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USE OF SHS REFRACTORIES FOR THE LINING OF FERROUS METALLURGY UNITS

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Results of use of SHS materials as refractory mortars for the lining of ferrous metallurgy units are presented. It is shown that using Termok-3 SHS mortars increases substantially the durability of the linings of units operating in a medium of both basic and acidic slags.

At present, acceleration of advancement of metallurgy makes the problems of intensification of production processes the most urgent ones. One of the most promising lines of perfecting high-temperature processes is creation of basically new materials [1-4].

Currently, about 60% of the total output of refractory products is consumed by ferrous metallurgy enterprises, whose production processes require operation of units under extreme conditions. The weakest link in the lining of the units is the brickwork joints. Melted metal and slag flowing into them and effects of corrosive gaseous media result in rapid wear of the lining.

Traditional refractory mortars are mixtures of ground refractory materials, which, after mixing with water, are used for binding individual components of the brickwork of thermal refractory units.

The choice of refractory mortars depends on the operational characteristics of the unit. A general requirement imposed on the mortars is their chemical homogeneity with the refractories to be bound (for instance, fireclay brickwork requires fireclay mortar). At present, ferrous metallurgy enterprises use mainly dinas (MD-92, MD-94) and aluminosilicate (MSh-39, MML-62, MMK-85) mortars and magnesite caustic powders (PMK-75, PMK-87, PMK-90) [5]. Water glass, lignosulfonates, and phosphate binder are used as a binder for these mortars.

In the interaction between the filler and the binder (the latter is removed from the system as the temperature rises), diffusion sintering takes place and propagates to a depth of about 15%. This is a time-consuming process and does not ensure hermetic sealing of the brickwork. The lining produced in this way does not have sufficient strength, which results in premature destruction of the brickwork because some bricks and sections of the lining fall out.

At the Kazakh Metallurgy Science and Technology Center for SHS, unconventional Termok-3PM SHS mortars were developed for use in a basic slag medium and Termok-3MM SHS mortars were developed for use in an acidic slag medium [6-8]. The main components of these mortars are a reducer (aluminum), an oxidant, a filler, and a mineral binder. In thermal units, using these mortars at temperatures of 1000-1200 °C, SHS results in sintering of mortar and brickwork components into a monolith at a rate of 1-3 mm/sec due to propagation of the combustion wave front to a depth of 70-80% of the lining thickness. In proportion to the wear the upper boundary of the sintering zone is shifted toward the outer surface of the lining.

Tests have shown that the content of aluminum in the mortar must be at least 8%; otherwise the heat released is insufficient for starting an exothermic reaction and for maintaining steady combustion. On the other hand, an increase in the aluminum content above 16% leads to fusion of the products, which lowers the lining quality. The high cost of aluminum dictates the choice of its content at 8% in the mortar composition.

X-ray phase analysis has shown that SHS occurring in the bulk of a refractory joint leads to formation of high-refractory phases: Al_2O_3, MgO, mullite $3Al_2O_3 \cdot 2SiO_2$, and spinel $MgAl_2O_4$.

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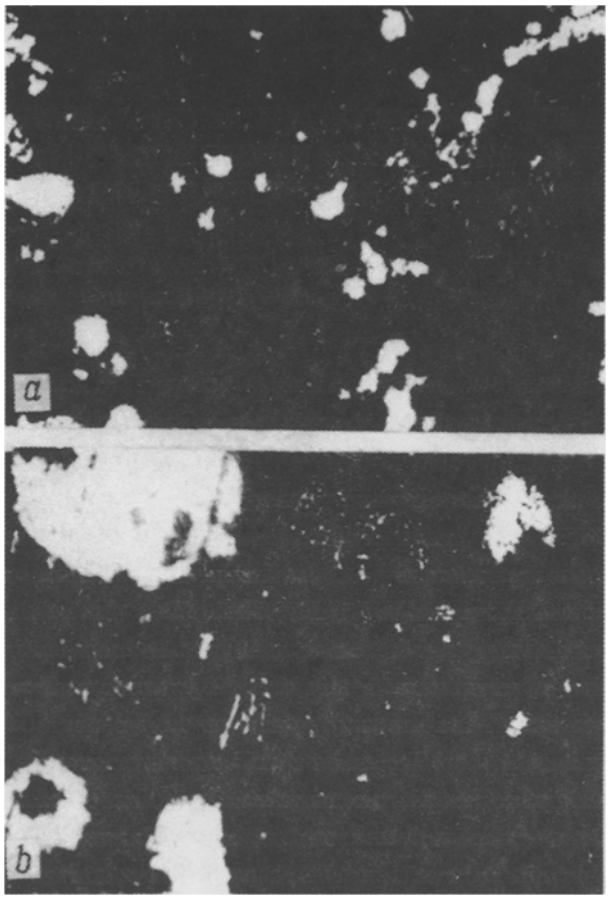

Fig. 1. Microsctructure of Termok-3MP mortar.

