slags and the different degree of supplementary sintering reinforces the differentiation of the zones and their physical properties.

In contrast to aluminosilicates and silica refractories, the possibility of increasing the quality of magnesite-chromite, magnesite and especially dolomite refractories containing free lime on account of further reductions in their porosity, has apparently reached the limit. Reduction in apparent porosity below 10-12%, we suggest, will reduce the spalling resistance of the articles; furthermore, it requires the use of much higher fabricating pressures, which on an industrial scale, for the manufacture of tonnage products, is very difficult. The proposal that further densification of refractories reduces their permeability to molten slags cannot be justified. It is possible to assume with a reduction in porosity there will be a reduction in the diameter of the pores as a result of which there will be an increase in the capillary forces of the suction of slags into the pores, which is not difficult of detect from the equation connecting the height of the liquid in the capillary (h) with the surface tension (S), the diameter of the capillaries (d) and the specific gravity of the liquid (6); h = 4S/d6.

The above ideas and some experimental data permit us to aim for the achievement of completely satisfactory lives in basic refractories on the basis of dolomite having a porosity of the order of 25-30%.

During tests on experimental tared dolomite brick in steel converters with top oxygen blow, it was found that the spent brick had a bulk density of 2.2-2.6 g/cm³ instead of 2.8-3.0 g/cm³ before service. Consequently, the true porosity in service was equal to about 25-33%.

*In the nature of a discussion.
Despite such a high porosity, the tarred dolomite brick made from dolomite containing 6.11% SiO₂, 6.0% Al₂O₃ + Fe₂O₃, 50.0% CaO, 36.0% MgO, 1.5% loss on ignition, in a 25-ton converter with a lining life of 119, 106 and 54 heats, had a wear rate per heat respectively of 2.6, 3.6 and 2.4 mm; and tarred dolomite brick made from purer dolomite containing 6.0% SiO₂, 2.5% Al₂O₃ + Fe₂O₃, 51.4% CaO, 37.8% MgO 2.5% loss on ignition, free lime 34.3% in a 55-ton converter with a lining life of 121, and 117 heats, had a wear rate per heat respectively of 1-2 and 3-3.5 mm.

Dense fired magnesite-chromite brick of the type PSh with a porosity of the order of 12-18% in the same conditions had a wear rate in the range 1.3-2.5 mm per heat.

During experiments it was also found that converter slag actively reacts with tarred-dolomite linings and forms a refractory crust 10-5 mm thick. The crust is so difficult to fuse that it is not completely eroded during the following heat. With magnesite-chromite linings the phenomenon of "welding" of the converter slag and the formation of the skin was not noted. Upon microscopic investigation of the reaction products of the converter slag with the dolomite by the crucible method, it was found that on the interval surface of the crucible the slag skin consists mainly of α-2CaO·SiO₂, and in the thicker wall there is a predominance of 3CaO·SiO₂ and ferrite phase.

In investigations of the brick worked in the walls of a 30-ton electric steel furnace at KMK [11] it was also found that easily fusible silicate melts in magnesite-chromite brick penetrate to a depth of 50-55 mm, and in tarred dolomite to 15-17 mm.

The above differences in the properties of tarred dolomite and magnesite-chromite refractories upon reaction with them of slag melts are due, it must be assumed, to the presence in the tarred dolomite refractories of free oxides of calcium, which are more active than magnesia [12, 15].

The presence in the tarred dolomite refractories of carbon also contributes to the formation of infusible crusts on account of the reduction of the iron oxide from the dicalcium ferrite to the ferrous oxide according to the equation 2CaO·Fe₂O₃ + C = 2CaO + 2FeO + CO.

The calcia being chemically more active than magnesia rapidly reacts with the meta-and orthosilicates of the slag melt with the formation of more infusible materials, enrich with highly refractory bi- and tricalcium silicates, as a result of which there is a reduction in the depth of penetration of the slag melts into the dolomite refractory.

Also worthy of attention is the wider testing in various parts of the structure of metallurgical furnaces, in addition to dolomite, of unfired and fired limestone brick.

Table 1 gives the properties of unfired and fired lime brick*. The limestone used to make the brick contains, %: 54.91 CaO, 0.45 MgO, 0.72 Fe₂O₃, 0.28 Al₂O₃, 0.04 SiO₂, 45.87 loss on ignition. After firing at 1700°C the apparent porosity of the lime in lumps was 27.4%. Into the composition of the mass containing 90% lime and 10% pitch the investigators introduced 2.8% anthracene oil.

After firing at 1750°C the lime brick, despite the high porosity -29.5%, has a high initial deformation temperature -1700°C, and 4% sag was not observed even at 1800°C.

There is no doubt that this feature of lime brick may prove to be very valuable in tests in the linings of steel converters and also in the structure of the upper parts of open-hearth furnaces and especially in the main roofs, bearing in mind the low bulk density of this brick and the low thermal conductivity.

*Study of the properties of the limestone brick by L. V. Kravets.