TABLE 1. Chemical Composition of Metallurgical Slags

Slag	Oxide content, %					
	SiO_2	Al_2O_3	CaO	MgO	FeO	MnO
Basic	10-20	5-10	30-50	5-15	10-20	5-10
Acidic	25-30	8-25	35-45	3-10	1-4	0.5-5.0

Two types of specific mortars developed correspond to acidic and basic slags. In this case the basicity index is the ratio of the total percentages of basic and acidic oxides CaO/SiO_2. The chemical composition of characteristic metallurgical slags is given in Table 1. In ferrous metallurgy a slag with a basicity index of 1.3-1.5 is considered acidic and that with an index of 1.8-2.5 is recognized to be basic.

Chemical analysis of a Termok-3PM sample taken from the region of contact with the metal and slag melts shows the presence of mainly MgO, $MgAl_2O_4$ and $Mg_{1-x}Fe_xO$ phases and a small amount of an FeO phase. The presence of iron compounds in the sample is a result of formation of highly refractory magnesium wüstite solid solutions in diffusion exchange of the refractories with the metal. Formation of these compounds subsequently hinders intensive erosion of the mortar during operation.

Petrographic analysis (Fig. 1) shows that the microstructure of the sample after combustion is rather homogeneous and the porosity is low. The main phase contains areas with a high reflectivity which, as rule, have a circular shape and are small in size. Their microhardness is 1195 MPa.

Using Termok-3MP mortar in the brickwork of an open-hearth furnace melting chamber allowed: a) "hot" repairs to be eliminated; b) the number of running repairs to be reduced by 1 or 2 a year; c) the service life of the lining to be increased by 10 days; d) the time of one heat to be reduced by 0.23 h.

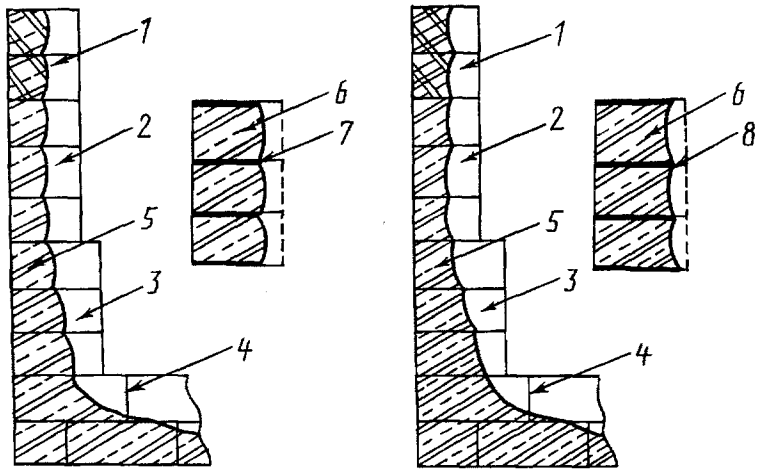

Fig. 2. Wear topography of the refractory lining of a casting ladle: 1) periclase brick, 2, 3) fireclay bricks, 4) ladle bottom, 5) residual thickness of the refractory, 6) brick wear, 7) wear of a fireclay joint, 8) wear of a Termok-3 joint.

Termok-3PM and Termok-3MM mortars were tested in casting ladles with capacities of 310, 175, 150, 100, 16, 3, and 1.5 ton, lined by aluminosilicate, high-alumina, and periclase bricks. Figure 2 shows schematically the wear topography of the refractory lining of the walls of the casting ladle (after 17 heats). The ladle is removed from service only because of substantial wear of bricks (complete burn-out), especially in the middle part of the working lining. Horizontal and vertical joints based on Termok-3 mortar extend 1.0-2.5 mm from the brick surface. Depending on the casting ladle tonnage (from 300 to 1.5 ton), the lining service life is increased 1.3 to 3 times, respectively.

The arches of electric furnaces were lined, using Termok-3KhP mortar (operating outside the metal-slag contact zone). The mortar provides sintering of the arch components with a high rate of the processes at the mortar-refractory contacts. Not only does this mortar provide sintering of individual bricks of the arch into a monolith and diminution of wear by mechanical fixation of spallings, but it also compensates for thermal elongation of bricks in operation of the furnace. Tests showed that arches lined with this mortar are less prone to deformation (distortion and swelling). High-refractory Termok-3PKh mortar increases the lining durability by 20-30%.

Thus, the present results show both prospects and feasibilities of using Termok-3 SHS refractories in ferrous metallurgy.

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